US EPA RECORDS CENTER REGION 5
1000462

RCRA PART B PERMIT APPLICATION

Submittal By:

Union Oil of California
Chicago Refinery
Lemont, Illinois

Volume II

Submitted to:

U.S. Environmental Protection Agency
Region V
230 Dearborn Street
Chicago, Illinois 60604

July, 1984

Prepared By:

Environmental Resources Management-North Central, Inc.
835 Sterling Avenue
Palatine, Illinois 60067

Project No. 4006JB

T. M. Gates, Inc.
787 Round Bottom Road
Milford, Ohio 45150

ERM-North Central, Inc.
835 Sterling Avenue
Palatine, Illinois 60067
(312) 934-4646

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July 13, 1984

Mr. Gale Hruska
U.S. Environmental Protection Agency
Region V
230 South Dearborn Street
Chicago, IL 60604

Project No. 4006JB

RE: RCRA Part B Permit Submittal
Union Oil, Chicago Refinery
I.D. No. ILD041550567

Dear Mr. Hruska:

Attached are four (4) sets of the remaining sections for the Union Oil of California Chicago Refinery, Part B Permit Application for their hazardous waste land treatment operation. This submittal completes the permit application sections that were submitted on May 31, 1984.

Also attached is a final completeness checklist to reference regulatory requirements with specific sections within the permit application.

Very truly yours,

ERM-NORTH CENTRAL, INC.

James W. Polich, P.E.

ljc

Enc.

cc: L.D. Erchull
Union Oil, Chicago Refinery

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TABLE OF CONTENTS
PART B PERMIT APPLICATION
UNION OIL COMPANY OF CALIFORNIA
Chicago Refinery

SECTION and TITLE	PAGE
LIST OF TABLES	xi
LIST OF FIGURES	xiv
VOLUME I	
A. PART A APPLICATION	A-1
Introduction	A-1
Part A Revisions	A-2
B. GENERAL FACILITY INFORMATION	B-1
B-1 General Facility Description	B-1
B-2 Topographic Map	B-4
B-2a Land Uses	B-5
B-2b Hazardous Waste Management Facility Boundaries	B-5
B-2c Wind Rose	B-6
B-2d Access Control	B-6
B-2d(1) Access to Refinery Grounds	B-7
B-2d(2) Access to Hazardous Waste Treatment Area	B-7
B-3 Injection and Withdrawal Wells	B-7
B-4 Buildings, Treatment, Storage and Disposal Areas (Other Structures)	B-8
B-5 Recreational Areas	B-8
B-6 Runoff Control System	B-8
B-7 Access and Internal Roads	B-9
B-8 Storm, Sanitary, and Process Sewers	B-9
B-9 Loading and Unloading Areas	B-10
B-10 Fire Control Facilities	B-11
B-11 Flood Control/Drainage Barriers	B-12
B-12 Location Information	B-12
B-12a Seismic Standard	B-12
B-12b Floodplain Standard	B-13
B-13 Federal Insurance Administration (FIA) Flood Map	B-13
B-13a Demonstration of Compliance	B-13
B-13a(1) Flood Proofing and Flood Protection Measures	B-13

SECTION and TITLE	PAGE
B-13a(2) Flood Plan	B-14
B-13b Plan for Future Compliance	B-14
B-14 Traffic Patterns	B-14
B-14a Access Roads	B-14
B-14a(1) Traffic Control	B-14
B-14a(2) Access Road Surfacing	B-15
B-14a(3) Load Bearing Capacity	B-16
B-14a(4) Traffic Control Signals	B-17
B-14b Internal Roads	B-17
B-14b(1) Internal Traffic Control	B-18
B-14b(2) Internal Road Surfacing	B-19
B-14b(3) Internal Road Load Bearing Capacity	B-19
B-14b(4) Internal Traffic Patterns	B-20
B-15 Location of Aquifers	B-21 ***
C. WASTE CHARACTERISTICS	C-1
Introduction	C-1
C-1 Chemical and Physical Analyses	C-1
C-1a List of Hazardous and Nonhazardous Wastes Treated at the Facility	C-1
C-1b Hazardous Wastes	C-5
C-1c Nonhazardous Wastes	C-6
C-2 Waste Analysis Plan	C-7
C-2a Parameters and Rationale	C-7
C-2b Sampling Methods	C-11
C-2c Analytical Methods	C-11
C-2d Sampling and Analytical Protocol	C-12
C-2e Frequency of Analyses	C-14
C-2f Additional Requirements for Wastes Generated Off-Site	C-16
D. PROCESS INFORMATION	D-1
Introduction	D-1
D-1 General Description of the Land Treatment Site	D-2
D-1a Soils and Topography	D-2
D-1b Geology and Hydrogeology	D-4
C-1c Past Operation Practices	D-6
D-2 Wastes to be Land Treated	D-8
D-2a Physical and Chemical Characteristics	D-8
D-2b Waste Application Rates	D-9
D-2c Waste Application Schedule	D-11
D-2c(1) Generation Rates	D-11
D-2c(2) Seasonal Restrictions	D-11
D-2c(3) Life Span of Facility	D-12
D-2d Waste Application Methods and Timing	D-15

SECTION and TITLE		PAGE

	D-2d(1) Waste Application Equipment and Procedures	D-15
	D-2d(2) Method and Frequency of Collection and Transportation of Wastes	D-17
	D-2d(3) Waste Application Restrictions	D-17
	D-2d(4) Plot Configurations	D-18
D-3	Treatment Zone Description	D-18
	D-3a Definition of Treatment Zone	D-18
	D-3b Soil Survey and Soil Series Description	D-19
	D-3c Soil Sampling Results	D-26
	D-3d Treatment Capacity Remaining	D-26
D-4	Soil Management	D-27
	D-4a Moisture Control	D-27
	D-4a(1) Run-on Control	D-27
	D-4a(2) Runoff Control	D-28
	D-4b pH Control	D-29
	D-4b(1) Current pH	D-29
	D-4b(2) Allowable pH Range	D-29
	D-4b(3) Methods of pH Control	D-30
	D-4c Enhancement of Microbial and Chemical Reactions	D-31
	D-4c(1) Waste Incorporation	D-31
	D-4c(2) Aeration of Soil	D-32
	D-4c(3) Microbial Innoculations	D-32
	D-4c(4) Fertilizer Applications	D-32
	D-4d Chemical Loadings to the Soil	D-33
	D-4d(1) Chromium	D-33
	D-4d(2) Lead	D-34
	D-4d(3) Sulfide	D-35
	D-4d(4) Sodium	D-36
D-5	Surface Water Control Plans	D-38
	D-5a Run-on Control	D-38
	D-5b Runoff Control	D-38
	D-5c Management Methods for Collected Run-on/Runoff	D-39
D-6	Control of Wind Dispersal	D-40
D-7	Monitoring Program	D-40
	D-7a Ground Water Monitoring	D-40
	D-7b Treatment Zone Soil Monitoring	D-41
D-8	Management of Ignitible or Reactive Wastes	D-42
D-9	Management of Incompatible Wastes	D-43
D-10	Inspection of Land Treatment Unit	D-43
D-11	Food Chain Crops	D-44
D-12	Establishment of Vegetative Cover at Closure	D-44

SECTION and TITLE	PAGE	
D-13 Containers	D-44	
D-14 Tanks	D-45	
D-15 Waste Piles	D-45	
D-16 Surface Impoundments	D-45	
D-17 Incinerators	D-46	
ATTACHMENT D-1 TREATMENT DEMONSTRATION PROGRAM		
E. GROUND WATER MONITORING	E-1	
Introduction	E-1	
E-1 General Description of Monitoring System	E-1	
E-1a Unsaturated Zone Monitoring	E-2	
E-1a(1) Lysimeter Installations	E-2	
E-1a(2) Soil Core Samples	E-2	
E-1a(3) Perched Water Table	E-2	
E-1b Ground Water Monitoring	E-3	
E-1b(1) Upgradient Monitoring Wells	E-3	
E-1b(2) Downgradient Monitoring Wells	E-4	
E-1b(3) Additional Monitoring Wells	E-4	
E-2 Site Characteristics	E-5	
E-2a Topography	E-5	
E-2b Geology	E-6	***
E-2c Hydrogeology	E-14	***
E-2c(1) Regional Hydrogeology	E-14	***
E-2c(2) Site Hydrogeology	E-18	***
E-2d Water Quality Data and Chemical Analysis of Soils	E-22	***
E-2d(1) Water Quality Data	E-23	***
E-2d(1)(a) Pore Water Monitoring - Lysimeter Samples	E-23	***
E-2d(1)(b) Perched Water Monitoring	E-24	***
E-2d(1)(c) Water Table Monitoring	E-24	***
E-2d(2) Chemical Analysis of Soils	E-25	***
E-2d(2)(a) Cation Exchange Capacity and pH	E-25	***
E-2d(2)(b) Soil Cores	E-26	***
E-3 Ground Water Monitoring - Saturated Zone	E-28	***
E-3a General Requirement - Well Placement and Design	E-28	***
E-3a(1) Definition of Uppermost Aquifer and Corresponding Wells	E-28	***
E-3a(2) Groundwater Flow Direction, Upgradient and Downgradient Wells	E-29	***

SECTION and TITLE	PAGE
E-3a(3) Point of Compliance and Corresponding Wells	E-29 ***
E-3a(4) Well Design and Appropriateness for Monitoring	E-30 ***
E-3b Sampling and Analytical Methods	E-33 ***
E-3b(1) Ground Water Surface, Elevation and Direction of Flow	E-33 ***
E-3b(2) Ground Water Sampling Procedure	E-34 ***
E-3b(3) Sample Preservation and Shipment	E-34 ***
E-3b(4) Analytical Methods	E-34 ***
E-3b(5) Chain of Custody	E-34 ***
E-3b(5)(a) Sample Identification	E-34 ***
E-3b(5)(b) Chain of Custody	E-35 ***
E-3c Statistical Analysis	E-38 ***
E-3d Detection Monitoring Program	E-40 ***
E-3d(1) Selection of Monitoring Parameters	E-40 ***
E-3d(2) Definition of Background Values for Parameters	E-42 ***
E-3d(3) Sampling Schedule	E-42 ***
E-3d(3)(a) Sampling Frequency	E-42 ***
E-3d(3)(b) Sampling Location	E-43 ***
E-3d(4) Procedures to Follow When a Statistically Significant Increase is Found	E-44 ***
E-3d(5) Change in the Detection Monitoring Program	E-46 ***
E-3e Compliance Monitoring Program	E-47 ***
E-3e(1) Program	E-47 ***
E-3d(2) Procedures to Terminate the Compliance Monitoring Program	E-47 ***
E-3f Remedial Action Program	E-48 ***
E-4 Unsaturated Zone Monitoring	E-48 ***
E-4a Concept and Purpose	E-48 ***
E-4b Perched Water Monitoring	E-49 ***
E-4b(1) Design and Placement of Wells	E-49 ***
E-4b(1)(a) Design	E-49 ***
E-4b(1)(b) Placement	E-49 ***
E-4b(2) Selection of Monitoring Parameters	E-50 ***
E-4b(2)(a) Parameters to be Monitoring During 1984/1985	E-50 ***
E-4b(2)(b) Parameters to be Monitored During Post-1984/1985 Period	E-51 ***

SECTION and TITLE	PAGE
E-4b(3) Sampling Schedule	E-51 ***
E-4b(3)(a) 1984/1985 Sampling Schedule	E-51 ***
E-4b(3)(b) Post-1984/1985 Sampling Schedule	E-52 ***
E-4b(4) Sampling Procedure	E-52 ***
E-4b(5) Sample Preservation and Shipment	E-52 ***
E-4b(6) Analytical Methods	E-52 ***
E-4b(7) Chain of Custody	E-53 ***
E-4b(8) Background Values for Parameters	E-53 ***
E-4b(9) Evaluation of Data	E-53 ***
E-4c Lysimeter - Pore Water Monitoring	E-55 ***
E-4c(1) Design and Placement of Lysimeters	E-55 ***
E-4c(1)(a) Design	E-55 ***
E-4c(1)(b) Placement	E-56 ***
E-4c(2) Selection of Monitoring Parameters	E-58 ***
E-4c(3) Sampling Schedule	E-60 ***
E-4c(4) Sampling Procedure	E-60 ***
E-4c(5) Sample Preservation and Shipment	E-62 ***
E-4c(6) Analytical Methods	E-62 ***
E-4c(7) Chain of Custody	E-63 ***
E-4c(7)(a) Sample Identification	E-63 ***
E-4c(7)(b) Chain of Custody	E-64 ***
E-4c(8) Background Values for Parameters	E-66 ***
E-4c(9) Evaluation of Data	E-67 ***
E-4c(10) Procedures Followed When Anomalous Increases in a Parameter Value is Found	E-68 ***
E-4d Soil Core Samples	E-70 ***
E-4d(1) Selection and Placement of Soil Cores	E-70 ***
E-4d(2) Selection of Monitoring Parameters	E-71 ***
E-4d(3) Sampling Schedule	E-72 ***
E-4d(4) Sampling Procedures	E-73 ***
E-4d(5) Sampling Preservation and Shipment	E-75 ***
E-4d(6) Analytical Methods	E-76 ***
E-4d(7) Chain of Custody	E-76 ***
E-4d(7)(a) Sample Identification	E-76 ***
E-4d(7)(b) Chain of Custody	E-77 ***
E-4d(8) Background Value for Parameters	E-80 ***
E-4d(9) Evaluation of Data	E-80 ***
E-4d(10) Procedures Followed When Anomalous Increases in a Parameter Value is Found	E-81 ***
E-5 References	E-83 ***

ATTACHMENT E-1 BORING LOGS/WELL CONSTRUCTION DIAGRAMS

SECTION and TITLE	PAGE

ATTACHMENT E-2 WATER WELL INVENTORY

ATTACHMENT E-3 PHYSICAL TESTING GRAIN SIZE DISTRIBUTION AND SOIL CLASSIFICATION

ATTACHMENT E-4 PORE WATER MONITORING LYSIMETER SAMPLES

ATTACHMENT E-5 MONITORING WELL GROUND WATER QUALITY DATA

ATTACHMENT E-6 SUMMARY OF CATION EXCHANGE CAPACITY AND pH OF SOIL SAMPLES

ATTACHMENT E-7 CHEMICAL ANALYSIS OF SOIL CORES

ATTACHMENT E-8 SAMPLING, PRESERVATION AND SHIPMENT INSTRUCTIONS

ATTACHMENT E-9 SAMPLE PRESERVATION

ATTACHMENT E-10 GROUND WATER ASSESSMENT PLAN

F. PROCEDURES TO PREVENT HAZARDS	F-1
Introduction	F-1
F-1 Security	F-1
F-1a Security Procedures and Equipment	F-1
F-1a(1) 24-Hour Surveillance System	F-3
F-1a(2) Barrier and Means to Control Entry	F-4
F-1a(2)(a) Barrier	F-4
F-1a(2)(b) Means to Control Entry	F-5
F-1a(3) Warning Signs	F-6
F-1b Waiver	F-6
F-2 Inspections	F-7
F-2a General Inspection Requirements	F-7
F-2a(1) Types of Problems	F-9
F-2a(2) Frequency of Inspection	F-12
F-2b Specific Process Inspection Requirements	F-12
F-2b(1) Container Inspection	F-12
F-2b(2) Tank Inspection	F-12
F-2b(3) Waste Pile Inspection	F-13
F-2b(4) Land Treatment System Inspection	F-13

SECTION and TITLE	PAGE

F-3 Waiver of Preparation and Prevention Requirements F-14
F-3a Equipment Requirements F-14
F-3a(1) Internal and External Communications F-14
F-3a(2) Emergency Equipment F-16
F-3a(3) Fire Control Equipment F-16
F-3b Aisle Space Requirements F-17
F-4 Preventive Procedures, Structures, and Equipment F-17
F-4a Loading/Unloading Operations F-17
F-4b Runoff F-18
F-4c Water Supply F-20
F-4d Equipment and Power Failure F-21
F-4e Personnel Protection Equipment F-22
F-5 Prevention of Reaction of Ignitible, Reactive, or Incompatible Wastes F-23
F-5a General Precautions for Handling Ignitable or Reactive Wastes F-23
F-5b General Precautions for Handling Incompatible Wastes F-24
F-5c Management of Ignitible or Reactive Wastes in Containers F-24
F-5d Management of Incompatible Wastes in Containers F-24
F-5e Management of Ignitible or Reactive Wastes in Tanks F-25
F-5f Management of Incompatible Wastes in Tanks F-25
F-5g Management of Ignitible or Reactive Wastes in Waste Piles F-25
F-5h Management of Incompatible Wastes in Waste Piles F-25

ATTACHMENT F-1 SECTIONS OF THE GUARD AND SECURITY MANUAL
ATTACHMENT F-2 FIRE EQUIPMENT INSPECTION PROCEDURES

VOLUME II

G. CONTINGENCY PLAN
Introduction G-1
G-1 General Information G-2
G-1a Land Treatment Area Drainage G-4
G-1b Security G-4
G-1c Hazardous Waste Characteristics G-7

SECTION and TITLE	PAGE	
G-1d Emergency Communication, Alarms and Equipment	G-10	
G-1d(1) Communications and Alarms	G-11	
G-1d(2) Fire Fighting and Emergency Equipment	G-11	
G-1e Spill Control Equipment	G-12	
G-2 Emergency Coordinator	G-13	
G-3 Implementation of Contingency Plan	G-14	
G-4 Emergency Response Procedures	G-15	
G-5 Emergency Equipment	G-22	
G-5a Testing and Maintenance of Emergency Equipment	G-24	
G-5b Available Support Emergency Equipment	G-25	
G-6 Coordination Agreements	G-25	
G-7 Evacuation Plan	G-27	
G-8 Amendment to the Contingency Plan	G-28	
G-9 Required Reports	G-29	
G-10 SPCC Plan	G-29	
G-11 Emergency Response During Land Treatment System Operation	G-30	*** ***
ATTACHMENT G-1 EMERGENCY PROCEDURES MANUAL		
ATTACHMENT G-2 SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN		
ATTACHMENT G-3 CONTINGENCY PLAN INCIDENT REPORTS		
H. PERSONNEL TRAINING	H-1	
Introduction	H-1	
H-1 Outline of Training Program	H-1	
H-1a Job Titles and Duties	H-1	
H-1b Training Content, Frequency, and Techniques	H-9	
H-1c RCRA Training Director	H-10	
H-1d Relevance of Training to Job Position	H-12	
H-1e Training for Emergency Response	H-12	
H-2 Implementation of Training Program	H-15	
ATTACHMENT H-1 JOB DESCRIPTIONS CHICAGO REFINERY		
I. CLOSURE, POST-CLOSURE PLANS, AND FINANCIAL REQUIREMENTS	I-1	***
Introduction	I-1	***
I-1 Closure Plan	I-2	***
I-1a Closure Performance Standard	I-2	***
I-1b Partial Closure	I-2	***

SECTION and TITLE		PAGE	
	I-1c Final Closure	I-3	***
	I-1d Maximum Waste Inventory	I-12	***
	I-1e Schedule for Closure	I-12	***
	I-1f Disposal of Contaminated Equipment	I-14	***
	I-1g Closure of Containers	I-15	***
	I-1h Closure of Tanks	I-15	***
	I-1i Closure of Waste Piles	I-15	***
	I-1j Closure Plan Amendment	I-15	***
I-2	Post-Closure Plan	I-16	***
I-3	Notice in Deed and Notice to Local Land Authority	I-19	***
I-4	Closure Cost Estimate	I-20	***
I-5	Post-Closure Cost Estimate	I-23	***
I-6	Financial Assurance Mechanism for Closure, Post-Closure and Liability Requirements	I-24	***
I-7	Proof of Financial Coverage by an Equivalent State Financial Mechanism	I-26	***

EXHIBIT I-1 LETTER FROM CHIEF FINANCIAL OFFICER

EXHIBIT I-2 REPORT FROM INDEPENDENT CERTIFIED PUBLIC ACCOUNTANT

EXHIBIT I-3 MOST RECENT ANNUAL REPORT - UNOCAL CORPORATION

J. OTHER FEDERAL LAWS J-1

K. CERTIFICATION K-1

APPENDIX A-LITERATURE REVIEW

LIST OF TABLES

SECTION AND TABLE NUMBER	TITLE	
C-1	Wastes to be Treated at the land Treatment Area	
C-2	Hazardous Wastes to be Land Treated	
C-3	Summary of Waste Analysis API-Separator Sludge	
C-4	Summary of Waste Analysis-Tank Cleaning Waste	
C-5	Summary of Waste Analysis-Clear Well Sludge	
C-6	Summary of Waste Analysis-Cooling Tower Sludge	
C-7	Summary of Waste Analysis-Heavy Oil Sludge	
C-8	Summary of Waste Analysis-Storm Water Pond Dredgings	
C-9	Summary of Waste Analysis-Water and Wastewater Sludge	
C-10	Analytical Parameters for Hazardous Waste Characterization	
C-11	Analytical Parameters for Nonhazardous Waste Characterization	
C-12	EPA Sampling Procedures	*
C-13	EPA Analytical Method Numbers	*
D-1	Historic Land Application Record	
D-2	Land Treatment Plot Loadings	
D-3	Waste Generation Rates and Frequency	

SECTION AND TABLE NUMBER	TITLE
D-4	Physical/Chemical Waste Characteristics
D-5	Surface Soil Analysis: West Land Treatment Plot - Area I
D-6	Subsoil Analysis: West Land Treatment Plot - Area I
D-7	Surface Soil Analysis: South Land Treatment Plot - Area II
D-8	Subsoil Analysis: South Land Treatment Plot - Area II
D-9	Surface Soil Analysis: Northwest Land Treatment Plot - Area III
D-10	Subsoil Analysis: Northwest Land Treatment Plot - Area III
D-11	Subsoil Analysis: Northeast Land Treatment Plot - Area IV
D-12	Composite Soil EP Toxicity Analysis
D-13	Background Soil Analysis
D-14	Life Span Calculations - Chromium
D-15	Life Span Calculations - Lead
D-16	List of Waste Handling Equipment
E-1	Stratigraphy and Aquifer Systems of Northeastern Illinois
E-2	Selected Soil Characteristics of the Union Oil Land Treatment Facility at the Chicago Refinery
E-3	Water Level Data - June 18, 1984

SECTION AND TABLE NUMBER	TITLE	
F-1	Personnel Responsible for Inspections	
F-2	Types of Problems Reviewed During Inspections	
G-1	Emergency Call List	
G-2	Environmental Coordinators for Emergency Response at Land Treatment Area	
G-3	Summary of Emergency Procedures	
G-4	Sources of Emergency Equipment Not Owned By Union Oil	
G-5	Location of Contingency Plan Copies	
G-6	Contingency Plan Record of Changes and Amendments	
H-1	Summary of Training for Facility Personnel	
H-2	Summary of Training Courses and Conferences	* *
H-3	Current Truck Drivers	*
I-1	Equipment Decontamination Procedures	
I-2	Post-Closure Inspection Procedures	
I-3	Estimate of Closure Costs: 3 Year Period	
I-4	Cost of Decontamination and Disposal of Equipment	
I-5	Estimate of Post-Closure Costs: 30 Year Period	

*** Revised 12/1/85

LIST OF FIGURES

SECTION AND FIGURE NUMBER	TITLE	
A-1	Facility Location Map	
A-2	Facility Base Map	
B-1	Location of Hazardous Waste Land Treatment System	
B-2	Topographic Map of Land Treatment System	
B-3	Topographic Map of Land Treatment System With Addition of 5 foot Contours	
B-4	Surface Wind Rose	
B-5	Traffic Patterns	
B-6	Fire Water System and Fire Hydrant Location	
B-7	Flood Plain Map	
B-8	Location of Geologic Cross-Section	***
B-9	Stratigraphy and Aquifer Systems	***
D-1	Land Treatment Plots	
D-2	Run-on & Runoff Control Conceptual Drawing	
D-3	Berm & Discharge Structure Cross Section	
E-1	Monitoring System for Land Treatment Area	
E-2	Location of Geologic Cross-Sections	
E-3	Generalized Geologic Cross-section A-A' Through Land Treatment Area	
E-4	Generalized Geologic Cross-Section B-B' Through Land Treatment Area	

SECTION AND FIGURE NUMBER	TITLE
E-5	Generalized Geologic Cross-Section C-C' Through Land Treatment Area
E-6	Generalized Geologic Cross-Section D-D' Through Land Treatment Area
E-7	Distribution of Groundwater Pumpage Centers in 1962
E-8	Estimated Yields of Shallow Dolomite Wells
E-9	Groundwater Contours
E-10	Chain of Custody Record
E-11	Lysimeter Installation and Sampling
F-1	Access to Tank Farm and Land Treatment Area
F-2	Land Treatment Facility Inspection Report Form
F-3	Location and Summary of Emergency Response Equipment
G-1	Location of Hazardous Waste Land Treatment System
G-2	Format for Hazardous Waste Emergency Event Report
G-3	Location and Summary of Emergency Response Equipment
G-4	Proposed Letter of Transmittal to Mutual Aid Organizations
H-1	Annual Report, Part I: Training Sessions Held

SECTION AND FIGURE NUMBER	TITLE
H-2	Hazardous Waste Management Personnel Training Data
H-3	Training Session Data Sheet
I-1	Closure Schedule
I-2	Location of Hazardous Waste Land Treatment Plots - Maximum Extent of Closure
I-3	Post - Closure Inspection Log

SECTION G

HAZARDOUS WASTE CONTINGENCY PLAN AND EMERGENCY PROCEDURES

(40 CFR PART 264, SUBPART D)

UNION OIL COMPANY OF CALIFORNIA
CHICAGO REFINERY
135TH STREET AND NEW AVENUE
LEMONT, ILLINOIS 60439

(312) 257-7761

*** Revised 12/1/85

MANAGEMENT APPROVAL AND DELEGATION OF AUTHORITY

THE PROVISIONS OF THIS HAZARDOUS WASTE CONTINGENCY PLAN WILL BE IMMEDIATELY CARRIED OUT WHENEVER THERE IS A FIRE, *** EXPLOSION, OR RELEASE OF HAZARDOUS WASTE OR HAZARDOUS WASTE CONSTITUENTS WHICH COULD THREATEN HUMAN HEALTH OR THE ENVIRONMENT.

THE INDIVIDUAL DESIGNATED AS THE EMERGENCY COORDINATOR, AND INDIVIDUALS DESIGNATED AS ALTERNATE EMERGENCY COORDINATORS IN THE ABSENCE OF THE EMERGENCY COORDINATOR, ARE AUTHORIZED TO COMMIT THE RESOURCES NEEDED TO CARRY OUT THIS CONTINGENCY PLAN.

SIGNATURE: DLB 12/2/85

NAME: A. J. ELISKALNS

TITLE: MANAGER, CHICAGO REFINERY

DATE: 12-2-85

TABLE OF CONTENTS
SECTION G
CONTINGENCY PLAN

SECTION and TITLE	PAGE
MANAGEMENT APPROVAL AND DELEGATION OF AUTHORITY	G-i
TABLE OF CONTENTS	G-ii
LIST OF TABLES	G-iii
LIST OF FIGURES	G-iv
INTRODUCTION	G-1
CONTINGENCY PLAN	G-1
G-1 General Information	G-2
G-1a Land Treatment Area Drainage	G-4
G-1b Security	G-4
G-1c Hazardous Waste Characteristics	G-7
G-1d Emergency Communication, Alarms and Equipment	G-10
G-1d(1) Communications and Alarms	G-11
G-1d(2) Fire Fighting and Emergency Equipment	G-11
G-1e Spill Control Equipment	G-12
G-2 Emergency Coordinator	G-13
G-3 Implementation of Contingency Plan	G-14
G-4 Emergency Response Procedures	G-15
G-5 Emergency Equipment	G-22
G-5a Testing and Maintenance of Emergency Equipment	G-24
G-5b Available Support Emergency Equipment	G-25
G-6 Coordination Agreements	G-25
G-7 Evacuation Plan	G-27
G-8 Amendment to the Contingency Plan	G-28
G-9 Required Reports	G-29
G-10 SPCC Plan	G-29
G-11 Emergency Response During Land Treatment System Operation	G-30 *** ***
ATTACHMENT G-1 EMERGENCY PROCEDURES MANUAL	
ATTACHMENT G-2 SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN	
ATTACHMENT G-3 CONTINGENCY PLAN INCIDENT REPORTS	

LIST OF TABLES
SECTION G
CONTINGENCY PLAN

TABLE NUMBER AND TITLE		PAGE
G-1	Emergency Call List	G-31
G-2	Environmental Coordinators for Emergency Response at Land Treatment Area	G-32
G-3	Summary of Emergency Procedures	G-33
G-4	Sources of Emergency Equipment Not Owned by Union Oil	G-34
G-5	Location of Contingency Plan Copies	G-41
G-6	Contingency Plan Record of Changes and Amendments	G-42

LIST OF FIGURES
SECTION G
CONTINGENCY PLAN

FIGURE NUMBER	TITLE
G-1	Location of Hazardous Waste Land Treatment System
G-2	Format for Hazardous Waste Emergency Event Report
G-3	Location and Summary of Emergency Response Equipment
G-4	Proposed Letter of Transmittal to Mutual Aid Organizations

SECTION G

CONTINGENCY PLAN

INTRODUCTION

The information contained herein is submitted in accordance with the requirements for a contingency plan, as contained in 40 CFR 264 Subpart D.

CONTINGENCY PLAN

The intent of 40 CFR 264, Subpart D-Contingency Plan and Emergency Procedures, is to ensure that facilities that treat, store, or dispose of hazardous wastes have established procedures in the event an emergency situation should arise.

G-1 General Information

The Union Oil Company of California, Chicago Refinery (hereafter referred to as the Chicago Refinery) is located in Will County, Illinois, near the city of Lemont, Illinois. The mailing address is:

Union Oil Company of California
Chicago Refinery
135th Street and New Avenue
Lemont, Illinois 60439.
Phone: (312) 257-7761

The Chicago Refinery is a petroleum refinery with a rated capacity of 154,000 barrels per day, employing approximately 705 people. The refinery produces 25 different products including:

- gasoline
- furnace oils
- jet fuels
- diesel fuels
- various specialty naphthas
- petroleum coke

This Contingency Plan specifically covers the land treatment area located as shown on Figure G-1.

The existing land treatment site encompasses approximately 28 acres, which includes four (4) land farm plots (13.3 acres), roadways, a nonhazardous waste storage and decant

basin, and untilled buffer zones around each land farm plot. The site was originally opened in 1973.

It is expected that only the following hazardous wastes will be treated at the land farm site; API separator sludge *** (K051) and slop oil emulsions (K049). The nonhazardous *** wastes which will continue to be treated include: water and wastewater treatment sludge; storm water holding basin sludge; heavy oil sludge (decant oil sediment); cooling tower sludge; clear well sludge; corrugated plate separator *** bottoms; and, tank cleaning wastes. ***

The contact and party responsible for the land treatment operation at the Chicago Refinery is:

The Superintendent of Transfer and Blending

(312) 257-7761

Due to the nature of the wastes applied and since all hazardous wastes will be subsurface injected, the possibility of a fire or explosion at the land treatment site is extremely remote. The following subsections however, outline the procedures to take if an emergency should occur.

G-1a Land Treatment Area Drainage

A drainage ditch for surface runoff flows through the land treatment area. This ditch collects runoff from the land treatment area as well as the area to the east. The flow in this ditch ultimately discharges to the Chicago Refinery's storm water retention ponds and is treated in their wastewater treatment plant. Discharge from the wastewater treatment plant is to the Sanitary and Ship Canal and currently has an NPDES Permit. Grading of the land treatment area minimizes runoff from the land farm plots.

G-1b Security

Security at the Chicago Refinery is maintained by a staff of trained security personnel who monitor entry and exit from the refinery grounds, as well as providing security measures within the plant.

All open gates are monitored by security personnel. Guards prevent entry of any person without prior authorization. Anyone found on the property without a temporary pass or contractor's badge, or without having registered at the South or North Gate, is escorted to the South Gate to await

clearance. A vehicle inspection is made of all vehicles leaving Union Oil property. A personnel security inspection is made of all individuals leaving Union Oil property on foot, except personnel leaving the main administration building.

There is one security officer assigned to a roving control post (a Union Oil vehicle) at all times and on all shifts. The primary function of this post is to patrol the refinery areas as well as the Tank Farms. The patrol is on the alert for anything abnormal with respect to safety or security of personnel or equipment. The hazardous waste land treatment area is included in this security inspection. In order to gain access to the hazardous waste land treatment area, entry to the Tank Farm, south of 127th Street and east of High Road, must first be made. Access to the Tank Farm can only be made in one of the following ways:

1. By showing proper identification to the North Gate Guard;

2. By use of an authorized vehicle; and,

3. By use of a remote control gate opener.

Access to the land treatment area from the Tank Farm is controlled by an 8 foot high chain link security fence. This fence is provided with warning signs and gates.

Each gate is posted with the sign bearing the legend: "Danger--Unauthorized Personnel Keep Out." These signs are also located on the fence so as to be seen from any approach to the land treatment area.

In addition to the general security provisions of fencing, gates, guards, and security personnel, a number of other features contribute to the safety and security of the Chicago Refinery. Employees have immediate access to alarms and telephone and/or radio communication equipment. The Chicago Refinery is supplied with an alarm system, a public address system, and an internal telephone system. The same telephone system is used for communications outside the plant. Additionally, extensive use of hand-held two-way radios is made. The tractor unit used to tow the liquid manure spreader and the hazardous waste vacuum truck are equipped with two-way radios.

Employees are required to show identification badges, with pictures, when reporting for work. Visitors must sign a log

sheet and carry a temporary pass, and contractors have an identification badge they must carry at all times.

G-1c Hazardous Waste Characteristics

Currently, no hazardous wastes are being land treated. The Chicago Refinery intends to start land treatment of hazardous wastes only after the Part B permit application has been approved.

Two listed hazardous wastes -- API separator sludge (K051) and slop oil emulsions (K049) -- have been identified for *** application to the land treatment plots.

Current generation of API separator sludge is approximately 13 dry tons per year. This waste is classified as hazardous due to the presence of chromium and lead and has a hazard code of T, Toxic.

The Chicago Refinery has not, to date, generated any slop oil emulsions due to the manufacturing process being used. This process has operated for approximately 14 years without any wastes being generated, but the waste has been

identified and included in this permit application as a contingency for treatment at the land treatment site. Slop oil emulsions are listed due to the presence of chromium and lead and has a hazard code of T, Toxic.

Tank cleaning wastes are generated on an intermittent basis. The last waste generated from tank cleaning was in 1981, and at that time, the waste had a flash point above 140°F and was therefore not classified as ignitible. A total of 150 dry tons was generated. All tank cleaning wastes will be analyzed according to the program set forth in Section C. If any such analyses shows a flash point less than 140°F, then the tank cleaning wastes will <u>not</u> be land treated. Consequently, any tank cleaning wastes land treated will be nonhazardous wastes. ***

The hazards associated with each of the above wastes can be summarized as follows:

Hazardous Waste	Hazard	Basis for Hazard Designation
API Separator Sludge	Toxic	Listed Waste K-051; lead and hexavalent chromium
Slop Oil Emulsions	Toxic	Listed Waste K049; lead and hexavalent chromium

Nonhazardous wastes are currently being treated at the land treatment site. In general, the annual quantity of nonhazardous wastes treated totals about 4,220 dry tons. Three of the nonhazardous wastes have intermittent generation rates, once every three to five years. Should all of these wastes be generated in the same year, the total nonhazardous waste quantity being treated would increase to approximately 4,600 dry tons.

The six nonhazardous wastes being land treated, along with the major waste constituent are:

Nonhazardous Waste	Major Waste Constituent
Clear Well Sludge	Inorganics

Cooling Tower Sludge	Inorganics
Corrugated Plate Separator Bottoms	Oil & Grease
Heavy Oil Sludge	Oil & Grease
Storm Water Pond Dredgings	Oil & Grease
Water & Wastewater Sludge	Oil & Grease

As previously indicated, since only nonhazardous tank *** cleaning wastes will be land treated, these wastes will also *** contribute an oil and grease fraction to the land treatment *** system. ***

G-1d Emergency Communication, Alarms and Equipment

All facilities at the Chicago Refinery are equipped with safety and emergency equipment to minimize the potential for emergencies specific to each area or process. Particular care has been taken to provide sufficient space to allow the unobstructed movement of personnel, fire protection equipment, spill control equipment, and decontamination equipment to any area in an emergency.

A security system adequate to insure the integrity of emergency preparedness is in place at the refinery.

G-1d(1) Communications and Alarms

The Chicago Refinery has an internal telephone system, a public address system, alarms, and two-way radio communications equipment. The internal telephone system also functions as an external telephone for contacting any local or long distance telephone number. Union Oil utilizes an emergency response whistle which is centrally controlled by the North Gate Guard House. On being contacted, either by dialing Extension 222 on the internal telephone system or by two-way radio communication on an emergency channel, the North Gate Guard House initiates an established emergency response procedure. Depending on the type of emergency, the North Gate Guard House calls for a fire response, medical aid, or the Emergency Coordinator.

G-1d(2) Fire Fighting and Emergency Equipment

The Chicago Refinery is served by fire hydrants with mains of either 10 or 12 inches carrying water at a nominal 150 pounds pressure. The fire hydrants nearest the land treatment area are along East 13th Street, and are located

from 120 to 1500 feet from all parts of the land treatment facility (Figure G-3).

The Chicago Refinery has dedicated fire trucks and other emergency response equipment on-site. This fire fighting equipment has the capability for water pumping, foam solution pumping, and dry chemical fire extinguishers. The emergency aid equipment includes air packs, a proximity suit, and a fully equipped ambulance. All of this equipment is under the direct supervision of the Fire Protection Supervisor, who also has responsibility for inspection, maintenance, and repair. A more complete list of emergency equipment is shown in Attachment G-1.

The location of the Chicago Refinery's fire station, and other mobile equipment located within the refinery is shown on Figure G-3.

G-1e Spill Control Equipment

The Refinery maintains the following spill control equipment:

- Two vacuum trucks assigned by truck dispatcher.

- Sorbent materials.

G-2 Emergency Coordinator

If an emergency situation develops of such proportion as to require the assistance of the plant fire or rescue squad, extension 222 (the refinery emergency telephone number) would be called immediately. This number rings at the North Gate Guard House which has responsibility for coordinating all emergency calls as well as monitoring the emergency frequency from the two-way radio communication system. If * the emergency concerns the hazardous waste storage, * transportation or the land treatment area, the Emergency * Coordinator is notified by pager or telephone. The * Emergency Coordinator has complete authority to commit all resources of the company in the event of an emergency. Table G-1 lists organizations that could possibly be contacted by the Emergency Coordinator in the event of such an emergency.

Zhe Emergency Coordinator has the flexibility to request * assistance and/or replacement whenever appropriate. Further, the North Gate Guard House maintains a listing of all home telephone numbers and, if the emergency occurs * after normal working hours, plant security will contact the * Emergency Coordinator at home. *

All individuals designated as Emergency Coordinators on * Table G-2 have practical refinery experience and have received both classroom and field training appropriate to their responsibilities. This training is periodically updated.

G-3 Implementation of the Contingency Plan

In order to minimize hazards to the environment or to human health, Chicago Refinery management has developed a

Contingency Plan that specifies procedures to be implemented at the facility in the event of a fire, explosion, hazardous waste spill, or other emergency that could threaten human health or the environment. The responsibility for implementation of these procedures and for coordination with local authorities and emergency response teams rests with the Emergency Coordinator. *

Table G-3 provides a summary of emergency procedures. All facility employees are trained in how to report emergencies.

The details of the Contingency Plan are described in the following sections.

G-4 Emergency Response Procedures

The following procedures are to be followed in the event of a fire, explosion, or spill at the hazardous waste land treatment area. It should be noted that Union Oil has issued specific response/responsibilities procedures to be

followed by employees, the fire brigade and other designated personnel to address all types of emergency/security procedures. The following paragraphs provide, in narrative format, an overview of the Chicago Refinery's comprehensive emergency response procedure as related to the land treatment area.

It is the responsibility of each employee to report any emergency by using the refinery emergency telephone number (222). This extension number 222 rings in the North Gate Guard House. The Guard on duty has the responsibility to first determine what type of emergency exists (ie., fire, medical aid required, spill) and then to initiate the proper response. Written documentation of these response procedures are contained in the Emergency Procedures Manual, a copy of which is maintained at the North Gate Guard House. The guard on duty has the responsibility to: sound the alarms; provide direction over the public address system; * contact the Emergency Coordinator (Table G-2) and request, * if directed by the Emergency Coordinator, outside assistance; and, control and direct outside emergency responses to the appropriate portion of the refinery.

As previously discussed, the North Gate Guard House also monitors the fire/security frequency at the Chicago Refinery.

A copy of the Emergency Procedures Manual discussed above is maintained at the North Gate Guard House and is included as Attachment G-1 to this Section.

After being notified, the Emergency Coordinator assumes * responsibility for implementing emergency procedures and for directing all emergency responses related to the storage, * transportation or land treatment of hazardous wastes at the * refinery. Table G-3 provides a summary of the emergency procedures that will be followed if an emergency occurs at the hazardous waste land treatment area.

The Emergency Coordinator is responsible for implementing or directing the implementation of the remainder of the procedures specified in the Emergency Procedures Manual (Attachment G-1). In general, his duties would include the following:

1) Identify the source and character of the incident and the type and quantity of any hazardous waste released. Assess possible hazards to human health or the environment that may result directly from

the problem or its control. Information contained in Subsection G-1c to this Contingency Plan, provides background data to the Emergency Coordinator which will assist him in his assessment.

2) Discontinue operations in the vicinity of the incident if necessary, to ensure that fires, explosions, or hazardous waste spills do not recur or spread to other parts of the refinery. While operations are dormant, monitor for leaks, pressure build-up, gas generation, or ruptures in valves, pipes, or other equipment that could have a secondary, adverse effect.

3) Authorize the North Gate Guard House to request assistance from local emergency response teams if their help is necessary to control the incident. Table G-1 provides telephone numbers for emergency assistance.

4) Direct plant personnel to control the incident until outside help arrives. Specifically:

- If required, authorize all employees not responding to the incident to leave the area. Shut off possible ignition sources, if appropriate. Security personnel are responsible for directing plant personnel such that they avoid the area of incident and leave emergency control procedures and response routes unobstructed.

- If a fire or explosion occurs, direct any fire-fighting activities. If a hazardous waste release occurs, coordinate waste containment and cleanup. *

- Have protected personnel on standby for rescue, if appropriate.

5) An incident endangering human health at the land treatment area is extremely unlikely, since no reactive or incompatible wastes are treated. If an incident threatening human health or the environment outside of the land treatment area should occur, the Emergency Coordinator will immediately:

- Determine whether evacuation of an outside area is necessary. If so, the Emergency Coordinator will then notify either the USEPA or the National Response Center (800-424-8802) of the emergency and provide the following information: *

  - name and telephone number of reporter
  - name and address of facility
  - time and type of incident
  - name and quantity of materials involved, if known
  - extent of injuries
  - possible hazards to human health or the environment outside the facility

- The Environmental Coordinator will also notify the Illinois ESDA to inform them of the situation *

(217/782-7860). Information identical to that above will be provided.

6) If hazardous waste has been released or produced through control of the incident, ensure that:

- Waste is collected and contained.

- Containers of waste are removed or isolated from the immediate site of the emergency.

- Treatment or storage of the recovered waste contaminated soil or surface water, or any other material that results from the incident or its control, is provided.

- After the emergency, ensure that all emergency equipment is clean, recharged and operational.

- Notify the USEPA Regional Administrator and the *

Illinois ESDA that clean-up procedures have been completed and that all emergency equipment is fit for its intended use before resuming operation in the affected area of the facility. The USEPA Regional Administrator and the Illinois ESDA telephone numbers are included in the emergency call list in Table G-1.

Record in the operating record the time, date, and details of the incident, and submit a written report to the USEPA Region V Administrator, and a copy to the Illinois EPA. This report will be submitted within 15 days of the incident. An outline of the emergency event report is shown as Figure G-2. *

G-5 Emergency Equipment

All facilities at the Chicago Refinery are equipped with safety and emergency equipment to minimize the potential for emergencies specific to each area or process. Particular care has been taken to provide sufficient space to allow the

unobstructed movement of personnel, fire protection equipment, spill control equipment, and decontamination equipment to any area in an emergency.

A security system adequate to ensure the integrity of emergency preparations is in place at the refinery.

Specific communications, fire equipment, hazardous spill equipment, and safety systems that may possibly be used in an emergency at the hazardous waste land treatment area are summarized below:

- Communications

  - In-plant telephone system, which connects directly with the Illinois Bell Telephone Company system
  - Hand-held two-way radio communication
  - Public address system

- Fire Fighting Capabilities (Figure G-3 and Attachment G-1)

  - Ten or twelve inch main fire

hydrants at nominal 150 pounds pressure located throughout the refinery

- Portable dry chemical fire extinguishers located throughout the refinery and in mobile vehicles
- Fire apparatus

- Spill Control Equipment

  - Two vacuum trucks assigned by truck dispatcher
  - Sorbent materials

A complete listing of available on-site emergency equipment is included in Attachment G-1 and is summarized on Figure G-3.

G-5a Testing and Maintenance of Emergency Equipment

All communications, emergency, and safety equipment is inspected and tested regularly to assure its proper operation in the event of an emergency.

G-5b Available Support Emergency Equipment

Sources of additional emergency equipment (not owned nor operated by Union Oil) is shown in Table G-4. The Emergency Coordinator has the authority to utilize any of the companies or services shown in Table G-4 in responding to an emergency. This list is maintained as part of the Emergency Procedures Manual.

G-6 Coordination Agreements

The Chicago Refinery has made every effort to minimize the possibility of a hazardous waste emergency, and when the final Part B submittal is made in July, 1984, will make advance arrangements with outside emergency response teams if outside emergency response is ever required. The details of the proposed approach follow.

The Chicago Refinery will arrange to familiarize local authorities and emergency response teams with: the layout of the facility; properties of materials handled and potential problems; the availability of, and access to, emergency equipment; and, emergency procedures. In addition to these arrangements, a copy of this Contingency Plan (when completed) will be submitted to each of these organizations.

A list of telephone numbers and emergency procedures for dealing with these organizations is provided for use by the Emergency Coordinator (Table G-1 and Attachment G-1). Organizations with which the Chicago Refinery has coordinated emergency arrangements already include:

1. Romeoville Fire Department
2. Lemont Fire Department
3. Northwest Homer Fire Department
4. Lockport Fire Department
5. Des Plaines Valley Mutual Aid Organization
6. Peoples Gas Light & Coke
7. Mobil Oil Refinery
8. Noreast Illinois Association of Industrial Mutual Aid

A copy of this Contingency Plan, has been forwarded to each *** of the above organizations. A copy of the transmittal *** letter is shown as Figure G-4. Copies of the signed, return *** certified mail receipts are attached as part of Figure G-4. ***

G-7 Evacuation Plan

All emergencies require prompt and deliberate action. In the event of any major emergency, it will be necessary to follow an established set of procedures. Such established procedures have been developed for evacuation of the main refinery facilities. However, since the land treatment system is remotely located with respect to the main refinery and since the land treatment system has restricted access, the main refinery evacuation plan is not applicable. Further, since no Chicago Refinery employee has any full time assignment either at the land treatment area, or at the adjacent Tank Farm, no formal evacuation plan is necessary. Should an emergency occur at the land treatment area while the land treatment plots are being worked, the employees have two-way radio communication for assistance, and after reporting the emergency, will drive to the gate at the Tank Farm area to await either assistance or the Emergency Coordinator.

No buildings or structures are associated with, nor are located within, the boundaries of the land treatment area. Since no incompatible or reactive wastes are land treated, the possibility of an emergency occurring that requires evacuation is slight. Should such an emergency occur during

hazardous waste hauling or application activities, the personnel present will contact the North Gate Guard House and notify him of the situation. This can be done by dialing the refinery emergency telephone number (222) from the nearest telephone (located in the Tank Farm adjacent to the land treatment area) or by using the two-way radios supplied in the vehicle. The North Gate Guard will then initiate the procedures previously described and shown in Attachment G-1. Responses appropriate to the specific emergency will be initiated by the Emergency Coordinator.

G-8 Amendments to the Contingency Plan

The Supervisor of Environmental Services is responsible for ensuring that copies of this Plan are deposited with all local authorities and emergency response teams described herein, and that all copies are amended in response to revision of the regulations, the failure of emergency procedures, changes in emergency equipment, or other facility changes that affect the potential for, or response to, a hazardous waste emergency.

Copies of this Contingency Plan, which includes the Chicago Refinery's Emergency Procedures Manual, are maintained at the following locations:

- Each Area Shift Supervisor's Office
- Fire Department Command Center
- Supervisor of Environmental Services Office

The Supervisor of Environmental Services will maintain a log of where all copies are and will also maintain a log which shows that amendments have been forwarded to each organization. Tables G-5 and G-6 will be used as these logs.

G-9 Required Reports

As required by 264.56 (J), any emergency event that requires implementing the contingency plan will be reported in writing within 15 days to the EPA Regional Administrator. A reporting format for emergency events involving hazardous waste is shown in Figure G-2. Copies of these reports will be kept on file at the Chicago Refinery by the Supervisor of Environmental Services.

G-10 SPCC Plan

A copy of the Chicago Refinery Spill Prevention Control and Countermeasure (SPCC) Plan is provided as Attachment G-2.

Appropriate spill response procedures for hazardous waste spills have been incorporated in both this document and the SPCC Plan.

G-11 Emergency Response During Land Treatment System Operation ***

Should emergencies arise during the operation of the land *** treatment system (i.e., while subsurface injection is *** underway, or while nonhazardous waste application or plot *** discing activities are underway), the emergency response *** procedures described in this Section G will be implemented. *** As a guide for how such response measures would proceed, *** several scenarios have been identified, and appropriate *** responses developed. These scenarios follow: ***

A. If the emergency occurs as hazardous wastes *** are being subsurface injected, the land farm *** personnel will immediately cease operation of *** all equipment and insure that the equipment, *** and any hazardous wastes still contained in *** the equipment, are secure and that all *** valves, pumps, and other devices are closed *** and in a locked position so that leaks cannot *** occur. ***

B. If the emergency involves a danger to the equipment and contents, as with a fire on the active land treatment plot, the land farm personnel will first move the equipment to a remote location away from the danger before securing the equipment. The personnel will then report the emergency and either initial a response, or wait for assistance to arrive.

C. As soon as practical, the contents of the injection equipment will be placed in a vacuum truck and removed to a secure location on the land treatment site until the emergency, and all subsequent response and/or clean-up activities, have been completed. If after the emergency is over, and the Operations Engineer determines that the land treatment operations can be initiated within 60 days, the vacuum truck, with its contents, may remain at the land treatment site. Alternatively, the contents may be disposed of at an approved off-site facility. If the

truck remains on-site, daily inspections will be made to insure all valves and pumps are in a locked position. Normal operations will immediately resume and the contents of the vacuum truck applied to the soil immediately after all repair and/or maintenance work has been completed.

D. If the Operations Engineer determines, or believes, that the land treatment operation cannot be resumed within 60 days, the wastes in the vacuum truck will be manifested and transported off-site to an approved hazardous waste disposal operation.

E. If a hazardous waste spill at the land treatment area occurs while a land treatment plot is being actively worked, all application and/or discing operations will immediately cease and land farm personnel will respond immediately to contain the spill using the response procedures discussed in

this Section G. The Emergency Coordinator will, after inspection of the spill area and assessment of the cause and clean-up action required, determine if land treatment of the hazardous wastes can be continued. If not, then such hazardous wastes will be manifested and transported to an approved off-site hazardous waste treatment operation.

TABLE G-1

EMERGENCY CALL LIST

Name	Telephone No.
Romeoville Fire Department	(815) 886-2171
Lemont Fire Department	(312) 257-2221
Northwest Homer Fire Department	(815) 838-2151
Lockport Fire Department	(815) 838-2121
Romeoville Police Department	(815) 886-2141
Will County Sheriff	(815) 727-6191
Silver Cross Hospital	(815) 740-1100
Des Plaines Valley Mutual Aid Organization	*
Peoples Gas Light & Coke	(815) 423-6143
Mobil Oil Refinery	(815) 423-5571
Noreast Illinois Association of Industrial Mutual Aid	*
USEPA Regional Authority	(312) 886-6148
Illinois ESDA	(217) 782-7860

*Specific written procedures are to be followed when contacting these organizations.

TABLE G-2

ENVIRONMENTAL COORDINATORS FOR EMERGENCY RESPONSE AT LAND TREATMENT AREA

PRIMARY EMERGENCY COORDINATOR:

Name:	D. W. Bruckert
Office Telephone:	Ext. 422
Home Address:	526 Ca-Crest Drive Joliet, IL 60435
Home Telephone:	(815) 729-2123

SECONDARY EMERGENCY COORDINATOR:

Name:	L. D. Erchull
Office Telephone:	Ext. 324
Home Address:	1245 Clyde Drive Naperville, IL 60540
Home Telephone:	(312) 357-7318

Name:	W. A. Withrow
Office Telephone:	Ext. 308
Home Address:	502 N. Catherine LaGrange Park, IL 60525
Home Telephone:	(312) 354-5816

Note: During normal working hours, 7:30 a.m. to 4:00 p.m., all Emergency Coordinators are physically located at the Chicago Refinery, 135th Street and New Avenue, Lemont, IL, and may be reached internally by dialing the above extension number. The general telephone number for the Chicago Refinery is (312) 257-7761.

TABLE G-3

SUMMARY OF EMERGENCY PROCEDURES

Action	Responsible Individual	Contact
1. In the event of an emergency, activate alarm	Facility Personnel	Extension 222
2. Notify Emergency Coordinator (Area Shift Supervisor)	North Gate Guard	Fire/Security Radio or Pager
3. Apply First Aid	Emergency Coordinator	
4. Notify Environmental Services	Emergency Coordinator	
5. Identify and characterize incident	Emergency Coordinator	
6. Discontinue operations in vicinity of incident	Emergency Coordinator	
7. Notify local emergency response teams	Emergency Coordinator	
8. Direct internal emergency control procedures	Emergency Coordinator	
9. Notify facility management personnel	Emergency Coordinator	See Emergency Call List
10. If health or environment outside of plant is affected:		
• Notify Supervisor of Environmental Services	Emergency Coordinator	See Emergency Call List
• Notify National Response Center	Supervisor of Environmental Services	Phone: (800) 424-8802
• Illinois ESDA	Supervisor of Environmental Services	Phone: (217) 782-7860
11. Direct collection, containment, and isolation of released hazardous waste	Emergency Coordinator	
12. Prepare emergency equipment for reuse	Emergency Coordinator	
13. Notify USEPA Regional Administrator of process resumption	Supervisor of Environmental Services	Region V 230 S. Dearborn St. Chicago, IL 60604 (312) 886-6148
14. Submit report to USEPA Regional Administrator within 15 days	Supervisor of Environmental Services	

TABLE G-4
SOURCES OF EMERGENCY EQUIPMENT
NOT OWNED BY UNION OIL

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No. Day	Telephone No. After Hours
Boats, Tows, and Barges	Hannah Inland Waterways Lemont, Illinois 2 Light Oil Barges 5 Black Oil Barges 1000 H.P. Tug Boat 1800 H.P. Tug Boat Small Aluminum Boat	Dispatch	(312)257-5456	(312)257-5456
	Lemont Ship 2000 H.P. Tow Boat Steel Work Floats (20' x 30')	Mr. Blackburn	(815)739-5000	(815)739-5000
	Material Service Corp. Marine Department	Charles Chapin Ken Allen Jack Thomas Guido Schumann	(815)838-3420	(312)358-2679 (815)725-7346 (815)838-5508 (815)838-3861
	Ohio Barge Lines 3200 H.P. Line Boat	Mr. Panzera	(815)726-6300	(815)726-6300
Boom	Illinois Chemical Corp. Highland Park, Illinois	William B. Katz	(312)433-1145	(312)433-1145
	Petrochem Services Lemont, Illinois	Don Pavlich	(312)257-5875	(312)257-5875
	Weil Service Products Chicago, Illinois		(312)528-6800	

TABLE G-4 (continued)

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No. Day	Telephone No. After Hours
Chemical Cleaning	C. H. Heist Joliet, Illinois Hi-Pressure Waterwash	Roger Wigal	(815)727-7327	
	Central Industrial Cleaners Chicago, Illinois Hi-Pressure Waterwash		(312)538-6337	(312)924-3838
	National Plant Services Chicago, Illinois Hi-Pressure Waterwash	Bill Ackerman	(312)731-0600	
	Service Master Industrial Cleaning General Chemical Clean-Up Hi-Pressure Waterwash		(312)656-6020	(312)656-6020
	Viking Associates Lockport, Illinois Hi-Pressure Waterwash	Doug Richter	(815)723-9396	(219)931-8044
Containing and Cleaning	Marine Pollution Control Corp. Detroit, Michigan	David Usher	(313)849-2333	
	OH Materials, Inc. Findlay, Ohio		(419)423-3526	(419)423-3526
	Weil Service Products Chicago, Illinois		(312)528-6800	

TABLE G-4 (continued)

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No. Day	Telephone No. After Hours
Diving Contractor	John Peterson Diving Services Morton Grove, Illinois Divers	John Geschrey	(312)774-7876	(312)966-1915
	Lindahl Marine Contractors,Inc. Divers		(312)593-5982	(219)949-6406
Hand Tools - Rakes, Shovels, Axes, Pitch-forks	Ace Hardware Co. Lockport, Illinois	Bill Miller	(815)838-0458	(815)726-5117
	Barrett Hardware Co. Joliet, Illinois	Ernie Paul	(815)726-4341	(815)723-9041
Hay - Straw	Joliet Grain Co. Joliet, Illinois 60 Bales and Emergency Contacts	Charles Malone	(815)725-5790	(815)838-0520
Heavy Equipment	Brown and Lambrecht Joliet, Illinois Bulldozers Rippers Scrapers Rollers Hi-Lifts Graders Cranes Sweeper Drill Compressor Pumps Chain Saws Brush Clippers Back Hoes	Jim Carnatch Jim Retenour	(815)727-9211	(815)462-5352

TABLE G-4 (continued)

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No1 Day	Telephone No1 After Hours
Heavy Equipment (Cont.)	Diamond Construction Co. Bulldozers Scrapers Graders Cranes Compressor Back Hoe	Larry Kubinski	(815)723-9321	(815)436-7167
	Len Cox, Jr. Excavating and Trucking Lockport, Illinois Loader Back Hoe	Len Cox, Jr.	(815)838-5741	(815)838-5741
	P. T. Ferro Construction Co. Semi's/Tractors Dump Trucks Pumps Compressors Back Hoes/End Loaders Hi-Lifts Trenching Machines Cranes	Peter Ferro Tony Ferro Jack Posture Peter Ferro, Jr.	(815)726-6284	(815)723-7665 (815)723-5812 (815)725-1975 (815)423-6163
Helicopters and Airplanes	Foster Helicopters	Tom Foster	(314)421-5440	(314)231-5828
	Lewis College R. D. Aviation Lockport, Illinois Observation Airplanes Only	Andy Zaglaniczny	(815)838-7909	(312)583-4192
	OH Materials, Inc. Findlay, Ohio Cessna, Seneca, Helicopters, Jet Service		(419)423-3526	(419)423-3526

TABLE G-4 (continued)

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No. Day	Telephone No. After Hours
Laborers and Supervision	Brown and Lambrecht Earthmovers, Inc. Joliet, Illinois 200 Men	Jim Ritenour	(815)727-9211	(815)462-5352
Lumber and Building Materials	Drake Lumber and Hardware Lockport, Illinois Lumber and Delivery	Bill Drake Bill Ziesemer Charles Henry	(815)838-5000	(815)838-0901 (815)838-1895 (815)838-1934
	Wickes Lumber Plainfield, Illinois	George Wick Plainfield Police Department	(815)436-5631	(815)436-2934
Skimmers	Illinois Chemical Corp. Highland Park, Illinois Skimming Pumps	William B. Katz	(312)433-1145	(312)433-1145
	Oil Mop, Inc. Belle Chasse, Louisiana		(504)394-6110	(504)394-6110
	Petrochem Services Lemont, Illinois	Don Pavlich	(312)257-5875	(312)257-5875
Sorbent Materials	Illinois Chemical Corp. Highland Park, Illinois 3M Products J&L Pom Poms	William B. Katz	(312)433-1145	(312)433-1145
Tank Trucks	Lockport Trucking Co. Lockport, Illinois 2 - 5000 Gal. Tankers 2 - 3000 Gal. Sludge Boxes	Jack Carlstrom	(815)723-3965	(815)725-8255 (815)838-1130

TABLE G-4 (continued)

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No. Day	Telephone No. After Hours
Tank Trucks Cont.	Ruan 20 Tankers Trucks 7000 Gal. with Pumps	Craig Johnson E. Scott	(312)257-2231	(312)554-3952 (815)436-2562
	Transport Service Co. Hinsdale, Illinois	Dan Kemp	(312)563-4100	
Trucks and Trailers	Brown and Lambrecht Earthmovers, Inc. Joliet, Illinois (6 Wheel Trucks, (20 Semi-Dump Trucks, (Bottom Dump Trucks Low-Boy Trailers Water Wagon (Semi)	Jim Ritenour	(815)727-9211	(815)462-5352
	Diamond Construction Co. Crest Hill, Illinois	Larry Kubinski	(815)723-9321	(815)436-7167
	Len Cox, Jr. Excavating and Trucking Lockport, Illinois Semi-Dump Truck Six-Wheel Dump Truck	Len Cox, Jr.	(815)838-5741	(815)838-5741
	Waxweiler Trucking Lockport, Illinois 2 Semi-Dump Trucks 2 Six-Wheel Dump Trucks		(815)838-9662	(815)838-9662
Trucks and Vans, Freight	Yellow Freight System, Inc. Joliet, Illinois Vans and Open Top Trucks	Bob Provincal Dick Wright	(815)729-4481	(815)727-6248

TABLE G-4 (continued)

Equipment or Supplies	Description of Equipment and Name of Company or Individual	Name of Contact	Telephone No. Day	Telephone No. After Hours
Vacuum Equipment	Carl's Septic Tank Cleaners Lemont, Illinois 2 Vacuum Trucks		(312)739-1495	(312)739-1495
	General Drainage, Inc. Chicago, Illinois 10 Vacuum Trucks	John Kruper	(312)375-6051	(219)949-5794
	Kimble Septic Service Joliet, Illinois 2 Vacuum Trucks	C. L. Kimble	(815)722-7569	(815)723-0541
	Petrochem Services Lemont, Illinois	Don Pavlich	(312)257-5875	(312)257-5875
	Viking Associates Lockport, Illinois	Doug Richter	(815)723-9396	(219)931-8044

TABLE G-5

LOCATION OF CONTINGENCY PLAN COPIES

Copy Number	Location
1	Supervisor of Environmental Services Office
2	Fire Department Command Center
3	North Plant Area Shift Supervisor Room
4	Cracking Department Area Shift Supervisor Room
5	Blend Center Area Shift Supervisor Room
6	Romeoville Fire Department
7	Lemont Fire Department
8	Northwest Homer Fire Department
9	Lockport Fire Department
10	Romeoville Police Department
11	Will County Sheriff
12	Silver Cross Hospital
13	Des Plaines Valley Mutual Aid Organization
14	Peoples Gas Light and Coke
15	Mobil Oil Refinery
16	Noreast Illinois Association of Industrial Mutual Aid

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40 CFR 265.53 requires that copies of the Contingency Plan and all revisions to the Plan must be maintained at the facility and submitted to all local police departments, fire departments, hospitals, and State and local emergency response teams that may provide emergency services to the facility.

TABLE G-6

CONTINGENCY PLAN RECORD OF CHANGES AND AMENDMENTS

40 CFR Part 265.54 requires that the Contingency Plan be reviewed, and immediately amended, if necessary, whenever:

a) The facility permit is revised;

b) The plan fails in an emergency;

c) The facility changes - in its design, construction, operation, maintenance, or other circumstances - in a way that materially increases the potential for fires, explosions, or releases of hazardous waste or hazardous waste constituents, or changes the response necessary in an emergency.

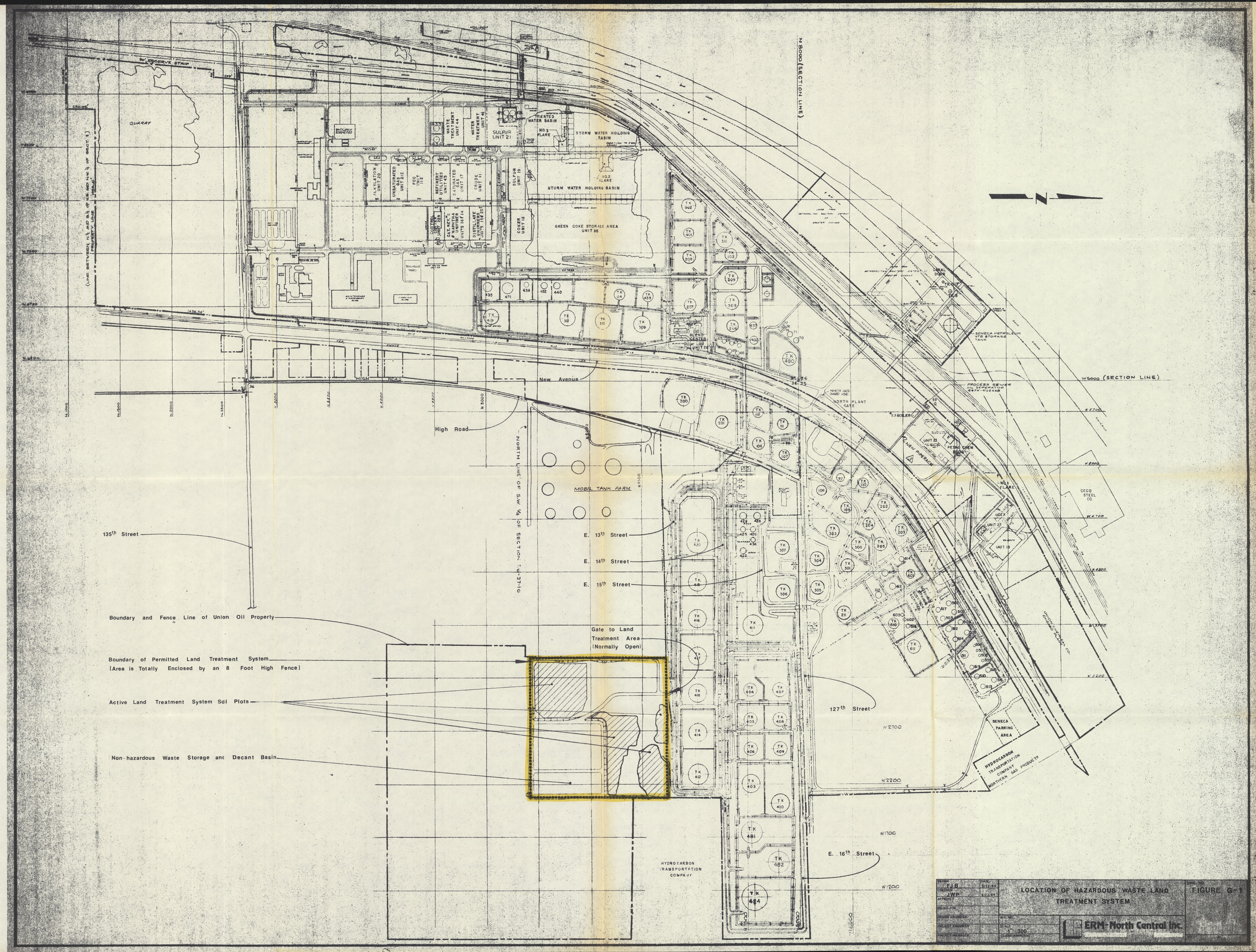
d) The list of emergency coordinators changes; or

e) The list of emergency equipment changes.

In the event that any of the above conditions occur, the Supervisor of Environmental Services will review the Contingency Plan and determine if revisions are necessary.

The Supervisor of Environmental Services will be responsible for insuring that revisions are incorporated into all copies of the Plan, and maintaining this log.

DATE	SUBSECTION(S) CHANGED/AMENDED	COPIES SENT	INITIALS



DRAWN FJB	DATE 5/22/84	LOCATION OF HAZARDOUS WASTE LAND TREATMENT SYSTEM	DWG. NO. FIGURE G-1
CHECKED JWP	5/22/84		
APPROVED			
ISSUED FOR			
DESIGN ENGINEER		W.O. NO.	
PROJECT ENGINEER		SCALE 1" = 300'	ERM-North Central Inc.
PROJECT MANAGER		CLIENT APPROVAL	

FIGURE G-2

FORMAT FOR HAZARDOUS WASTE EMERGENCY EVENT REPORT

From _____ of _____

Facility: Union Oil Company of California, Chicago Refinery

Facility Owner/Operator: Union Oil Company of California, Chicago Refinery

Facility Location: 135th Street and New Avenue, Lemont, Illinois, 60439

Background Information

The new part of the Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present refinery has storage capacity of about 7.5 million barrels (315 million gallons. Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1983 was approximately 100,000 barrels per day of crude oil.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the villages of Lemont and Romeoville. The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canals. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.C. Topographic Map for locations of the facility relating to surrounding areas submitted with the SPCC Plan on February 2, 1983.

The report would then continue in a narrative form providing information on:

A. Classification of waste(s) involved.

B. Quantity of material involved.

C. Location of spill or incident.

D. Date and time of occurrence or discovery.

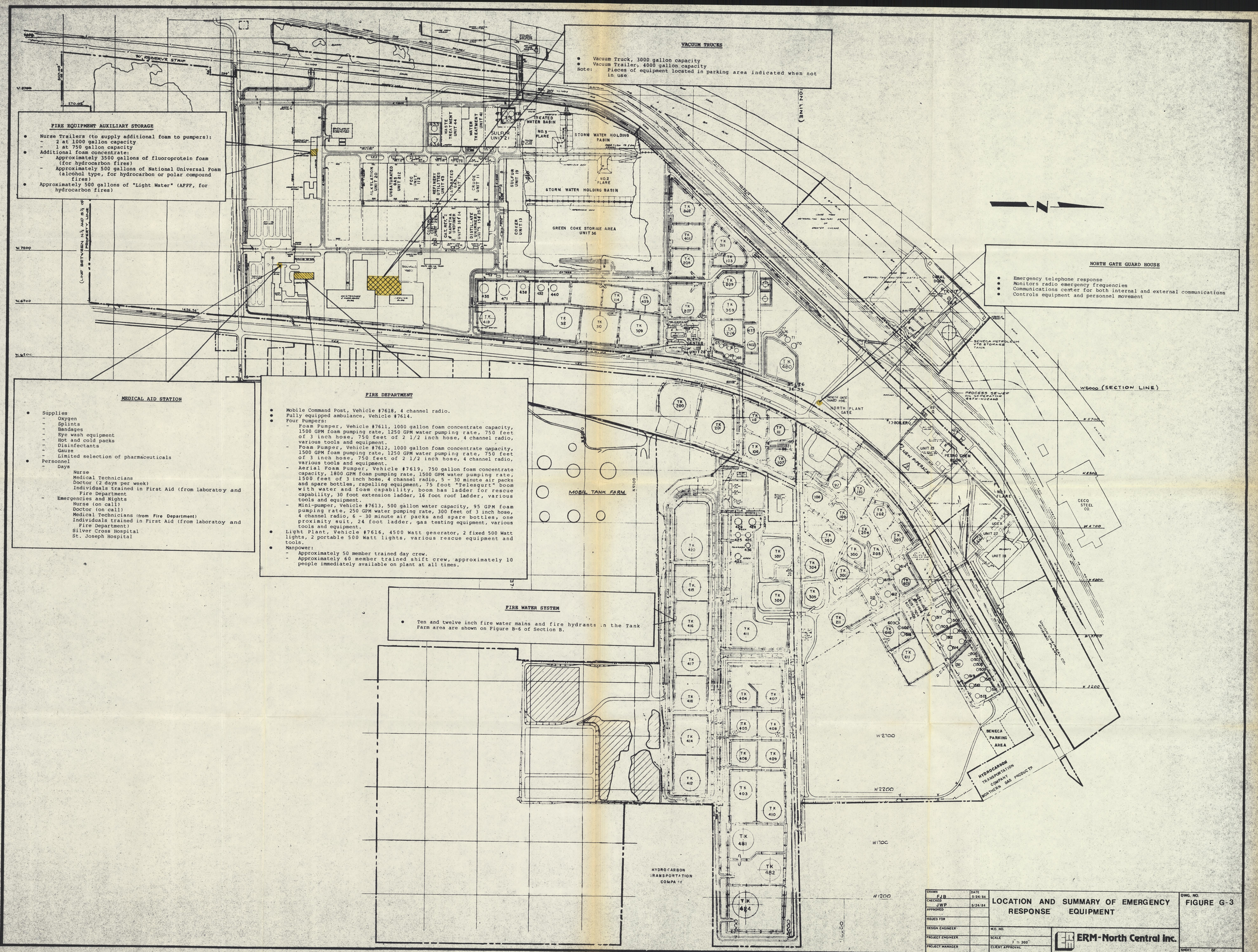
E. Other chemicals at the scene.

F. Potential problems.

G. Actions taken.

H. Measures to minimize recurrence.

I. Copies of any pertinent information.



VACUUM TRUCKS

- Vacuum Truck, 3000 gallon capacity
- Vacuum Trailer, 4000 gallon capacity

Note: Pieces of equipment located in parking area indicated when not in use

FIRE EQUIPMENT AUXILIARY STORAGE

- Nurse Trailers (to supply additional foam to pumpers):
  - 2 at 1000 gallon capacity
  - 1 at 750 gallon capacity
- Additional foam concentrate:
  - Approximately 3500 gallons of fluoroprotein foam (for hydrocarbon fires)
  - Approximately 500 gallons of National Universal Foam (alcohol type, for hydrocarbon or polar compound fires)
- Approximately 500 gallons of "Light Water" (AFFF, for hydrocarbon fires)

NORTH GATE GUARD HOUSE

- Emergency telephone response
- Monitors radio emergency frequencies
- Communications center for both internal and external communications
- Controls equipment and personnel movement

MEDICAL AID STATION

- Supplies
  - Oxygen
  - Splints
  - Bandages
  - Eye wash equipment
  - Hot and cold packs
  - Disinfectants
  - Gauze
  - Limited selection of pharmaceuticals
- Personnel
  - Days
    - Nurse
    - Medical Technicians
    - Doctor (2 days per week)
    - Individuals trained in First Aid (from laboratoy and Fire Department
  - Emergencies and Nights
    - Nurse (on call)
    - Doctor (on call)
    - Medical Technicians (from Fire Department)
    - Individuals trained in First Aid (from laboratoy and Fire Department)
    - Silver Cross Hospital
    - St. Joseph Hospital

FIRE DEPARTMENT

- Mobile Command Post, Vehicle #7618, 4 channel radio.
- Fully equipped ambulance, Vehicle #7614.
- Four Pumpers:
  - Foam Pumper, Vehicle #7611, 1000 gallon foam concentrate capacity, 1500 GPM foam pumping rate, 1250 GPM water pumping rate, 750 feet of 3 inch hose, 750 feet of 2 1/2 inch hose, 4 channel radio, various tools and equipment.
  - Foam Pumper, Vehicle #7612, 1000 gallon foam concentrate capacity, 1500 GPM foam pumping rate, 1250 GPM water pumping rate, 750 feet of 3 inch hose, 750 feet of 2 1/2 inch hose, 4 channel radio, various tools and equipment.
  - Aerial Foam Pumper, Vehicle #7619, 750 gallon foam concentrate capacity, 1800 GPM foam pumping rate, 1500 GPM water pumping rate, 1500 feet of 3 inch hose, 4 channel radio, 5 - 30 minute air packs and spare bottles, rapelling equipment, 75 foot "Telesqurt" boom with water and foam capability, boom has ladder for rescue capability, 30 foot extension ladder, 16 foot roof ladder, various tools and equipment.
  - Mini-pumper, Vehicle #7613, 500 gallon water capacity, 95 GPM foam pumping rate, 250 GPM water pumping rate, 300 feet of 3 inch hose, 4 channel radio, 6 - 30 minute air packs and spare bottles, one proximity suit, 24 foot ladder, gas testing equipment, various tools and equipment.
- Light Plant, Vehicle #7616, 4500 Watt generator, 2 fixed 500 Watt lights, 2 portable 500 Watt lights, various rescue equipment and tools.
- Manpower:
  - Approximately 50 member trained day crew.
  - Approximately 60 member trained shift crew, approximately 10 people immediately available on plant at all times.

FIRE WATER SYSTEM

- Ten and twelve inch fire water mains and fire hydrants in the Tank Farm area are shown on Figure B-6 of Section B.

DRAWN FJB	DATE 5/24/84	LOCATION AND SUMMARY OF EMERGENCY RESPONSE EQUIPMENT	DWG. NO. FIGURE G-3
CHECKED JWP	5/24/84		
APPROVED			
ISSUED FOR			
DESIGN ENGINEER		W.O. NO.	ERM-North Central Inc.
PROJECT ENGINEER		SCALE 1" = 300'	
PROJECT MANAGER		CLIENT APPROVAL	SHEET OF

*** Revised 12/1/85

FIGURE G-4

LETTER OF TRANSMITTAL TO MUTUAL AID ORGANIZATIONS ***

(Date)

Part B Permit - Section G

The attached information has been sent to all organizations who may response in any capacity to a major hazardous waste emergency at Union Oil's Chicago Refinery. This information is being forwarded to your organization in response to the permitting requirements in 40 CFR Section 264.37 under the Resource Conservation and Recovery Act of 1976. The Chicago Refinery operates a land treatment system for on-site generated hazardous waste and nonhazardous waste.

Enclosed please find Section G of Union Oil's Part B Permit Application. This section presents information on emergency procedures and equipment to be used in case of a major hazardous waste accident at the Chicago Refinery requiring mutual aid.

Only a remote possibility of a major accident exists at Union Oil's land treatment system; however, this information will be useful if an accident should occur.

Please acknowledge receipt of this information, for Union Oil's records, to:

Union Oil Company of California
Chicago Refinery
Lemont, Illinois 60439

Attention: Mr. L. D. Erchull

Thank you for your consideration in this matter.

Very truly yours,

D. W. Bruckert, Supervisor
Environmental Services

ATTACHMENT G-1

EMERGENCY PROCEDURES MANUAL

CHICAGO REFINERY

4/23/82

EMERGENCY PROCEDURES

UNION OIL COMPANY OF CALIFORNIA - CHICAGO REFINERY

INTRODUCTION

The following emergency procedures have been designed to eliminate confusion and to assign specific duties to personnel who are directly involved with the emergency. It is designed to be both simple and concise. This section of the manual is divided into the following sections:

Section A. General

Section B. Emergency Organization

1. Shift Fire Crew
2. Day (Volunteer) Fire Crew

Section C. Emergency Organization Response Patterns

1. Fires and Potential Fires
2. Injuries

Section D. Emergency Communications System

Section E. Call-Out Procedures for Emergencies and Disasters

Section F. Disaster Plan

1. General
2. Refinery Manager Duties
3. Operations Command Center
4. Mobile Command Center
5. Industrial Relations Center
6. Maintenance Center
7. Status and Manpower Center
8. Environmental Center
9. Summary of Center Locations and Telephone Numbers

Section G. Mutual Aid - Industrial and Municipal

1. Requests

   a. Municipal
   b. Industrial

2. Assists

Section H. Environmental Emergency Procedures

4/23/82

Section A. GENERAL

This manual is distributed extensively throughout the Chicago Refinery. In order for this manual to be effective, every supervisor, Fire Department and Shift Fire Crew member must be familiar with its contents and his/her particular function. Due to circumstances, some changes in responsibility may be necessary at the time of the emergency. Should a person be unavailable, a predesignated alternate shall be responsible for the emergency function of the unavailable person.

It is the responsibility of each of those listed in Disaster Plan Section F to designate an alternate upon receipt of this manual and to keep this position current.

All personnel (supervisory or hourly) who are not directly involved with the emergency must stay out of the area. Fire fighters, responding apparatus and other necessary equipment must have access to the emergency area. This rule will be strictly enforced.

No Chicago Refinery employee is authorized to release emergency-related information to members of the press or general public except as designated by me or my designee.

APPROVED:

A. J. Eliskalns, Refinery Manager

SECTION B. EMERGENCY ORGANIZATION

Refinery fire protection for fires and potential fires is handled by the Shift Fire Crew and/or the Day Fire Crew.

SHIFT FIRE CREW

The purpose of the Shift Fire Crew is to provide fire protection when the Day Fire Crew is not present. The Shift Fire Crew is headed by the Petrochemical Department Shift Supervisor unless the incident involves the Petrochemical Operating Area. In this case, the Blending and Transfer Shift Supervisor shall assume the responsibilities as head of the Shift Fire Crew. Whenever possible, both the Petrochemical and Blending and Transfer Shift Supervisor shall respond, with the Blending and Transfer Shift Supervisor assisting the Petrochemical Shift Supervisor when both are present. The acting coordinator of the Shift Fire Crew shall hereafter be referred to as the Shift Fire Chief.

The Shift Fire Crew is comprised of the following job classifications:

1. Pumpers
2. Laboratory Personnel
3. Coke Handlers
4. Shift Pipefitters

Training sessions for Shift Fire Crew personnel are held on a bi-monthly basis. Classes consist of practical and classroom instruction to enable members to adequately perform fire fighting duties.

DAY (VOLUNTEER) FIRE CREW

The Day Fire Crew provides fire protection during weekdays, between 7:30 A.M. and 4:00 P.M. and assists the Shift Fire Crew upon request. Membership consists of both salaried and hourly personnel who normally work straight days and who have volunteered for membership.

Training sessions for the Day Fire Crew are held on a monthly basis. Additional half-day classes will be held monthly for members classified as apparatus engineers. Apparatus engineers will be certified after passing a comprehensive written and practical examination.

4/23/82

Standing Orders for Firefighters

1. When reporting to the fire scene, go to 7618 (command post - gear truck) and obtain your turnout gear.

2. You will be informed by the Fire Officer in Charge where your squad is working. You will then report to your assigned Lieutenant.

3. All injuries, no matter how small, must be reported to your officer immediately.

4. Radio transmissions must be brief and to the point. Signal 10 Codes will be used whenever possible. When transmitting, talk in a normal tone of voice. Screaming into the mike is not necessary.

5. Each firefighter will be responsible for his/her turnout gear. Each person is assigned a matching number of his/her helmet, coat, and boots.

6. No firefighter should respond to a fire call if he/she is "under the weather".

7. No firefighter will be excused from duty until all apparatus has been returned to service.

8. All hourly firefighters will sign the overtime sheet at the fire station and South Gate.

9. Firefighters are responsible for their home radio receivers. These are company property and are subject to the disposition of the Company.

SECTION C. EMERGENCY ORGANIZATION RESPONSE PATTERNS

The following response procedures for both the Day Fire Crew and the Shift Fire Crew are followed at Chicago Refinery.

The Refinery emergency telephone number is 222. The whistle will sound for the following conditions:

a) Fire or Potential Fire - Ten one-second blasts

b) Injury - One ten-second blast.

c) Conditional All-Clear - Three three-second blasts

1. FIRES AND POTENTIAL FIRES

A. Weekdays - 7:30 A.M. to 4:00 P.M.

All daytime emergencies will be handled by the Day Fire Crew. The Fire Chief or the Fire Officer in charge will be responsible for assessing the situation and placing calls for municipal or industrial mutual aid.

The Shift Fire Chief and the Process Supervisor for the area involved will report to the scene and provide necessary information to the Fire Chief. Operating Superintendents may respond to the scene at their own discretion.

Other supervisory personnel are not to respond to the scene of potential fires or fires.

The following is the normal sequence of response for all daytime alarms at the Chicago Refinery:

Alarm	Response
1. First Alarm	All Firefighters 7611 (1250 Pumper) 7612 (1250 Pumper) 7613 (250 Pumper) 7614 (Rescue Truck) 7616 (Light Plant) 7618 (Command Post - Gear Truck) 7619 (Telesqurt)

4/23/82

Section C

Alarm	Response
2. Second Alarm	First call to Romeoville Fire Dept. (1000 GPM Pumper, 1250 GPM 50 ft. telesqurt, light plant) and/or Lemont Fire Dept. (1000 GPM Pumper)
3. Third Alarm	Call Lockport and/or Northwest Homer Fire Department (Lockport 1250 GPM Pumper; Northwest Homer 1250 GPM Pumper
4. Fourth Alarm	Any additional requests for the Des Plaines Valley Mutual Aid Association or the Noreast Illinois Association of Industrial Mutual Aid.

B. Nights, Weekends, Holidays

The Shift Fire Crew, under the direction of the Shift Fire Chief, is responsible for handling minor potential fires and fires at times when the Day Fire Crew is not present. Laboratory personnel are responsible for responding with 7611 and 7613. Other Shift Fire Crew personnel shall respond directly to the scene. Protective clothing is mandatory. It is located in the back of the Shift Fire Chief's pickup truck. The Shift Fire Crew has the responsibility for responding to the emergency and is under the direct supervision of the Shift Fire Chief. Members of the Shift Fire Crew will not return to their normal job function until released by the Shift Fire Chief or the Fire Officer in charge.

The Shift Fire Chief is responsible for determining whether he has sufficient manpower to adequately handle the emergency. Should additional manpower be necessary, the Shift Fire Chief will radio Base 6 and request that the Day Crew members be notified. Should the situation warrant, Romeoville and/or Lemont Fire

4/23/82

Departments will also be notified. (See Section G, part 1, Mutual Aid Request.) Other mutual aid, industrial or municipal, can be called upon as necessary by the Shift Fire Chief, the Fire Chief or the Fire Officer in charge.

The following is the normal sequence of response for night, weekend and holiday alarms at Chicago Refinery:

Alarm	Response
1. First Alarm (Potential Fire and Fires)	Shift Fire Crew 7611 (1250 Pumper) 7613 (250 Pumper)
2. Second Alarm (Potential Fire and Fires)	Day Fire Crew 7612 (1250 Pumper) 7614 (Rescue Truck) 7616 (Light Plant) 7618 (Command Post - Gear Truck) 7619 (Telesqurt)
3. Third Alarm	Romeoville (1250 GPM Pumper, 1250 GPM 50 ft. Telesqurt, Light Plant, and/or Lemont Fire Departments (1000 GPM Pumper)
4. Fourth Alarm	First calls will be to Lockport and Northwest Homer; any additional requests for the Des Plaines Valley Mutual Aid Association or the Noreast Illinois Association of Industrial Mutual Aid will be made by the Fire Officer in charge.

2. INJURIES

A. Weekdays - 7:30 AM to 4:00 PM

Registered Emergency Medical Technicians will respond to the scene of the emergency . Anytime an employee must be taken to the hospital, the Municipal Fire Department having jurisdiction (Romeoville Fire Department south of the Blend Center, Lemont Fire Department north of the Blend Center) will be requested to dispatch an ambulance. The Union Oil Rescue Truck (7614) will not leave the Refinery unless authorized by the Fire Chief or Supervisor Fire, Safety, Security.

B. Nights, Weekends, Holidays

1. The Blending and Transfer Shift Supervisor and the laboratory personnel on shift are responsible for administering first aid during nights, weekends and holidays.

2. All calls to Romeoville or Lemont for an ambulance will be made by the North Plant Guard at the request of laboratory personnel or the Shift Fire Chief.

3. The Guard will first determine:

   a) Where the ambulance is needed;

   b) How many individuals injured; and

   c) Type of injury, i.e., possible burn, possible broken bones, possible gas, possible heart, unknown, etc.

4. The Guard will provide pertinent information to the appropriate Fire Department:

   a) Incidents south of the Blend Center... Romeoville Fire Department (3 units) ...Phone 81-886-2171.

   b) Incidents north of Blend Center... Lemont Fire Department (2 units). Phone 9-257-2221.

5. Once a Fire Department is notified, the Guard need not call additional Fire Departments. The Fire Department contacted is responsible for making sure that an ambulance responds to the request.

6. The Roving Guard (7652) will escort the ambulance to the accident scene. Under no circumstances will the Refinery Rescue Truck be used for transportation during nights, weekends or holidays.

7. Any person injured at Chicago Refinery will be transported to Silver Cross Hospital.

SECTION D. EMERGENCY COMMUNICATIONS SYSTEM

The North Plant Guard Gate (Base 6) will take the emergency call, sound the appropriate alarm, handle all emergency radio transmissions and sound the all-clear when instructed to do so by the Shift Fire Chief or the Fire Officer in charge.

The Shift Fire Chief will authorize Base 6 to telephone Romeoville or Lemont Fire Department for assistance on all fires occurring on nights, weekends and holidays.

A voice actuated tape recorder located at Base 6 will be recording all transmissions on the emergency frequenc from the time of the emergency until the all-clear has been given.

SUMMARY OF COMMUNICATION CENTER INSTRUCTIONS

1. Fire or Potential Fire

   a) Activate the fire/potential fire whistle (Ten one-second blasts).

   b) Activate the tape recorder.

   c) Make P.A. and radio announcement as to details and location of fire.

   d) Handle all emergency radio traffic.

   e) Activate conditional all clear whistle when instructed to do so by Fire Officer in charge.

   f) Announce all-clear on P.A. system when so notified by the Fire Officer in charge.

2. Injury

a) Activate the injury whistle. (One ten-second blast).

b) Activate the tape recorder.

c) Make P.A. and radio announcement as to details and location of injury.

d) Handle all emergency radio traffic.

e) On night shifts, weekends and holidays - request ambulance as instructed by Shift Fire Chief.

f) Instruct Roving Guard to escort ambulance to accident scene.

REVISED 11/29/83

FIRE AND SECURITY RADIO SYSTEM DIRECTORY

CALL LETTERS - KCK885/
FREQUENCY - R 158.370/T153.095 MHZ

BASE STATIONS

5 Truck Dispatcher
6 North Gate
7 Medical Department Nurse
8 South Gate
9 Room 107 Administration Building
10 Lab Building Library Outlet
21 Operator

MOBILE UNITS(17 Total)

Unit	FIRE DEPT. NO.	DESCRIPTION	SERIAL NUMBER
*Personal Vehicle	7601	Chief (Pirc)	203 CCY 0579
3800	7601A	Fire/Safety Supv. Vehicle	LG 2159
Personal Vehicle	7602	Deputy Fire Chief	LG 2129
Personal Vehicle	7603	Assistant Chief (Novotny)	LG 2139
Personal Vehicle	7604	Assistant Chief (Fronek)	203 CCW 3564
*5401	7611	Fire Truck No. 1	203 CCY 580
*5400	7612	Fire Truck No. 2	LG 2099
*6435	7613	Fire Truck No. 3	RG 6909
*6536	7614	Rescue Truck	TG 3350
6502	7616	Light Plant	LG 2149
*6618	7618	Command Center	203 CCE 1436
*6778	7619	Telesqurt	203 CCY 0581
6632	7652	Roving Guard	MG 259M
6593		Maintenance (T-43)	LG 2089
6594		Maintenance (T-44)	RG 826B
00		Safety Inspector	LG 2119
6848		Safety Inspector	LG 2169

PORTABLE UNITS	U.O.C. NO.	ASSIGNED TO	SERIAL NUMBER
7601*	126	Fire Chief (Pirc)	420 AHW 0129
7601**	18	Fire Chief (Pirc)	278 ADQ 1165
7602*	93	Deputy Fire Chief (Brandolino)	U21 E6M
7602	24	Deputy Fire Chief (Brandolino)	278 ACG 2460
7603*	5	Asst. Fire Chief (Novotny)	278 ACG 2455
7604*	51	Asst. Fire Chief (Fronek)	R46 E32
7605	29	F., S., S. Supv. (Novotny)	U21 E5M
7606	109	Lieutenant (Ephraim)	278 ACG 2458
7607*	125	Lieutenant (Abrams)	420 AHW 0128
7652	50	Roving Guard	278 ACG 2459
7680	108	Shift Fire Chief (Petrochem)	278 ACG 2457
7681	106	Shift Fire Chief (B&T)	278 ACG 2454
Spares	114		278 ACG 0742
	107		278 ACG 2461
	91		278 ACG 2455
	57***		278 ACG 2462
	17****		ADQ 1164
	101*****		278 ACG 2781

* Operates on 158.370, 154.400, 154.250, 154.265
** Operates on 154.400, 154.265
*** Operates on 154.400 ONLY
**** Operates on 158.370, 154.400
***** Operates on 154.250 ONLY

DTP/ls

4/23/82

SECTION D

SIGNAL 10 RADIO CODE

USE THIS CODE WHERE APPLICABLE

10-0	Caution
10-1	Unable to copy
10-2	Signal good
10-3	Stop transmitting
10-4	Acknowledgement
10-6	Out of car
10-7	Out of service
10-8	In service
10-9	Repeat
10-10	Fight in progress
10-12	Stand-by
10-14	Prowler
10-18	Quickly
10-19	Return to last call
10-20	Location
10-21	Telephone call
10-22	Disregard
10-23	Arrive at scene
10-24	Assignment complete
10-25	Report in person
10-26	Voice scrambe on
10-27	Voice scramble off
10-30	Unnecessary use of radio
10-31	Crime in progress
10-33	Emergency
10-41	Begin tour of duty
10-42	End tour of duty
10-43	Information
10-44	Permission to leave
10-50	Accident
10-59	Convoy or escort
10-69	Message received
10-70	Fire Alarm
10-72	Report progress of fire
10-73	Smoke report
10-74	Negative
10-76	Enroute
10-77	Time of arrival
10-78	Need assistance
10-85	Delayed due to
10-89	Bomb threat
10-93	Blockade
10-97	Check signal (radio test)

SECTION E. CALL-OUT PROCEDURES FOR EMERGENCIES AND DISASTERS

Call out procedures for major emergencies and disasters at Chicago Refinery are handled by the North Plant Guard and are initiated upon authorization by the Shift Fire chief.

All Fire Department members and the following Operations, Maintenance and Administrative personnel have home alert receivers and are alerted when a major emergency exists:

Refinery Manager
General Superintendent of Operations
Superintendent of Blending and Transfer
Superintendent of Cracking
Superintendent of Crude Processing
Superintendent of Petrochemical Department
General Superintendent of Maintenance
Superintendent of Specialty Crafts
Supervisor of Field Maintenance
Refinery Chief Engineer
Superintendent of Industrial Relations
Supervisor, Fire, Safety and Security

For all major emergencies, the following procedure will be followed:

Upon activation of the home alert receivers for major potential fires and fires, the following personnel will respond:

1. All Fire Department personnel.

2. The Superintendent of the area involved.

All Fire Department personnel and the Superintendent of the area involved will report to the mobile command center which will be located at or near the emergency scene.

If the emergency is serious enough in nature and will require long-term firefighting operations, or for other extenuating circumstances, the Disaster Plan will be activated. Call-out procedures for a disaster will be handled by the North Gate Guard and will require the response of all Fire Department members and all personnel with home radios. The Disaster Plan can be put into effect by the Shift Fire Chief or the Fire Chief. Since the disaster may or may not be declared with the initial alarm, all Superintendents with radios must assure themselves that the situation has been controlled without activation of the Disaster Plan before resetting the home receiver. If necessary, the home radio will be reactivated on the authority of the Fire Officer in charge.

4/23/82

SECTION E

Procedures for handling environmental emergencies such as oil spills, air pollution, and hazardous materials releases are described in Section H.

4/23/02

Section F. DISASTER PLAN

1. The Disaster Plan, not to be confused with the procedures to be followed during a fire or potential fire, will be activated by the Shift Fire Chief or the Fire Chief when:

   a) The emergency requires long-term firefighting operations as evaluated by the Fire Officer in charge;

   b) Additional supervisory help is required; or

   c) When extenuating circumstances or adverse conditions (such as tornadoes, torrential rains, power loss, etc.) dictate.

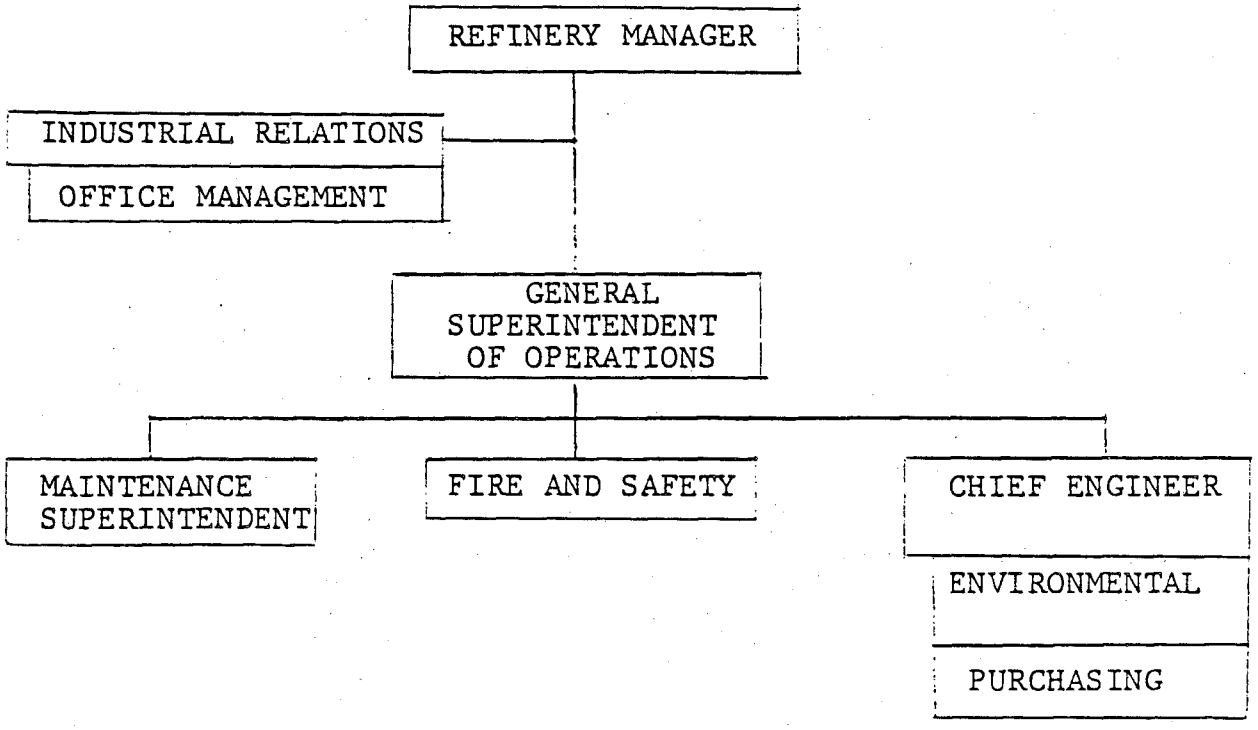
The Disaster Plan is divided into seven sections describing the responsibilities and location assignments of personnel involved.

The attached Emergency Organization chart is effective during a disaster.

The last page of this section is to be reviewed periodically to keep all personnel familiar with the plan.

4/23/82

DISASTER PLAN ORGANIZATION



4/23/82

2. Refinery Manager Duties

   a) Report to Administration Building Room 228.

   b) Advise corporate officers of the situation.

   c) Advise other companies that may be affected.

   d) Keep abreast of operations and public relations.

   e) Issue statements to the news media as necessary.

3. Operations Command Center

   a) General Superintendent of Operations or Designated Alternate

      i) Report to Room 202 in the Administration Building. This will be the Operations Command Center.

      ii) Insure that unit or shift personnel are providing the Refinery Fire Chief with technical information concerning the area involved.

      iii) Consider the impact of the emergency on the ability of the Refinery to contain incoming raw materials and intermediate refinery streams and take action as needed..

      iv) Consider operating manpower requirements and take action as necessary.

      v) Assign a historian to note emergency operating procedures for critique purposes.

   b) Operations Superintendents or Designated Alternates

      The Superintendent and Supervisor of the area involved will report to the Mobile Command Center vehicle at the scene, assess the situation and report back to the General Superintendent of Operations by phone as soon as possible.

      All other Operations Superintendents are to report to their respective Control Centers to evaluate the effect of the emergency on their areas of responsibility.

      Additional assignments will come from the General Superintendent of Operations or his designated alternate.

4/23/82

c) Operations Supervisors or Designated Alternates

Other operations supervisors will respond to the Refinery as requested. If, when called by telephone, a designated place to report is not specified, the operating supervisor will report to the Administration Building Cafeteria and immediately notify extension 332.

d) General Superintendent of Operations

The General Superintendent of Operations is responsible for all operating manpower and equipment needs. Sources of these needs should be planned ahead so that both his alternate and other personnel involved are familiar with the plan.

4. Mobile Command Center

a) The Fire Department equipment van (7618) will be the Mobile Command Center. The van shall be centrally located by the Fire Officer in charge. This vehicle is designated as a central meeting place for the Senior Fire Officer, Supervisor of Fire, Safety, and Security, and the Operating Supervisors of the area involved.

The following equipment is available in the front section:

(1) A four channel scanning transmitter for contacting responding mutual aid apparatus (including our own fire/security frequency)

(2) An eight channel scanning transmitter on all Operating Division frequencies.

(3) Operating unit diagrams

(4) Fire-water system diagrams

(5) Pencils, pens, paper and a blackboard

(6) Tank Fire Preplan Manual

(7) Mutual Aid Books

(8) Hazardous Material Handbooks

The back section contains fire fighter turnout clothing.

4/23/82

5. INDUSTRIAL RELATIONS CENTER

a) Superintendent of Industrial Relations

i) Report to Room 104 (Superintendent of Industrial Relations office) in the Administration Building. This will be the Industrial Relations Center.

ii) Establish communications with Security Supervisor:

aa) Arrange for Security to assist police agencies with crowd and traffic control.

bb) Contact to be established with local police agencies.

iii) Assign switchboard responsibilities.

iv) Establish First Aid Post:

aa) Call out Refinery Nurse.

bb) Advise company physician of situation.

cc) Maintain record of number of casualties and nature of injury (also name, if known).

v) Establish Press Relations

aa) Have Security direct press to Administration Building lobby.

bb) Issue press statements as directed by manager.

vi) Provide food and shelter for emergency personnel.

vii) Make notification of next of kin in the event of fatalities or injuries.

b) Industrial Relations Supervisors

All other Industrial Relations and Office Management supervisors will respond to the Refinery as requested, and report to the Industrial Relations Center.

The Superintendent of Industrial Relations will be responsible for various needs during the disaster.

6. Maintenance Center

a) General Superintendent of Maintenance (or alternate)

i) Report to Room 242 in the Administration Building. This will be the Maintenance Center. Notify General Superintendent of Operations that the Maintenance Center is in Operation.

ii) Coordinate all men and equipment of a maintenance nature that may be requested.

iii) Establish shift assignments for key supervisory personnel.

iv) Establish staging areas and assign work as necessary.

v) Contact various firms for materials and supplies if deemed necessary.

vi) Provide various crafts as needed for continued plant operation or cleanup operations.

b) Maintenance Superintendents (or alternates)

All Maintenance Superintendents are to report to the Maintenance Center in the Administration Building. Specific assignments will be made by the General Superintendent of Maintenance.

c) Maintenance Supervisors

All Maintenance Supervisors will respond to the Refinery as requested. If, when called by telephone, a designated place to report is not specified, each Maintenance Supervisor will report to the Administration Building Cafeteria and immediately notify extension 320.

d) The General Superintendent is responsible for all maintenance manpower and equipment needs. Sources of these should be planned ahead so that both his alternate and other personnel involved are familiar with the plan.

7. Status and Manpower Center

a) Chief Engineer

i) Report to Room 203 in the Administration Building. This will be the Status and Manpower Center. Notify the General Superintendent of Operations that the Status and Manpower Center is in operation.

ii) Notify Environmental Supervisor to report and establish Environmental Center.

iii) Coordinate dispatching of personnel from manpower pool.

iv) Using a plot plan of the involved area, establish and maintain a status board.

v) Recommend outside technical manpower and supplies to the Plant Manager.

vi) Monitor laboratory results to insure non-contamination of products. Advise Operations in the event of a problem.

8. Environmental Center

a) Environmental Supervisor

i) Report to Room 230 in the Administration Building. This will be the Environmental Center.

ii) Record liability claims and environmental information associated with the emergency.

aa) Assign a supervisor to log all details of a liability claims and environmental problems.

bb) Notify pollution agencies as necessary.

4/23/82

9. Summary of Command Center Locations and Telephone Numbers

a) Operations Command Center

Room 202 of the Administration Building - Extension 332.

b) Mobile Command Center

At disaster scene -- contact via Fire/Security radio.

c) Industrial Relations Center

Room 104 of the Administration Building - Extension 216.

d) Maintenance Center

Room 242 of the Administration Building - Extension 320.

e) Status and Manpower Center

Room 203 of the Administration Building - Extension 289.

f) Environmental Center

Room 230 of the Administration Building - Extension 308.

SECTION G. MUTUAL AID - INDUSTRIAL AND MUNICIPAL

1. Requests

a) Municipal

The Des Plaines Valley Fireman's Mutual Aid Organization is composed of 24 Fire Departments, largely but not entirely composed of municipal fire departments. The municipal fire departments listed can be relied on for manpower and pumpers, aerials, extrication and cutting equipment as listed in the mutual aid manuals. Requests for mutual aid are to be made by telephone from the North Gate Guard Station or by the Fire Chief by radio.

b) Industrial

The Noreast Illinois Association of Industrial Mutual Aid (NIAIMA, pronounced NAY-MUH) is composed of area refineries and petrochemical complexes. Equipment is available on a 24-hour basis. The following procedure is to be followed when requesting help from NIAIMA members.

The complete N.I.A.I.M.A. Emergency Manual is kept in the office of the Fire Protection Supervisor, the Shift Fire Chief and the Mobile Command Center. The Fire Ground Officer in charge will institute any request for mutual aid and be responsible for the following:

i) Determine whether the fire/emergency is or may be beyond the control of in-plant personnel/equipment and available municipal help.

ii) Determine the specific type and amount of equipment and supplies needed.

iii) Locate nearest source(s) for the required aid in the "N.I.A.I.M.A." Manual.

4/23/82

iv) Call number(s) listed in Manual and give:

aa) Code words: "This is a 'FIRE' emergency".

bb) Name and location of requesting company and plant; and the nature of the emergency.

cc) Specific information on equipment, material, supplies, or other help that is required.

dd) Point at which to be delivered.

ee) Route or approach suggestions.

ff) Name and title of Company Representative requesting aid.

gg) Name of caller and phone number in case further contact is needed.

v) Secure name of person taking request and confirm that aid will be sent.

vi) Designate a responsible person to meet the incoming aid at the staging location designated by the Fire Chief.

vii) Provide plant or municipal manpower to use the equipment received from the responding mutual aid companies.

2. Assists

Requests for mutual aid assistance from either NIAIMA or Des Plaines Valley members are to be handled as follows:

a) South Plant Guard

i) Take the caller's name and the Fire Department that he represents.

ii) Take the location of the emergency.

4/23/82

iii) Write down what equipment he needs.

iv) Call and tell the Shift Fire Chief exactly what you have written down.

b) Shift Fire Chief

i) Make arrangements to have requested materials transferred, if that is the case.

EXAMPLE

"Mobil Oil requests 300 gallons of XL-3 foam." Shift Fire Chief must arrange for fork lift truck to pick the pallet of foam up and place on Company truck. Company truck will then be driven to Mobil Oil.

ii) Notify the Fire Protection Supervisor, the next available ranking Fire Officer and the Supervisor of Fire, Safety and Security.

iii) If mobile apparatus is requested, the equipment will not leave the plant without a Fire Department Officer on the apparatus.

4/23/82

SECTION H ENVIRONMENTAL EMERGENCY PROCEDURES

The following table lists the environmental emergency plans in use at Chicago Refinery, their purposes, and the department(s) responsible for their implementation.

	Emergency Plan	Purpose	Department Responsible For Plan Implementatio
		Minimize hazards to human health or to the environment from release of:	
1.	Emission Reduction Plans: a. Air Pollution Watch b. Air Pollution Yellow Alert c. Air Pollution Red Alert d. Air Pollution Emergency	Nitrogen oxides, sulfur oxides, or particulates to the air.	Plant Manager (on IEPA Notice). a.b.c., Operations General Supt. or designated alternate. d. All Division Heads.
2.	Oil Spill Plan	Liquid hydrocarbons to a navigable waterway.	Blending and Transfer Dept; Conservation Dept.
3.	Hazardous Substance Release Plan.	Aromatic Solvents, Caustic, acid, anti-knock compounds to air, water or soil.	Operations Division Depts.
4.	Land Farm Emergency Plan.	Sludge to air, water or soil due to run-off, fire, or explosion.	Conservation Dept.

COMPANY: Union Oil Company of California

	1	2	3	4	5
APPARATUS TYPE	FOAM ENGINE	FOAM ENGINE	MINI PUMP	FOAM AERIAL	
APPARATUS NUMBER	7611	7612	7613	7619	
WATER CAPACITY, GPM	1250	1250	250	1500	
FOAM CAPACITY, GPM	1500	1500	100	1500	
FOAM CAPACITY, GALLONS	1000	1000	100	750	
FOAM TYPE	XL-3	XL-3	AFFF	XL-3	
DRY CHEMICAL, POUNDS	0	0	0	0	
DRY CHEMICAL, TYPE	-	-	-	-	
HOSE THREAD, TYPE	NST	NST	NST	NST	
1-1/2" ATTACK LINES, FT.	500	500	150	0	
2-1/2 or 3" HOSE, FT.	1200	1200	400	1200	
4" HOSE, FT.	0	0	0	0	
HARD SUCTION, DIA./LENGTH	20'-6"	20'-6"	20'-2½"	0	
MONITOR, FIXED	1	1	0	Aerial	
MONITOR, PORTABLE	2	2	1	0	
COMMUNICATIONS: F1	154.400	154.400	154.400	154.400	
F2	154.250	154.250	154.250	154.250	
F3	154.265	154.265	154.265	154.265	
SCBA, UNITS/SPARE BOTTLES	0	0	6/4	2/0	

MAILING ADDRESS:
Union Oil Co. of California
Chicago Refinery
Lemont, IL 60439

EMERGENCY PHONE:
(312) 257-7761

BUSINESS PHONE:
(312) 257-7761

FIRE CHIEF:
Dale T. Pirc

SECONDARY:
NAME:
Raymond L. Brandolino

NAME:
Jim Abrams

OTHER ITEMS*						DESCRIPTION, MODEL, ETC.
2 Self-Contained Acid Suits			2			
1 Sky-Genie			1			
1 Stokes Basket			1			
1 Chlorine "B" Kit			1			
XL-3 Foam						2000 gal., 55 gal. drums

*PLEASE LIST FIRE/RESCUE/HAZMAT SUPPLIES THAT YOU COULD SEND.

REVISED:

MUTUAL AID ARRIVING AT THE REFINERY

DURING A FIRE AT THE REFINERY, NO ARRIVING MUTUAL AID, EITHER INDUSTRIAL OR MUNICIPAL, WILL ENTER THE REFINERY WITHOUT CONSENT OF THE SENIOR OFFICER IN CHARGE. THIS INCLUDES POLICE SQUADS, CIVIL DEFENSE ORGANIZATIONS, ETC. IF A VEHICLE ARRIVES AT THE GATE WITHOUT PRIOR NOTIFICATION, CONTACT THE SENIOR OFFICER FOR CLEARANCE. A LOG IS TO BE KEPT OF ALL ARRIVING VEHICLES WHICH WILL INCLUDE THE VEHICLE NUMBER, THE NAME OF THE ORGANIZATION ENTERING THE REFINERY AND THE NUMBER OF PEOPLE IN OR ON THAT VEHICLE. NO ONE FROM AN OUTSIDE MUNICIPAL OR INDUSTRIAL FIRE DEPARTMENT IS TO ENTER THE REFINERY IN HIS PERSONAL VEHICLE.

REVISED
8/15/80

FIRES, POTENTIAL FIRES

NIGHTS, WEEKENDS, AND HOLIDAYS

1. SOUND THE APPROPRIATE IN-PLANT ALARM.

2. ACTIVATE THE TAPE RECORDER.

3. ANNOUNCE OVER THE IN-PLANT PUBLIC ADDRESS SYSTEM AND OVER THE FIRE/SECURITY RADIO, THE LOCATION AND NATURE OF THE EMERGENCY.

4. FILL IN THE APPROPRIATE INFORMATION ON THE "222 SHEETS" PROVIDED.

5. DO NOT CALL OUT THE UNION OIL FIRE DEPARTMENT UNLESS INSTRUCTED TO DO SO BY THE SHIFT FIRE CHIEF 7680. THE SHIFT FIRE CHIEF WILL DETERMINE IF HELP IS NEEDED AND WILL REQUEST IT ACCORDINGLY. IF THE SHIFT FIRE CHIEF REQUESTS THE UNION OIL FIRE DEPARTMENT BE NOTIFIED ACTIVATE THE HOME FIRE RADIOS BY ACTIVATING CODES 12, 32, 42 AND 52 ON THE ENCODER LOCATED ON THE CONSOLE. IF YOU ARE REQUESTED TO ACTIVATE THE HOME FIRE RADIOS, DO SO AND FOLLOW WITH AN ANNOUNCEMENT DESCRIBING THE LOCATION AND NATURE OF THE EMERGENCY. THIS IS TO BE DONE ON THE AUTHORITY OF THE SHIFT FIRE CHIEF ONLY!

6. IF THE SHIFT FIRE CHIEF 7680 DETERMINES OUTSIDE HELP OTHER THAN OUR FIRE DEPARTMENT IS NEEDED, YOU MAY BE REQUESTED TO NOTIFY ONE OF TWO MUNICIPAL FIRE DEPARTMENTS:

   1. ROMEOVILLE FIRE DEPARTMENT - 81-886-2171
   2. LEMONT FIRE DEPARTMENT - 83-257-2221

   ADDITIONAL HELP WILL BE REQUESTED BY THE SENIOR OFFICER IN CHARGE THROUGH THE ROMEOVILLE FIRE DEPARTMENT.

7. IF INDUSTRIAL MUTUAL AID IS REQUIRED, YOU MAY BE REQUESTED TO PLACE A PHONE CALL TO PEOPLES GAS, LIGHT AND COKE, OR MOBIL OIL REFINERY.

   * PEOPLES GAS, LIGHT AND COKE - 815-423-6143
   * MOBIL OIL REFINERY - 815-423-5571

   *THESE ARE LONG DISTANCE CALLS. TO PLACE A LONG DISTANCE CALL, CONTACT THE SOUTH GATE AND REQUEST THEIR ASSISTANCE. YOU WILL BE INFORMED OF DETAILS OF THE REQUEST BY THE SENIOR OFFICER IN CHARGE OF THE FIRE.

8. ANNOUNCE THE "ALL CLEAR" WHEN REQUESTED TO DO SO BY THE SENIOR OFFICER IN CHARGE ONLY!

REVISED
8/15/80

INJURIES

NIGHTS, WEEKENDS, HOLIDAYS

1. SOUND THE APPROPRIATE IN-PLANT ALARM.
2. ACTIVATE THE TAPE RECORDER.
3. ANNOUNCE OVER THE IN-PLANT PUBLIC ADDRESS SYSTEM AND THE FIRE/SECURITY RADIO, THE LOCATION OF THE INJURY.
4. DO NOT CALL FOR AN OUTSIDE AMBULANCE UNTIL REQUESTED TO DO SO BY THE SHIFT FIRE CHIEF OR LABORATORY PERSONNEL. IF THE INJURED PERSON IS SOUTH OF THE BLEND CENTER, CALL THE ROMEOVILLE FIRE DEPARTMENT, 81-886-2171. IF THE INJURED PERSON IS NORTH OF THE BLEND CENTER, CALL THE LEMONT FIRE DEPARTMENT, 83-257-2221.

REVISED
8/15/80

ATTACHMENT G-2

SPILL PREVENTION CONTROL AND
COUNTERMEASURE PLAN

CHICAGO REFINERY

SPILL PREVENTION CONTROL AND COUNTERMEASURE PLAN (SPCC PLAN)

FOR

CHICAGO REFINERY

UNION OIL COMPANY OF CALIFORNIA

The Chicago Refinery of Union Oil Company of California is a facility that refines crude oil into finished products. The Refinery is located on an 860 acre tract of land in Will County between the villages of Lemont and Romeoville.

The address and telephone number of the facility is as follows:

Chicago Refinery
Union Oil Company of California
135th Street and New Avenue
Lemont, Illinois 60439

Telephone: (312)257-7761

Revised 1/14/83

MANAGEMENT APPROVAL

This SPCC Plan will be implemented as herein described:

Signature _____

Name A. J. Eliskalns

Title Manager, Chicago Refinery

CERTIFICATION

I hereby certify that I have examined the facility and being familiar with the provisions of 40 CFR, Part 112, attest that this SPCC Plan has been prepared in accordance with good engineering practices.

Walt Jenkins

Printed Name of Registered Professional Engineer

Signature of Registered Professional Engineer

Registration No. 62-29276 State: Illinois

Date January 24, 1983

TABLE OF CONTENTS

112.7(a)	SPILL RECORD
112.7(b)	POTENTIAL EQUIPMENT FAILURE
112.7(c)	SPILL CONTAINMENT FACILITIES
112.7(d)	PRACTICALITY
112.7(e)(1)	FACILITY DRAINAGE
112.7(e)(2)	BULK STORAGE TANKS
112.7(e)(3)	FACILITY TRANSFER OPERATIONS
112.7(e)(4)	FACILITY TANK CAR AND TANK TRUCK LOADING/UNLOADING RACK
112.7(e)(8)	INSPECTIONS AND RECORDS
112.7(e)(9)	SECURITY
112.7(e)(10)	PERSONNEL, TRAINING AND SPILL PREVENTION PROCEDURES
112.4	SPILL EVENT REPORT AND PLAN AMENDMENTS
	U.S. EPA'S REGULATIONS

112.7(a) SPILL RECORD

1. This facility, over the past year, has had a reportable non-transportation related spill. Yes X No_____

2. Descriptions of any reportable spills are given below, including corrective action taken and plans for preventing recurrence.

   A. There has been seepage of oil into the I&M Canal. This seepage appears related to groundwater level and is not due to any spill incident. The sources of oil are not known. Oil appears to have contaminated certain underground areas in the old Refinery over the past fifty years. Oil is retained within company property limits. The situation is under control and is being improved by continuing program of plant improvements of drainage and housekeeping items.

   B. Oil seepage to Sanitary and Ship Canal - March 10, 1976 - see pages 5A - 5C.

   C. Oil seepage to Sanitary and Ship Canal - July 2, 1976 - see pages 5D - 5F.

   D. Oil spill to Sanitary and Ship Canal - May 18, 1979 - see pages 5G - 5H.

   E. Oil seepage to I&M Canal - December 15, 1981 - see pages 5I - 5J.

   F. Oil seepage to I&M Canal - December 3, 1982 - see page 5K.

   G. Oil seepage to I&M Canal - April 5, 1983 - see page 5L.

   H. Xylene spill to I&M Canal - April 21, 1983 - see page 5M.

   I. Oil seepage to I&M Canal - July 2, 1983 - see Page 5N.

   J. Oil Spill to I&M Canal - January 13, 1984 - see Page 5O.

   K. Oil Seepage to I&M Canal - March 2, 1984 - see Page 5P

   L. Oil Seepage to I&M Canal - March 26, 1984 - see Page 5Q

Chicago Refinery
March 15, 1976

TO: J. R. Mortenson

OIL SEEPAGE INCIDENT

On Wednesday, March 10, 1976, at 3:50 AM, Mr. Ed Ferry, a Union Oil Company Tankerman, observed oil seeping into the Chicago Sanitary and Ship Canal at the Chicago Refinery barge loading dock. Plant supervisors were alerted and the U. S. Coast Guard was notified by 4:00 AM.

Oil was discovered flowing from open sewer system catch basins in the south dock area and soaking into the ground. On further investigation, the south end sewer system sump pump was found to have a broken shaft coupling making it inoperative. The sewer system collects oil from curbed loading spots for barge loading operations as well as storm water and field water drainage. The sump pumps discharge this material to the ballast and sewer water storage tank.

The Refinery's large vacuum truck was available so it was dispatched immediately to the dock and began pumping out the sewer system by 4:00 AM. Additional help was called and a slick bar boom was deployed along the dock facing together with 3M sausage-type absorbent booms. A permanent slick bar boom situated downstream of barge loading operations was also extended to collect escaping oil. By 5:15 AM most of the seeping oil was contained.

at 7:45 AM the small Refinery vacuum truck arrived and began removing oil contained by the slick bar booms in the canal. The large truck could not be used for this service as it could not be maneuvered close enough to the dock edge to be effective and it was already being used most effectively pumping out the sewer sump. By 9:00 AM, the small truck had picked up the bulk of the oil collected behind the slick bars.

FORM 1-9583 (11-72) PRINTED IN U.S.A.

Pump repairman arrived at 7:50 AM and had made temporary repairs by 9:00 AM. The repaired pump quickly pumped out the oil from the sewer so the system was returned to normal conditions except for the oil which had soaked into the ground and continued to seep out the dock wall crevices. At approximately 6:30 AM, Mr. Kenneth Kolar, U.S.C.G., arrived and assisted in the placement of a secondary boom at the permanent installation. At about noon, Lt. Gerald Jenkins arrived to inspect the area and at his request our longest slick bar of 359 ft. was extended along the face of the canal providing double containment of the seepage area.

At 2:00 PM, the south pump bearings were replaced providing more reliable pump operation. By 3:30 PM seepage had diminished to trace amounts. The vacuum truck was kept on duty throughout the night removing small quantities of oil as it accumulated.

The sewer system overflow was determined to have been caused by a failure of the flow check valve on the downstream side of the south sump pump and the failure of the pump coupling. The check valve had worn so that it did not seal properly permitting oil to flow from the pump discharge line into the south sewer system. The flow resulted either from the pumpout of the north sump or by siphoning from the ballast tank.

There is no way to determine the loss of oil into the canal. Mr. Kolar advised us he estimated on the basis of downstream investigations that approximately 300 gallons had escaped.

Each sump has an independent high level alarm and light installed adjacent to the sump. When the sewer overflow was discovered, the alarm light was lit but the horn was not sounding. The alarm light is small and partially shielded so that it can only be seen from the shore side whereas personnel traffic usually follows a path on the canal side of the sump pump. There is no explanation as to why the horn did not sound.

To protect against reoccurrence, new check valves will be installed in both north and south sewer systems and alarm system lights and horns relocated.

D. V. Fulton

D. V. Fulton

BJNotheisen/ams
cc: L. R. McKenzie
D. J. Metz

UNION 76

OPR 260-76

Chicago Refinery
March 16, 1976

TO: R. V. McDowell

UPGRADE BARGE LOADING DOCK
SEWER AND BALLAST SYSTEM

Please prepare a process design and cost estimate to upgrade the sewer and ballast system at the Barge Loading Dock. The scope of project includes:

1. Relocate or modify the sump high level alarm horns so they can be heard. Revise alarm lights so they can be visible from canal side of Unit.

E 5040

2. Revise ballast piping to discharge separately into ballast tank 44TK-3.

3.* Design spare pumps for 33G-1 and 33G-2 sumps. Instrumentation to automatically start spare pumps.

4.* Separate sumps 33G-1 and 33G-2 so one is for process sewer and the other is for the interceptor system.

5. Revise 33G-1 and 33G-2 discharge piping so material cannot gravitate or be pumped back from Tank 44TK3 or from the companion sewer sump.

6.* Replace tile in the interceptor ditch that has failed.

7. Install cement catch basins so areas of potential leakage are contained in the sewer system.

Separate the costs for items No. 3, No. 4, and No. 6.

L. R. McKelvie

L. R. McKelvie

LRM/ams

cc: D. V. Fulton

H. D. Haas
3-25-76

OIL SEEPAGE INTO SHIP AND SANITARY CANAL AT CHICAGO REFINERY MARINA

Date - July 2, 1976

Time - At 0010 hours, Mr. E. Ferry (Dockman) found the small gasoline dispensing tank overflowing on the ground and into the sewer system. Some gasoline was percolating through gravel resulting in minor seepage into canal along the face of the Canal Dock.

Operation - No barge loading or unloading was being performed at the dock during shift. No towboats requested refueling service during the shift.

Mr. Ferry (Dockman) found the following unauthorized hookup and transfer at 0010 hours.

Someone had disconnected the drain piping and had connected an air hose to the 4B barge loading arm. The other end of the hose was stuck into the gasoline dispensing tank fill pipe. The Premium Gasoline manifold valve to the 4B loading arm was open, and the drain valve was open. Premium Gasoline was gravitating into the dispensing tank and overflowing onto the pad.

An investigation is being made to determine who made the unauthorized hookup and who started the unauthorized transfer and when and why.

Action Taken - Immediately, shut off gasoline gravitating to the tank and started containment, cleanup, and notification.

1. Installed absorbant booms between Canal wall and two barges tied off downstream of point of seepage.
2. Checked sump pump emptying process sewer.
3. Vacuum truck cleaning up oil seepage between Canal wall and barges.
4. Notified Coast Guart at about 0200 hours, who in turn notified Metropolitan Sanitary District.
5. Washed down the gravel with water after oil containment equipment was put in place.

Amount of Seepage -

Estimate the seepage into the Canal at about one (1) barrel.

Edward Ferry.
E. Ferry, Dockman

D. J. Metzger
D. Metzger, Shift Supv.

L. L. Toon
L. L. Toon, Loading Supv.

LRMcKelvie/ams

Corrective Action - Incident of July 2, 1976

1. July 12, 1976 a work order was written to remove the gasoline dispensing tank from the Marina Area.

2. July 14, 1976, plant electricians disconnected power from gasoline dispensing equipment, which was then removed from the Marina and taken to the Braun Building area.

3. July 13 and 14, 1976, Mr. Ed Ferry was given disciplinary lay-off.

4. October 19 and 20, 1976, Mr. George Bokan was given disciplinary lay-off.

Oil Spill Into Ship and Sanitary Canal

On Friday, May 18, 1979, at 1250 hours, an oil spill occurred into the Sanitary and Ship Canal at the Chicago Refinery barge loading dock. Plant supervisors were alerted. Since U. S. Coast Guard Personnel were making an inspection of the barge dock at this time, they called the spill into their Chicago Office. Later they insisted that Union Oil Comp personnel also call the spill into their office. This was done at 1410 hours by L. D. Erchull.

Ed Schultz, Jr., a Union Oil Company Tankerman cracked open the main valve on a line containing carbon black feedstock (Decant Oil) leading to a chiksan (loading arm) so that a sample could be taken for testing. Inadvertently, the chiksan was not blinded at that time so that 3 - 5 gallons of oil escaped onto the canal.

As soon as the tankerman noticed the spill, a few seconds elapsed, the valve was closed and the flow of oil ceased.

The spill was contained and picked up by sorbant booms on the canal. The canal wall and the side of the barge were also cleaned of oil.

To prevent reoccurrence, refer to page 5H.

UNION 76

Chicago Refinery
June 1, 1979

TO: Canal Dock

Chiksan Loading Arms

To prevent a reoccurrence of what happened 5/18/79, (spillage of Decant Oil into Canal) effective immediately a new policy will be initiated to have chiksans blinded following the unhooking of barges.

This also means that if another barge is to load the same product the chiksan must be blinded until barge is spotted.

C. J. Abrams Jr.
C. J. Abrams, Jr.

CJA:rea
cc: Shift Supervisors
Mr. L. D. Erchull

ENV 170-81

CERTIFIED MAIL
RETURN RECEIPT REQUESTED
971205

December 21, 1981

Attn: MST3 Crowder
USCG Marine Safety Office
610 S. Canal Street
Chicago, Illinois 60607

Background Statement On Oil Seepage Incident To I&M Canal On December 15, 1981

The purpose of this statement is to provide background information on the events which probably led up to the oil seepage incident to the I&M Canal on December 15, 1981. At the time of the seepage incident the terminus of the sewer system from the north part of the refinery to the storm water basin was under water due to the higher than normal level of the storm water basin.

The Waste Treatment Plant has experienced increased organic loading and mechanical equipment failures in the past two months. The higher organic loadings made it necessary to reduce charge rates to the Waste Treatment Unit which were further reduced when mechanical failures were experienced with the primary clarifier. When the primary treatment section of the Waste Treatment Unit is lost, a decrease in efficiency of the biological section is observed. This inturn requires that the charge to the Waste Treatment Unit be reduced to maintain compliance with strict state and federal effluent limitations.

Since the primary clarifier was returned to service on December 11, the stormwater basin has been steadily drawn down. Union will continue to draw the basin down as rapidly as possible without violating any effluent limitations. In order to minimize the stormwater basin level, untreated wastewater was recycled for process use into the plant cooling water system. This

recycle scheme is continuing on an emergency basis. However, recycle is only a temporary treatment of a symptom and not a cure to the problem. Therefore, a survey to determine the source of the higher than normal organic loadings was initiated prior to the seepage into the canal. Other action taken to increase treatment efficiency during this period was reseeding of the biological unit with bacteria from a local area chemical company and the continued addition of mutant bacteria for the past two months.

Due to a great many uncertanties at this time, we are unable to estimate when the storm water basin will return to a normal level. Cleanup efforts are proceeding on the I&M Canal but the task is proving to be very difficult due to the fact that the canal is completely frozen over due to the low temperatures. We are also proceeding to remove oil from the submerged sewer line from the north part of the refinery to the storm water basin.

An engineering project is being initiated to evaluate action needed to prevent recurrence of this incident.

Very truly yours,

A. J. Eliskalns

LDE:mln

bcc: H. D. Haas

Union Oil Company of California
Chicago Refinery, Lemont, Illinois 60439
Telephone (312) 257-7761

ENV 237-82

cc: J.K. Bassett/J.E. Ganzmann/J.C. Wilkes
H. D. Haas
T. R. Thomas - Los Angeles

CERTIFIED MAIL #P 334 829 221
RETURN RECEIPT REQUESTED

A.J. Eliskalns
Manager, Chicago Refinery

December 20, 1982

Attn: GM3 Eisenbraun
USCG Marine Safety Office
610 S. Canal Street
Chicago, Illinois 60706

I&M Canal Oil Spill

Dear Sir:

Due to record rains in the month of November (6") the level in the storm water basin was higher than normal. On December 3, 1982, a total of 3.15 inches of rain fell over the Refinery. This quantity of water could not be contained in the storm water basin and subsequently backed up the entire sewer system in the north part of the Refinery. Oil usually contained within the sewer system was apparently forced through cracks in the sewer pipe and leaked into the I&M Canal.

The level of the storm water basin is being reduced as radidly as possible. This is being accomplished by charging wastewater to the waste treatment plant at its maximum rate without violating any effluent specifications. In order to also help to lower the basin level, untreated wastewater was recycled for use in the Refinery cooling water system on an emergency basis.

Oil is being removed from the I&M Canal and the sewer system. All oil spilled into the canal has been contained by booms within the Refinery. We estimate that 1800 barrels of oil have been removed from the canal. This oil is of similar nature to gasoline without the light end portion.

A project to investigate the actual cause of sewer leakage and method of repair is underway.

Very truly yours,

A. J. Eliskalns

LDE:dlw

cc: Mr. Jay Patel - IEPA Maywood
Certified Mail #P334 829 222

Union 76 Division: Eastern Region

Union Oil Company of California
Chicago Refinery
Lemont, Illinois 60439
Telephone (312) 257-7761

ENV 94-83

union 76

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

A. J. Eliskalns
Manager, Chicago Refinery

April 13, 1983

U.S.C.G. Marine Safety Office
ATTN: GM3 Eisenbraun
610 South Canal Street
Chicago, Illinois 60706

Dear Sir:

I&M Canal Oil Seepage

Between April 2, 1983, and April 3, 1983, a total of 2.65 inches of rain fell over the Refinery. This quantity of water was contained in the storm water basin but the entire sewer system in the north part of the Refinery was submerged due to the high storm water basin level. Oil is thought to have accumulated, by a means not yet known, in the trench containing the sewer system. Pressure caused by the high storm water basin level appears to force the oil through existing fissures which end in the I&M Canal.

The level of the storm water basin is being reduced as rapidly as possible. This is being accomplished by charging wastewater to the Waste Treatment Plant at its maximum rate without violating any effluent specifications. In order to help lower the basin level, untreated wastewater is being recycled for use in the Refinery cooling water system on an emergency basis.

Oil is being removed from the I&M Canal and the sewer system. All oil which seeped into the canal has been contained by booms within the Refinery. We estimate that 45 barrels of oil have been removed from the canal.

The investigation is continuing in order to determine the actual mechanism of oil seepage in the I&M Canal.

Very truly yours,

A. J. Eliskalns

LDE:dlw

bcc JK Russell
ND [illegible]
TP [illegible]

Union 76 Division: Eastern Region

Union Oil Company of California
Chicago Refinery
Lemont, Illinois 60439
Telephone (312) 257-7761

ENV 109-83

union 76

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

. J. Eliskalns
nager, Chicago Refinery

April 28, 1983

U.S.C.G. Marine Safety Office
ATTN: MST3 Boltersdorf
610 South Canal Street
Chicago, Illinois 60706

Dear Sir:

Statement on Xylene Spill to
I&M Canal on April 21, 1983

On Thursday, April 21, 1983, at 1145 hours, a spill of xylene occurred into the I&M Canal. The appropriate Refinery departments and governmental agencies were notified of the incident.

Union Oil was attempting to put the xylene line into service from the Tank Farm to the Barge Loading Dock which is located on the Chicago Sanitary and Ship Canal. This line was removed from service to relocate a section of the line onto a different section of pipe supports. As this line was being charged with xylene, product was observed leaking out of a split in the bottom of the line as it just starts to cross over the I&M Canal. The pump was shut down and within a short period of time, the flow of xylene into the canal stopped. The investigation is continuing in order to determine the mechanism for failure of the line.

The xylene was contained by booms and cleanup started using Refinery vacuum trucks. We estimate that we have recovered 50 barrels of product from the canal.

Very truly yours,

A J Eliskalns/LDE

A. J. Eliskalns

LDE:dlw

cc: J. A. Patel - IEPA-Maywood, Illinois
Certified Mail-Return Receipt Requested

union 76

Chicago Refinery
July 13, 1983

H. D. Haas

I&M Canal Oil Seepage

Between July 1, 1983 and July 4, 1983, a total of 4.4 inches of rain fell over the Refinery. This quantity of water could not be contained in the storm water basin and subsequently backed up the entire sewer system in the north part of the Refinery. Oil is thought to have accumulated, by a means not yet known, in the trench containing the sewer system. Pressure caused by the high storm water basin level appears to force the oil through existing fissures which end in the I&M Canal.

The level of the storm water basin is being reduced as rapidly as possible. This is being accomplished by charging wastewater to the Waste Treatment Plant at its maximum rate without violating any effluent specifications. In order to help lower the basin level, untreated wastewater is being recycled for use in the Refinery cooling water and utility water systems on an emergency basis.

Oil is being removed from the I&M Canal and the sewer system. All oil which seeped into the canal has been contained by booms within the Refinery. We estimate that 100 barrels of oil have been removed from the canal.

The investigation is continuing in order to determine the actual mechanism of oil seepage in the I&M Canal.

L. D. Erchull

L. D. Erchull

LDE:dlw

1-0C02 (1-73)
PRINTED IN U.S.A.

Union 76 Division: Eastern Region

Union Oil Company of California
Chicago Refinery
Lemont, Illinois 60439
Telephone (312) 257-7761

ENV 21-84

union 76

CERTIFIED MAIL
RETURN RECEIPT REQUESTED
#P 334 827 545

A. J. Eliskalns
Manager, Chicago Refinery

January 26, 1984

U.S.C.G. Marine Safety Office
ATTN: Mr. Evans
610 South Canal Street
Chicago, Illinois 60706

Dear Sir:

I&M Canal Oil Discharge

On January 13, 1984, at 0900, hydrocarbon was discovered in the I&M Canal. The appropriate Refinery departments and governmental agencies were notified of the incident.

The cause of the leak has not yet been determined, but we suspect there may be a problem in our Tank Farm sewer system. This is being investigated.

A containment boom was placed in the area of the discharge in the canal and for back up purposes, we also placed a boom down stream.

All of the surface oil has been removed except for the oil under the ice. When the weather permits this oil will be removed.

Sincerely,

A. J. Eliskalns

ARGill:dlw

bcc: JKBassett/JSNoreiko
TRThomas/WWCrim
H. D. Haas

Union 76 Division, Eastern Region

Union Oil Company of California
Chicago Refinery
Lemont, Illinois 60439
Telephone (312) 257-7761

ENV 71-84

union 76

CERTIFIED MAIL
RETURN RECEIPT REQUESTED
#P 334 827 561

J. Eliskalns
Chicago Refinery

March 7, 1984

U.S.C.G. Marine Safety Office
Attn: P. O. Evans
610 South Canal Street
Chicago, Illinois 60706

Dear Sir:

I&M Canal Oil Seepage

On March 2, 1984, oil seepage was observed under the ice in the I&M Canal. The appropriate regulatory agencies were notified of the incident.

The mechanism for the seepage at this time is not known. Normally, a high stormwater basin level will cause the sewer system in this area of the Refinery to be submerged. This in turn would cause oil to be forced through fissures into the I&M Canal. At this time the stormwater basin was not at a high level. The basin was steadily coming down from the high level of February 14, 1984.

Oil is being removed from the I&M Canal and the sewer system. All oil which seeped into the canal has been contained by booms within the Refinery. We are not able to estimate the volume of oil within the canal at this time, although it was not substantial.

Very truly yours,

A. J. Eliskalns

✓LDE:dlw

bcc: JKBassett/JSNoreiko
TRThomas/WWCrim

ENV 89-84

UNION

CERTIFIED MAIL
RETURN RECEIPT REQUESTED
#P08 8720183

April 3, 1984

U.S.C.G. Marine Safety Office
Attn: MST 3 Boltersdorf
610 South Canal Street
Chicago, Illinois 60706

Dear Sir:

I&M Canal Oil Seepage

Between March 15, 1984, and March 21, 1984, a total of 3.08 inches of rain fell over the Refinery. This quantity of water was contained in the storm water basin but the entire sewer system in the north part of the Refinery was submerged due to the high storm water basin level. Oil is thought to have accumulated in the trench containing the sewer system. Pressure caused by the high storm water basin level appears to force the oil through existing fissures which end in the I&M Canal.

The level of the storm water basin is being reduced as rapidly as possible. This is being accomplished by charging wastewater to the Wastewater Treatment Plant at its maximum rate without violating any effluent specifications. In order to help lower the basin level, untreated wastewater is being recycled for use in the Refinery cooling water and utility water systems on an emergency basis.

Oil is being removed from the I&M Canal and the sewer system. All oil which seeped into the canal has been contained by booms within the Refinery. We are not able to estimate the volume of oil within the canal at this time, although it was not substantial.

Very truly yours,

A. J. Eliskalns

LDE:dlw

bcc: J. K. Bassett
D. W. Bruckert
W. W. Crim

112.7(b) POTENTIAL EQUIPMENT FAILURE

1. Nearest Navigable Water:

(1) Chicago Sanitary and Ship Canal

The refinery has about 3,000 feet of frontage along the canal. About 1,000 feet are used for oil loading and unloading facilities.

The non-transportation related facility is the drainage sewer. It collects all hydrocarbons accidentally discharged onto cement pads which surround each Chicksan loading facility. The sewer drains to two separate collection sumps, one for the North loading area and another for the South loading area. These sumps, when filled to certain level, are pumped by level control activated pumps to the ballast water tank which in turn is pumped to #4 Separator.

Since the abandoned I&M Canal channel lies between the non-transportation portion of the refinery facilities and the Chicago Sanitary and Ship Canal, it is judged that no spill from these facilities other than the above can enter the Sanitary and Ship Canal.

(2) Illinois and Michigan Canal

The I&M Canal adjoins one entire side of the refinery processing and storage areas lying between the refinery and the Sanitary and Ship Canal for a distance of about two miles. This is a drainage ditch for storm water with heavy flow during flood periods and little or no flow during dry periods.

2. Possible Spill Sources:

(1) Chicago Sanitary and Ship Canal

Source	Type of Failure
Sewer Collection Sumps	Overflow caused by: 1. Mechanical failure of pump. 2. Failure of high level warning device. 3. Failure of check valve.

(2) Illinois and Michigan Canal

Source	Type of Failure	Maximum Volume
Storage tanks, piping pipelines, sewers, unit process equipment, loading racks	Mechanical, leaks, ruptures, spills, overflows	The Refinery storage capacity is about 7.5 million barrels. Hydrocarbon on hand at any one time is about 4 million barrels.

112.7(c) SPILL CONTAINMENT FACILITIES

Secondary containment and diversionary structures are used for possible spill sources:

Source	Type of Containment or Diversionary Structure
Tanks	Dikes and dike drains (controlled) to storm water basin.
Loading Racks	Curbing, gutters, drains to storm water basin.
Pipelines	Curbing, gutters, retaining walls, drains to storm water basin.
Towers & Vessels	Curbing, gutters, retaining walls, drains to storm water basin.
Oil & Water Separators	Curbing, gutters, drains to storm water basin.

Floating booms, sorbent materials and mobile pumping equipment are available and used for containing or collecting oil.

The Refinery has a very elaborate system for preventing oil getting onto water which then is very difficult to clean-up. The Refinery has a slop oil system to recover and reprocess any hydrocarbon which doesn't meet product specifications.

The Refinery also has three separate plant wide sewer systems:

1. The sanitary waste is collected and sent to the waste treatment unit for clean-up. (See drawings 2987-152-CE-5 and 2987-152-CE-6) (Attachments 1 & 2).

2. The oily contaminated waste water is collected in the process water system and the oil is removed by an API separator. The oil-free water is then charged to the storm water basin. (See drawings 2987-152-CE-11 and 2987-152-CE-12) (Attachments 3 & 4).

3. The Refinery's storm water which could be accidently contaminated is discharged to the storm water basin for surge control. Pumps send the water to the waste treatment plant for treatment. (See drawings 2987-152-CE-11 and 2987-152-CE-12) (Attachments 3 & 4).

4. Numerous process units have separate sewer systems which allow contaminants to be reconverted or neutralized before they enter the storm pond.

The storm water basin was designed to contain runoff based on a total precipitation of 4 inches for a 24-hour period. The storm water basin is divided into two parts connected by submerged lines. Oil captured in the storm water basin is retained in the east basin. Essentially oil-free water enters the west basin.

Waste water from the west basin is pumped to waste water treatment unit for treatment and to the water treatment unit for reuse. Effluent from the waste water treatment unit flows to the treated water basin and then is pumped on level control to Sanitary and Ship Canal. (See Attachment 5).

112.7(c) SPILL CONTAINMENT FACILITIES (Cont.)

If the storm water run-off exceeds the sum of the storm basin capacity, the treatment plant capacity and the water reuse capacity, the west protion of the storm water basin may overflow oil-free water into the I&M Canal. Flow of the storm water to the waste treatment is handled by two pumps, 44GM-405 and 44GM-414.

112.7(d) PRACTICALITY

Chicago Refinery has the necessary structures and equipment listed in 112.7(c) to prevent discharged oil from reaching navigable water. In addition to this, Chicago Refinery has a strong Refinery "Oil Spill Emergency Plan" outlining procedures, containment equipment, clean-up equipment, and oil spill mutual aid information and is attached as part of this SPCC Plan. The attachment is part of the Chicago Refinery Canal Dock Operations Manual prepared in accordance with Title 33 CFR, Part 154.300.

112.7(e)(1) FACILITY DRAINAGE

112.7(e)(1)(i)

Drainage from diked storage areas is restrained by gate valves. These valves are normally in the closed position. After precipitation has fallen into a diked storage area, an operator will drain the water either into the process water system for oil removal or to the storm water basin when he has received permission. This allows the waste treatment department to control the flow of water to the treating facilities and not overload the facilities.

112.7(e)(1)(ii)

Flapper-type drain valves are not used in diked storage areas.

112.7(e)(1)(iii)

The drainage system from all undiked areas in the Refinery which could be contaminated with oil, flows to the storm water basin for containment. Oil is periodically removed from this basin by vacuum equipment and reprocessed. This water is then charged to the waste treatment unit for treatment and discharge into the Sanitary and Ship Canal as on specification effluent.

112.7(e)(1)(iv)

Not Applicable.

112.7(e)(1)(v)

Drainage water goes by natural hydraulic flow to the storm water basin. Process water either goes by natural hydraulic flow or by lift station pumps to an oil-water separator. Each lift station is equipped with two pumps with appropriate controls for automatic operation on level control. In the event of any equipment failure, all water would make its way into the storm water basin; thereby preventing discharge of oil into navigable waters.

See Union Oil Company Drainage Maps B-7357-23. (Attachments 6 & 7).

112.7(e)(2) BULK STORAGE TANKS

112.7(e)(2)(i)

All tanks used for storage are compatible with the material stored and conditions of storage such as pressure, temperature and corrosivity. Tanks are constructed according to API specifications.

112.7(e)(2)(ii)

The volume of tank diked areas is greater than the largest single tank capacity plus an allowance for precipitation. Diked areas are sufficiently impervious to contain spilled oil due to being constructed of clay.

112.7(e)(2)(iii)

Drainage of precipitation from diked areas into an open water course, bypassing in-plant treatment is not possible.

112.7(e)(2)(iv)

The Refinery has two buried metallic storage tanks which are used to store gasoline and fuel oil for use in fueling the vehicles used in the Refinery. These tanks were coated and wrapped to prevent corrosion. A daily comparison of tank gauge verses fueling receipts is used to indicate whether these tanks are leaking. Even if these tanks were to leak, the product would ultimately travel to our storm water basin and not enter a navigable water course.

112.7(e)(2)(v)

The Refinery has no partially buried metallic storage tanks.

112.7(e)(2)(vi)

Aboveground storage tanks are periodically tested by the following methods:

1. Hydrostatic testing
2. Visual inspection
3. Shell thickness testing
   Comparison records of shell thickness reduction are maintained.

The outside of the tank is observed frequently for signs of deterioration and leaks, by operating personnel, which might cause a spill or accumulation of oil inside diked areas. This testing is conducted by our Corrosion and Fouling Control Group, which is headed by a state registered vessel inspector.

112.7(e)(2)(vii)

The steam return or exhaust lines from internal heating coils discharges into an area which ultimately drains to the storm water basin. There is no potential to discharge into an open water course.

112.7(e)(2)(viii)

All bulk storage tanks are externally inspected (including seams, rivets, bolts, gaskets, nozzle connections, valves, connected pipelines and tank foundation and/or supports) for leaks and failures.

Tanks are engineered to avoid spills by the following:

1. High liquid level alarms with an audible and visual signal at a constantly manned station.
2. Direct radio communication between the tank gauger and pumping station.
3. Fast means of determining the liquid level in tanks. Levels are monitored by computer.
4. Liquid level sensing devices are inspected and tested on a scheduled, periodic basis.

112.7(e)(2)(ix)

Effluent from the waste treatment plant flows to the treated water basin. Water is pumped from this basin to the Sanitary and Ship Canal as effluent. There is little potential to become contaminated with oil so the problem of oil appearing in the effluent is not significant. The only other effluent from the property is the emergency storm water pond overflow discussed in Section 112.7(c) above. This is oil-free and is sampled when it overflows.

112.7(e)(2)(x)

Large visible oil leaks in diked areas are promptly corrected.

112.7(e)(2)(xi)

Mobile or portable oil storage tanks are positioned so as to prevent spilled oil from reaching navigable waters. Any leakage or spillage will either be contained in a diked area or would flow to the storm water basin where the oil will be removed and reprocessed.

112.7(e)(3) FACILITY TRANSFER OPERATIONS

112.7(e)(3)(i)

Buried pipelines are wrapped and coated to reduce corrosion. When a pipe section is exposed, it is inspected and corrective action taken as necessary.

Refinery oil lines installed since 1968 are aboveground. There are few remaining underground oil lines in the refinery. These are being put aboveground wherever possible.

112.7(e)(3)(ii)

Pipeline terminal connections are capped or blank-flanged and marked if the pipeline is not in service or on standby service for long periods.

112.7(e)(3)(iii)

Pipe supports are designed to minimize abrasion and corrosion and allow for expansion and contraction.

112.7(e)(3)(iv)

All aboveground valves and pipelines are observed by operating personnel on a routine periodic basis (including flange joints, valve glands and bodies, catch pans, pipeline supports, locking of valves and metal surfaces).

112.7(e)(3)(v)

Critical or particularly vulnerable areas are barricaded to prevent vehicles from damaging aboveground piping.

112.7(e)(4) FACILITY TANK CAR AND TANK TRUCK LOADING/UNLOADING RACK

112.7(e)(4)(i)

Tank car and tank truck loading/unloading procedures meet the minimum requirements and regulations established by the Department of Transportation.

112.7(e)(4)(ii)

The loading/unloading racks drainage is designed to go to the process sewer system or the storm water pond.

112.7(e)(4)(iii)

A physical barrier system and warning signs are provided in the tank car loading/unloading areas to prevent vehicular departure before disconnect of transfer lines.

At the solvents truck rack it is the responsibility of the loader to remove the overhead loading lines from the compartments of the truck prior to departure.

At the gasoline loading rack there exists a brake interlock system. As long as the loading lines are connected to the truck, the truck brakes are automatically engaged. When the lines are removed, the brake interlock system is also disconnected.

112.7(e)(4)(iv)

Drains and outlets on tank trucks and tank cars are checked for leakage before loading, unloading and departure.

112.7(e)(8) INSPECTIONS AND RECORDS

The required inspections follow written procedures.

Inspection records for 112.7(e)(3)(i) and an annual report for 112.7(e)(2)(vi) and 112.7(e)(2)(viii) are kept in refinery files. Other routine visual inspections are not recorded except where deficiencies are noted.

112.7(e)(9) SECURITY

112.7(e)(9)(i)

Chicago Refinery is fenced except for frontages along the canals. All unattended gates are locked. The two main gates are staffed by guards 24 hours per day, 7 days per week.

112.7(e)(9)(ii)

The Refinery complies because it operates on a continuous basis, 24 hours per day, 7 days per week, and not on a non-operating or non-standby status.

112.7(e)(9)(iii)

The Refinery complies because it operates on a continuous basis, 24 hours per day, 7 days per week, and not on a non-operating or non-standby status.

112.7(e)(9)(iv)

The loading/unloading connections of oil lines are capped or blank-flanged at all times when not in service.

112.7(e)(9)(v)

Adequate lighting is provided for night operation and security.

112.7(e)(10) PERSONNEL, TRAINING AND SPILL PREVENTION PROCEDURES

112.7(e)(10)(i)

The Refinery complies as to instructing its personnel on the operating and maintenance of equipment to prevent discharges of oil and applicable pollution control laws, rules and regulations.

112.7(e)(10)(ii)

The designated person who is accountable for oil spill prevention and who reports to line management is the Supervisor of Environmental Services, who presently is H. D. Haas.

112.7(e)(10)(iii)

Spill prevention briefings for the operating personnel are conducted on a periodic basis.

112.4-.5 SPILL EVENT REPORT AND PLAN AMENDMENTS

A. The regulations require a facility which discharges into navigable waters more than 1,000 gallons of oil in a single event or harmful quantities of oil in two events in a 12-month period to file a spill event report with the U.S. EPA Regional Administrator within 60 days, giving the following information:
   1. Name of the facility.
   2. Name of the owner or operator of the facility.
   3. Location of the facility.
   4. Date and year of initial facility operation.
   5. Maximum storage or handling capacity of the facility and normal daily throughput.
   6. Description of the facility including maps, flow diagrams, and topographical maps.
   7. A complete copy of the SPCC Plan with any amendments.
   8. The cause(s) of such spill, including a failure analysis of system or subsystem in which failure occurred.
   9. The corrective actions and/or countermeasures taken, including an adequate description of equipment repairs and/or replacement.
   10. Additional preventive measures taken or contemplated to minimize the possibility of recurrence.
   11. Such other information as the Regional Administrator may reasonably require pertinent to the Plan or spill event.

B. After review of the spill event report, the Regional Administrator may amend the SPCC Plan.

C. Owners shall amend the SPCC Plan whenever there is a change in the facility design, construction, operation, or maintenance which materially affects the facility's potential for the discharge of oil into navigable waters.

D. The Plan must be reviewed every three years and amended if new field-proven technology will significantly reduce the likelihood of a spill event from the facility.

E. No amendment to an SPCC Plan shall be effective unless it has been certified by a Professional Engineer.

SPILL EVENT REPORT 1

From seepages of December 15, 1981, and December 3, 1982, into the I&M Canal.

Facility - Union Oil Company of California - Chicago Refinery

Facility Owner/Operator - Union Oil Company of California - Chicago Refinery

Facility Location - 135th Street and New Avenue
Lemont, Illinois 60439

The new part of Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present refinery has storage capacity of about 7.5 million barrels (315 million gallons). Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1982 was approximately 100,000 barrels per day.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the villages of Lemont and Romeoville. The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canal. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.S. Topographic Map for locations of the facility relating to surrounding areas. (Attachments 8 & 9).

The seepage from December 15, 1981, contaminated the I&M Canal in Area 1 shown on the Chicago Refinery Plot Plan located 1000 - 1300 feet SW of #4 Separator. The seepage from December 3, 1982, contaminated the I&M Canal in Areas 2 and 3 shown on the Chicago Refinery Plot Plan located 600 - 1000 feet SW of #4 Separator and 150 feet NE of #4 Separator. See Attachment 8.

Oil is removed from North Plant process water in #4 Separator which discharges into the North Plant storm sewer. The combined waters then flow to the storm water basin located approximately 3300 feet SW of the separator.

At this time we are still not sure of the exact mechanism by which oil finds its way onto the I&M Canal in Areas 1 and 2. Oil may be

forced out of the sewers at an opening by the high water levels and collects in the trench holding the "Big Inch" sewer. Oil also may be entering the sewer trench somewhere upstream and flowing into this area. High groundwater level is then causing the oil to migrate through fissures in the rock onto the Canal.

High water levels in the storm water basin would submerge the upstream "Big Inch" sewer line. On December 15, 1981, the high storm water basin level was caused by problems in the Waste Water Treatment Plant which could not process sufficient wastewater to lower the basin level on December 3, 1982, was caused by heavy rainfall received in the Refinery December 2 - 3, 1982.

Since the seepage of December 15, 1981, the Operations and Maintenance Departments have been coordinating their efforts in periodically removing accumulated trapped oil from the sewer oil traps. An engineering project has been undertaken to investigate the sewer line from south of #4 Separator to near the storm water basin. Eleven holes were dug to expose sections of the sewer to determine whether any failures of the line occurred. No failures of the line were observed. In one location sufficient oil was observed in the trench so a shallow oil-recovery well was located here. We have been periodically removing oil from this well with vacuum trucks.

At this time we are not sure of the exact mechanism by which oil finds its way onto the I&M Canal in Area 3. Heavy rainfall experienced in the Refinery December 2 - 3, 1982, caused leakage in the North Plant storm water system and overflow of the North Plant process water system into the storm sewer. The heavy rainfall raised the underground water table because the storm water basin was full and water could not drain from the North Plant to the storm basin. The water table then reached a level where a fissure exists between the North Plant and the bank of the Canal. Since oil floats on water, this material would be the first to seep into the Canal.

Upon discovering the seepage of oil into the I&M Canal, oil booms were deployed and vacuum trucks were used to remove the accumulated oil. Vacuum trucks were also used to remove oil trapped in the sewer, until sewer levels returned to normal. In order to reduce the sewer levels as rapidly as possible, the Waste Water Treatment Plant was at its maximum rate without violating any effluent specification. Untreated wastewater was also being recycled for use in the Refinery cooling water system on an emergency basis.

Measures to minimize recurrence are as follows:

a. Oil levels in the "Big Inch" sewer will be monitored and oil accumulations removed.

b. The ditch housing the "Big Inch" sewer may be able to serve as an interceptor ditch. Management approval may be sought to install additional deeper oil-recovery wells adjacent to the ditch if favorably determined by the Engineering Department. These wells will be located parallel to where the oil is seeping into the Canal.

c. Preliminary excavations at various locations indicated the area of major seepage appeared to be the vicinity of the railroad/ roadway crossing intersection. (Area 2 on the Refinery Plot Plan). Preliminary work is being done to determine whether to expose about 400 feet of sewer line to check for defects and if necessary, be repaired.

d. A project request will be submitted for management approval to install a process sewer at the North Plant flare. Existing drainage of process water is presently to the storm sewer.

e. After the formulation of project requests, studies will be conducted by the Engineering Department to determine whether increasing the process sewer capacity at the BCT Unit and near the cooling tower to the lift station flowing to the separator will minimize the overflow of oil from the process sewer into the storm sewer. If this project is practical, supplemental 1983 budget requests will be submitted for the above projects.

SPILL EVENT REPORT 2

From seepage of April 5, 1983 into I&M Canal.

Facility - Union Oil Company of California - Chicago Refinery

Facility Owner/Operator - Union Oil Company of California - Chicago Refinery

Facility Location - 135th Street and New Avenue
Lemont, Illinois 60439

The new part of Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present Refinery has storage capacity of about 7.5 million barrels (315 million gallons). Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1982 was approximately 100,000 barrels per day of crude oil.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the village of Lemont and Romeoville. The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canals. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.S. Topographic Map for locations of the facility relating to surrounding areas submitted with the SPCC Plan on February 2, 1983.

The seepage from April 5, 1983 contaminated the I&M Canal in the area 50-150 feet SW of the railroad bridge crossing the I&M Canal. See Attachment 10.

At this time we are still not sure of the exact mechanism by which oil finds its way onto the I&M Canal. Oil may be forced out of the sewers at an opening by the high water levels and collects in the trench holding the "Big Inch" sewer. Oil also may be entering the sewer trench somewhere upstream and flowing into this area. High groundwater level is then causing the oil to migrate through fissures in the rock onto the canal.

High water levels in the storm water basin would submerge the upstream "Big Inch" sewer line. Over the period of March 31-April 3, the Refinery received 2.65" of rain which raised the basin level by 7 feet.

Since the seepage of December 15, 1981 the Operations and Maintenance Departments have been coordinating their efforts in periodically removing accumulated trapped oil from the sewer oil traps. We have also been periodically removing oil from a shallow oil-recovery well located adjacent to the sewer line trench.

At this time we continue to permanently position numerous sections of oil containment boom which will prevent large sections of the canal becoming contaminated. The seepage of oil was detected by observing pockets of oil trapped between the boom and the bank of the canal. Vacuum trucks were used to remove the accumulated oil. Vacuum trucks were also used to remove oil trapped in the sewer, until the sewer levels returned to normal. In order to reduce the sewer levels as rapidly as possible, the Wastewater Treatment Plant was operated at its maximum rate without violating any wastewater effluent specification. Untreated wastewater was also being recycled into the Refinery for use in the utility water system and cooling towers.

Measures to minimize recurrence are as follows:

a. Oil levels in the "Big Inch" will be monitored and oil accumulations removed.

b. A modified procedure has been devised to control the operating level of the storm water basin by the initiation of recycling untreated wastewater from the storm water basin to the utility water system and the cooling towers. Storm water also will be retained in the tank farm dikes until it can be processed through the Wastewater Treatment Unit.

c. A project request is being submitted for management approval to install a process sewer at the North Plant flare. Existing drainage of process water is presently to the storm sewer.

d. Studies are being conducted by the Engineering Department to determine whether increasing the process sewer capacity at the BCT Unit and near the cooling tower to the lift station flowing to the separator will minimize the overflow of oil from the process sewer into the storm sewer. If this project is practical, budget requests will be submitted for the above project.

e. In conjunction with the construction of new process units in the area of the North Plant, the old #4 Trap will be replaced with a new modern design oil water separator sometime late in 1983.

SPILL EVENT REPORT 3

From xylene spill of April 21, 1983 into I&M Canal.

Facility - Union Oil Company of California - Chicago Refinery

Facility Owner/Operator - Union Oil Company of California - Chicago Refinery

Facility Location - 135th Street and New Avenue
Lemont, Illinois 60439

The new part of Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present refinery has storage capacity of about 7.5 million barrels (315 million gallons). Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1982 was approximately 100,000 barrels per day of crude oil.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the villages of Lemont and Romeoville. The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canals. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.C. Topographic Map for locations of the facility relating to surrounding areas submitted with the SPCC Plan on February 2, 1983.

The xylene spill from April 21, 1983 contaminated the I&M Canal in the area from the railroad bridge crossing the I&M Canal to 150 feet downstream. See Attachment 11.

The xylene barge loading line was taken out of service to relocate a section of the line onto a different section of pipe supports. The line was water washed and air blown prior to blinding. Additional low point bleeders were added to the line at points where it was judged to need drainage. A low point bleeder was not added at the point where the line crosses the I&M Canal. This section of line contained water which froze causing the underside of the line to crack. As the line was being charged with xylene, product was observed leaking out the underside of the line. The pump was shut down and within a short period of time, the flow of xylene into the canal stopped.

Measures to minimize recurrence are as follows:

a. Ten feet of the line was replaced where it was defective.

b. Failure to add a bleeder at the point of pipe failure was an oversight. Our current procedure contains all the necessary steps to avoid this type of mishap in the future.

SPILL EVENT REPORT 4

From seepage of July 2, 1983 into I&M Canal.

Facility - Union Oil Company of California - Chicago Refinery

Facility Owner/Operator - Union Oil Company of California
Chicago Refinery

Facility Location - 135th Street and New Avenue
Lemont, Illinois 60439

The new part of Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present Refinery has storage capacity of about 7.5 million barrels (315 million gallons). Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1982 was approximately 100,000 barrels per day of crude oil.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the village of Lemont and Romeoville, The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canals. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.S. Topographic Map for locations of the facility relating to surrounding areas submitted with the SPCC Plan on February 2, 1983.

The seepage from July 2, 1983 contaminated the I&M Canal in the area 50-150 feet SW of the railroad bridge crossing the I&M Canal. See Attachment 12.

An investigation of the oil seepages to the I&M Canal is continuing. We are attempting to characterize the oil through chemical tests. We have sampled oil on the canal, oil in the "Big Inch" sewer line, oil in the "Big Inch" trench and oil off the three process sewer lift stations leading to the North Plant oil-water separator. To date, we have not been successful in pinpointing the source of the oil finding its way onto the canal.

It is the belief of the Refinery that the cause of the I&M Canal oil seepage is the substandard oil-water separator located in the North Plant area of the Refinery. This separator dates from the 1950's but by today's standards is inadequate.

This part of the Refinery has only one combined process-stormwater sewer system. The newer South Plant part of the Refinery has separate process and stormwater sewer systems. The North Plant combined process-stormwater system during nonstorm conditions pumps all water via lift stations to the oil-water separator (#4 Trap). During storm conditions oil and water will overflow the lift stations. This oil and water can migrate through the soil to the area of the "Big Inch" trench. Also during storm events, when the stormwater basins are full, #4 Trap will be submerged thereby allowing oil and water to flow into the "Big Inch" line leading to the stormwater basin. The Refinery received heavy amounts of precipitation during late June and early July. On June 27-30, the stormwater basins were partially filled due to receiving 2.1 inches of rain. The stormwater basins were filled on July 1-2 after receiving 4.4 inches of rain. Due to the above events, oil seepage was observed in the I&M Canal on July 2, 1983.

Since the seepage of December 15, 1981 the Operations and Maintenance Departments have been coordinating their efforts in periodically removing accumulated trapped oil from the sewer oil traps. We have also been periodically removing oil from a shallow oil-recovery well located adjacent to the sewer line trench.

At this time we continue to permanently position numerous sections of oil containment boom which will prevent large sections of the canal becoming contaminated. The seepage of oil was detected by observing pockets of oil trapped between the boom and the bank of the canal. Vacuum trucks were used to remove the accumulated oil. Vacuum trucks were also used to remove oil trapped in the sewer, until the sewer levels returned to normal. In order to reduce the sewer levels as rapidly as possible, the Wastewater Treatment Plant was operated at its maximum rate without violating any wastewater effluent specification. Untreated wastewater was also being recycled into the Refinery for use in the utility water system and cooling towers.

Measures to minimize recurrence are as follows:

a. Oil levels in the "Big Inch" will be monitored and oil accumulations removed.

b. A modified procedure has been devised to control the operating level of the storm water basin by the initiation of recycling untreated wastewater from the storm water basin to the utility water system and the cooling towers. Storm water also will be retained in the tank farm dikes until it can be processed through the Wastewater Treatment Unit.

c. In conjunction with the construction of new process units in the North Plant area, the old #4 Trap will be replaced by February 1984 with a new modern design oil-water separator. Project costs are estimated to be $450,000.

d. A project has been approved to install two oil collection sumps in the "Big Inch" trench and to examine underground tie-in points for oil seepage to the I&M Canal. Project completion is estimated to be late September 1983. Project costs are estimated to be $15,000.

e. A project request is being submitted for management approval to install a process sewer at the North Plant flare. Existing drainage of process water is presently to the storm sewer.

f. Studies are being conducted by the Engineering Department to determine whether increasing the process sewer capacity at the BCT Unit and near the cooling tower to the lift station flowing to the separator will minimize the overflow of oil from the process sewer into the storm sewer. If this project is practical, budget requests will be submitted for the above project.

SPILL EVENT REPORT 5

From oil spill of January 13, 1984, into I&M Canal.

Facility - Union Oil Company of California - Chicago Refinery

Facility Owner/Operator - Union Oil Company of California - Chicago Refinery

Facility Location - 135th Street and New Avenue - Lemont, Illinois 60439

The new part of Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present refinery has storage capacity of about 7.5 million barrels (315 million gallons). Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1982 was approximately 100,000 barrels per day of crude oil.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the villages of Lemont and Romeoville. The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canals. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.C. Topographic Map for locations of the facility relating to surrounding areas submitted with the SPCC Plan on February 2, 1983.

The oil spill of January 13, 1984, contaminated the I&M Canal in a small area 300 feet north of the Union Chemicals Division railroad bridge. We estimate that less than one barrel of oil was spilled. See Attachment 13.

The mechanism for the contamination in the I&M Canal is stated as follows. A process sewer lift station in an area of the tank farm was at a high level. Oil leaked into the ground through a crack in the process sewer upstream of the lift station. The oil then saturated the ground in the area of the leak. The oil then drained out of the ground and into an adjacent surface drainage system which empties non-oily stormwater into the I&M Canal.

Measures to minimize recurrence are as follows:

1. Level controls were reset to drain the lift station sump at a lower level.

2. The level in the sump was checked once per shift to ensure that a high level would not result from malfunctions of level controls.

3. Steam was introduced into the lift station sump as conditions warranted in order to prevent the possibility of a pump freeze-up.

4. The process sewer line was excavated. A crack was discovered and repaired.

5. We are presently attempting to devise a method of checking the integrity of the process sewer system in that area of the Refinery tank farm where the oil spill resulted.

LDE:dlw

SPILL EVENT REPORT 6

From seepages of March 2, 1984, and March 26, 1984, into the I&M Canal.

Facility - Union Oil Company of California - Chicago Refinery
Facility Owner/Operator - Union Oil Company of California - Chicago Refinery
Facility Location - 135th Street and New Avenue
Lemont, Illinois 60439

The new part of the Chicago Refinery became operational in 1970 and older portions of the facility date from the previous refinery which has operated at this location since the 1930's.

The present refinery has storage capacity of about 7.5 million barrels (315 million gallons). Hydrocarbon on hand at any time is about 4 million barrels (168 million gallons). Normal average daily throughput for 1983 was approximately 100,000 barrels per day.

The Chicago Refinery is a fully integrated refinery which processes crude oil and other miscellaneous feedstocks into gasoline, diesel fuel, turbine fuel, aromatic solvents, aliphatic solvents, coke and sulfur. The Refinery is located on an 860 acre tract of land in Will County between the villages of Lemont and Romeoville. The Refinery is bounded on the south by 135th Street, on the west by the I&M and Sanitary and Ship Canal. The Refinery tankage is located on both sides of 127th Street, west of Smith Road. See the Refinery Plot Plan and the U.S.G.S. Topographic Map for locations of the facility relating to surrounding areas submitted with the SPCC Plan on February 2, 1983.

The seepage from March 2, 1984, and March 26, 1984, contaminated the I&M Canal in the area shown on the map located 900 feet south of the railroad bridge crossing the canal. We estimate that 50 and 150 gallons respectively were recovered from the I&M Canal for these two spills. See Attachment 14.

As shown in previous spill reports, it was the belief of the Refinery that the cause of the I&M Canal oil seepage was the substandard oil-water separator located in the North Plant area of the Refinery. We have completed the project to replace the old oil-water separator with a new modern design oil-water separator. This new separator was placed in service in February, 1984. Not enough time has passed to determine whether this change in separators will decrease the frequency and volume of oil seepage onto the I&M Canal.

In spite of the above belief, we have undertaken a systematic approach to examine the sewer systems in the older North Plant area of the Refinery. We are attempting to prioritize the sections of the sewer system which may have the highest potential for leakage. We then will excavate selected sections and repair these sections if this proves to be necessary.

The "Big Inch" trench by nature of location and depth will act as an interceptor trench to collect oil which may migrate from the processing areas of the Refinery.

Numerous oil recovery sumps have been installed in the "Big Inch" trench. A Refinery vacuum truck is used to remove this oil and place it into the oil recovery system before it is allowed to seep through existing fissues in the rock trench. We have also excavated the "Big Inch" sewer to examine joints and junction boxes. With the exception of a leak or the connection to old #4 Separator, which was repaired, we have not found leaking joints which could be major contributers to this oil finding its way into the "Big Inch" trench. Over five hundred feet of process sewer line has been excavated from the Udex Unit lift station to the Cat Reformer lift station. We have found defects in this sewer line. Significant portions of this section of line will be replaced or repaired as required.

Recently, a project request was submitted for management approval to inspect a section of process and storm sewer lines which lead from the tank farm to the lift station feeding the oil-water separator. Depending on the outcome of the inspection, further studies may be required.

At present, the Operations and Maintenance Departments have been coordinating their efforts in periodically removing accumulated trapped oil from the sewer oil traps. We have also been periodically removing oil from numerous shallow oil-recovery sumps located in the "Big Inch" sewer line trench.

At this time we continue to permanently position numerous sections of oil containment boom which prevent large sections of the canal from becoming contaminated. The seepage of oil is detected by observing pockets of oil trapped between the boom and the bank of the canal. Vacuum trucks are used to remove the accumulated oil. During periods of heavy rainfall or snow melt, the stormwater basin will fill thereby causing the "Big Inch" sewer to become submerged.

Measures to minimize recurrance are as follows:

a) Oil leaks in the "Big Inch" sewer and trench will be monitored and oil accumulations removed.

b) A modified procedure has been devised to control the operating level of the stormwater basin by the initiation of recycling untreated wastewater from the stormwater basin to the utility water system and the cooling towers. Storm water also will be retained in the tank farm dikes until it can be processed through the Wastewater Treatment Unit.

c) A new modern design oil-water separator has been placed in service in February, 1984. More time must pass before we can determine whether this will ease the seepage of oil to the I&M Canal.

d) We presently have installed four oil recovery sumps in the "Big Inch" trench and are considering a fifth. In addition, there are two shallow well sumps between the I&M Canal and the "Big Inch" trench.

e) Three "Big Inch" junction boxes were inspected for leakage. One joint was leaking which was repaired. We believe further investigation is unwarranted.

f) An analysis of the project to install a process sewer at the North Plant Flare has been completed. The amount of oil present is far too small to contribute significantly to the oil collected from the sumps along the "Big Inch". This project will not be done. We will construct a storm sewer to send this material to the "Big Inch" sewer.

g) Studies will continue to define the sewer size near the North Plant cooling tower needed to prevent overflowing the process sewer into the "Big Inch" sewer.

h) A project is presently underway to modify the sewer box piping at the BCT unit. Completion is expected by the end of April, 1984.

i) The Udex Unit process sewer lift station effluent line has been excavated and inspected. At least 3 holes were found in the underground line. This line will be replaced or repaired as required.

LDE:dlw

ENVIRONMENTAL PROTECTION AGENCY REGULATIONS ON OIL POLLUTION PREVENTION

(40 CFR 112; 38 FR 34164, December 11, 1973; Amended by 39 FR 31602, August 29, 1974; 41 FR 12657, March 26, 1976)

PART 112—OIL POLLUTION PREVENTION

Non-transportation Related Onshore and Offshore Facilities

AUTHORITY: Secs. 311(j)(1)(C), 311(j)(2), 501(a), Federal Water Pollution Control Act (Sec. 2, Pub. L. 92-500, 86 Stat. 816 et seq. (33 U.S.C. 1251 et seq.)); Sec. 4(b), Pub. L. 92-500, 86 Stat. 897; 5 U.S.C. Reorg. Plan of 1970 No. 3 (1970), 35 FR 15623, 3 CFR 1966-1970 Comp.; E.O. 11735, 38 FR 21243, 3 CFR.

§ 112.1 General applicability.

(a) This part establishes procedures, methods and equipment and other requirements for equipment to prevent the discharge of oil from non-transportation-related onshore and offshore facilities into or upon the navigable waters of the United States or adjoining shorelines.

(b) Except as provided in paragraph (d) of this section, this part applies to owners or operators of non-transportation-related onshore and offshore facilities engaged in drilling, producing, gathering, storing, processing, refining, transferring, distributing or consuming oil and oil products, and which, due to their location, could reasonably be expected to discharge oil in harmful quantities, as defined in Part 110 of this chapter, into or upon the navigable waters of the United States or adjoining shorelines.

(c) As provided in sec. 313 (86 Stat. 875) departments, agencies, and instrumentalities of the Federal government are subject to these regulations to the same extent as any person, except for the provisions of § 112.6.

(d) This part does not apply to:

(1) Facilities, equipment or operations which are not subject to the jurisdiction of the Environmental Protection Agency, as follows:

(A) onshore and offshore facilities, which, due to their location, could not reasonably be expected to discharge oil into or upon the navigable waters of the United States or adjoining shorelines. This determination shall be based solely upon a consideration of the geographical, locational aspects of the facility (such as proximity to navigable waters or adjoining shorelines, land contour, drainage, etc.) and shall exclude consideration of manmade features such as dikes, equipment or other structures which may serve to restrain, hinder, contain, or otherwise prevent a discharge of oil from reaching navigable waters of the United States or adjoining shorelines; and

(B) equipment or operations of vessels or transportation-related onshore and offshore facilities which are subject to authority and control of the Department of Transportation, as defined in the Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency, dated November 24, 1971, 36 FR 24000.

(2) those facilities which, although otherwise subject to the jurisdiction of the Environmental Protection Agency, meet both of the following requirements:

(A) the underground buried storage capacity of the facility is 42,000 gallons or less of oil, and

(B) the storage capacity, which is not buried, of the facility is 1,320 gallons or less of oil, provided no single container has a capacity in excess of 660 gallons.

[41 FR 12657, March 26, 1976]

(e) This part provides for the preparation and implementation of Spill Prevention Control and Countermeasure Plans prepared in accordance with § 112.7, designed to complement existing laws, regulations, rules, standards, policies and procedures pertaining to safety standards, fire prevention and pollution prevention rules, so as to form a comprehensive balanced Federal/State spill prevention program to minimize the potential for oil discharges. Compliance with this part does not in any way relieve the owner or operator of an onshore or an offshore facility from compliance with other Federal, State or local laws.

§ 112.2 Definitions.

For the purposes of this part:

(a) "Oil" means oil of any kind or in any form, including, but not limited to petroleum, fuel oil, sludge, oil refuse and oil mixed with wastes other than dredged spoil.

(b) "Discharge" includes but is not limited to, any spilling, leaking, pumping, pouring, emitting, emptying or dumping. For purposes of this part, the term "discharge" shall not include any discharge of oil which is authorized by a permit issued pursuant to Section 13 of the River and Harbor Act of 1899 (30 Stat. 1121, 33 U.S.C. 407), or Sections 402 or 405 of the FWPCA Amendments of 1972 (86 Stat. 816 et seq., 33 U.S.C. 1251 et seq.).

(c) "Onshore facility" means any facility of any kind located in, on, or under any land within the United States, other than submerged lands, which is not a transportation-related facility.

(d) "Offshore facility" means any facility of any kind located in, on, or under any of the navigable waters of the United States, which is not a transportation-related facility.

(e) "Owner or operator" means any person owning or operating an onshore facility or an offshore facility; and in the case of any abandoned offshore facility, the person who owned or operated such facility immediately prior to such abandonment.

(f) "Person" includes an individual, firm, corporation, association, and a partnership.

(g) "Regional Administrator", means the Regional Administrator of the Environmental Protection Agency, or his designee, in and for the Region in which the facility is located.

(h) "Transportation-related" and "non-transportation-related" as applied to an onshore or offshore facility, are defined in the Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency, dated November 24, 1971, 36 FR 24080.

(i) "Spill event" means a discharge of oil into or upon the navigable waters of the United States or adjoining shorelines in harmful quantities, as defined at 40 CFR Part 110.

(j) "United States" means the States, the District of Columbia, the Commonwealth of Puerto Rico, the Canal Zone, Guam, American Samoa, the Virgin Islands, and the Trust Territory of the Pacific Islands.

(k) The term "navigable waters" of the United States means "navigable waters" as defined in section 502(7) of the FWPCA, and includes:

(1) all navigable waters of the United States, as defined in judicial decisions prior to passage of the 1972 Amendments to the FWPCA (Pub. L. 92-500), and tributaries of such waters;

(2) interstate waters;

(3) intrastate lakes, rivers, and streams which are utilized by interstate travelers for recreational or other purposes; and

(4) intrastate lakes, rivers, and streams from which fish or shellfish are taken and sold in interstate commerce.

(l) "Vessel" means every description of watercraft or other artificial contriv-

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ance used, or capable of being used as a means of transportation on water, other than a public vessel.

§ 112.3 Requirements for preparation and implementation of Spill Prevention Control and Countermeasure Plans.

(a) Owners or operators of onshore and offshore facilities in operation on or before the effective date of this part that have discharged or, due to their location, could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines, shall prepare a Spill Prevention Control and Countermeasure Plan (hereinafter "SPCC Plan"), in writing and in accordance with section 112.7. Except as provided for in paragraph (f) of this section, such SPCC Plan shall be prepared within six months after the effective date of this part and shall be fully implemented as soon as possible, but not later than one year after the effective date of this part.

[41 FR 12657, March 26, 1976]

(b) Owners or operators of onshore and offshore facilities that become operational after the effective date of this part, and that have discharged or could reasonably be expected to discharge oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines, shall prepare an SPCC Plan in accordance with § 112.7. Except as provided for in paragraph (f) of this section, such SPCC Plan shall be prepared within six months after the date such facility begins operations and shall be fully implemented as soon as possible, but not later than one year after such facility begins operations.

(c) Owners or operators of onshore and offshore mobile or portable facilities, such as onshore drilling or workover rigs, barge mounted offshore drilling or workover rigs, and portable fueling facilities shall prepare and implement an SPCC Plan as required by paragraphs (a), (b) and (d) of this section. The owners or operators of such facility need not prepare a new SPCC Plan each time the facility is moved to a new site. The SPCC Plan may be a general plan, prepared in accordance with section 112.7, using good engineering practice. When the mobile or portable facility is moved, it must be located and installed using the spill prevention practices outlined in the SPCC Plan for the facility. No mobile or portable facility subject to this regulation shall operate unless the SPCC Plan has been implemented. The SPCC Plan shall only apply while the facility is in a fixed (non-transportation) operating mode.

[41 FR 12657, March 26, 1976]

(d) No SPCC Plan shall be effective to satisfy the requirements of this part unless it has been reviewed by a Registered Professional Engineer and certified to by such Professional Engineer. By means of this certification the engineer, having examined the facility and being familiar with the provisions of this part, shall attest that the SPCC Plan has been prepared in accordance with good engineering practices. Such certification shall in no way relieve the owner or operator of an onshore or offshore facility of his duty to prepare and fully implement such Plan in accordance with § 112.7, as required by paragraphs (a), (b) and (c) of this section.

(e) Owners or operators of a facility for which an SPCC Plan is required pursuant to paragraphs (a), (b) or (c) of this section shall maintain a complete copy of the Plan at such facility if the facility is normally attended at least 8 hours per day, or at the nearest field office if the facility is not so attended, and shall make such Plan available to the Regional Administrator for on-site review during normal working hours.

(f) Extensions of time.

(1) The Regional Administrator may authorize an extension of time for the preparation and full implementation of an SPCC Plan beyond the time permitted for the preparation and implementation of an SPCC Plan pursuant to paragraphs (a), (b) or (c) of this section where he finds that the owner or operator of a facility subject to paragraphs (a), (b) or (c) of this section cannot fully comply with the requirements of this part as a result of either nonavailability of qualified personnel, or delays in construction or equipment delivery beyond the control and without the fault of such owner or operator or their respective agents or employees.

(2) Any owner or operator seeking an extension of time pursuant to paragraph (f)(1) of this section may submit a letter of request to the Regional Administrator. Such letter shall include:

(i) A complete copy of the SPCC Plan, if completed;

(ii) A full explanation of the cause for any such delay and the specific aspects of the SPCC Plan affected by the delay;

(iii) A full discussion of actions being taken or contemplated to minimize or mitigate such delay;

(iv) A proposed time schedule for the implementation of any corrective actions being taken or contemplated, including interim dates for completion of tests or studies, installation and operation of any necessary equipment or other preventive measures.

In addition, such owner or operator may present additional oral or written statements in support of his letter of request.

(3) The submission of a letter of request for extension of time pursuant to paragraph (f)(2) of this section shall in no way relieve the owner or operator from his obligation to comply with the requirements of § 112.3 (a), (b) or (c). Where an extension of time is authorized by the Regional Administrator for particular equipment or other specific aspects of the SPCC Plan, such extension shall in no way affect the owner's or operator's obligation to comply with the requirements of § 112.3 (a), (b) or (c) with respect to other equipment or other specific aspects of the SPCC Plan for which an extension of time has not been expressly authorized.

§ 112.4 Amendment of SPCC Plans by Regional Administrator.

(a) Notwithstanding compliance with § 112.3, whenever a facility subject to § 112.3 (a), (b) or (c) has: Discharged more than 1,000 U.S. gallons of oil into or upon the navigable waters of the United States or adjoining shorelines in a single spill event, or discharged oil in harmful quantities, as defined in 40 CFR Part 110, into or upon the navigable waters of the United States or adjoining shorelines in two spill events, reportable under section 311(b)(5) of the FWPCA, occurring within any twelve month period, the owner or operator of such facility shall submit to the Regional Administrator, within 60 days from the time such facility becomes subject to this section, the following:

(1) Name of the facility;

(2) Name(s) of the owner or operator of the facility;

(3) Location of the facility;

(4) Date and year of initial facility operation;

(5) Maximum storage or handling capacity of the facility and normal daily throughput;

(6) Description of the facility, including maps, flow diagrams, and topographical maps;

(7) A complete copy of the SPCC Plan with any amendments;

(8) The cause(s) of such spill, including a failure analysis of system or subsystem in which the failure occurred;

(9) The corrective actions and/or countermeasures taken, including an adequate description of equipment repairs and/or replacements;

(10) Additional preventive measures taken or contemplated to minimize the possibility of recurrence;

(11) Such other information as the Regional Administrator may reasonably require pertinent to the Plan or spill event.

(b) Section 112.4 shall not apply until the expiration of the time permitted for the preparation and implementation of an SPCC Plan pursuant to § 112.3 (a), (b), (c) and (f).

(c) A complete copy of all information provided to the Regional Administrator pursuant to paragraph (a) of this section shall be sent at the same time to the State agency in charge of water pollution control activities in and for the State in which the facility is located. Upon receipt of such information such State agency may conduct a review and make recommendations to the Regional Administrator as to further procedures, methods, equipment and other requirements for equipment necessary to prevent and to contain discharges of oil from such facility.

(d) After review of the SPCC Plan for a facility subject to paragraph (a) of this section, together with all other information submitted by the owner or operator of such facility, and by the State agency under paragraph (c) of this section, the Regional Administrator may require the owner or operator of such facility to amend the SPCC Plan if he finds that the Plan does not meet the requirements of this part or that the amendment of the Plan is neces-

sary to prevent and to contain discharges of oil from such facility.

(e) When the Regional Administrator proposes to require an amendment to the SPCC Plan, he shall notify the facility operator by certified mail addressed to, or by personal delivery to, the facility owner or operator, that he proposes to require an amendment to the Plan, and shall specify the terms of such amendment. If the facility owner or operator is a corporation, a copy of such notice shall also be mailed to the registered agent, if any, of such corporation in the State where such facility is located. Within 30 days from receipt of such notice, the facility owner or operator may submit written information, views, and arguments on the amendment. After considering all relevant material presented, the Regional Administrator shall notify the facility owner or operator of any amendment required or shall rescind the notice. The amendment required by the Regional Administrator shall become part of the Plan 30 days after such notice, unless the Regional Administrator, for good cause, shall specify another effective date. The owner or operator of the facility shall implement the amendment of the Plan as soon as possible, but not later than six months after the amendment becomes part of the Plan, unless the Regional Administrator specifies another date.

(f) An owner or operator may appeal a decision made by the Regional Administrator requiring an amendment to an SPCC Plan. The appeal shall be made to the Administrator of the United States Environmental Protection Agency and must be made in writing within 30 days of receipt of the notice from the Regional Administrator requiring the amendment. A complete copy of the appeal must be sent to the Regional Administrator at the time the appeal is made. The appeal shall contain a clear and concise statement of the issues and points of fact in the case. It may also contain additional information from the owner or operator, or from any other person. The Administrator or his designee may request additional information from the owner or operator, or from any other person. The Administrator or his designee shall render a decision within 60 days of receiving the appeal and shall notify the owner or operator of his decision.

[41 FR 12657, March 26, 1976]

§ 112.5 Amendment of Spill Prevention Control and Countermeasure Plans by owners or operators.

(a) Owners or operators of facilities subject to § 112.3 (a), (b) or (c) shall amend the SPCC Plan for such facility in accordance with § 112.7 whenever there is a change in facility design, construction, operation or maintenance which materially affects the facility's potential for the discharge of oil into or upon the navigable waters of the United States or adjoining shorelines. Such amendments shall be fully implemented as soon as possible, but not later than six months after such change occurs.

(b) Notwithstanding compliance with paragraph (a) of this section, owners and operators of facilities subject to § 112.3 (a), (b) or (c) shall complete a review and evaluation of the SPCC Plan at least once every three years from the date such facility becomes subject to this part. As a result of this review and evaluation, the owner or operator shall amend the SPCC Plan within six months of the review to include more effective prevention and control technology if: (1) Such technology will significantly reduce the likelihood of a spill event from the facility, and (2) if such technology has been field-proven at the time of the review.

(c) No amendment to an SPCC Plan shall be effective to satisfy the requirements of this section unless it has been certified by a Professional Engineer in accordance with § 112.3(d).

§ 112.6 Civil penalties for violation of Oil Pollution Prevention Regulations.

Owners or operators of facilities subject to § 112.3(a), (b) or (c) who violate the requirements of this Part 112 by failing or refusing to comply with any of the provisions of § 112.3, § 112.4 or § 112.5 shall be liable for a civil penalty of not more than $5,000 for each day such violation continues. Civil penalties shall be imposed in accordance with procedures set out in Part 114 of this subchapter D.

§ 112.7 Guidelines for the preparation and implementation of a Spill Prevention Control and Countermeasure Plan.

The SPCC Plan shall be a carefully thought-out plan, prepared in accordance with good engineering practices, and which has the full approval of management at a level with authority to commit the necessary resources. If the plan calls for additional facilities or procedures, methods, or equipment not yet fully operational, these items should be discussed in separate paragraphs, and the details of installation and operational start-up should be explained separately. The complete SPCC Plan shall follow the sequence outlined below, and include a discussion of the facility's conformance with the appropriate guidelines listed:

(a) A facility which has experienced one or more spill events within twelve months prior to the effective date of this part should include a written description of each such spill, corrective action taken and plans for preventing recurrence.

(b) Where experience indicates a reasonable potential for equipment failure (such as tank overflow, rupture, or leakage), the plan should include a prediction of the direction, rate of flow, and total quantity of oil which could be discharged from the facility as a result of each major type of failure.

(c) Appropriate containment and/or diversionary structures or equipment to prevent discharged oil from reaching a navigable water course should be provided. One of the following preventive systems or its equivalent should be used as a minimum:

(1) Onshore facilities.

(i) Dikes, berms or retaining walls sufficiently impervious to contain spilled oil

(ii) Curbing

(iii) Culverting, gutters or other drainage systems

(iv) Weirs, booms or other barriers

(v) Spill diversion ponds

(vi) Retention ponds

(vii) Sorbent materials

(2) Offshore facilities.

(i) Curbing, drip pans

(ii) Sumps and collection systems

(d) When it is determined that the installation of structures or equipment listed in § 112.7(c) to prevent discharged oil from reaching the navigable waters is not practicable from any onshore or offshore facility, the owner or operator should clearly demonstrate such impracticability and provide the following:

(1) A strong oil spill contingency plan following the provision of 40 CFR Part 109.

(2) A written commitment of manpower, equipment and materials required to expeditiously control and remove any harmful quantity of oil discharged.

(e) In addition to the minimal prevention standards listed under § 112.7 (c), sections of the Plan should include a complete discussion of conformance with the following applicable guidelines, other effective spill prevention and containment procedures (or, if more stringent, with State rules, regulations and guidelines):

(1) *Facility drainage (onshore); (excluding production facilities).* (i) Drainage from diked storage areas should be restrained by valves or other positive means to prevent a spill or other excessive leakage of oil into the drainage system or inplant effluent treatment system, except where plan systems are designed to handle such leakage. Diked areas may be emptied by pumps or ejectors; however, these should be manually activated and the condition of the accumulation should be examined before starting to be sure no oil will be discharged into the water.

(ii) Flapper-type drain valves should not be used to drain diked areas. Valves used for the drainage of diked areas should, as far as practical, be of manual, open-and-closed design. When plant drainage drains directly into water courses and not into wastewater treatment plants, retained storm water should be inspected as provided in paragraph (e)(2)(iii) (B, C and D) before drainage.

(iii) Plant drainage systems from undiked areas should, if possible, flow into ponds, lagoons or catchment basins, designed to retain oil or return it to the facility. Catchment basins should not be located in areas subject to periodic flooding.

(iv) If plant drainage is not engineered as above, the final discharge of all in-plant ditches should be equipped with a diversion system that could, in

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the event of an uncontrolled spill, return the oil to the plant.

(v) Where drainage waters are treated in more than one treatment unit, natural hydraulic flow should be used. If pump transfer is needed, two "lift" pumps should be provided, and at least one of the pumps should be permanently installed when such treatment is continuous. In any event, whatever techniques are used facility drainage systems should be adequately engineered to prevent oil from reaching navigable waters in the event of equipment failure or human error at the facility.

(2) *Bulk storage tanks (onshore); (excluding production facilities).* (i) No tank should be used for the storage of oil unless its material and construction are compatible with the material stored and conditions of storage such as pressure and temperature, etc.

(ii) All bulk storage tank installations should be constructed so that a secondary means of containment is provided for the entire contents of the largest single tank plus sufficient freeboard to allow for precipitation. Diked areas should be sufficiently impervious to contain spilled oil. Dikes, containment curbs, and pits are commonly employed for this purpose, but they may not always be appropriate. An alternative system could consist of a complete drainage trench enclosure arranged so that a spill could terminate and be safely confined in an in-plant catchment basin or holding pond.

(iii) Drainage of rainwater from the diked area into a storm drain or an effluent discharge that empties into an open water course, lake, or pond, and bypass-ing the in-plant treatment system may be acceptable if:

(A) The bypass valve is normally sealed closed.

(B) Inspection of the run-off rain water ensures compliance with applicable water quality standards and will not cause a harmful discharge as defined in 40 CFR 110.

(C) The bypass valve is opened, and resealed following drainage under responsible supervision.

(D) Adequate records are kept of such events.

(iv) Buried metallic storage tanks represent a potential for undetected spills. A new buried installation should be protected from corrosion by coatings, cathodic protection or other effective methods compatible with local soil conditions. Such buried tanks should at least be subjected to regular pressure testing.

(v) Partially buried metallic tanks for the storage of oil should be avoided, unless the buried section of the shell is adequately coated, since partial burial in damp earth can cause rapid corrosion of metallic surfaces, especially at the earth/air interface.

(vi) Aboveground tanks should be subject to periodic integrity testing, taking into account tank design (floating roof, etc.) and using such techniques as hydrostatic testing, visual inspection or a system of non-destructive shell thickness testing. Comparison records should be kept where appropriate, and tank supports and foundations should be included in these inspections. In addition, the outside of the tank should frequently be observed by operating personnel for signs of deterioration, leaks which might cause a spill, or accumulation of oil inside diked areas.

(vii) To control leakage through defective internal heating coils, the following factors should be considered and applied, as appropriate.

(A) The steam return or exhaust lines from internal heating coils which discharge into an open water course should be monitored for contamination, or passed through a settling tank, skimmer, or other separation or retention system.

(B) The feasibility of installing an external heating system should also be considered.

(viii) New and old tank installations should, as far as practical, be fail-safe engineered or updated into a fail-safe engineered installation to avoid spills. Consideration should be given to providing one or more of the following devices:

(A) High liquid level alarms with an audible or visual signal at a constantly manned operation or surveillance station; in smaller plants an audible air vent may suffice.

(B) Considering size and complexity of the facility, high liquid level pump cutoff devices set to stop flow at a predetermined tank content level.

(C) Direct audible or code signal communication between the tank gauger and the pumping station.

(D) A fast response system for determining the liquid level of each bulk storage tank such as digital computers, telepulse, or direct vision gauges or their equivalent.

(E) Liquid level sensing devices should be regularly tested to insure proper operation.

(ix) Plant effluents which are discharged into navigable waters should have disposal facilities observed frequently enough to detect possible system upsets that could cause an oil spill event.

(x) Visible oil leaks which result in a loss of oil from tank seams, gaskets, rivets and bolts sufficiently large to cause the accumulation of oil in diked areas should be promptly corrected.

(xi) Mobile or portable oil storage tanks (onshore) should be positioned or located so as to prevent spilled oil from reaching navigable waters. A secondary means of containment, such as dikes or catchment basins, should be furnished for the largest single compartment or tank. These facilities should be located where they will not be subject to periodic flooding or washout.

(3) *Facility transfer operations, pumping, and in-plant process (onshore); (excluding production facilities).* (i) Buried piping installations should have a protective wrapping and coating and should be cathodically protected if soil conditions warrant. If a section of buried line is exposed for any reason, it should be carefully examined for deterioration. If corrosion damage is found, additional examination and corrective action should be taken as indicated by the magnitude of the damage. An alternative would be the more frequent use of exposed pipe corridors or galleries.

(ii) When a pipeline is not in service, or in standby service for an extended time the terminal connection at the transfer point should be capped or blank-flanged, and marked as to origin.

(iii) Pipe supports should be properly designed to minimize abrasion and corrosion and allow for expansion and contraction.

(iv) All aboveground valves and pipelines should be subjected to regular examinations by operating personnel at which time the general condition of items, such as flange joints, expansion joints, valve glands and bodies, catch pans, pipeline supports, locking of valves, and metal surfaces should be assessed. In addition, periodic pressure testing may be warranted for piping in areas where facility drainage is such that a failure might lead to a spill event.

(v) Vehicular traffic granted entry into the facility should be warned verbally or by appropriate signs to be sure that the vehicle, because of its size, will not endanger above ground piping.

(4) *Facility tank car and tank truck loading/unloading rack (onshore).* (i) Tank car and tank truck loading/unloading procedures should meet the minimum requirements and regulation established by the Department of Transportation

(ii) Where rack area drainage does not flow into a catchment basin or treatment facility designed to handle spills, a quick drainage system should be used for tank truck loading and unloading areas. The containment system should be designed to hold at least maximum capacity of any single compartment of a tank car or tank truck loaded or unloaded in the plant.

(iii) An interlocked warning light or physical barrier system, or warning signs, should be provided in loading/unloading areas to prevent vehicular departure before complete disconnect of flexible or fixed transfer lines.

(iv) Prior to filling and departure of any tank car or tank truck, the lowermost drain and all outlets of such vehicles should be closely examined for leakage, and if necessary, tightened, adjusted, or replaced to prevent liquid leakage while in transit.

(5) *Oil production facilities (onshore).* (i) *Definition.* An onshore production facility may include all wells, flowlines, separation equipment, storage facilities, gathering lines, and auxiliary non-transportation-related equipment and facilities in a single geographical oil or gas field operated by a single operator.

(ii) *Oil production facility (onshore) drainage.* (A) At tank batteries and central treating stations where an accidental discharge of oil would have a reasonable possibility of reaching navigable waters, the dikes or equivalent required under § 112.7(c)(1) should have drains closed and sealed at all times except when rainwater is being drained. Prior to drainage, the diked area should be inspected as provided in paragraph (e)(2)(iii) (B), C), and (D). Accumulated oil on the rainwater should be picked up and returned to storage or disposed of in accordance with approved methods.

(B) Field drainage ditches, road ditches, and oil traps, sumps or skimmers, if such exist, should be inspected at regularly scheduled intervals for accumulation of oil that may have escaped from small leaks. Any such accumulations should be removed.

(iii) *Oil production facility (onshore) bulk storage tanks.* (A) No tank should be used for the storage of oil unless its material and construction are compatible with the material stored and the conditions of storage.

(B) All tank battery and central treating plant installations should be provided with a secondary means of containment for the entire contents of the largest single tank if feasible, or alternate systems such as those outlined in § 112.7(c)(1). Drainage from undiked areas should be safely confined in a catchment basin or holding pond.

(C) All tanks containing oil should be visually examined by a competent person for condition and need for maintenance on a scheduled periodic basis. Such examination should include the foundation and supports of tanks that are above the surface of the ground.

(D) New and old tank battery installations should, as far as practical, be fail-safe engineered or updated into a fail-safe engineered installation to prevent spills. Consideration should be given to one or more of the following:

(1) Adequate tank capacity to assure that a tank will not overfill should a pumper/gauger be delayed in making his regular rounds.

(2) Overflow equalizing lines between tanks so that a full tank can overflow to an adjacent tank.

(3) Adequate vacuum protection to prevent tank collapse during a pipeline run.

(4) High level sensors to generate and transmit an alarm signal to the computer where facilities are a part of a computer production control system.

(iv) *Facility transfer operations, oil production facility (onshore).* (A) All above ground valves and pipelines should be examined periodically on a scheduled basis for general condition of items such as flange joints, valve glands and bodies, drip pans, pipeline supports, pumping well polish rod stuffing boxes, bleeder and gauge valves.

(B) Salt water (oil field brine) disposal facilities should be examined often, particularly following a sudden change in atmospheric temperature to detect possible system upsets that could cause an oil discharge.

(C) Production facilities should have a program of flowline maintenance to prevent spills from this source. The program should include periodic examinations, corrosion protection, flowline replacement, and adequate records, as appropriate, for the individual facility.

(6) *Oil drilling and workover facilities (onshore)* (i) Mobile drilling or workover equipment should be positioned or located so as to prevent spilled oil from reaching navigable waters.

(ii) Depending on the location, catchment basins or diversion structures may be necessary to intercept and contain spills of fuel, crude oil, or oily drilling fluids.

(iii) Before drilling below any casing string or during workover operations, a blowout prevention (BOP) assembly and well control system should be installed that is capable of controlling any well head pressure that is expected to be encountered while that BOP assembly is on the well. Casing and BOP installations should be in accordance with State regulatory agency requirements.

(7) *Oil drilling, production, or workover facilities (offshore).* (i) Definition: "An oil drilling, production or workover facility (offshore)" may include all drilling or workover equipment, wells, flowlines, gathering lines, platforms, and auxiliary nontransportation - related equipment and facilities in a single geographical oil or gas field operated by a single operator.

(ii) Oil drainage collection equipment should be used to prevent and control small oil spillage around pumps, glands, valves, flanges, expansion joints, hoses, drain lines, separators, treaters, tanks, and allied equipment. Drains on the facility should be controlled and directed toward a central collection sump or equivalent collection system sufficient to prevent discharges of oil into the navigable waters of the United States. Where drains and sumps are not practicable oil contained in collection equipment should be removed as often as necessary to prevent overflow.

(iii) For facilities employing a sump system, sump and drains should be adequately sized and a spare pump or equivalent method should be available to remove liquid from the sump and assure that oil does not escape. A regular scheduled preventive maintenance inspection and testing program should be employed to assure reliable operation of the liquid removal system and pump start-up device. Redundant automatic sump pumps and control devices may be required on some installations.

(iv) In areas where separators and treaters are equipped with dump valves whose predominant mode of failure is in the closed position and pollution risk is high, the facility should be specially equipped to prevent the escape of oil. This could be accomplished by extending the flare line to a diked area if the separator is near shore, equipping it with a high liquid level sensor that will automatically shut-in wells producing to the separator, parallel redundant dump valves, or other feasible alternatives to prevent oil discharges.

(v) Atmospheric storage or surge tanks should be equipped with high liquid level sensing devices or other acceptable alternatives to prevent oil discharges.

(vi) Pressure tanks should be equipped with high and low pressure sensing devices to activate an alarm and/or control the flow or other acceptable alternatives to prevent oil discharges.

(vii) Tanks should be equipped with suitable corrosion protection.

(viii) A written procedure for inspecting and testing pollution prevention equipment and systems should be prepared and maintained at the facility. Such procedures should be included as part of the SPCC Plan.

(ix) Testing and inspection of the pollution prevention equipment and systems at the facility should be conducted by the owner or operator on a scheduled periodic basis commensurate with the complexity, conditions and circumstances of the facility or other appropriate regulations.

(x) Surface and subsurface well shut-in valves and devices in use at the facility should be sufficiently described to determine method of activation or control, e.g., pressure differential, change in fluid or flow conditions, combination of pressure and flow, manual or remote control mechanisms. Detailed records for each well, while not necessarily part of the plan should be kept by the owner or operator.

(xi) Before drilling below any casing string, and during workover operations a blowout preventer (BOP) assembly and well control system should be installed that is capable of controlling any well-head pressure that is expected to be encountered while that BOP assembly is on the well. Casing and BOP installations should be in accordance with State regulatory agency requirements.

(xii) Extraordinary well control measures should be provided should emergency conditions, including fire, loss of control and other abnormal conditions, occur. The degree of control system redundancy should vary with hazard exposure and probable consequences of failure. It is recommended that surface shut-in systems have redundant or "fail close" valving. Subsurface safety valves may not be needed in producing wells that will not flow but should be installed as required by applicable State regulations.

(xiii) In order that there will be no misunderstanding of joint and separate duties and obligations to perform work in a safe and pollution free manner, written instructions should be prepared by the owner or operator for contractors and subcontractors to follow whenever contract activities include servicing a well or systems appurtenant to a well or pressure vessel. Such instructions and procedures should be maintained at the offshore production facility. Under certain circumstances and conditions such contractor activities may require the presence at the facility of an authorized representative of the owner or operator who would intervene when necessary to prevent a spill event.

(xiv) All manifolds (headers) should be equipped with check valves on individual flowlines.

(xv) If the shut-in well pressure is greater than the working pressure of the flowline and manifold valves up to and including the header valves associated with that individual flowline, the flowline should be equipped with a high pressure sensing device and shutin valve at the wellhead unless provided with a pressure relief system to prevent over pressuring.

(xvi) All pipelines appurtenant to the facility should be protected from corrosion. Methods used, such as protective coatings or cathodic protection, should be discussed.

(xvii) Sub-marine pipelines appurtenant to the facility should be adequately protected against environmental stresses and other activities such as fishing operations.

(xviii) Sub-marine pipelines appurtenant to the facility should be in good

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operating condition at all times and inspected on a scheduled periodic basis for failures. Such inspections should be documented and maintained at the facility.

(8) *Inspections and records.* Inspections required by this part should be in accordance with written procedures developed for the facility by the owner or operator. These written procedures and a record of the inspections, signed by the appropriate supervisor or inspector, should be made part of the SPCC Plan and maintained for a period of three years.

(9) *Security (excluding oil production facilities).* (i) All plants handling, processing, and storing oil should be fully fenced, and entrance gates should be locked and/or guarded when the plant is not in production or is unattended.

(ii) The master flow and drain valves and any other valves that will permit direct outward flow of the tank's content to the surface should be securely locked in the closed position when in non-operating or non-standby status.

(iii) The starter control on all oil pumps should be locked in the "off" position or located at a site accessible only to authorized personnel when the pumps are in a non-operating or non-standby status.

(iv) The loading/unloading connections of oil pipelines should be securely capped or blank-flanged when not in service or standby service for an extended time. This security practice should also apply to pipelines that are emptied of liquid content either by draining or by inert gas pressure.

(v) Facility lighting should be commensurate with the type and location of the facility. Consideration should be given to: (A) Discovery of spills occurring during hours of darkness, both by operating personnel, if present, and by non-operating personnel (the general public, local police, etc.) and (B) prevention of spills occurring through acts of vandalism.

(10) *Personnel, training and spill prevention procedures.* (i) Owners or operators are responsible for properly instructing their personnel in the operation and maintenance of equipment to prevent the discharges of oil and applicable pollution control laws, rules and regulations.

(ii) Each applicable facility should have a designated person who is accountable for oil spill prevention and who reports to line management.

(iii) Owners or operators should schedule and conduct spill prevention briefings for their operating personnel at intervals frequent enough to assure adequate understanding of the SPCC Plan for that facility. Such briefings should highlight and describe known spill events or failures, malfunctioning components, and recently developed precautionary measures.

Appendix

Memorandum of Understanding between the Secretary of Transportation and the Administrator of the Environmental Protection Agency.

Section II—Definitions

The Environmental Protection Agency and the Department of Transportation agree that for the purposes of Executive Order 11548, the term:

(1) "Non-transportation-related onshore and offshore facilities" means:

(A) Fixed onshore and offshore oil well drilling facilities including all equipment and appurtenances related thereto used in drilling operations for exploratory or development wells, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(B) Mobile onshore and offshore oil well drilling platforms, barges, trucks, or other mobile facilities including all equipment and appurtenances related thereto when such mobile facilities are fixed in position for the purpose of drilling operations for exploratory or development wells, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(C) Fixed onshore and offshore oil production structures, platforms, derricks, and rigs including all equipment and appurtenances related thereto, as well as completed wells and the wellhead separators, oil separators, and storage facilities used in the production of oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(D) Mobile onshore and offshore oil production facilities including all equipment and appurtenances related thereto as well as completed wells and wellhead equipment, piping from wellheads to oil separators, oil separators, and storage facilities used in the production of oil when such mobile facilities are fixed in position for the purpose of oil production operations, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(E) Oil refining facilities including all equipment and appurtenances related thereto as well as in-plant processing units, storage units, piping, drainage systems and waste treatment units used in the refining of oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(F) Oil storage facilities including all equipment and appurtenances related thereto as well as fixed bulk plant storage, terminal oil storage facilities, consumer storage, pumps and drainage systems used in the storage of oil, but excluding inline or breakout storage tanks needed for the continuous operation of a pipeline system and any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(G) Industrial, commercial, agricultural or public facilities which use and store oil, but excluding any terminal facility, unit or process integrally associated with the handling or transferring of oil in bulk to or from a vessel.

(H) Waste treatment facilities including in-plant pipelines, effluent discharge lines, and storage tanks, but excluding waste treatment facilities located on vessels and terminal storage tanks and appurtenances for the reception of oily ballast water or tank washings from vessels and associated systems used for off-loading vessels.

(I) Loading racks, transfer hoses, loading arms and other equipment which are appurtenant to a nontransportation-related facility or terminal facility and which are used to transfer oil in bulk to or from highway vehicles or railroad cars.

(J) Highway vehicles and railroad cars which are used for the transport of oil exclusively within the confines of a nontransportation-related facility and which are not intended to transport oil in interstate or intrastate commerce.

(K) Pipeline systems which are used for the transport of oil exclusively within the confines of a nontransportation-related facility or terminal facility and which are not intended to transport oil in interstate or intrastate commerce, but excluding pipeline systems used to transfer oil in bulk to or from a vessel.

(2) "transportation-related onshore and offshore facilities" means:

(A) Onshore and offshore terminal facilities including transfer hoses, loading arms and other equipment and appurtenances used for the purpose of handling or transferring oil in bulk to or from a vessel as well as storage tanks and appurtenances for the reception of oily ballast water or tank washings from vessels, but excluding terminal waste treatment facilities and terminal oil storage facilities.

(B) Transfer hoses, loading arms and other equipment appurtenant to a nontransportation-related facility which is used to transfer oil in bulk to or from a vessel.

(C) Interstate and intrastate onshore and offshore pipeline systems including pumps and appurtenances related thereto as well as in-line or breakout storage tanks needed for the continuous operation of a pipeline system, and pipelines from onshore and offshore oil production facilities, but excluding onshore and offshore piping from wellheads to oil separators and pipelines which are used for the transport of oil exclusively within the confines of a nontransportation-related facility or terminal facility and which are not intended to transport oil in interstate or intrastate commerce or to transfer oil in bulk to or from a vessel.

(D) Highway vehicles and railroad cars which are used for the transport of oil in interstate or intrastate commerce and the equipment and appurtenances related thereto, and equipment used for the fueling of locomotive units, as well as the rights-of-way on which they operate. Excluded are highway vehicles and railroad cars and motive power used exclusively within the confines of a nontransportation-related facility or terminal facility and which are not intended for use in interstate or intrastate commerce.

ATTACHMENT G-3

CONTINGENCY PLAN INCIDENT REPORTS

CHICAGO REFINERY

INCIDENT REPORTS

The Chicago Refinery has had no incidents or emergencies that required the implementation of this Contingency Plan. Should such an incident occur, then copies of any incident reports would be added to this Contingency Plan as part of this Attachment G-3.

ATTACHMENTS TO FIGURE G-4

COPIES OF SIGNED, CERTIFIED

MAIL RECEIPTS FOR

CONTINGENCY PLAN

PS Form 3811, July 1983

DOMESTIC RETURN RECEIPT

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:

Mr. Don Knauer
Peoples Gas Light & Coke
Route 1 Box 64-D
Elwood, IL 60421

4. Type of Service: [ ] Registered [ ] Insured [X] Certified [ ] COD [ ] Express Mail

Article Number: P088720260

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee: X John Finsel
6. Signature – Agent: X
7. Date of Delivery: 7-24-84
8. Addressee's Address (ONLY if requested and fee paid): Peoples Gas Rt 1 Box 64D Elwood Ill 60421

PS Form 3811, July 1983

DOMESTIC RETURN RECEIPT

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:

Sheriff John H. Shelley
Will County Sheriff's Dept.
14 W. Jefferson St.
Joliet, IL 60431

4. Type of Service: [ ] Registered [ ] Insured [X] Certified [ ] COD [ ] Express Mail

Article Number: P088720257

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee: X Sharon L. Pavlich
6. Signature – Agent: X 7/24/84
7. Date of Delivery: 14W Jeff
8. Addressee's Address (ONLY if requested and fee paid)

PS Form 3811, July 1983

DOMESTIC RETURN RECEIPT

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:

Chief James Miller
Route 7 and 7th
Lockport, IL 60441

4. Type of Service: [ ] Registered [ ] Insured [X] Certified [ ] COD [ ] Express Mail

Article Number: P088720266

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee: X James Miller
6. Signature – Agent: X
7. Date of Delivery: 7-25-84
8. Addressee's Address (ONLY if requested and fee paid)

LOCKPORT IL JUL 25 1984 USPO

PS Form 3811, July 1983

DOMESTIC RETURN RECEIPT

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:

Mr. Keyton Nixon
Silver Cross Hospital
1200 Maple Road
Joliet, IL 60432

4. Type of Service: [ ] Registered [ ] Insured [X] Certified [ ] COD [ ] Express Mail

Article Number: P088720258

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee: A C Larson
6. Signature – Agent: X SP
7. Date of Delivery: JUL 24 1984
8. Addressee's Address (ONLY if requested and fee paid)

PS Form 3811, July 1983

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:
Chief Robert Stark
Romeoville Police Dept.
10 Montrose
Romeoville, IL 60441

4. Type of Service:
[ ] Registered [ ] Insured
[X] Certified [ ] COD
[ ] Express Mail

Article Number
P088720256

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee
X [signature]

6. Signature – Agent
X

7. Date of Delivery
7-24-84

8. Addressee's Address (ONLY if requested and fee paid)
10 Montrose Ave

DOMESTIC RETURN RECEIPT

PS Form 3811, July 1983

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:
L. L. Smith, Mobil Oil Co.
P.O. Box 874
Joliet, IL 60434

4. Type of Service:
[ ] Registered [ ] Insured
[X] Certified [ ] COD
[ ] Express Mail

Article Number
P088720259

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee
X [signature]

6. Signature – Agent
X

7. Date of Delivery
JUL 24 1984

8. Addressee's Address (ONLY if requested and fee paid)

DOMESTIC RETURN RECEIPT

PS Form 3811, July 1983

SENDER: Complete items 1, 2, 3 and 4.

Put your address in the "RETURN TO" space on the reverse side. Failure to do this will prevent this card from being returned to you. The return receipt fee will provide you the name of the person delivered to and the date of delivery. For additional fees the following services are available. Consult postmaster for fees and check box(es) for service(s) requested.

1. [X] Show to whom, date and address of delivery.
2. [ ] Restricted Delivery.

3. Article Addressed to:
Chief A. L. Stadelmaier
Romeoville Fire Dept.
18 Montrose Dr.
Romeoville, IL 60441

4. Type of Service:
[ ] Registered [ ] Insured
[X] Certified [ ] COD
[ ] Express Mail

Article Number
P088720263

Always obtain signature of addressee or agent and DATE DELIVERED.

5. Signature – Addressee
X [signature]

6. Signature – Agent
X

7. Date of Delivery
7-24-84

8. Addressee's Address (ONLY if requested and fee paid)
13 Montrose Ave

DOMESTIC RETURN RECEIPT

SECTION H

PERSONNEL TRAINING

INTRODUCTION

The information contained in this section outlines the personnel training requirements for the Chicago Refinery hazardous waste land treatment operation in accordance with the requirements of 40 CFR 264.16.

H-1 Outline of Training Program

H-1a Job Titles and Duties

There are five individuals directly involved with the land treatment system at Union Oil, exclusive of the maintenance personnel who transport the waste and apply it to the land treatment plots. These five positions are: (I) the Superintendent of Transfer and Blending; (II) the Operations Engineer; (III) the Supervisor of Environmental Services;

(IV) the Environmental Science Analyst; and (V) the Foreman for Truck Drivers, Auto Mechanics, and Mobile Equipment Maintenance. Job descriptions for these positions are provided in Attachment H-1. Since these are general descriptions for the above positions, specific responsibilities and duties pertaining to hazardous waste management for each position follow.

I. Position Title: Superintendent of Transfer and Blending

Name: J. S. Noreiko *

Specific responsibilities and duties pertaining to hazardous waste management:

- Maintains compliance with government regulations in the area of waste treatment and waste management.

- Responsible for proper operation of the land treatment system.

Experience and Qualifications: Typical requirements for this position include at least a Bachelor's Degree, normally in engineering, and five to ten years of applicable refinery experience.

II. Position Title: Operations Engineer

Name: J. E. Purtell *

Specific responsibilities and duties pertaining to hazardous waste management:

- Ensures that the type and quantity of wastes applied to the land treatment plots are compatible with the system's capabilities.

- Completes and maintains manifests for sludge transfer from the wastewater and water treatment units to the land treatment area.

- Arranges for the collection and analysis of all soil, ground water, and lysimeter samples associated with the land treatment system.

- Prepares and updates the Chicago Refinery ground water quality assessment plan for the land treatment system.

- Maintains the Chicago Refinery land treatment system log book which includes all information related to the land treatment operation.

- Develops and overviews the training program for the Chicago Refinery land treatment system.

- Provides direction, overview and operational control for all other aspects of the Chicago Refinery land treatment system.

Experience and Qualifications: Typical requirements for this position include at least a Bachelor's Degree, and five to ten years of applicable refinery experience.

III. Position Title: Supervisor of Environmental Services

Name: D. W. Bruckert *

Specific responsibilities and duties pertaining to hazardous waste management:

- Maintain familiarity with state, federal, and local environmental regulations; monitor refinery operations to assure compliance with all regulatory requirements.

- Coordinates with other departments in situations of environmental non-compliance.

- Acquire and review as necessary--operating, construction, discharge, and other permits from local, state, and federal agencies.

- Coordinates preparation and update of various spill control plans.

- Prepares, reviews and submits various monthly, quarterly, and annual reports to agencies.

- Accompanies agency personnel during plant inspections.

- During a plant emergency, assist with press, public relations, and environmental inspections at direction of the plant manager.

Experience and Qualifications: A Bachelor's Degree in environmental sciences or the equivalent, and five to ten years experience in the environmental field.

IV. Position Title: Environmental Science Analyst

Name: L. D. Erchull *

Specific responsibilities and duties pertaining to hazardous waste management:

- Maintain familiarity with state, federal, and local environmental regulations; monitor refinery operations to assure compliance with all regulatory requirements.

- Coordinates with other departments in situations of environmental non-compliance.

- Acquire and review as necessary--operating, construction, discharge, and other permits from local, state, and federal agencies.

- Coordinates preparation and update of various spill control plans.

- Prepares, reviews and submits various monthly, quarterly, and annual reports to agencies.

- Accompanies agency personnel during plant inspections.

- During a plant emergency, assist with press, public relations, and environmental inspections at direction of the plant manager.

- Reports directly to Supervisor of Environmental Services. In absence of the Supervisor of Environmental Services, performs his duties.

Experience and Qualifications: A Bachelor's Degree in environmental sciences or the equivalent, and five to ten years experience in the environmental field.

V. Position Title: Foreman of Truck Drivers, Auto Mechanics, and Mobile Equipment Maintenance

Name: G. L. Boland *

Specific responsibilities and duties pertaining to hazardous waste management:

- Supervise truck drivers who transport waste to the land farm and operate the land farm equipment.

- Work with Environmental Services and Operations to clean up spills and in controlling transportation of waste.

Experience and Qualifications: Experience and knowledge of mobile equipment maintenance and operation. Organizational, supervisory, and administrative capabilities are also required.

Included in Attachment H-1 is a functional description of job activities for the truck drivers who transport the wastes. Table H-3 is a current listing of individuals who are drivers. *

H-1b Training Content, Frequency, and Techniques

A formal hazardous waste training program for all personnel involved with the land treatment operations at the Chicago Refinery has been instituted. Under this program, training is provided at specific intervals, depending on employee level, and detailed records of all training conducted are maintained. Table H-1 summarizes both training frequency and content. As Table H-1 shows, the program provides hazardous waste management training to each person depending on their position. Specifically, three levels of training are provided at the Union Oil, Chicago Refinery:

- Training of all employees--in basic safety and emergency procedures.

- Training for operating personnel--in hazardous waste handling, maintenance, and emergency procedures.

- Training for supervisory personnel--in detailed safety and emergency procedures, spill cleanup, basic hazardous waste management practices, and RCRA related requirements.

All training efforts are directed by the Operations Engineer who is responsible for training frequency, content and selection of instructor. When appropriate, outside training instructors are brought to the Chicago Refinery to supplement inhouse training. Supervisors are used at monthly training sessions to review and introduce new procedures on safety, communication and emergency response procedures. Other Chicago Refinery personnel, such as the Supervisor of Environmental Services or the Fire Protection Supervisor, are used in both classroom presentations and field demonstrations. The field demonstrations provide hands-on experience for personnel in emergency response procedures, such as fire-fighting and spill containment.

H-1c RCRA Training Director

The following position has the responsibility to direct the training program:

Operations Engineer

This individual has overall responsibility for insuring that the hazardous waste training program is fully implemented and operates continuously. Specific responsibilities include:

- Developing and implementing the training program
- Selecting instructors
- Participating in the design of training material
- Assisting in training logistics (e.g., scheduling)
- Conducting an annual review of the training program
- Maintaining training records

The Operations Engineer and staff, as Training Director and * Assistants, has been trained in hazardous waste procedures * and is familiar with RCRA requirements. Table H-2 * summarizes the RCRA related training to date of the * Operations Engineer. The collective experience and *** education reflected in the listing on Table H-2 and in *** Section H-1a is more than adequate for operation of the land *** treatment system. Individuals listed on Table H-2 work and *** consult with each other on a day-to-day basis. Other *** training courses and conferences, as attended, will be added *** to Table H-2 to document continued training of the Chicago *** Refinery personnel. ***

H-1d Relevance of Training to Job Position

The Operations Engineer is responsible for teaching hazardous waste management procedures, including contingency plan implementation, to all waste handling personnel. The training program is tiered (Table H-1) to provide training to personnel at levels that are relevant to their positions and responsibilities. For example, supervisory personnel receive training on record keeping and other procedures required for compliance, whereas the operators do not. Operators are specifically trained on proper and safe operating procedures and on how to respond effectively to a spill or other emergency.

H-1e Training for Emergency Response

This training program is designed to insure that personnel not only handle hazardous waste in a safe manner, but also properly respond to emergency situations. For example, hazardous waste management training is provided to each ***

Emergency Coordinator. This training includes emergency *** response procedures, the characteristics of the wastes being handled, containment and spill response procedures, and implementation of the Contingency Plan (Section G).

The program trains hazardous waste handling/management personnel to maintain compliance under both normal operating and emergency conditions.

Training elements addressing non-routine or emergency situations (unscheduled shut-downs and start-ups related to storms, fires, explosions, spills) include:

- Procedures for locating, using, inspecting, repairing, and replacing facility emergency and monitoring equipment.

- Emergency communication procedures and alarm systems.

- Response to fires or explosions.

- Response to, and procedures for, containing, controlling, and mitigating spills.

- Shut-down of operations.

In addition to the hazardous waste management personnel, the Day or Shift Fire Crew will respond to all fires and other general plant emergencies. The Day Fire Crew is present during week-days between 7:30 a.m. and 4:00 p.m., and on request of the Shift Fire Crew, will provide backup support during other shifts. The Shift Crew provides fire protection when the Day Shift is not present. All Fire Crews are trained both with classroom and practical instruction. Monthly training is required for the Day Crew and bimonthly training is required for the Shift Crew. An additional monthly half-day class is required for Day Crew fire members classified as Apparatus Engineers. Records of the training program are kept on file at the Chicago Refinery.

Each Emergency Coordinator receives training in general *** emergency response procedures as well as specific training in their functions and responsibilities as Emergency Coordinator. This training includes classroom, field, and self-study (ie., reading and familiarity with Contingency Plan) programs.

H-2 Implementation of Training Program

The Operations Engineer and all current waste handling personnel have been trained at the time of this submittal. Prior to any renewed treatment of hazardous wastes at the land farm, all personnel with applicable responsibilities for the land farm operation will receive updated training. All new personnel or newly assigned personnel must complete this training program within six months of assignment to the land treatment operations or within six months of their date of employment, whichever is later. No employee hired with any duties in the hazardous waste management area will work unsupervised prior to completion of the training program.

Should a personnel change occur in the Operations Engineer position, the new individual will be supported by all other departments (such as Environmental Services), and the prior Operations Engineer, until the new individual is familiar with his hazardous waste management responsibilities.

In February of each year a review of the training program is conducted. All personnel involved in the land treatment operation participate in this exercise by evaluating the courses they have taken. The Operations Engineer has responsibility for conducting this review and documenting findings on a annual report (Figure H-1).

A report will also be completed in February of each year by the Operations Engineer. This report will summarize training activities reviewed, review procedure used, participants, findings of the review, and plan of action for the coming year.

The Operations Engineer at the facility is responsible for maintaining all training records. These records consist of

completed versions of the forms shown in Figures H-1, H-2, and H-3, and provide the following:

- Documentation of all formal training conducted at the facility, specifically providing the title of the training course, the date, the instructor, description of the course content, and the names of employees that attended (Figure H-1).

- An up-to-date training record of each individual involved in hazardous waste management. The record includes the name, qualifications, experience, job title and responsibilities, and training provided (Figure H-2).

- A listing of the training session attendees for each course given, the dates, description of training course, and the instructor (Figure H-3).

The materials utilized in the training program are maintained in a central file and updated routinely by the Operations Engineer. These records will be kept until

closure of the land treatment area for current employees, and for three years from the date of the individual employee's termination for former employees.

In addition to the above formal training program, notification of changes and/or bulletins which will summarize and reinforce past training will be periodically distributed. The Operations Engineer has responsibility for issuing these notifications to the appropriate personnel. Copies of these notifications/bulletins, along with a distribution list, are maintained as part of the training records.

TABLE H-1

SUMMARY OF TRAINING
FOR FACILITY PERSONNEL

Title	Training to be Provided	Frequency
All Personnel	• Basic safety procedures. • Emergency procedures for coping with fires, explosions and spills. • Use of communication and alarm systems.	Monthly
Operating Personnel who routinely handle hazardous waste	• Use of emergency equipment. • Spill clean-up procedures (basic). • Use of safety equipment. • Transportation requirements. • Hazardous waste handling procedures. • Explosion and fire response procedures.	Start of each operating season

TABLE H-1

SUMMARY OF TRAINING FOR FACILITY PERSONNEL (Continued)

Title	Training to be Provided	Frequency
Supervisory Personnel	• Inspection procedures. • Procedures for using emergency and monitoring equipment. • Shutdown of operations. • Spill clean-up procedures. • Basic chemistry of hazardous materials. • Basic overview of RCRA.	Annually *
Fire Crew	• Procedure for using, inspecting, repairing, and replacing emergency and monitoring equipment. • Implementation of the Contingency Plan. • Emergency medical techniques. • Fire fighting techniques	Monthly

TABLE H-1

SUMMARY OF TRAINING FOR FACILITY PERSONNEL (Continued)

Title	Training to be Provided	Frequency	
Area Shift Supervisor	• Emergency response procedures. • Hazardous waste management practices. • Hazards associated with wastes. • Implementation of the Contingency Plan.	Annually	*

TABLE H-2

SUMMARY OF TRAINING COURSES AND CONFERENCES

Name	Date	Title
L. D. Erchull	Sept. 17-21, 1979	Hazardous Materials Engineering
L. E. Erchull	May 20-21, 1980	Working Together to Manage Wastes
J. E. Purtell	Sept. 25, 1980	Industrial Hygiene Surveillance
J. F. Martens	Nov. 12-13, 1980	Land Application of Sludge
J. E. Purtell	Jan. 14, 1981	USEPA, DOT Waste Disposal Regulations
L. D. Erchull	Jan. 19-20, 1981	Disposal of Oily & Industrial Sludges by Land Treatment
L. D. Erchull	Aug. 25-26, 1981	Working Together to Manage Wastes
L. D. Erchull	March 22-23, 1982	Fundamentals of Groundwater Quality Protection
L. D. Erchull	June 8-9, 1982	Working Together to Manage Wastes
L. D. Erchull	June 28-29, 1983	Working Together to Manage Wastes
L. D. Erchull	Feb. 22-23, 1984	RCRA - Part B Permitting
L. D. Erchull	May 22-23, 1984	Working Together to Manage Wastes

TABLE H-3

CURRENT TRUCK DRIVERS (December, 1984)

L. Farmer

T. P. Fitzgerald

W. C. Fox

J. A. Fracaro(H)

D. A. Kapinus

M. Levanich

J. C. Matejcak

F. R. Oliver

J. E. Pardo

R. C. Peterson

E. L. Poole

R. Radjenovich

FIGURE H-1

ANNUAL REPORT

PART 1: TRAINING SESSIONS HELD

Title	Date	Description of Training	Instructor	No. of Employees Trained

* INSTRUCTIONS:

This form must be completed by the Operations Engineer to maintain a summary of each year's training activities.

FIGURE H-2
HAZARDOUS WASTE MANAGEMENT
PERSONNEL TRAINING DATA

Name: _____

Title: _____

Hazardous Waste Management Responsibility Area:

_____

Qualifications:

Job Responsibilities:

RCRA Related Training Record:

Title and Description of Training	Date Completed

Instructions: This form must be prepared, updated, and filed by the Operations Engineer for each employee with a designated hazardous waste management responsibility. At minimum, personnel in charge of waste analysis, manifest system, inspection, training, and emergency coordination must be covered, as well as operating personnel who routinely handle hazardous wastes.

FIGURE H-3

TRAINING SESSION DATA SHEET*

Title of Training Session: _____

Date: _____

Description of Training:

Name of Instructor: _____

_____

_____

_____

_____

_____

Name of Employees Attending Session:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
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35. _____
36. _____
37. _____
38. _____
39. _____
40. _____

* INSTRUCTIONS

This form must be completed by the instructor each time a scheduled training session is conducted. The form must be returned promptly to the Operations Engineer and maintained for the record files.

ATTACHMENT H-1

Job Descriptions

Chicago Refinery

Attachment H-1

Union Oil Company of California

Job Description

No. 31115

Department REFINING & TRANSPORTATION Payroll Title Superintendent - Transfer & Blending

Division UNION 76: EASTERN REGION Descriptive Title Superintendent - Transfer & Blending

Unit CHICAGO REFINERY Date May 1, 1984

Location LEMONT, ILLINOIS

Fair Labor Standards Act Overtime Provision Status — Exempt XX / Subject

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POSITION

Reports to the General Superintendent of the Operations Division.

It is the responsibility of the Superintendent, Transfer & Blending:

1. To provide a reliable supply of crude oil and other raw materials to the processing departments.

2. To receive, blend, store and ship the products manufactured by the processing departments.

3. To safely and efficiently operate the piping systems outside the process units, the tankage, the product blending facilities, the loading facilities (barge, tank car and truck) and pipeline shipping and receiving facilities.

4. To properly operate the following process units: Water Treating Unit 410, Waste Water Treating Unit 440, South Plant Flare System and Landfarm.

These responsibilities are largely handled by delegation of authority to subordinate Engineers and Supervisors.

SPECIFIC FUNCTIONS

1. Interface with his superiors, peers and subordinates to ensure a safe work environment in his area of responsibility.

2. Supervises staffing and operation of Refinery facilities for storage and movement of all raw materials, intermediate stocks and finished products.

3. Directs all in-line blending operations to assure that optimum value is obtained from stocks.

4. Control shipments to assure compliance with specifications.

5. Contact processing, planning, laboratory and distribution departments as required to maximize profits from production.

6. Maintain his physical plant in good condition by obtaining timely service from the Maintenance Division.

7. Prepare budgets and control costs for his operations.

INFORMATION CONTAINED HEREIN RELATES TO THE ABOVE MENTIONED JOB AT THE TIME THE DESCRIPTION WAS MADE. A NEW JOB DESCRIPTION SHOULD BE PROVIDED IN EVENT THERE IS A MAJOR CHANGE IN FUNCTIONS OR OTHER PERTINENT DATA RELATING TO THE JOB. THE DUTIES INCLUDED IN THIS DESCRIPTION ARE INDICATIVE OF THE SKILLS, KNOWLEDGES, AND ABILITIES REQUIRED TO PERFORM THIS JOB, BUT THIS DESCRIPTION MUST NOT BE CONSIDERED TO INCLUDE ALL DUTIES WHICH MAY BE ASSIGNED TO THIS CLASSIFICATION, OR WHICH ARE CURRENTLY BEING PERFORMED IN SUCH CLASSIFICATION.

FORM 1-1061 (10-75) PRINTED IN U.S.A.

SUPERINTENDENT - TRANSFER & BLENDING

8. Supervise relationships with departmental hourly employees and their union representatives to be fair and encourage productivity with safety as a mandatory feature of every job.

9. Directs his Engineers and Supervisors in the development and implementation of cost reduction and profit improvement projects in his area of responsibility.

10. Promotes efficiency and productivity of Engineers and Supervisors in his Department by establishing and reviewing progress toward objectives.

11. Interfaces with other Department Heads to assure the coordination of his Department's activities with other line and staff activities to meet the overall Refinery objectives.

12. Maintain an effective disciplinary program to encourage acceptable performance.

13. Maintains compliance with government laws and regulations in the area of waste treatment and waste management.

Attachment H-1

Union Oil Company of California

Job Description

No.

Department REFINING & TRANSPORTATION Payroll Title Operations Engineer

Division 76 Division: Eastern Region Descriptive Title Waste/Water/Landfarm Operations Engineer

Unit Chicago Refinery Date January 1, 1984

Location Lemont, Illinois

Fair Labor Standards Act Overtime Provision Status — Exempt XX / Subject

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POSITION

Reports to the Superintendent of an Operating Department.

It is the responsibility of a Waste/Water/Landfarm Operations Engineer assigned to Blending and Transfer to provide technical staff service to the Superintendent and other line supervisors in the Operating Department. He maintains contacts with other staff departments within the Refinery and assists the Superintendent in gaining effective use of those departments in achieving departmental and Refinery goals.

SPECIFIC FUNCTIONS

1. Maintains technical surveillance of unit operations in his assigned department.

2. Identifies and defines ways to improve the operation of process equipment so that safety and on-stream efficiency may be improved, costs reduced and specifications met.

3. Initiates improvement projects on behalf of his assigned department and develops economic justifications and sensitivity analyses for such projects.

4. Maintains effective communication with Engineering, Laboratory and Maintenance Departments to see that departmental projects are completed properly to meet departmental objectives.

5. Assists Process Foremen in development of operating procedures.

6. Assists Superintendent and Process Foremen in special operating situations, such as shutdowns and startups, by inspecting equipment and checking and revising operating procedures.

7. Advises the Superintendent and Process Foremen on technical matters providing solutions to technical problems which do not warrant inquiry of the Engineering Department.

8. From time to time, serves as relief Process Supervisor or Superintendent.

INFORMATION CONTAINED HEREIN RELATES TO THE ABOVE MENTIONED JOB AT THE TIME THE DESCRIPTION WAS MADE. A NEW JOB DESCRIPTION SHOULD BE PROVIDED IN EVENT THERE IS A MAJOR CHANGE IN FUNCTIONS OR OTHER PERTINENT DATA RELATING TO THE JOB. THE DUTIES INCLUDED IN THIS DESCRIPTION ARE INDICATIVE OF THE SKILLS, KNOWLEDGES, AND ABILITIES REQUIRED TO PERFORM THIS JOB, BUT THIS DESCRIPTION MUST NOT BE CONSIDERED TO INCLUDE ALL DUTIES WHICH MAY BE ASSIGNED TO THIS CLASSIFICATION, OR WHICH ARE CURRENTLY BEING PERFORMED IN SUCH CLASSIFICATION.

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Waste/Water/Landfarm Operations Engineer

ADDITIONAL SPECIFIC FUNCTIONS

1. Ensures that the type and quantity of waste applied to the land treatment plots are compatible with the system's capabilities.

2. Completes manifests for each sludge movement from Waste Treatment Unit 44 and Water Treatment Unit 41 to the Refinery Landfarm.

3. Arranges for the collection and analysis of all soil, groundwater and lysimeter samples associated with the Refinery Landfarm.

4. Prepare and update the Chicago Refinery Groundwater Quality Assessment Plan.

5. Maintain the Chicago Refinery Landfarm Log Book which includes all information related to the Refinery Landfarm.

6. Develops and overviews the training program for the Chicago Refinery land treatment system.

7. Provides direction, overview and operational control for all other aspects of the Chicago Refinery land treatment system.

Attachment H-1

Union Oil Company of California

Job Description

No.

Department: REFINING & TRANSPORTATION
Payroll Title: Supervisor, Environmental Services

Division: Union 76: Eastern Region
Descriptive Title: Supervisor, Environmental Services

Unit: Chicago Refinery
Date: March 1, 1984

Location: Lemont, Illinois

Fair Labor Standards Act Overtime Provision Status — Exempt: XX; Subject:

POSITION

Reports to the Refinery Manager.

He must be familiar with State, Federal and Local Environmental Regulations and monitor Refinery operations to assure compliance with all regulation requirements.

Supervises two Environmental Science Analysts and an Environmental Foreman.

SPECIFIC DUTIES

A. Monitor compliance with regulations primarily through his staff for the following:

1. Effluent Water Discharge
2. Solid Waste Disposal
3. Hazardous Waste Disposal
4. Oil Spills
5. Air Regulations
6. Noise Regulations
7. Odor Emissions to Atmosphere
8. Hazardous Substance Spills

B. Acquire and review as necessary operating, construction, discharge and other permits from Local, State and Federal Agencies.

C. Coordinate with other Departments in the matter of non-compliance for items in "A".

D. Coordinate preparation and update of various spill plans (SPCC).

E. Prepare or review and submit various monthly, quarterly and annual reports to Agencies.

F. Keep current with proposed new Agency Regulations and offer comments and testimony prior to their passage and/or adoption.

G. Develop annual expense budget for Environmental Control Unit 859.

H. Accompany Agency personnel in plant inspections.

INFORMATION CONTAINED HEREIN RELATES TO THE ABOVE MENTIONED JOB AT THE TIME THE DESCRIPTION WAS MADE. A NEW JOB DESCRIPTION SHOULD BE PROVIDED IN EVENT THERE IS A MAJOR CHANGE IN FUNCTIONS OR OTHER PERTINENT DATA RELATING TO THE JOB. THE DUTIES INCLUDED IN THIS DESCRIPTION ARE INDICATIVE OF THE SKILLS, KNOWLEDGES, AND ABILITIES REQUIRED TO PERFORM THIS JOB, BUT THIS DESCRIPTION MUST NOT BE CONSIDERED TO INCLUDE ALL DUTIES WHICH MAY BE ASSIGNED TO THIS CLASSIFICATION, OR WHICH ARE CURRENTLY BEING PERFORMED IN SUCH CLASSIFICATION.

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Supervisor, Environmental Services

I. Collect and coordinate data necessary for variance requests.

J. During plant emergency, assist with press, public relations and environmental inspectors at direction of the Refinery Manager.

K. Represent the Refinery at local industry groups on environmental matters.

L. Acts as consultant to State Legislative Agencies on environmental issues.

M. Represents the oil industry in an advisory capacity for bodies such as:

1. State Chamber of Commerce.

2. Illinois Manufacturers Association.

3. Illinois Environmental Concensus Forum.

N. Administer salaries and conduct performance evaluations for the Environmental Services Department personnel.

Attachment H-1

Union Oil Company of California

Job Description

No. 15320

Department REFINING & TRANSPORTATION Payroll Title ENVIRONMENTAL SCIENCE ANALYST

Division UNION 76: EASTERN REGION Descriptive Title ENVIRONMENTAL SCIENCE ANALYST

Unit CHICAGO REFINERY Date August 1, 1981

Location LEMONT, ILLINOIS

Fair Labor Standards Act Overtime Provision Status — Exempt xx / Subject

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ENVIRONMENTAL SCIENCE ANALYST

POSITION

Reports to the Environmental Services Supervisor.

He must be familiar with State, Federal and Local Environmental Regulations and monitor Refinery operations to assure compliance with all regulation requirements.

SPECIFIC DUTIES

A. Monitor compliance with regulations for the following:

1. Effluent Water Discharge
2. Solid Waste Disposal
3. Hazardous Waste Disposal
4. Oil Spills
5. Air Regulations
6. Noise Regulations
7. Odor Emissions to Atmosphere
8. Hazardous Substance Spills

B. Acquire and review as necessary operating, construction, discharge and other permits from Local, State and Federal Agencies.

C. Coordinate with other Departments in the matter of non-compliance for items in "A".

D. Prepare and update various spill plans (SPCC).

E. Prepare or review and submit various monthly, quarterly and annual reports to Agencies.

F. Keep current with proposed new Agency Regulations and offer comments and testimony prior to their passage and/or adoption.

G. Develop annual expense budget for Environmental Control Unit 859.

H. Accompany Agency personnel in plant inspections.

I. Collect and coordinate data necessary for variance requests.

INFORMATION CONTAINED HEREIN RELATES TO THE ABOVE MENTIONED JOB AT THE TIME THE DESCRIPTION WAS MADE. A NEW JOB DESCRIPTION SHOULD BE PROVIDED IN EVENT THERE IS A MAJOR CHANGE IN FUNCTIONS OR OTHER PERTINENT DATA RELATING TO THE JOB. THE DUTIES INCLUDED IN THIS DESCRIPTION ARE INDICATIVE OF THE SKILLS, KNOWLEDGES, AND ABILITIES REQUIRED TO PERFORM THIS JOB, BUT THIS DESCRIPTION MUST NOT BE CONSIDERED TO INCLUDE ALL DUTIES WHICH MAY BE ASSIGNED TO THIS CLASSIFICATION, OR WHICH ARE CURRENTLY BEING PERFORMED IN SUCH CLASSIFICATION.

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UNION OIL COMPANY OF CALIFORNIA

CHICAGO REFINERY

JOB DESCRIPTION

ENVIRONMENTAL SCIENCE ANALYST

SPECIFIC FUNCTIONS (Cont'd.)

J. During plant emergency, assist with press, public relations and environmental inspectors at direction of the Plant Manager.

Attachment H-1

Chicago Refinery - Truck Driver Classification - Vehicle and Duty List

A. Vehicles to be operated by truck department

1. Dispatch trucks - flatbed stake type.
2. Fork lift.
3. Fuel truck.
4. Vacuum truck.
5. Taxi and out of plant messenger vehicles.
6. Sludge farming tractor and equipment.
7. Trucks assigned to truck department.

B. Duties

1. Deliver tools, men and materials.
2. Load or unload trucks, dump barrels, deliver oil to compressors and oil storage building, and other palletize deliveries.
3. Deliver fuel to underground storage tanks, portable equipment and vehicles.
4. Operate vacuum truck picking up spills and hauling various types of liquid materials.
5. Operate case tractor for plowing, discing, and injecting sludge.
6. Operate IH tractor for weed and grass cutting and snow plowing.
7. Use trucks equipped with snow plow to plow snow from refinery roads.
8. Operate dump truck, salt spreading, snow plowing and hauling.
9. Tow equipment when needed.

SECTION I

CLOSURE, POST-CLOSURE PLANS, AND FINANCIAL REQUIREMENTS

INTRODUCTION

This Section is submitted in accordance with the requirements of 40 CFR 264.112 through 115, and 264.280. This closure plan identifies all steps that will be necessary to close the land treatment area at any point during its intended operating life. A post-closure plan is also included. Both the closure and post-closure plan have been designed to ensure that the land treatment area, when closed, will include necessary maintenance and monitoring until such time that the requirements of 264.280(d)(3) have been documented. Closure and post-closure will be implemented such that all closure activities undertaken will not threaten human health or the environment.

Two copies of the Closure Plan will be maintained at the Chicago Refinery. Both copies will be updated as required.

I-1 Closure Plan

I-1a Closure Performance Standard

Final closure of the land treatment system will be directed by the Operations Engineer according to the procedures described below. As individual operating equipment used at the land treatment site is retired, only the procedures described in Table I-1 that are specific to that equipment need be implemented, followed by a "certification of closure" by the Operations Engineer and an independent registered professional engineer. Regardless of the extent of closure, all normal monitoring and inspection activities will be continued. These activities are described in Section E and in Section F-2.

The Chicago Refinery land treatment system will be closed in a manner that minimizes the need for further maintenance and controls, minimizes, or eliminates threats to human health and the environment.

I-1b Partial Closure

The Chicago Refinery land treatment site will be operated such that hazardous wastes will be subsurface injected immediately after being collected and transported to the

land treatment plots. The Chicago Refinery has the flexibility to control the generation of hazardous waste and subsequent deliveries to the land treatment area. Consequently, if the area inspections show that some type of repair or maintenance is required, these repair or maintenance items will be implemented and reinspected prior to any delivery of hazardous wastes. There are no circumstances then that would require partial closure.

I-1c Final Closure

The land treatment area will undergo final closure if:

- Unacceptable migration of contaminants occurs such that a corrective action program under 40 CFR 264.100 must be implemented.

- If soil sampling of the active treatment zone shows a build-up of metals that approaches the EPA suggested limiting metals concentrations (chromium and lead concentrations of 1,000 mg per kilogram of soil).

- Soil core analyses show EP Toxicity results that exceed the maximum concentration of metals shown in Table 1 of 40 CFR 261.24.

There are no current plans to permanently close the Chicago Refinery, and it is unlikely that a total refinery shut-down would occur during the active life and the 30 year post-closure period of the land treatment area. In the unlikely event a decision is made to shut-down the refinery, the closure and post-closure plans contained herein will be revised and resubmitted to the appropriate regulatory authorities.

After it is determined that final closure will be implemented, this plan and any revisions thereto, will be submitted to the USEPA Region V Administrator at least 180 days before the anticipated commencement of closure. Final closure of the land treatment system will proceed according to the following general schedule:

(1) Final closure will only be initiated at the beginning of an operating season. The Chicago Refinery controls the time at which a hazardous waste is "generated" from process operations to allow for inactive land

treatment system periods, such as winter months and wet periods. The Chicago Refinery will continue this practice and the generation of the final quantity of hazardous wastes will be scheduled for the beginning of an operating season.

(2) 180 days prior to the anticipated final application of hazardous wastes to the land treatment system, this closure plan will be submitted to the USEPA Region V Administrator.

(3) Final closure procedures will commence within 30 days after the final application of hazardous wastes to the soil plot or plots.

Final closure procedures will involve continued discing/aeration of the land treatment system for two seasons (2 years) after the final application of hazardous wastes, to insure that all organics are completely degraded. A two-year closure period is required based on biological degradation half-lifes for API separator sludge and other refinery wastes of one-half year or less, as reported in the literature (Appendix A, references 2, 6, 9, 12 and 15). At

the end of the second season, all equipment used in the land treatment operation will be decontaminated by hydroblasting on the edge of one of the land treatment plots. A final cover of timothy, clover, alsike, and rye (a volume mixture of 50%, 35%, 5%, and 10%) will be sowed on the land treatment plots to provide a protective cover and to prevent wind dispersion of soil.

The mixture of perennial sod crops (grasses) have been selected since they provide the best protection against erosion and a significantly longer period of ground cover than annual grasses and/or small grains. Perennial grasses offer several other advantages: they can tolerate temporary flooding as well as dry conditions; they are fairly tolerant of contaminants; are self-seeding; and, provide excellent protection against erosion due to the inter-locking root system developed by the mature plant. The final cover selected has been based on local use for pasture land by a local farmer, and has been reviewed against the listing of acceptable cover plants in the EPA publication SW-874, titled "Hazardous Waste Land Treatment", dated April, 1983. Regional adaption (i.e., midwest portion of the United States) and other considerations as identified in the above document indicate that the proposed mixture should serve as an excellent plant cover. The grasses to be used include:

Common Name	Scientific Name
Timothy	Phelum pratense
Clover	Trifolium incarnatum
Alsike	Trifolium hybridum
Rye	Lolium perenne

At closure, all of the land treatment plots will be final graded and the cover grass mixture will be broadcast spread by ground application. Immediately thereafter, the land treatment plots will be harrowed to increase soil-seed contact to cover the seeds with soil. Amount of seed to be used will be based on the formulas provided in the previously cited EPA document, (Page 497) based on percent purity and germination stated on the manufacturer's/supplier's analysis. Rates will be increased by 75% to account for the use of broadcast spreading.

Once established, the Chicago Refinery need not mow or otherwise maintain the final cover, rather, the land treatment plots will be established and maintained as a "natural prairie". However, during the first two years, fertilizer will be broadcast spread in the early spring (during final snow melt and prior to spring rains) to insure

a well established grass. Also throughout the post-closure period, estimates will be made (by field measurement) as to the amount of cover grass lost due to winter kill. When the amount of bare and/or exposed dirt approaches ten percent (10%) of the land area covered by any individual land treatment plot, those exposed areas will be re-seeded.

During the two-year closure period, all normal site monitoring, as specified in Section E, will continue. At the end of the second year, composite soil samples (six samples randomly taken from each land treatment plot to produce three composite samples per plot) will be taken and analyzed for indicator organics as well as for EP Toxicity. It is fully expected that the soil will be shown as being "nonhazardous" and therefore can be left in place. If it is found that additional time is required to complete the degradation of the organics, Union Oil will modify the closure plant to provide for such an extension.

Figure I-1 graphically depicts the closure schedule anticipated for the land treatment area. During the final operating season, hazardous and nonhazardous wastes will be scheduled for delivery such that the last application of either hazardous or nonhazardous wastes will be approximately mid-September. Plowing and discing of the

land treatment plots throughout this last operating season will continue as normally practiced. Plowing of each plot will be conducted approximately once per month, or every four weeks. Discing of each plot will be conducted every two weeks. This schedule will be maintained until approximately mid-November, which is normally the end of the operating season. The nonhazardous waste storage and decant basin will be filled with clean dirt and graded to conform with the surrounding topography. The area will then be sowed with a grass and clover mixture to provide vegetation cover.

Equipment used during this last operating season will be cleaned at the edge of one of the treatment plots such that all cleaning residues will flow onto the treatment plot. Decontamination and cleaning will consist of hydroblasting, followed by a triple steam cleaning. Between each steam cleaning, a cold water rinse will be used to insure all portions of the equipment is clean. Equipment not required for the next operating season (as vacuum trucks) will be sold as surplus equipment. Equipment required for the next operating season (tractor, chisel plow, offset disc) will be stored for the winter months.

During the last three operating seasons (year zero and the first and second year after final application of wastes), the Chicago Refinery will maintain all normal plowing/discing schedules, as well as soil sampling and pH control. All land treatment plots will be plowed once per month, and disced once every two weeks. At the end of each operating season, the equipment decontamination/cleaning procedure previously described will be used.

All other land treatment operating parameters will be maintained and continued during the last three operating seasons. This will include:

1. Maintenance and control of all drainage patterns such that run-on is diverted away from each land treatment plot.

2. Maintenance and control of all runoff control from the land treatment plots. Runoff will continue to be directed to the NPDES permitted wastewater treatment facility.

   Sludges from this facility however, will be directed to an approved off-site waste disposal operation.

3. Continued use of the ground water and unsaturated zone monitoring points, which includes sampling and laboratory analysis.

At the end of the second operating season (second year), after the equipment has been decontaminated/cleaned, all remaining equipment will be sold as surplus equipment. All treatment plots will then be sowed with a final cover of grasses and clover that will hold the soil surface in place. This grass and clover mixture is self-seeding and therefore ground cover maintenance will be nominal.

Throughout the final operating season, and the next two operating seasons, the Chicago Refinery will continue all normal inspection, monitoring and ground water and soil analytical programs. These activities are described in detail in other sections of this document. At the end of the second season operating season, the Chicago Refinery will begin post-closure monitoring and inspection procedures, which are described in a later portion of this Section.

After the closure plan has been submitted and approved, but before the final operation season begins, the Chicago Refinery will contract with an independent registered

professional engineer to overview the three-year closure period. At the end of the second year, after the final grass and clover cover has been sowed, the engineer will prepare a certification of closure. This certification, with a similar certification from the Operations Engineer, will be submitted to the USEPA Region V Administrator in conformance with 40 CFR 280(b).

I-1d Maximum Waste Inventory

This Part B Permit Application does not include any storage facilities. However, for estimating purposes, it can be assumed that the maximum amount of hazardous wastes that will be applied on an annual basis to the land treatment area for final disposal totals 163 dry tons (65,200 gallons) of hazardous wastes and 4,457 dry tons (1,782,800 gallons) of nonhazardous wastes, for a total of approximately 4,620 dry tons (1,848,000 gallons). All wastes will be disposed of on the land treatment plots.

I-1e Schedule For Closure

The general schedule for closure has been described in Section I-1c, Final Closure, and is summarized graphically in Figure I-1. Because operation of the land treatment

system is not limited by age or total past use, the year of closure cannot be anticipated at this time. For purposes of this permit application, the date of final closure has been assumed to be in September, 1995. Unless the build-up of heavy metals in the soil approaches the EPA suggested limiting concentrations, the land treatment system will be operated as long as it remains economically advantageous to do so.

The schedule shown in Figure I-1 can be used for tracking the progress of closure, once the decision to close has been made. Equipment replacement during the normal operating life of the land treatment plots will be dictated by maintenance requirements, as determined by routine inspection, and cannot be projected. Should equipment replacement be necessary, the equipment will be decontaminated as described below, prior to removal from service.

Completion of final closure will require approximately two years from the date when the last application of hazardous wastes are made to a land treatment plot or plots. If it appears that final closure will require more time than estimated herein, the Operations Engineer will contact the

USEPA Region V Administrator for approval of an extension to the closure schedule.

I-1f Disposal of Contaminated Equipment

All equipment used at the land treatment system which may have been contaminated with hazardous wastes, will be decontaminated and cleaned at the edge of one of the land treatment plots. This procedure (Table I-1) will insure that all decontamination and cleaning residues are contained on the treatment plot and will be incorporated into the soil. The decontamination/cleaning will consist of a hydroblast to remove all waste/soil adhering to the equipment. This will be followed by a triple steam cleaning with a cold, clear water rinse after each steam cleaning.

The above procedures will be used when retiring individual pieces of equipment, and immediately at the end of the last operating season for the final equipment decontamination and cleaning.

All equipment retired from service, or at the final closure of the land treatment area, will be sold as surplus equipment after decontamination and cleaning.

I-1g Closure of Containers

Not applicable.

I-1h Closure of Tanks

Not applicable.

I-1i Closure of Waste Piles

Not applicable.

I-1j Closure Plan Amendment

The closure plan will be amended whenever changes in operating plans or facility design effect the closure plan, or whenever there is a change in the expected year of closure. The closure plan will be amended within 60 days after such a change occurs. The Operations Engineer is responsible for amending the closure plan and insuring that all revisions are included in the copies of this permit application maintained at the Chicago Refinery. This closure plan, and any revisions thereto, will be available for inspection at the Chicago Refinery, by the appropriate regulatory agency personnel.

I-2 Post-Closure Plan

At the end of the three year final closure period, the Chicago Refinery will implement the post-closure plan and maintain and inspect the land treatment area as described below.

After the certification of closure by an independent registered professional engineer and the Operations Engineer has been prepared and submitted to USEPA Region V, the Chicago Refinery intends to implement the post-closure plan by:

1. Utilizing Chicago Refinery security personnel to weekly (on a random schedule) inspect the fences and gates to insure that the fence remains intact and that all gates are locked.

2. The Operations Engineer, currently J. E. Purtell, will be responsible for the post-closure plan both prior to closure and during the post-closure period. The Operations Engineer will also be responsible for post-closure care, including post-closure inspections and corrective actions.

The Operations Engineer is located at the previously provided Union Oil address.

It is fully expected that all organics will have degraded within the three-year closure period such that no further operational maintenance, as plowing, discing, and pH control will be required. Consequently, this post-closure plan basically consists of continued ground water and unsaturated zone monitoring for a 30 year period. The surrounding fence and gates will be maintained throughout this 30 year period, as will access for sampling, inspection and/or maintenance.

Quarterly, the Operations Engineer -- currently a Mr. J. E. Portell, located at the Chicago Refinery -- will conduct an inspection of the complete land treatment area. This inspection will include all items shown on Table I-3, and will consist of a visual inspection of those areas also shown on Table I-2. Inspection logs (Figure I-1) will be used to develop an inspection record, and will be maintained by the Operations Engineer at the Chicago Refinery.

If the quarterly inspection shows repair or maintenance is required, the Operations Engineer has the authority to implement such repairs, and will do so by contracting for such services.

Ground water and unsaturated zone monitoring will be continued with samples taken on the schedule shown below:

Post-Closure Year	Sample Frequency
1 to 3	Quarterly
4 to 5	Bi-yearly
6 to 30	Bi-yearly

Analytical screening to detect migration of either organic and inorganic contaminants will consist of the screening procedures presented in Section E.

Run-on will be controlled by continued use, and maintenance of, site drainage which diverts all potential run-on around each land treatment plot. Run-off control will also continue to utilize the berm and controlled discharge arrangement operated during the active life of the land treatment site. As previously discussed, the Chicago Refinery will sample and analyze run-off from the land treatment plots to document that run-off is nonhazardous. The run-off will continue to be directed to the NPDES permitted wastewater treatment facility during the post-closure period.

The post-closure plan will be amended whenever changes in operating plans or facility design effect the post-closure plan, or should closure plan changes require modifications to the post-closure plan. The post-closure plan will be amended within 60 days after such a change occurs. The Operations Engineer is responsible for amending the post-closure plan and insuring that all revisions are included in the copies of this permit application maintained at the Chicago Refinery. This post-closure plan, and any revisions thereto, will be available for inspection at the Chicago Refinery, by either Illinois or USEPA regulatory agency personnel.

I-3 Notice in Deed and Notice to Local Land Authority

The Chicago Refinery will record a notation on the deed and property description of the land treatment area (as permitted under this Part B Permit Application) that will, in perpetuity, notify any potential purchaser of the property that the land has been used to treat hazardous waste and that its use is restricted under 40 CFR 264.117 (c); further, within 90 days after final closure, the Chicago Refinery will have a survey made for the purpose of preparing a property plot showing the location of the land

treatment plots, and this survey plot will be filed with both the local land authority and the USEPA Region V Administrator. A record of the type of hazardous wastes treated at the site, the location of where these hazardous wastes were applied and the quantities, will accompany the survey plot.

I-4 Closure Cost Estimate

Closure cost information is submitted in accordance with the requirements of 40 CFR 264.142, and 264.143.

This subsection presents the cost estimate for final closure and the retirement, decontamination, and disposal of individual hazardous waste handling equipment at the land treatment system, according to the procedures described in the previous sections. The estimated cost of final closure corresponds to the activities required to close the facility under the conditions that would make closure the most expensive, including:

- Maximum anticipated treatment of 4,620 dry tons of hazardous and nonhazardous wastes.

- Maximum extent of facility operation, as indicated on Figure I-2.

This estimate and all subsequent revisions will be kept by the Operations Engineer at the refinery at all times, and will be made available to either Illinois or USEPA inspectors on request. It should be noted that salary costs and other personnel related expenses (as obtaining samples)are not included in the closure cost estimate since these costs would be on-going costs incurred by the Chicago Refinery.

The total estimated cost of final closure of the land treatment operation amounts to $68,000 in 1984 dollars (Table I-3). This includes the cost of decontamination of all hazardous waste handling equipment and disposal of cleaning residues within the land treatment area, and the sowing of a final cover material to control erosion. The cost of decontaminating and disposing of individually retired equipment is presented in Table I-4.

The Operations Engineer is responsible for amending the estimated costs for final closure and for individual equipment retirement whenever these costs are affected by a change in the closure plan. In addition, these cost

estimates will be adjusted for inflation as of May 19 of each year using an inflation factor derived from the annual Implicit Price Deflator for Gross National Product as published by the U.S. Department of Commerce in its Survey of Current Business. The inflation factor is calculated by dividing the latest published annual Deflator by the Deflator for the previous year. The previous year's closure cost estimate is then adjusted by multiplying it by this inflation factor. For example:

1984 closure cost estimate		$ 68,000.00
1984 GNP deflator	@	220.52
1985 GNP deflator (hypothetical)	@	235.00

1985 adjusted closure cost would be adjusted by:

$$\frac{235.00}{220.52} \ (\$68,000) = \$\ 72,465$$

Estimates of the cost of individual equipment retirement as well as that of final closure will be adjusted each year. This estimate, and all subsequent revisions will be kept by the Operations Engineer at the refinery at all times, and

will be made available to either Illinois or USEPA inspectors on request.

I-5 Post-Closure Cost Estimate

Post-closure cost information is submitted in accordance with the requirements of 40 CFR 264.144 and 264.145.

This subsection presents the cost estimate for post-closure care, including security, monitoring, and periodic maintenance. No equipment is anticipated as being required, therefore, no cost estimate for equipment maintenance and replacement is included. Should maintenance be required, it is intended that contract service for such maintenance be will be used. As with the closure cost estimate, labor and personnel costs will be incurred by the Chicago Refinery.

This estimate and all subsequent revisions will be kept by the Operations Engineer at the refinery at all times, and will be made available to either Illinois or USEPA inspectors on request.

The total estimated post-closure costs for the 30 year period amounts to $220,500 in 1984 dollars (Table I-5).

This includes the cost for security inspection, sampling and analytical work, as well as fence and site maintenance.

The Operations Engineer is responsible for amending the estimated costs for post-closure whenever these costs are affected by a change in the post-closure plan. As described in Section I-4, the post-closure cost estimate will be adjusted annually for inflation by using the identical procedure used for closure costs.

I-6 Financial Assurance Mechanism for Closure, Post-Closure and Liability Requirements

The Chicago Refinery has elected to satisfy the financial assurance provisions of 40 CFR 264.143 and 40 CFR 264.147 by using the financial test and corporate guarantee for: closure; post-closure; and, liability requirements for sudden and nonsudden accidental occurrences of Section 264.151(g). Exhibits I-1, I-2, and I-3 are included in the back of this Section I to document this compliance:

Exhibit I-1: A letter from Chief Financial Officer (Illinois form IL 532-1206), worded as specified in Section 264.151 (g) and signed by Philip

Blaney, Vice-President, Finance, for Unocal Corporation and Union Oil of California.

Exhibit I-2: March 27, 1984, Specified report from independent certified public accountant Coopers and Lybrand.

Exhibit I-3: Copy of the 1983 Annual Report for the Unocal Corporation, of which the Union Oil Company of California is a subsidiary.

These three Exhibits will be updated annually, and the Operations Engineer will be responsible for replacing these Exhibits in each copy of the Part B permit application maintained at the Chicago Refinery. Such updated Exhibits will be available for inspection at the Chicago Refinery by either Illinois or USEPA regulatory agency personnel.

I-7 Proof of Financial Coverage by an Equivalent State Financial Mechanism

The Chicago Refinery will meet the requirements of 264.143, 264.145, and 264.147 without using any Illinois State mechanisms.

TABLE I-1

EQUIPMENT DECONTAMINATION PROCEDURES

1. Equipment to be decontaminated will be moved to the edge of one of the land treatment plots, at the upper slope, such that all wash/rinse waters will flow away from the equipment and be contained on the land treatment plot.

2. A high pressure water system (hydroblast) will be used to flush all soil/waste materials that are adhering to the equipment. This hydroblast will include all outer equipment surfaces, under-carriage, engine compartment and wheels or tracks. A visual inspection will be made to insure that no obvious residues remain on the equipment.

3. Following the hydroblast cleaning, a portable steam generator will be used to provide a triple steam cleaning of the equipment. After each steam cleaning, a cold water rinse will be used on all surfaces.

4. A final visual inspection will be made to insure that no pockets or accumulations of soil/waste can be found. If any such accumulations are found, the above procedures will be repeated.

TABLE I-2

POST-CLOSURE INSPECTION PROCEDURES

Responsible Personnel	Inspection Area	Frequency	Inspection Criteria
Security Guards	Fence & Gates	Weekly	Gates locked
	Monitoring Wells	(Random)	Signs in place
			No breaks in fence
Operations Engineer	Roads	Quarterly	Passable, no potholes
	Berms	Quarterly	Failure; Erosion
	Monitoring Wells	Quarterly	Caps in place; accessible
	Site Conditions	Quarterly	General aesthetics
	Run-on Diversion Ditches	Quarterly	Clear of debris
	Run-off Control	Quarterly	Clear of debris
	Fence & Gates	Quarterly	Locked & no breaks
	Signs	Quarterly	In-place & legible
	Vegetation	Quarterly	Coverage & general conditions

TABLE I-3

ESTIMATE OF CLOSURE COSTS
3 YEAR PERIOD

Description/Activity	Estimated Cost (1984 Dollars)
1. First Year	
Plowing:	
(13.3 acres)(7 Times/Season)(1 hr/acre)($12/hr)	$1,120
Discing:	
(13.3 acres)(14 Times/Season)(1 hr/acre)($12/hr)	2,230
2. Second Year	
Plowing:	
(13.3 acres)(7 Times/Season)(1 hr/acre)($13/hr)	1,210
Discing:	
(13.3 acres)(14 Times/Season)(1 hr/acre)($13/hr)	2,420
3. Decontamination of Equipment	
After last application	2,500
After first year	1,250
After second year	1,250
4. Seeding	1,720
5. Upgrade Fencing	12,500
6. Sampling and Analytical; 3 Year Period	21,800
7. Site Runoff and Run-on Control System; Repair and Upgrade	20,000
	$68,000

TABLE I-4

COST OF DECONTAMINATION AND DISPOSAL OF EQUIPMENT

Description/Activity	Estimated Cost (1984 Dollars)
1. Hydroblasting:	
Rental of Equipment	$ 800
Hoses & connection to water hydrant	600
Electrical Generator Rental	500
2. Steam Cleaning:	
Rental of Steam Generator	350
Hoses & connection to water hydrant	250
3. Assumed Salvage Value	0
	$2,500

Note: Normal equipment requirements for the second and third year of closure would reduce the above estimate by approximately half for each year.

TABLE I-5

ESTIMATE OF POST-CLOSURE COSTS
30 YEAR PERIOD

Description/Activity	Estimated Cost (1984 Dollars)	
1. Sampling and Analytical:		
Year 1 to 3; Quarterly Samples	$ 24,000	
Year 4 to 5; Biyearly Samples	16,500	
Year 6 to 30; Biyearly Samples	111,000	***
2. Fence Maintenance:		
Repair/replace sections every 5 years 6 replacements x ($5,000 each)	30,000	
3. Site Maintenance (generally every 5 years):		
Reseeding; 3 times at $2,000/time	6,000	
Road and access control; 6 times at $2,000/time	12,000	
Drainage maintenance; 6 times at $3,500/time	21,000	
	$220,500	***

TABLE I-1

EQUIPMENT DECONTAMINATION PROCEDURES

1. Equipment to be decontaminated will be moved to the edge of one of the land treatment plots, at the upper slope, such that all wash/rinse waters will flow away from the equipment and be contained on the land treatment plot.

2. A high pressure water system (hydroblast) will be used to flush all soil/waste materials that are adhering to the equipment. This hydroblast will include all outer equipment surfaces, under-carriage, engine compartment and wheels or tracks. A visual inspection will be made to insure that no obvious residues remain on the equipment.

3. Following the hydroblast cleaning, a portable steam generator will be used to provide a triple steam cleaning of the equipment. After each steam cleaning, a cold water rinse will be used on all surfaces.

4. A final visual inspection will be made to insure that no pockets or accumulations of soil/waste can be found. If any such accumulations are found, the above procedures will be repeated.

TABLE I-2

POST-CLOSURE INSPECTION PROCEDURES

Responsible Personnel	Inspection Area	Frequency	Inspection Criteria
Security Guards	Fence & Gates Monitoring Wells	Weekly (Random)	Gates locked Signs in place No breaks in fence
Operations Engineer	Roads	Quarterly	Passable, no potholes
	Berms	Quarterly	Failure; Erosion
	Monitoring Wells	Quarterly	Caps in place; accessible
	Site Conditions	Quarterly	General aesthetics
	Run-on Diversion Ditches	Quarterly	Clear of debris
	Run-off Control	Quarterly	Clear of debris
	Fence & Gates	Quarterly	Locked & no breaks
	Signs	Quarterly	In-place & legible
	Vegetative Cover	Quarterly	Coverage & general conditions

TABLE I-3

ESTIMATE OF CLOSURE COSTS
3 YEAR PERIOD

Description/Activity	Estimated Cost (1984 Dollars)
1. First Year	
Plowing:	
(13.3 acres)(7 Times/Season)(1 hr/acre)($12/hr)	$1,120
Discing:	
(13.3 acres)(14 Times/Season)(1 hr/acre)($12/hr)	2,230
2. Second Year	
Plowing:	
(13.3 acres)(7 Times/Season)(1 hr/acre)($13/hr)	1,210
Discing:	
(13.3 acres)(14 Times/Season)(1 hr/acre)($13/hr)	2,420
3. Decontamination of Equipment	
After last application	2,500
After first year	1,250
After second year	1,250
4. Seeding	1,720
5. Upgrade Fencing	12,500
6. Sampling and Analytical; 3 Year Period	21,800
7. Site Runoff and Run-on Control System; Repair and Upgrade	20,000
	$68,000

TABLE I-4

COST OF DECONTAMINATION AND DISPOSAL OF EQUIPMENT

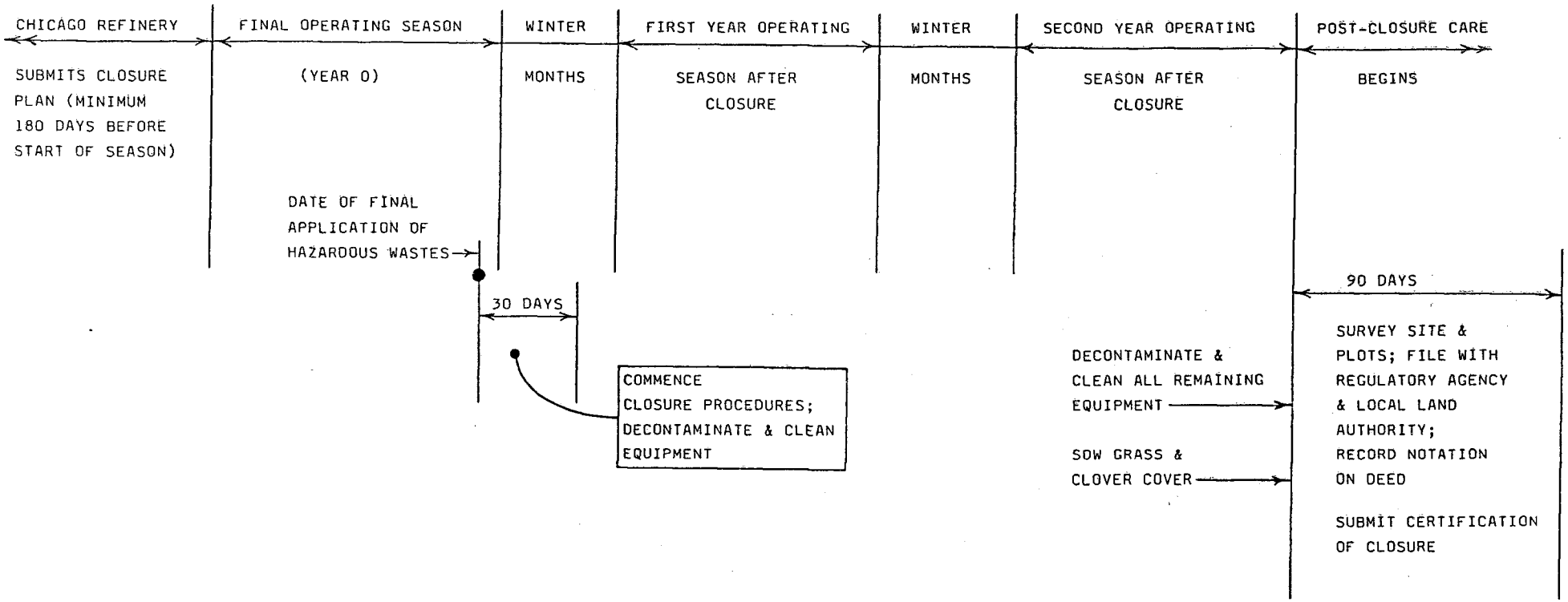
Description/Activity	Estimated Cost (1984 Dollars)
1. Hydroblasting:	
Rental of Equipment	$ 800
Hoses & connection to water hydrant	600
Electrical Generator Rental	500
2. Steam Cleaning:	
Rental of Steam Generator	350
Hoses & connection to water hydrant	250
3. Assumed Salvage Value	0
	$2,500

Note: Normal equipment requirements for the second and third year of closure would reduce the above estimate by approximately half for each year.

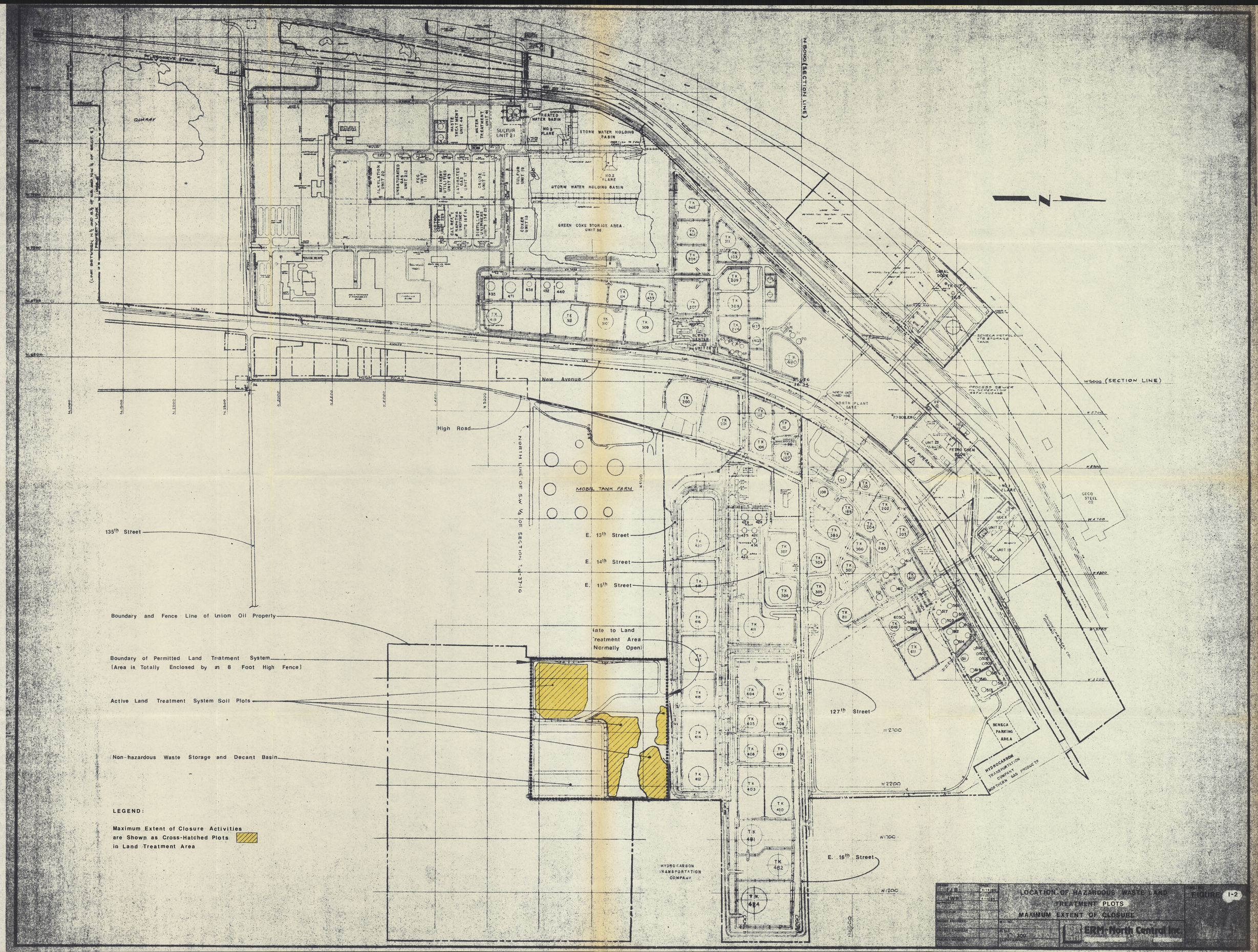
TABLE I-5

ESTIMATE OF POST-CLOSURE COSTS
30 YEAR PERIOD

Description/Activity	Estimated Cost (1984 Dollars)
1. Sampling and Analytical:	
Year 1 to 3; Quarterly Samples	$24,000
Year 4 to 5; Biyearly Samples	16,500
Year 6 to 30; Yearly Samples	55,500
2. Fence Maintenance:	
Repair/replace sections every 5 years 6 replacements x ($5,000 each)	30,000
3. Site Maintenance (generally every 5 years):	
Reseeding; 3 times at $2,000/time	6,000
Road and access control; 6 times at $2,000/time	12,000
Drainage maintenance; 6 times at $3,500/time	21,000
	$165,000



DRAWN	DATE	CLOSURE SCHEDULE	DWG. NO. FIGURE I-1
CHECKED			
APPROVED			
ISSUED FOR			
DESIGN ENGINEER		W.O. NO.	ERM-North Central Inc.
PROJECT ENGINEER		SCALE	
PROJECT MANAGER		CLIENT APPROVAL	SHEET OF



F.I.B.		LOCATION OF HAZARDOUS WASTE LAND TREATMENT PLOTS MAXIMUM EXTENT OF CLOSURE
HWP		FIGURE 1-2
		ERM-North Central Inc.

FIGURE I-3

POST-CLOSURE INSPECTION LOG

Date of Inspection:
Name of Inspector:

Note the Condition of the Following Items:	Adequate	Inadequate
1. Fence, Gates & Locks:		
2. Warning Signs:		
3. Berms:		
4. Monitoring Wells/Lysimeters:		
5. Roadways:		
6. Run-On Diversion Ditches:		
7. Run-off Control:		

If repairs are required, note below:

Attach copies of all repair/maintenance requests and completion report or invoices.

Signature_____

EXHIBIT I-1

Letter From Chief Financial Officer

(Illinois Form IL 532-1206 LPC 154 2/84)

LETTER FROM CHIEF FINANCIAL OFFICER

(To demonstrate liability coverage and/or to demonstrate both liability coverage and assurance of closure and/or post-closure care.)

Director
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62706

Dear Sir or Madam:

I am the chief financial officer of Unocal Corporation and Union Oil Company of California, 461 South Boylston Street, Los Angeles, CA (1) 90017.

This letter is in support of the use of the financial test to demonstrate financial responsibility for liability coverage and closure and/or (2) post-closure care as specified in Subpart H of 40 CFR Parts 264 and 265 and/or Subpart H of 35 Illinois Administrative Code Parts 724 and 725.

The owner or operator identified above is the owner or operator of the following facilities for which liability coverage is being demonstrated through the financial test specified in Subpart H of 40 CFR Parts 264 and 265 and/or tests equivalent or substantially equivalent, and/or Subpart H of 35 Illinois Administrative Code Parts 724 and 725:

USEPA I.D. No. See ATTACHMENT A

(3)

Name

Address

Please attach a separate page if more space is needed for all facilities.

See Instruction (4)

1. This firm is the owner or operator of the following facilities for which financial assurance for closure and/or post-closure care is demonstrated through the financial test specified in Subpart H of 35 Ill. Adm. Code Parts 724 and 725. The current closure and/or post-closure cost estimates covered by the test are shown for each facility: (LIST ALL THE ILLINOIS FACILITIES USING THE FINANCIAL TEST)

	Closure Amount (6)	Post-Closure Amount (7)	Closure and Post-Closure Amounts (8)
USEPA I.D. No. 0415 50567 (5)			
Name Chicago Refinery (Union Oil Company)	$68,000	$165,000	$233,000
Address 135th Street and New Avenue			
City Lemont, IL 60439			
USEPA I.D. No.			
Name			
Address			
City			

This Agency is authorized to require this information under Illinois Revised Statutes, 1981, Chapter 111 1/2, Section 2110. Disclosure of this information is required. Failure to do so may result in a civil penalty not to exceed $25,000 per day of violation. Falsification of this information may constitute a Class 4 felony, which also carries a fine of up to $25,000 per day of violation for the first offense. This form has been approved by the Forms Management Center.

Please attach a separate page if more space is needed for all facilities.

2. This firm guarantees, through the corporate guarantee specified in Subpart H of 35 Ill. Adm. Code Parts Parts 724 and 725, the closure and/or post-closure care of the following facilities owned or operated by subsidiaries of this firm. The current cost estimates for closure and/or post-closure care so guaranteed are shown for each facility: (LIST ALL THE ILLINOIS FACILITIES USING THE CORPORATE GUARANTEE)

I PA I.D. No. (5)	Closure Amount (6)	Post-Closure Amount (7)	Closure and Post-Closure Amounts (8)
Name None			
Address			
City			
USEPA I.D. No.			
Name			
Address			
City			

Please attach a separate page if more space is needed for all facilities.

3. For states other than Illinois this owner or operator or guarantor is demonstrating financial assurance for the closure or post-closure care of the following facility through the use of a test equivalent or substantially equivalent to the financial test specified in Subpart H of 40 CFR Parts 264 and 265. The current closure and/or post-closure cost estimates covered by such a test are shown for each facility: (LIST ALL FACILITIES WHICH ARE NOT IN ILLINOIS BUT ARE SUBJECT TO A STATE OR FEDERAL FINANCIAL ASSURANCE REQUIREMENT THAT ARE ASSURED BY A FINANCIAL TEST OR CORPORATE GUARANTEE)

I PA I.D. No. (5)	Closure Amount (6)	Post-Closure Amount (7)	Closure and Post-Closure Amounts (8)
Name See ATTACHMENT B			
Address			
City			
USEPA I.D. No.			
Name			
Address			
City			

Please attach a separate page if more space is needed for all facilities.

4. This firm is the owner or operator of the following hazardous waste management facilities for which financial assurance for closure or, if a disposal facility, post-closure care, is *NOT* demonstrated either to IEPA, USEPA or a State through the financial test or any other financial assurance mechanism specified in Subpart H of 40 CFR Parts 264 and 265 or equivalent or substantially equivalent state mechanisms. The current closure and/or post-closure cost estimates not covered by such financial assurance are shown for each facility: (LIST FACILITIES IN RCRA AUTHORIZED STATES WHERE THERE IS NO STATE FINANCIAL ASSURANCE REQUIREMENT)

I PA I.D. No. (5)	Closure Amount (6)	Post-Closure Amount (7)	Closure and Post-Closure Amounts (8)
Name None			
Address			
City			

USEPA I.D. No. _____

Name _____

Address _____ _____

_____

Please attach a separate page if more space is needed for all facilities.

This owner or operator is required (9) to file a Form 10K with the Securities and Exchange Commission (SEC) for the latest fiscal year.

The fiscal year of this owner or operator ends on December 31 (10)*. The figures for the following items marked with an asterisk are derived from this owner's or operator's independently audited, year-end financial statements for the latest completed fiscal year, ended December 31, 1983 (11).

Part A. Liability Coverage for Accidental Occurrences (See Instruction 12 and (13)

Alternative I

1. Amount of annual aggregate liability coverage to be demonstrated ..... $_____

*2. Current assets ..... $_____

*3. Current liabilities ..... $_____

4. Net working capital (line 2 minus line 3) ..... $_____

*5. Tangible net worth ..... $_____

*6. If less than 90% of assets are located in the U.S., give total U.S. assets ..... $_____

	Yes	No
7. Is line 5 at least $10 million?	_____	_____
8. Is line 4 at least 6 times line 1?	_____	_____
9. Is line 5 at least 6 times line 1?	_____	_____
*10. Are at least 90% of assets located in the U.S.? If not, complete line 11.	_____	_____
11. Is line 6 at least 6 times line 1?	_____	_____

Signature _____

Typed name _____

Title _____

Date _____

Part A. Liability Coverage for Accidental Occurrences (See Instruction 12 and (13)

Alternative II

1. Amount of annual aggregate liability coverage to be demonstrated ..... $_____

2. Current bond rating of most recent issuance and name of rating service ..... _____

3. Date of issuance of bond ..... _____

4. Date of maturity of bond ..... _____

*5. Tangible net worth ..... $_____

*6. Total assets in U.S. (required only if less than 90% of assets are located in U.S.) ..... $_____

	Yes	No
7. Is line 5 at least $10 million?	_____	_____
8. Is line 5 at least 6 times line 1?	_____	_____
*9. Are at least 90% of assets located in the U.S.? If not, complete line 10.	_____	_____
10. Is line 6 at least 6 times line 1?	_____	_____

ature _____

Typed name _____

Title _____

Date _____

Part B. Closure or Post-Closure Care and Liability Coverage (See Instructions 14 and 15)

Alternative I

1.	Sum of current closure and post-closure cost estimates (total of *all* cost estimates listed above)	$ 11,455,140
2	Amount of annual aggregate liability coverage to be demonstrated	$ 8,000,000
3.	Sum of lines 1 and 2	$ 19,455,140
*4.	Total liabilities (if any portion of your closure or post-closure cost estimates is included in your total liabilities, you may deduct that portion from this line and add that amount to lines 5 and 6)	$ 4,047.9 million
*5.	Tangible net worth	$ 5,180.1 million
*6.	Net worth	$ 5,180.1 million
*7.	Current assets	$ 1,896.4 million
*8.	Current liabilities	$ 1,439.6 million
9.	Net working capital (line 7 minus line 8)	$ 456.8 million
*10.	The sum of net income plus depreciation, depletion, and amortization	$ 1,422.6 million
*11.	Total assets in U.S. (required only if less than 90% of assets are located in the U.S.)	$ 7,759.1 million

		Yes	No
12.	Is line 5 at least $10 million?	X	
13.	Is line 5 at least 6 times line 3?	X	
14.	Is line 9 at least 6 times line 3?	X	
*15.	Are at least 90% of assets located in the U.S.? If not, complete line 16.		X
16.	Is line 11 at least 6 times line 3?	X	
17.	Is line 4 divided by line 6 less than 2.0?	X	
18	's line 10 divided by line 4 greater than 0.1?	X	
19	s line 7 divided by line 8 greater than 1.5?		X

Signature: Philip Blamey

Typed name: Philip Blamey

Title: Vice President, Finance

Date: March 27, 1984

Part B. Closure or Post-Closure Care and Liability Coverage (See Instructions 14 and 15)

Alternative II

1. Sum or current closure and post-closure cost estimates (total of all cost estimates listed above) ..... $ 11,455,140
2. Amount of annual aggregate liability coverage to be demonstrated ..... $ 8,000,000
3. Sum of lines 1 and 2 ..... $ 19,455,140
4. Current bond rating of most recent issuance and name of rating service ..... Aal Moody's
5. Date of issuance of bond 11/1/82
6. Date of maturity of bond 11/1/92

*7. Tangible net worth (if any portion of the closure or post-closure cost estimates is included in "total liabilities" on your financial statements you may add that portion to this line) ..... $ 5,180.1 million

*8. Total assets in the U.S. (required only is less than 90% of assets are located in the U.S.) ..... $ 7,759.1 million

		Yes	No
9.	Is line 7 at least $10 million?	X	
10.	Is line 7 at least 6 times line 3?	X	
*11.	Are at least 90% of assets located in the U.S.? If not, complete line 12.		X
12.	Is line 8 at least 6 times line 3?	X	

Signature Philip Blamey

Typed name Philip Blamey

Title Vice President, Finance

March 27, 1984

ATTACHMENT A.

EPA I.D. No. TXD010794097 - Beaumont Refinery, P.O. Box 237, Beaumont, TX 77627
Closure Cost Est. $4,081,000 Post-Closure Est. $2,489,000
Closure and Post-Closure $6,570,000

EPA I.D. No. ILD041550567 - Chicago Refinery, 135th St. & New Avenue, Lemont, IL 60439
Closure Cost Est. $68,000 Post-Closure Cost Est. $165,000
Closure and Post-Closure $233,000

EPA I.D. No. CAD009108705 - San Francisco Refinery, Rodeo, CA 94572
Closure Cost Est. $394,000 Post-Closure Cost Est. $361,000
Closure and Post-Closure $755,000

EPA I.D. No. CAT080010796 - Santa Maria Refinery, Rt. 3 Box 7600, Arroyo Grande, CA 93420
Closure Cost Est. $520,000 Post-Closure Est. None
Closure and Post-Closure $520,000

EPA I.D. No. ORD000618041 - Union Chemicals Nitrogen Div. Rivergate Terminal, 14003 N. Rivergate Blvd, Portland, OR 97203
Closure Cost Est. $200 Post-Closure Cost Est. None
Closure and Post-Closure $200

EPA I.D. No. AKD092876390 - Kenai Plant, P.O. Box 575, Kenai, AK 99611
Closure Cost Est. $232,000 Post-Closure Cost Est. None
Closure and Post-Closure $232,000

EPA I.D. No. CAD000626135 - Union Chemical Nitrogen Div. Sacramento Terminal, 3961 Channel Drive, West Sacramento, CA 95691
Closure Cost Est. $400 Post-Closure Est. None
Closure and Post-Closure $400

EPA I.D. No. COD076448794 - Molycorp, Inc., P.O. Box 37, Louviers, CO 80131
Closure Cost Est. $209,600 Post-Closure Est. None
Closure and Post-Closure $209,600

ATTACHMENT A.
(continued)

EPA I.D. No. PAD003025624 - Molycorp, Inc., 350 N. Sherman St., York, PA 17403
Closure Cost Est. $11,940 Post-Closure Est. None
Closure and Post-Closure $11,940

EPA I.D. No. CAD009539321 - Molycorp, Inc. Mountain Pass Operation, Mountain Pass, CA 92366
Closure Cost Est. $2,340,000 Post-Closure Est. $260,000
Closure and Post-Closure $2,600,000

EPA I.D. No. PAD030068282 - Molycorp, Inc.
P.O. Box 500, Washington, PA 15301
Closure Cost Est. $319,000 Post-Closure Est. $2,000
Closure and Post-Closure $321,000

EPA I.D. No. WAC068794387 - Allstate Oil Co. dba Inman Oil Co., 1300 W. 12th St., Vancouver, WA 98660
Closure Cost Est. $2,000 Post-Closure Est. None
Closure and Post-Closure $2,000

ATTACHMENT B.

EPA I.D. No. TXD010794097 - Beaumont Refinery, P.O. Box 237, Beaumont, TX 77627
Closure Cost Est. $4,081,000 Post-Closure Est. $2,489,000
Closure and Post-Closure $6,570,000

EPA I.D. No. CAD009108705 - San Francisco Refinery, Rodeo, CA 94572
Closure Cost Est. $394,000 Post-Closure Cost Est. $361,000
Closure and Post-Closure $755,000

EPA I.D. No. CAT080010796 - Santa Maria Refinery, Rt. 3 Box 7600, Arroyo Grande, CA 93420
Closure Cost Est. $520,000 Post-Closure Est. None
Closure and Post-Closure $520,000

EPA I.D. No. ORD000618041 - Union Chemicals Nitrogen Div. Rivergate Terminal, 14003 N. Rivergate Blvd, Portland, OR 97203
Closure Cost Est. $200 Post-Closure Cost Est. None
Closure and Post-Closure $200

EPA I.D. No. AKD092876390 - Kenai Plant, P.O. Box 575, Kenai, AK 99611
Closure Cost Est. $232,000 Post-Closure Cost Est. None
Closure and Post-Closure $232,000

EPA I.D. No. CAD000626135 - Union Chemical Nitrogen Div. Sacramento Terminal, 3961 Channel Drive, West Sacramento, CA 95691
Closure Cost Est. $400 Post-Closure Est. None
Closure and Post-Closure $400

EPA I.D. No. COD076448794 - Molycorp, Inc., P.O. Box 37, Louviers, CO 80131
Closure Cost Est. $209,600 Post-Closure Est. None
Closure and Post-Closure $209,600

ATTACHMENT B.
(continued)

EPA I.D. No. PAD003025624 - Molycorp, Inc., 350 N. Sherman St., York, PA 17403
Closure Cost Est. $11,940 Post-Closure Est. None
Closure and Post-Closure $11,940

EPA I.D. No. CAD009539321 - Molycorp, Inc. Mountain Pass Operation, Mountain Pass, CA 92366
Closure Cost Est. $2,340,000 Post-Closure Est. $260,000
Closure and Post-Closure $2,600,000

EPA I.D. No. PAD030068282 - Molycorp, Inc.
P.O. Box 500, Washington, PA 15301
Closure Cost Est. $319,000 Post-Closure Est. $2,000
Closure and Post-Closure $321,000

EPA I.D. No. WAC068794387 - Allstate Oil Co. dba Inman Oil Co., 1300 W. 12th St., Vancouver, WA 98660
Closure Cost Est. $2,000 Post-Closure Est. None
Closure and Post-Closure $2,000

EXHIBIT I-2

Report From Independent Certified Public Accountant

Coopers
&Lybrand

certified public accountants

1000 West Sixth Street
Post Office Box 17919
Los Angeles, Ca 90017-0919

telephone (213) 481-1000
telex 9103213148
cables Colybrand

in principal areas of the world

March 27, 1984

Union Oil Company of California
Union Oil Center
Los Angeles, California 90017

Gentlemen:

We have examined the consolidated balance sheet of Unocal Corporation and its consolidated subsidiary, Union Oil Company of California, as of December 31, 1983, and related consolidated statements of earnings, shareowners' equity, and changes in financial position for the year then ended, and have issued our report thereon dated February 14, 1984. Our examination was made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

At your request, we performed the following agreed-upon procedures:

1. Read 40 CFR 264.147(f)(3)(iii) of the Environmental Protection Agency (EPA) "Standards Applicable to Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities: Liability Requirements" in the Federal Register dated April 16, 1982. Such section sets forth the reporting requirements of the auditors of Unocal Corporation and its consolidated subsidiary, Union Oil Company of California, pursuant to the EPA rules and regulations.

2. As to the following selected financial data required by 40 CFR 264.151(g) Part B:

   A. We compared the amounts listed below for December 31, 1983 and for the year then ended to the aforementioned consolidated financial statements and related notes to consolidated financial statements and found them to be in agreement.

   B. We compared the amounts as listed below to Union Oil Company of California's letter dated March 27, 1984, found them to be in agreement.

Selected Financial Data	In Millions Of Dollars
Total liabilities	$4,047.9
Tangible net worth	$5,180.1
Net worth	$5,180.1
Current assets	$1,896.4
Current liabilities	$1,439.6
Net income	$625.9
Depreciation and amortization	796.7
	$1,422.6

Asset Data	
United States	$7,206.1
Corporate and unallocated	553.0
Total assets in the United States	7,759.1
Foreign assets	1,468.9
Total consolidated assets	$9,228.0

In connection with the procedures referred to above, no matters came to our attention that caused us to believe that the above amounts should be adjusted.

Very truly yours,

Coopers & Lybrand

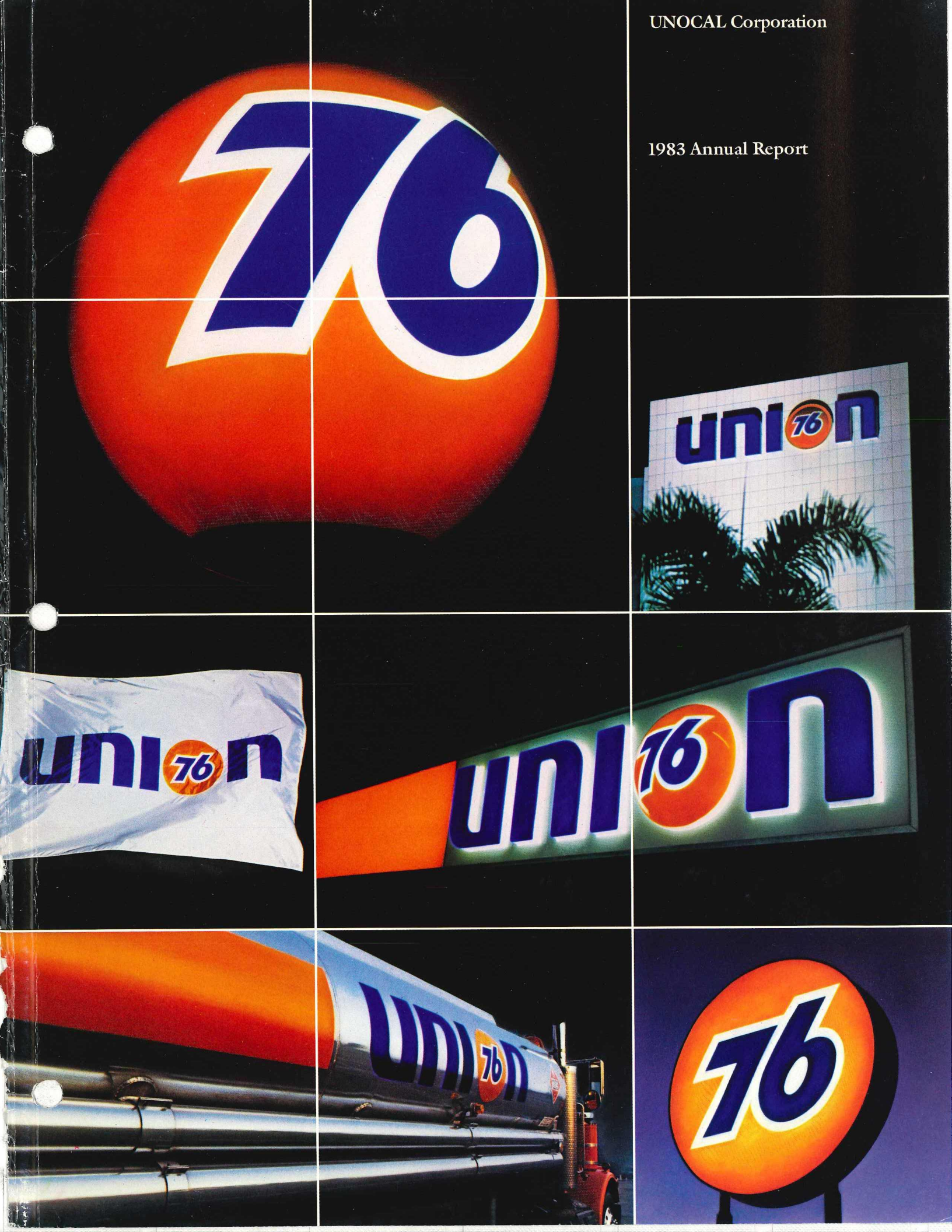
EXHIBIT I-3

Most Recent Annual Report

Unocal Corporation

UNOCAL Corporation

1983 Annual Report



The Company

Unocal Corporation, a Delaware holding company, is the parent of Union Oil Company of California (Union), an integrated, high technology earth resources company.

Union explores for, develops and produces conventional crude oil and natural gas resources in the United States, Canada and overseas. In addition, Union is a leader in the development of alternative energy resources. The company is the world's largest producer of geothermal energy, producing steam to power more than 1.5 million kilowatts of electrical generating capacity in the United States and the Philippines. Union's 10,000 barrel per day shale oil project in western Colorado, now in start-up, will be the United States' first commercial shale oil venture.

The company also manufactures and markets a wide range of petroleum products, chemicals, fertilizers and specialty metals.

The Cover

Union Oil Company of California's familiar "76" trademark has long been a sign of quality motor fuels and lubricants. Today, the well-known "Sign of the 76" stands not only for petroleum products, but also a wide range of chemicals, fertilizers and specialty metals which are sold in the United States and overseas.

1984 Annual Meeting

The 1984 annual meeting of sha owners will be held on Monday, April 30, 1984, at 10:00 a.m. Paci Daylight Saving Time in the audi rium of Union Oil Center, 461 S Boylston Street, Los Angeles, Ca nia. The Board of Directors exte cordial invitation to all shareowr to attend this meeting. A formal notice, together with a proxy stat ment and form of proxy, will be mailed to each shareowner in M at which time proxies will be requested by management.

Services for Shareowners

The following may be obtained b writing to the Corporate Secreta Unocal Corporation, P.O. Box 76 Los Angeles, California 90051 o calling toll free California (800) 252-0470, toll free outside Calif (800) 421-8086:

- Annual Report on Form 10-K, filed with the Securities and Exchange Commission.
- Chairman and President Fred Hartley's regular newsletter to employees.
- Information concerning the A matic Dividend Reinvestment Service, which provides a simple method to reinvest dividends an to invest additional funds toward purchase of the company's comm shares.
- *Seventy Six* magazine containi articles concerning company activities.
- Information concerning your shareholder account.

Stock Transfer Agent

Union Oil Company of Californi
Los Angeles, California 90051

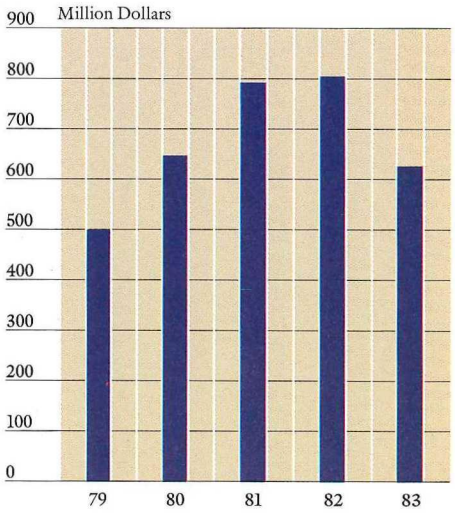
Stock Registrar

Security Pacific National Bank
Los Angeles, California 90051

Highlights

	1983	1982	1981
Financial			
(dollars in millions except per share amounts)			
Total revenues	**$10,690.5**	$10,899.1	$11,296.2
Net earnings	**$ 625.9**	$ 804.0	$ 791.4
Per share	**$3.60**	$4.63	$4.56
Return on average shareowners' equity	**12.6%**	18.2%	20.8%
Cash dividends declared—per share	**$1.00**	$1.00	$.90
Shareowners' equity	**$ 5,180.1**	$ 4,745.1	$ 4,114.2
Per share	**$29.82**	$27.33	$23.70
Capital and exploration expenditures	**$ 1,751.0**	$ 2,075.7	$ 1,961.4
Total assets	**$ 9,228.0**	$ 8,511.3	$ 7,592.8
Funds provided from operations (cash flow)	**$ 1,799.2**	$ 1,987.1	$ 1,811.7
Operations			
Reserves at year end			
Crude oil (million barrels)	**715**	728	731
Natural gas (billion cubic feet)	**6,365**	6,393	7,121
Geothermal (billion kilowatt hours)	**202**	208	210
Production—daily			
Crude oil (barrels)	**226,000**	220,000	215,800
Natural gas (thousand cubic feet)	**982,500**	1,178,900	1,206,300
Natural gas liquids (barrels)	**17,500**	20,100	20,300
Geothermal (million kilowatt hours)	**16.0**	13.7	12.7
Input to crude oil processing units (barrels daily)	**380,300**	363,900	372,400
Sales of petroleum products (barrels daily)	**386,000**	364,200	365,300

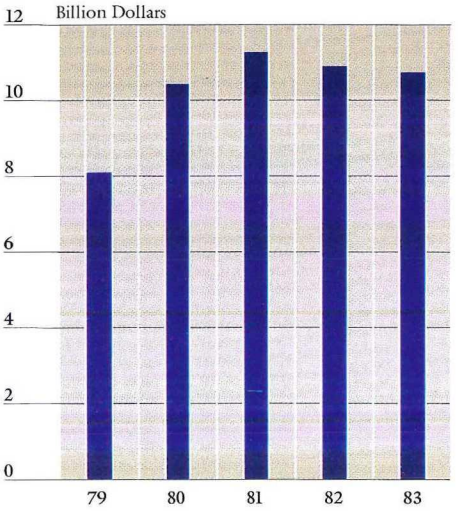
Net Earnings



To our shareowners:

For the record, 1983 was the year Union Oil Company of California, a California corporation, became the subsidiary of Unocal Corporation, a Delaware holding company. The major purpose of this reincorporation, which was approved at the April annual meeting by a substantial majority, is to assure that all shareholders are treated fairly if an outside group should attempt to obtain control of the company. In addition, the holding company structure provides added flexibility for the company to expand, if economically sound, into areas (such as regulated industries) that are currently difficult for Union Oil to enter.

Total Revenues
(including consumer excise taxes)



The year 1983 was a year of change, both for Unocal and the petroleum industry. Reflecting the combined impacts of three industry-wide adverse factors—reduced natural gas sales, lower average natural gas prices and depressed refining and marketing margins—Unocal's earnings declined by 22 percent from 1982's record high level. With the present general improvement in business conditions and the return to a more normal winter, we now anticipate higher earnings in 1984.

Net 1983 earnings by Unocal Corporation and its wholly owned subsidiary, Union Oil Company of California, were $626 million, down from $804 million in 1982. Earnings per share were $3.60, compared with $4.63 from the previous year. Total 1983 revenues were $10.7 billion, down from $10.9 billion in 1982.

Because of lower earnings, we reduced 1983's capital and exploration spending to $1.75 billion, down from nearly $2.1 billion in 1982. Some $1.4 billion, or 83 percent of 1983's spending, was for energy-related activities—oil and gas, shale oil, geothermal and coal.

Fortunately, competition significantly reduced construction and drilling costs, so we got more for our money compared to the boom oil years of the early 1980s.

The company's financial structure continues to be strong. At the end of 1983, long-term debt, including capital lease obligations, was 20.1 percent of total capitalization, compared with 21.1 percent in 1982. Dividends paid per common share totaled one dollar in 1983, the 68th consecutive year in which quarterly cash dividends were paid.

It is encouraging to note that 1983 saw significant gains in the nation's economy:

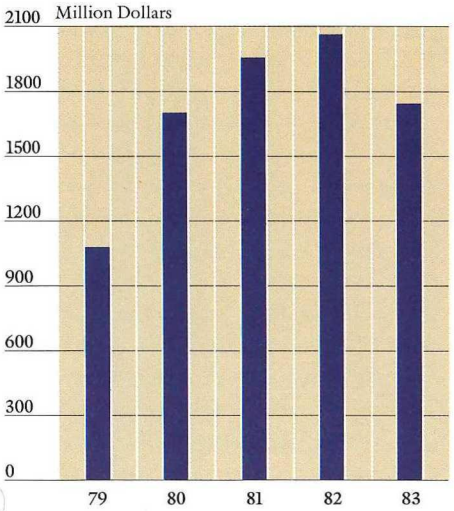
- Inflation in 1983 was 3.2 percent, the lowest rate since 1967 and down drastically from the 1980 high of 13.5 percent.
- Employment is at an all-time high and worker productivity is increasing. From 1982 to 1983, productivity increased by nearly three percent per man hour, with a similar increase expected in 1984. Lower inflation and higher productivity can be the springboard for long-term prosperity at stable prices.
- Interest rates are down sharply from the 21 percent prime rate in 1981, but for some reason remain three percent or more higher than they should be and are, therefore, a continuing possible cause for a future surge of inflation.

Despite the short-term problems of 1983, our strategy for the future has not changed. We are an independent high-technology company seeking innovative and profitable ways to find and produce a variety of the earth's resources. We continue to focus on expanding our resource base, especially domestic oil and natural gas, on reducing costs, and on pursuing ways to expand the markets for our products.

Both our worldwide and our domestic oil production rose in 1983. Our year-end domestic oil reserves exceeded those of the prior year.

Our refining, marketing and chemical operations, despite the problems of a recession and general product oversupply, all operated efficiently and profitably. Our total sales of refined petroleum products increased by six percent, to 386,000 barrels per day.

Capital and Exploration Expenditures



At year end, we successfully brought into production our large new molybdenum mine and modernized mill at Questa, New Mexico—a $250 million vote of confidence in the future.

Our alternative energy resources—geothermal and oil shale—also continue to grow in importance. Of the dollars invested in energy-related projects in 1983, 13 percent was spent on geothermal energy and oil shale projects.

In 1983, our net geothermal production in the United States and the Philippines was up 17 percent from the prior year, and was the energy equivalent of 24,000 barrels of oil per day. At year end, we had completed work on Phase I of our commercial shale oil project—a 10,000 barrel per day plant in western Colorado—and moved into equipment testing and start-up activities.

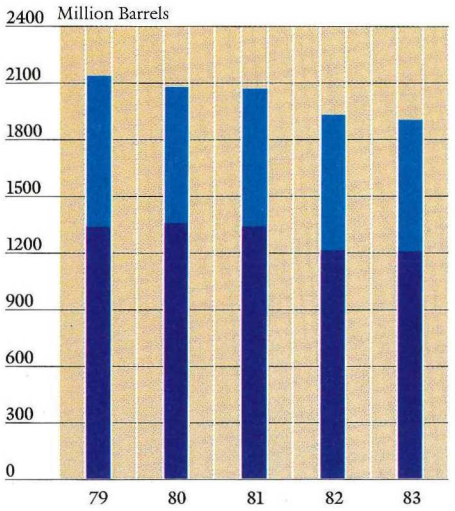
Innovation remains the key to our future—in resource development, in process technology and in products and services. With our proven management team and our strong financial structure, I am confident that our long-term outlook is excellent.

I wish to thank our shareowners, employees and customers for their continued strong support.

Fred L. Hartley

Chairman and President
February 27, 1984

Crude Oil and Natural Gas Reserves: Crude Oil Equivalent*



Worldwide
■ Crude Oil
■ Natural Gas
**Based on energy*

Worldwide Petroleum Exploration and Production Highlights

- Second consecutive year of higher worldwide crude oil production.
- Increases in domestic crude oil reserves and production.
- Discovery of an important new oil field in the Santa Maria Basin offshore California.

Capital and exploration expenditures for petroleum exploration and production activities, the foundation of the company's growth and continued profitability, totaled nearly $1.2 billion in 1983, an 18 percent decrease from 1982. Of this total, 52 percent was spent in the United States.

Worldwide net crude oil and condensate production averaged 226,000 barrels per day, up three percent from 220,000 barrels per day in 1982. Net proven crude oil and condensate reserves were 715 million barrels, compared with 728 million barrels in 1982.

Net natural gas production for the year averaged 982 million cubic feet per day, compared with 1,179 million cubic feet per day during 1982. Year-end worldwide natural gas reserves were 6,365 billion cubic feet, compared with 6,393 billion cubic feet in 1982.

Union Oil and Gas Division

Domestic capital and exploration expenditures totaled nearly $606 million in 1983, a 31 percent decrease from 1982. This investment resulted in bringing new fields into production, discovering new reserves and acquiring competitive lease positions in prime prospective areas.

Domestic operations represented 68 percent of the company's crude oil production and 83 percent of its natural gas production. In the U.S., crude oil and condensate production averaged 152,900 barrels per day, up one percent from 151,300 barrels per day in 1982. Domestic crude oil and condensate reserves were 527 million barrels, an increase from 523 million barrels at the end of 1982.

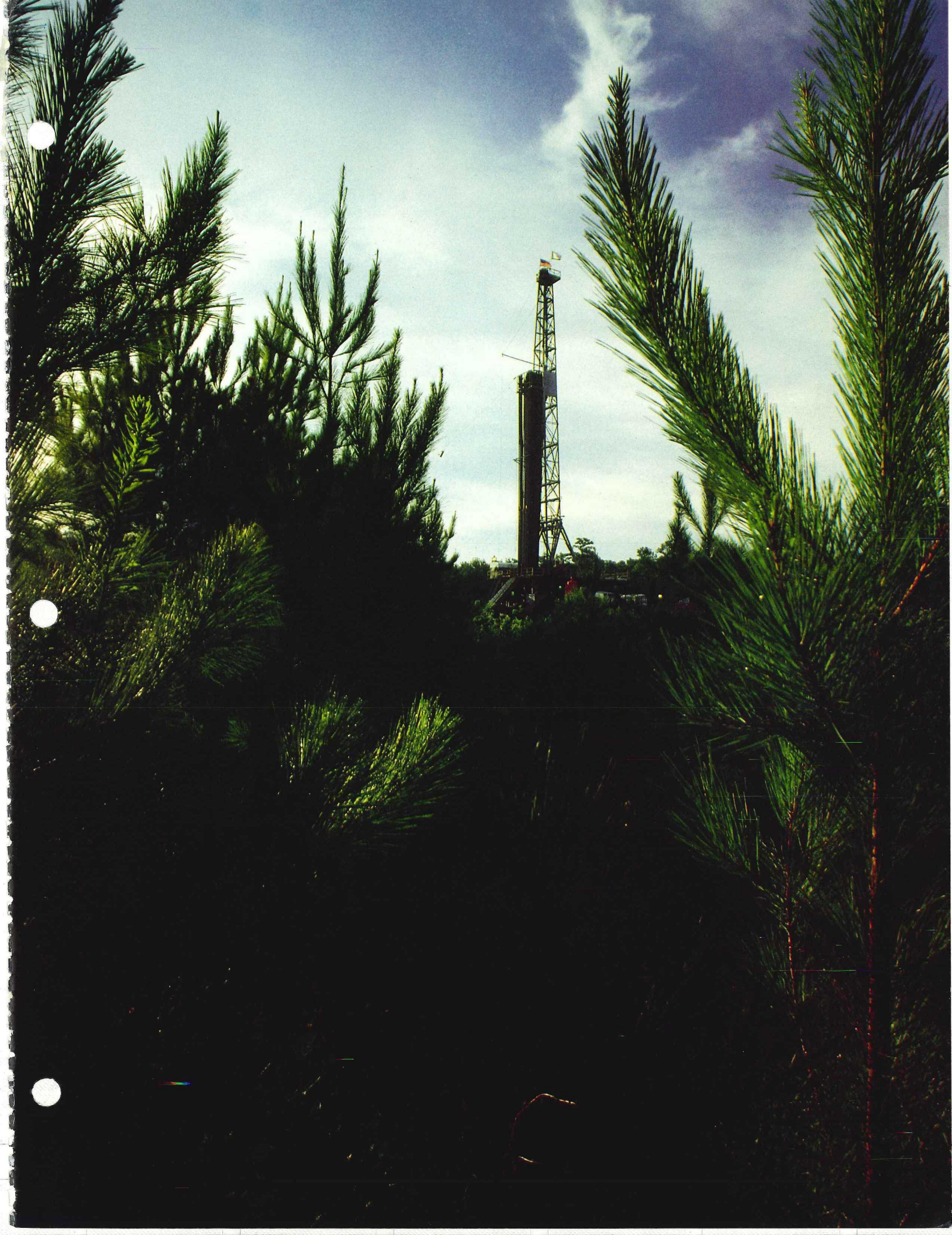
Net domestic natural gas production averaged 817 million cubic feet per day, compared with 1,036 million cubic feet per day in 1982. This lower level reflected reduced demand for natural gas due to the recession, a mild winter and conservation. Our average domestic natural gas sales price dropped from $2.33 per thousand cubic feet in 1982 to $2.15 this year. Domestic natural gas reserves were 5,049 billion cubic feet, compared with 5,170 billion cubic feet in 1982.

At year end, demand for natural gas in the home heating and commercial markets showed improvement while demand lagged in the industrial area where conservation and fuel switching had greater impact. We believe this lower production and average price is a short-term problem, and we anticipate that natural gas demand and revenues will increase in 1984.

One principal area of activity was offshore California where Union's operations yielded increased production and a significant crude oil discovery.

Natural gas production began in December from Platform Habitat in the Pitas Point field in the Santa Barbara Channel. Production is expected to reach 60 million cubic feet per day by mid-1984. Union has a 60 percent interest in the field.

Union's aggressive domestic exploration program included this wildcat well on the Alabama-Coushatta Indian Reservation in Texas, 75 miles northeast of Houston. Natural gas has been tested on these lands, and follow-up drilling is planned in early 1984.



Platform Helder is in one of the three oil fields developed by Union in the Dutch sector of the North Sea. In 1983, oil production from the Helder, Helm and Hoorn fields off the coast of the Netherlands reached more than 30,000 barrels per day.

Offshore Huntington Beach, Union holds a 46 percent interest in the new Beta field. A platform was installed in the field, and crude oil production will begin in 1984.

Union discovered the Point Pedernales oil field on a federal lease block in the Santa Maria Basin. Follow-up drilling confirmed the initial discovery, which is part of one of the most promising offshore oil development areas of recent years. A field development plan submitted to the County of Santa Barbara calls for installation of one or more platforms with an undersea pipeline to shore. Production could begin late in 1985 if there are no permitting delays. Union owns a one-third interest in the field.

In Texas, Union's onshore exploration program found natural gas on the Alabama-Coushatta Indian reservation, 75 miles northeast of Houston. The first well tested at an initial rate of 13.5 million cubic feet of gas per day, and the company plans additional drilling on these lands early in 1984.

Union was an active participant in federal offshore lease sales in 1983. The company spent $118 million in bonus payments for varying interests in 66 tracts covering nearly 328,000 acres in Alaska, the Gulf of Mexico, and the Atlantic Ocean.

Enhanced recovery projects using thermal and chemical techniques played an important role in increasing oil production. Steam projects have been particularly successful in California where heavy oil production exceeds 15,000 barrels per day.

To expand the use of advanced techniques to analyze prospects and provide improved information for area-wide lease sales, Union established new geophysical processing centers in Anchorage and Houston.

Foreign Oil and Gas Operations

The company's major 1983 foreign exploration, development and production efforts were in Thailand, Indonesia, the Netherlands, Ireland, United Kingdom, and Canada. Capital and exploration expenditures totaled $556 million.

Net foreign crude and condensate production averaged 73,100 barrels per day, up six percent from 68,700 barrels per day in 1982. Foreign crude and condensate reserves at year end were 188 million barrels, compared with 205 million barrels the year before.

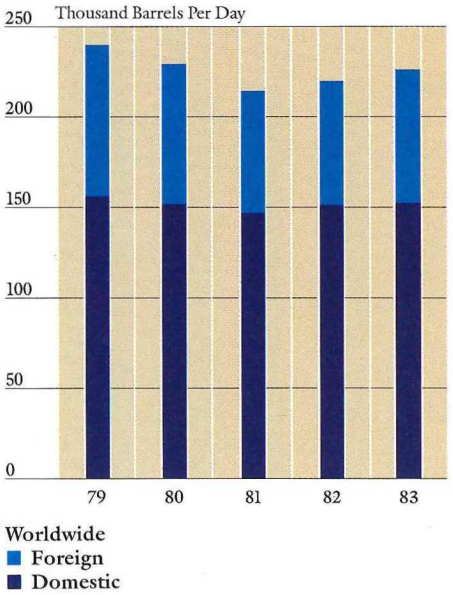
Net foreign natural gas production, principally in Thailand, Indonesia and Canada, averaged 165 million cubic feet per day, up 15 percent from 143 million cubic feet per day last year. Foreign natural gas reserves were 1,316 billion cubic feet, up nearly eight percent from 1,223 billion cubic feet at year-end 1982.

Union International Oil Division

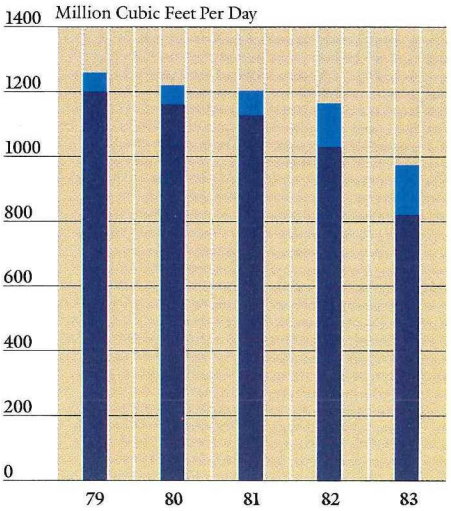
In Indonesia, Union extended the productive limits of the Attaka field offshore East Kalimantan and is developing two new smaller offshore fields, Rajah and West Yakin. These two new fields will begin producing by mid-1984.

Crude oil production began in July from Hoorn, the third field developed by Union in the Dutch sector of the North Sea. Gross production from the Hoorn, Helm and Helder fields reached more than 30,000 barrels per day, 20 percent above earlier peak production estimates. Union has an 80 percent interest in the three fields.

Crude Oil Production



Natural Gas Production



Worldwide
■ Foreign
■ Domestic

Union continued offshore exploration efforts elsewhere in northwestern Europe. The company has a one-third interest in an oil discovery off southeast Ireland in the Celtic Sea. The discovery well tested at a combined daily rate of 9,900 barrels of 44 degree API oil and 2.1 million cubic feet of natural gas. A confirmation well is underway to help determine the size of the field. If the field is commercial, it will be the first oil field in Ireland. Union holds interests ranging from 14 to 33 percent in 15 blocks offshore southern Ireland.

In the United Kingdom sector of the North Sea, Union discovered oil on block 29/8B. Located 140 miles southeast of Aberdeen in 330 feet of water, the well tested at a rate of 4,315 barrels of 41.2 degree API oil per day. Union's interest in the block is approximately 40 percent. The company will serve as operator and conduct additional exploration to determine whether the discovery is commercial.

Union Oil Company of Thailand

Union began production of natural gas from the Baanpot field in the Gulf of Thailand in November under the second sales agreement with the Petroleum Authority of Thailand. The field development schedule was accelerated to allow early production just seven months after the start of development.

Two other fields included in the second contract, Platong and Satun, will begin production in 1985.

Development of the Erawan field continued in 1983 with the installation of two additional platforms. Seven well platforms are operating in the field, with three more scheduled to be added in 1984. For the year, gross production from Erawan averaged 146 million cubic feet per day. Union holds an 80 percent interest in the field.

Union Oil Company of Canada Limited

Union made good progress in several areas through its wholly owned subsidiary, Union Oil Company of Canada Limited. The company acquired two exploration licenses in north central Alberta, giving it an interest in 5,120 acres on trend with the Slave field where Union made an oil discovery in 1982. Two wells drilled this year confirmed the discovery. Another well, drilled as an extension to the main pool, encountered 44 feet of oil pay, the most promising well drilled in the field to date.

Drilling activity in Canada included 41 exploration and development wells resulting in 14 oil and 10 natural gas wells.

For the year, our net crude oil and condensate production in Canada averaged 11,600 barrels per day, up two percent from 1982. Net natural gas production averaged 46.9 million cubic feet per day, 11 percent above the 42.3 million cubic feet per day the previous year.

A bitumen, or very heavy oil, pilot research project operated by Union in northeast Alberta continued to show encouraging results. Union and its partners are studying the possibility of expanding this steam injection project to a production rate of 5,000 barrels per day by the end of 1985.

Construction of the Obed Marsh Thermal Coal Project in west central Alberta progressed on schedule in 1983. Initial coal production is expected in mid-1984 with first deliveries to customers following in the fourth quarter. The three million ton per year project is located seven miles from the Canadian National Railway, ensuring efficient and reliable access to Canada's major western coal ports.

Union will own in excess of 90 percent of the project when the mine construction is completed.

Continued development drilling and the addition of two new platforms enabled Union to produce an average of 146 million cubic feet per day of natural gas from the Erawan field in the Gulf of Thailand. Three more production platforms are planned for installation in the field in 1984.

A drilling crew adds a string of drill pipe to a geothermal exploration well on the island of Java in Indonesia. During 1983, Union drilled four successful geothermal exploration wells in the Gunung Salak area, located 40 miles south of Jakarta.

Alternative Energy Resources Highlights

- Fifth straight year of increased geothermal energy production.
- Successful geothermal exploration in Indonesia.
- Completion of construction and beginning of start-up at the nation's first commercial shale oil project.

Union is the world leader in two important alternative energy resources—geothermal energy and oil shale. During 1983, capital and exploration expenditures were $82 million for geothermal energy and $106 million for shale oil.

Union Geothermal Division

Net geothermal energy production in the United States and the Philippines averaged 16 million kilowatt hours per day, up 17 percent from 13.7 million kilowatt hours per day in 1982. At year end, geothermal energy reserves totaled 304 million equivalent oil barrels, compared with 312 million equivalent oil barrels at year-end 1982.

At The Geysers project in Northern California, Union began supplying geothermal steam to a 15th electrical generating plant in January. This raised the total field capacity for Union's production facilities to 984,000 kilowatts, enough to meet the electricity needs of a city of one million people. Union has a 50 percent interest in this venture.

In the Imperial Valley, the operating experience from our two pilot demonstration projects is providing the technology to harness the valley's vast geothermal resources. At the Brawley and Salton Sea projects, Union's steam production systems continue to operate at high efficiency levels.

At Heber, also in the Imperial Valley, Union will supply geothermal fluids to a 65,000 kilowatt binary generating plant and a 52,000 kilowatt double flash generating plant. The California Public Utilities Commission approved construction of these plants, which are expected to begin operations in 1985. Union holds a one-third interest in the venture.

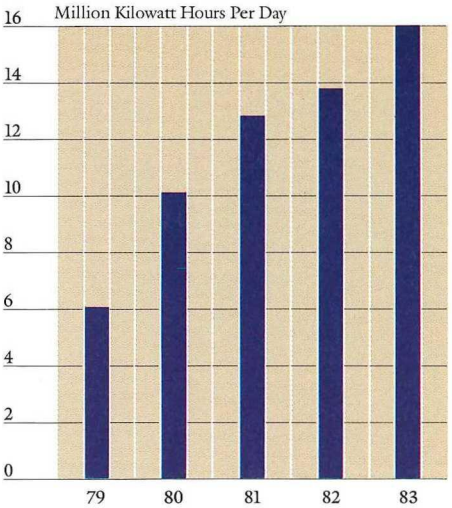
Union's geothermal projects in the Philippines recorded steady progress in 1983, supplying steam to 10 generating plants with a capacity of 550,000 kilowatts. At Tiwi, two power plants, which began operating at low levels in 1982, achieved full operating capacity during 1983. In addition, two new pipelines were completed, allowing for extension of the field into new productive areas.

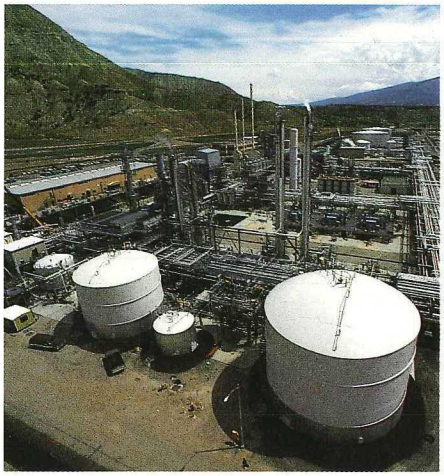
At Makiling-Banahao, work progressed on a 110,000 kilowatt generating plant scheduled for completion in 1984. This plant will increase the field's capacity to 330,000 kilowatts and take Philippine capacity to 660,000 kilowatts.

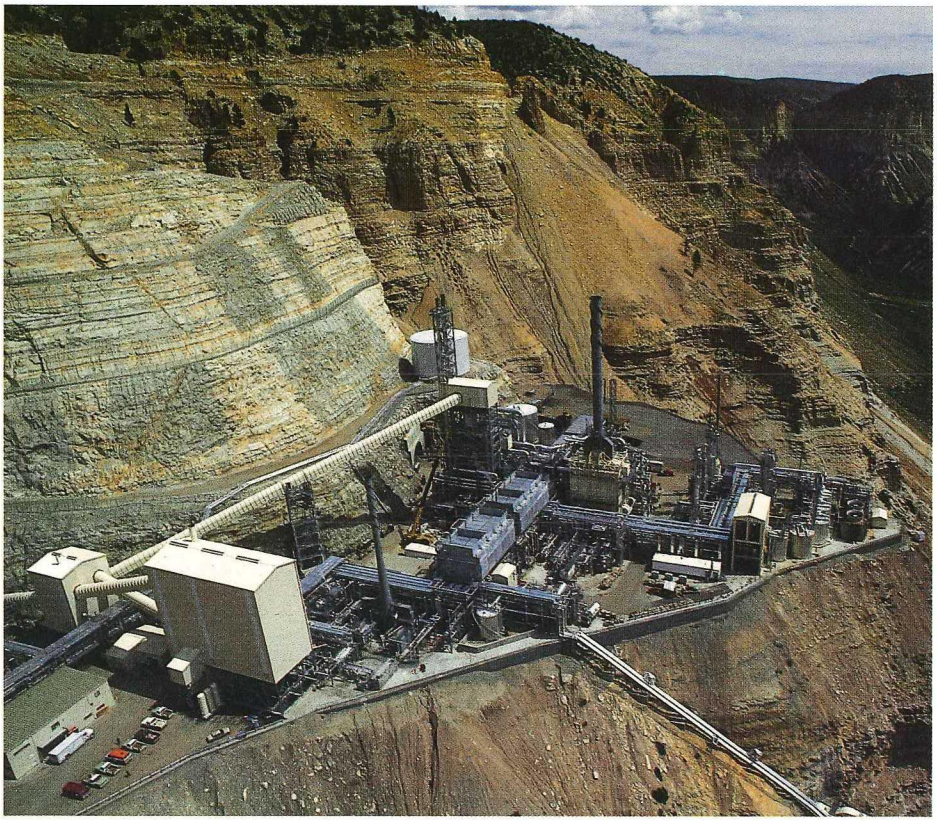
In Indonesia, Union drilled four successful exploration wells in the Gunung Salak area on the island of Java during the year, and additional drilling is under way. Union has a joint venture agreement with Pertamina, the Indonesian state oil company, to explore for and develop geothermal resources in the Gunung Salak area south of Jakarta.

In Japan, where Union is operator of a joint venture with two Japanese firms, the company conducted geological and geophysical exploration work during the year. Exploration drilling will continue through 1984 in order to evaluate the prospect.

Geothermal Production







Union Energy Mining Division
The company completed construction of the $640 million, 10,000 barrel per day shale oil project in western Colorado essentially on schedule and began equipment testing and start-up activities.

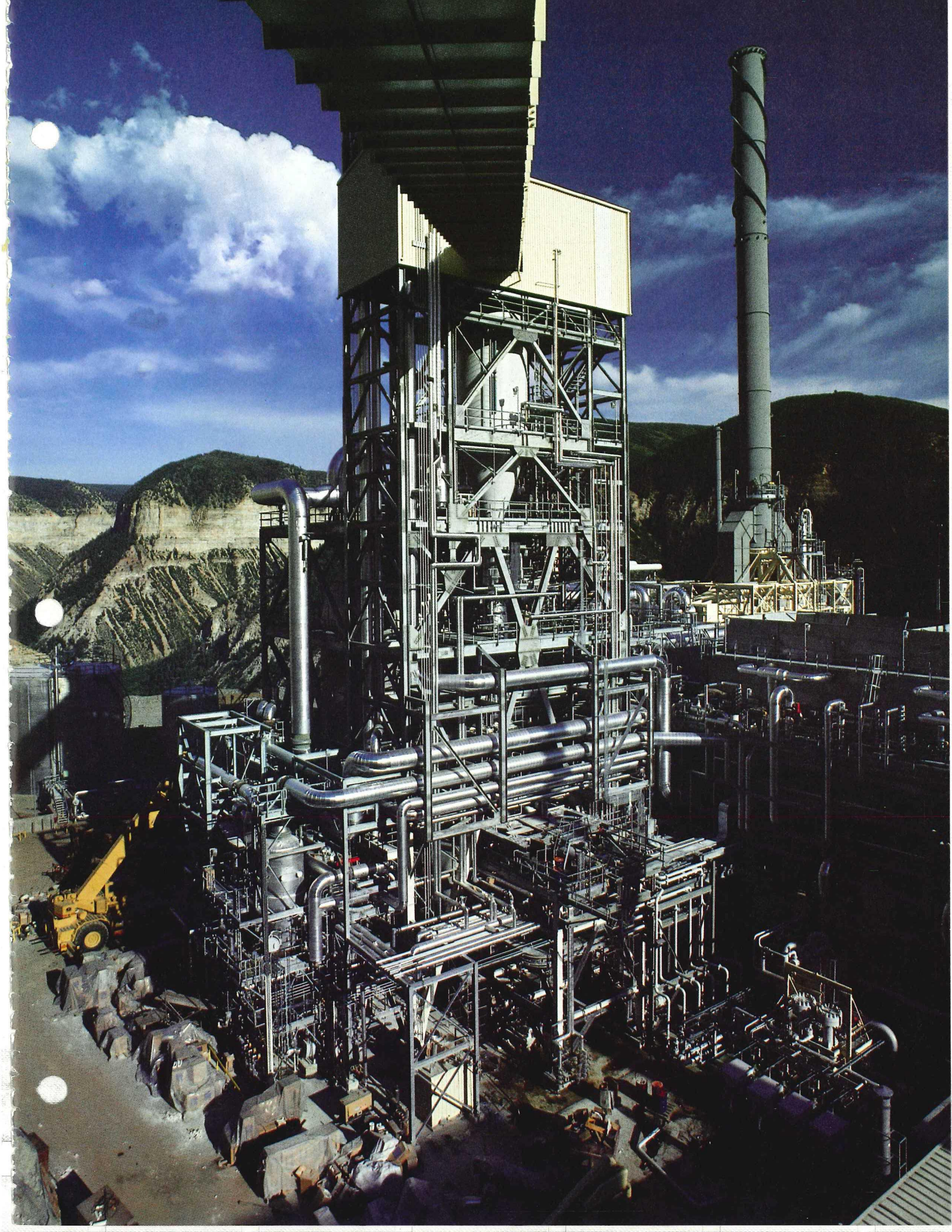
Union's project includes an underground room and pillar mine, a retort designed to process 12,500 tons of shale ore per day and an upgrading facility to convert raw shale oil generated in the retort into high quality synthetic crude.

While minor quantities of raw shale oil were produced late in 1983, sustained production was not achieved. Our retort is a unique process facility, particularly so because it handles large tonnages of rock at elevated temperatures and requires the separation of solids, liquids and gases in a continuous counterflow process system. It is encouraging that the rock pump—the heart of the retort—works very well, essentially as designed.

We continue to make short retorting runs, gather data and make appropriate facility modifications to accomplish our goal. Much has been learned about the operation of a large-scale plant which could not be fully determined in advance. We are confident we will succeed as we have in so many pioneering and innovative developments in the past.

Almost all of the Phase I syncrude produced will be refined into products for use by the U.S. Department of Defense. Jet fuel and military diesel refined by others from this syncrude will be used by U.S. Air Force bases in Utah and Idaho.

The retorting complex (left) at Union's Colorado shale oil project sits on a five-acre bench, 1,000 feet above the valley floor. The 108-foot-high upflow retort (right), the heart of Union's shale oil project, will process 12,500 tons of ore per day and extract 10,000 barrels per day of raw shale oil. The upgrading facility (top left) is designed to remove impurities from the raw shale oil, yielding a high quality synthetic crude oil.



FOSTER WHEELER ENERGY CORPORATION
110 SOUTH ORANGE AVENUE
LIVINGSTON NEW JERSEY 07039
U.S.A.

Refining and Marketing Highlights

- Modification of refineries to improve competitive position.
- Higher petroleum products sales.
- Record volumes from Auto/Truckstop system operations.

Union 76 Division

Improved refinery efficiencies, combined with lower crude oil costs and an attractive product mix, contributed to a strong sales performance by Union's refining and marketing business segment in 1983. This success came despite lower overall product demand in the industry and intense price competition throughout much of the year.

The company's refineries operated at 78 percent of capacity, up from 74 percent a year ago, while conversion units—Unicrackers, fluid catalytic crackers and cokers—ran at near capacity levels.

With higher refinery runs, the company used more foreign crude. In 1983, foreign crude supplies accounted for 15 percent of our refinery input, compared with 12 percent the year before.

The company also completed, or moved ahead with several refinery projects to improve efficiencies or increase the company's capability to process more lower-priced crude oils.

At Union's Los Angeles Refinery, modifications to the fluid catalytic cracker improved product yields and energy efficiency while reducing emissions.

After 35 years of service, the company's first coker, built at the San Francisco Refinery in 1948, finally wore out. A complete rebuilding of this coker is under way. By adding two additional drums to the existing coker at the Chicago Refinery, it is possible to expand the capacity by 45 percent at a low capital cost. When completed, these two projects will enable the company to convert additional heavier feedstocks into petroleum coke and higher-quality cracking stocks.

A crane lifts a 147-ton, 80-foot-tall coker drum into place at the company's Chicago Refinery. With the addition of two of these drums to the existing coker, Union will increase the unit's capacity by 45 percent at a low capital cost.

In marketing, despite ample crude supplies and declining overall product demand, Union increased sales of petroleum products to 386,000 barrels per day, up six percent from 364,200 barrels per day in 1982.

Union's Auto/Truckstop system, the nation's largest, achieved new records for gallonage in 1983. Motor fuel sales at Auto/Truckstops were 30 percent above the prior record level set in 1979.

In the eastern U.S., three-fourths of the company's product sales are through jobbers, and these jobbers added nearly 500 Union-branded service stations in 1983.

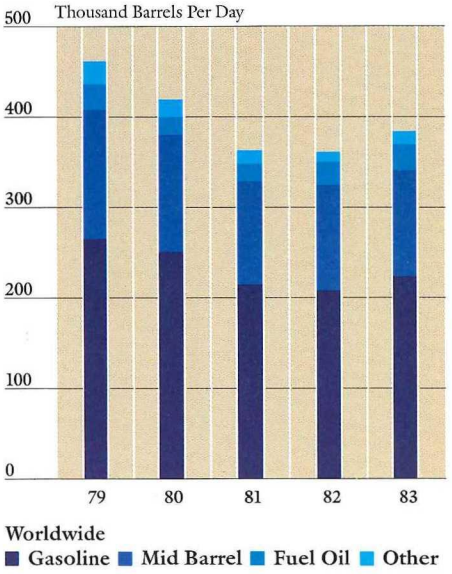
In the West, Union built on its successful programs offering unique gasoline grades, a combination of full and self serve stations and the 76 PROTECH guaranteed automotive repair service. This strategy earned Union an increase in market share in California, the nation's largest gasoline market. Union is the only major West Coast supplier of leaded premium, which accounts for 30 percent of our retail gasoline sales in the West.

In November, the company added the 76 PROTECH auto repair program to the greater Los Angeles area, making the program available to motorists along the entire West Coast. More than 400 Union dealers now participate.

On a nationwide basis we added 400,000 new credit card accounts during the year, bringing the total number to 4.4 million, a 10 percent increase over 1982.

At year end, we sold, at a small profit, our 50 percent interest in Kyung In Energy Co., a South Korean refining and electricity generating venture, to our partner, Korea Explosives Group. The sale involved a 60,000 barrel refinery and an oil-fired electrical generating plant, both completed in 1972.

Petroleum Product Sales



Union increased its share of the solvent products market by expanding the network of Union Chemicals Distribution Centers. Distribution centers, such as this one in Dallas, market less-than-carload-lot quantities of solvent and chemical products to customers.

Metals and Chemicals Highlights

- A new molybdenum mine and modernized mill brought on stream.
- Improved market share for solvent products.
- Greater emphasis on foreign markets for fertilizer products.

Union Chemicals Division

Union's metals and chemicals business segments, while impacted by generally poor economic conditions through much of the year, began to show improvement as 1983 closed.

Molycorp, Inc. In September, Molycorp, a wholly owned subsidiary, began producing molybdenum from its new underground mine and modernized mill at Questa, New Mexico. The mine will have the capacity to produce about 18,000 tons per day by 1985. Each ton of ore yields about three pounds of molybdenum, used as a steel alloy and in petroleum refining catalysts.

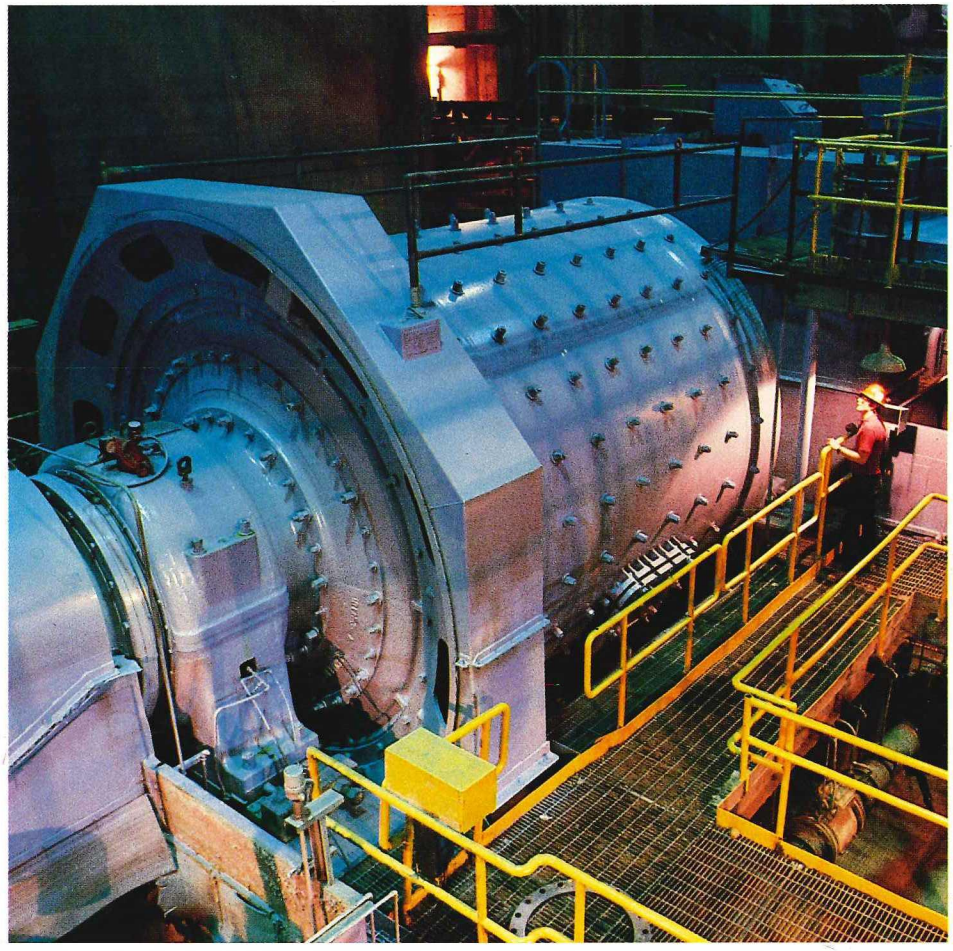
The $250 million investment in the mine and mill at Questa will enable Molycorp to produce molybdenum at competitive costs and meet increases in demand as economic conditions improve.

From its mine and mill facilities at Mountain Pass, California, Molycorp is the world's largest producer of lanthanides, or rare earths. Sales increased about 20 percent from 1982 levels.

Because of their unique properties, lanthanide elements are used in a number of products ranging from metallurgical and catalyst applications to optics, electronics and extremely strong permanent magnets.

The permanent magnets, which are based on a lanthanide called samarium, are used in a great variety of consumer electronics. In addition, work is under way in developing even stronger and lighter permanent magnets based on another lanthanide, neodymium.

Molycorp's large reserves at Mountain Pass assure sufficient lanthanide supplies to meet market growth well into the next century.



Rotating grinding mills pulverize water-slurried ore to a fine powder as part of the process to recover molybdenum at Molycorp's Questa project.

Chemicals Activities. The major emphasis for petrochemicals in 1983 was the addition of new chemical distribution plants and the introduction of new products.

In 1983, new Union Chemicals Distribution Centers opened in Cleveland, Cincinnati and Pensacola. These new outlets, coupled with increased advertising, expanded the company's market share for solvent products.

The company also introduced new vinyl acetate and styrene butadiene emulsions for application in coatings, adhesives and textiles.

A new chemicals product quality improvement program started in 1983. The program involves significant employee participation and new automation equipment. A batch process computer, designed to increase productivity, reduce energy costs and insure consistent quality, was installed at the Charlotte, North Carolina, polymer plant. Similar systems are planned for our five other polymer plants.

Fertilizer Activities. Sales of nitrogen fertilizer products in the domestic market were adversely affected by the federal Payment in Kind Program, which reduced planted acreage, and by West Coast weather conditions. However, higher sales in overseas markets in the Pacific Basin partially offset the effect of lower domestic sales.

The urea/ammonia plants at Kenai, Alaska, operated at capacity during the year. As the market recovers, production at the Brea, California, plant will be increased to meet anticipated increased domestic fertilizer demand.

Petroleum Coke Activities. Union experienced a resurgence in demand for coke as aluminum producers reopened plants and resumed operations late in the year. To broaden our coke product spectrum, we are building a 130,000 ton per year needle coker at the Chicago Refinery.

This unit, to come on line in 1985, will open a new market for the company—premium quality low sulfur needle coke used in making electrodes for electric arc steel furnaces. These furnaces melt scrap metal to produce lower cost steel, thereby enabling U.S. producers to have a better chance to compete effectively with foreign steel companies.

At the Contra Costa, California, coke calcining plant, a $43 million electrical cogeneration plant successfully began operations in the fourth quarter. Heat from the coking kilns is used to power a 27,000 kilowatt generating turbine, with electricity being sold to Pacific Gas and Electric Company for distribution to its customers. This cogeneration project is a fine example of combining energy conservation with good economics.

Research Highlights

- Development of a computerized well log program.
- Introduction of new chemicals and lubricants products.
- Unicracking technology licensed to five plants.

Union Science and Technology Division

Union's research effort in 1983 focused on providing new methods for finding and producing energy resources as well as developing better conversion processes and profitable new products.

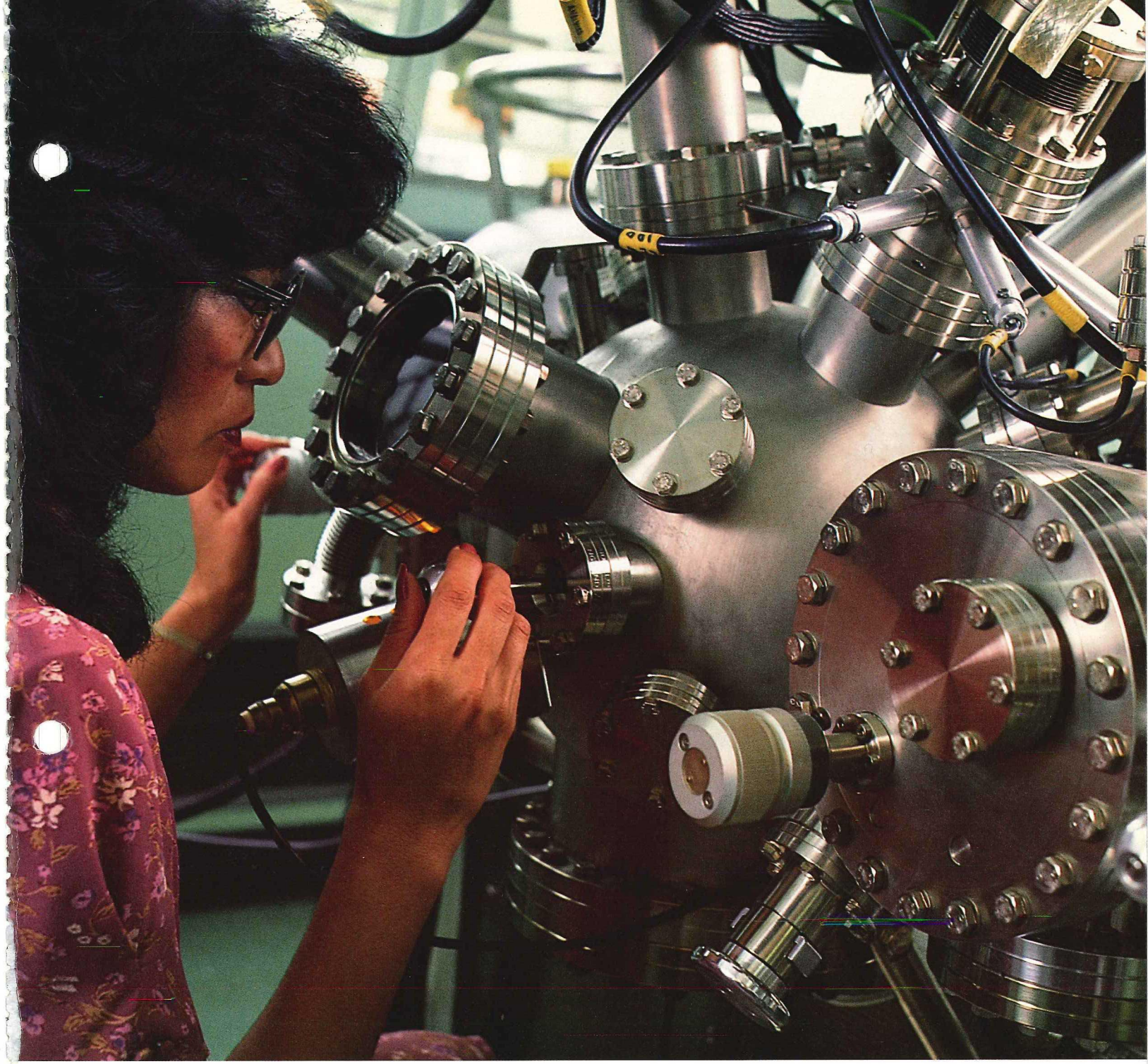
A new computer program for interpreting well logs was successfully field tested. The program, which locates additional producing intervals that are not identified through conventional methods, resulted in a significant increase in oil production.

Two new chemical techniques that minimize well plugging in fields undergoing thermal recovery were also successfully field tested.

Environmental protection research included successful demonstration of the company's Unisulf process for removing sulfur compounds from waste refinery gases and commercial application of a new method for treating acidic waste water.

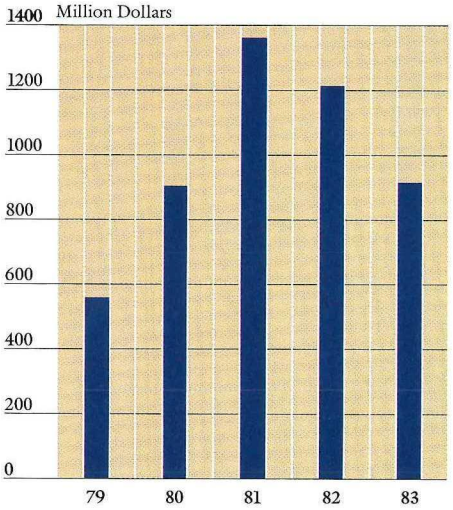
New agricultural products developed by research included a growth enhancer which increases certain crop yields by up to 25 percent in experimental plots and a urea-sulfuric acid fertilizer complex to decompose crop stubble. New oil products included a number of crankcase and industrial oils.

Union continued to license process technology. Five hydrocracking plants, with a combined capacity of more than 80,000 barrels per day, were licensed to use Union's Unicracking process. Three of these plants were conversions of plants that were originally built to use technology developed by other licensors. Union also developed a new catalyst for removing metals from residual oil.



A technician at the Fred L. Hartley Research Center analyzes the surface of a catalyst using a photoelectron spectrometer. Catalytic research in 1983 yielded a new catalyst for removing metals from residual oil.

Total Taxes
(excluding consumer excise taxes)



Real Estate Highlights

- Sales up 60 percent.
- A new condominium project launched.

Union Real Estate Division
With improved economic conditions and an easing of interest rates, Union's real estate operations posted improved sales and earnings in 1983. Total sales of residential, industrial and surplus properties increased by more than 60 percent over the previous year.

The residential lot sales program at a 50-acre Lake Arrowhead shoreline development started successfully, while lot sales continued at Aliso Hills in Orange County, Carbon Canyon near Brea, Connemara-By-The-Sea in San Juan Capistrano and Round Hills Estates North adjacent to Mt. Diablo in the Oakland area.

The company also recorded increased industrial lot sales in California at its developments in Brea and Simi Valley.

Union's subsidiary, Moreland Development, broke ground in December on the first phase of a planned 372-unit condominium project in Laguna Hills. Moreland also received subdivision map approval for a 170-acre industrial development in Simi Valley.

Corporate Affairs

As a major corporation, our basic economic role is to provide a fair return on capital to our shareowners by manufacturing quality products for our customers on a competitive and profitable basis.

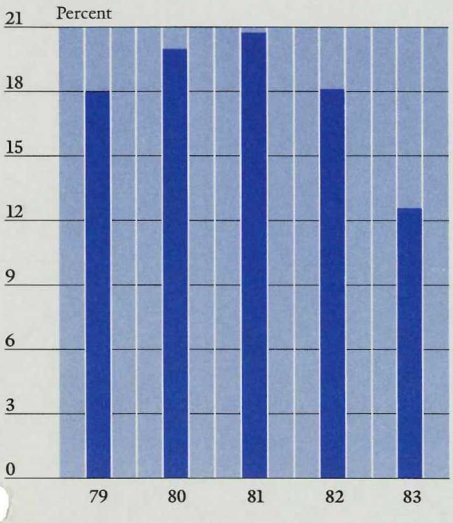
We are committed to growth by reinvesting earnings which in turn will create jobs and advancement opportunities for our employees. Union employed 20,304 men and women in 1983, up slightly from the previous year. Total payroll and benefit expenditures were more than $785 million.

In addition, 1983 income and operating taxes totaled $919 million, one and one-half times the company's net earnings.

Union's financial contributions to local communities go beyond payrolls and taxes. Through the Union Oil Company Foundation, the company supports various educational, cultural and civic endeavors. The company also supports the United Way and similar appeals through payroll deduction of employee pledges and matching these donations with corporate funds on a nationwide one-to-one basis.

- In 1983, Mr. Charles F. Parker, having reached the mandatory retirement age, did not stand for reelection to the board of directors. Mr. Parker retired after nearly 51 years of valued leadership and service.
- Mr. George B. Snyder, vice president of Engineering and Construction, retired after 45 years of outstanding and loyal service.

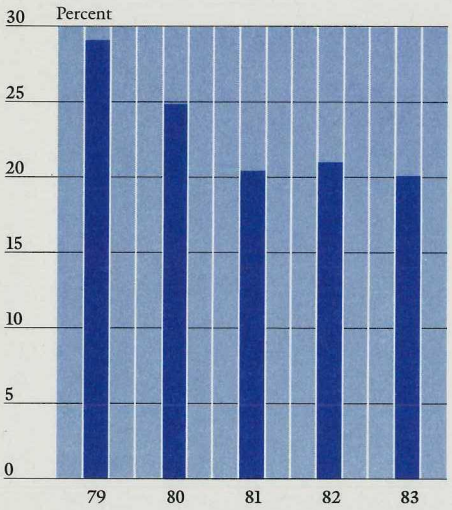
Return on Average Shareowners' Equity



Contents

Management's Discussion and Analysis 22
Accountants' Report 23
Consolidated Earnings 24
Consolidated Balance Sheet 25
Changes in Consolidated Financial Position 26
Consolidated Shareowners' Equity 27
Notes to Consolidated Financial Statements 28
Oil and Gas Reserve Data 36
Metals Reserve Data 38
Selected Financial Data 40
Operating Summary 42

Long-Term Debt as a Percent of Total Capitalization



Management's Discussion and Analysis of Financial Condition and Results of Operations

Unocal's net earnings for 1983 were $625.9 million, a decrease of $178.1 million, or 22.2 percent, from 1982 net earnings of $804.0 million. Net earnings for 1981 were $791.4 million. Return on average shareowners' equity was 12.6 percent in 1983, compared with 18.2 percent in 1982 and 20.8 percent in 1981.

The principal negative factors causing the 1983 earnings decrease were lower domestic natural gas production and average sales price due to reduced market demand; decreased refining and marketing earnings due to lower margins from lower selling prices; decreased investment and energy tax credits from lower expenditures on construction of shale oil facilities; and lower chemicals earnings due to depressed market conditions.

Positive factors which partially offset the above included higher foreign oil and gas production earnings, mainly in Canada and the Netherlands; increased domestic crude and condensate production; and lower costs of dry holes and exploration.

In the fourth quarter of 1983 the company completed negotiations for the disposal of its 50 percent interest in the Korean affiliate, Kyung In Energy Company. With this agreement the company recorded its share of Kyung In's 1983 earnings from refining and marketing operations and a modest gain on the sale of its ownership interest.

Total revenues in 1983 were $10.7 billion, down $209 million from 1982. This decrease was largely due to lower refined product sales prices and lower domestic natural gas sales volumes and average price caused by depressed market conditions.

Total costs and other deductions increased by $130 million in 1983 compared with 1982. Cost of products sold and operating expense increased by $128 million due to general increases in operating expenses. Depreciation and amortization expense increased by $73 million as a result of higher capital expenditure levels in recent years. Selling, administrative and general expense declined by $41 million mainly as a result of lower service charge fees paid to Union Oil Credit Corporation, a wholly owned nonconsolidated finance subsidiary, due to its lower financing activities.

Higher 1982 net earnings versus 1981 were due principally to improved domestic refining and marketing earnings; increased earnings from Kyung In Energy Company; higher investment and energy tax credits generated by the shale oil project; and improved foreign and domestic oil and gas production earnings. Partially offsetting these increases were lower gains on sales of assets; lower chemicals earnings; higher exploration and dry hole costs; and higher interest expense.

Funds provided from operations totaled $1,799 million in 1983, $1,987 million in 1982 and $1,812 million in 1981. Capital and exploration expenditures were $1,751 million in 1983, $2,076 million in 1982 and $1,961 million in 1981. The principal reasons for the decrease in 1983 were lower construction expenditures on the completed shale oil project and lower expenditures for domestic oil and gas exploration and development. It is anticipated that capital and exploration expenditures will approximate $2.1 billion in 1984 with the major portion directed to projects in the United States. It is anticipated that domestic expenditures will focus on oil and gas exploration and development, refinery improvement projects, and continuation of construction of a needle coker at the company's Chicago Refinery. Foreign expenditures will continue to be directed to oil and gas exploration and development in various countries and the development of Canadian coal resources.

In 1983, the company effected new long-term borrowings totaling $152 million. This includes a $125 million floating rate issue due 1986 to 1989 and $26 million in several industrial development and pollution control revenue bond issues at various rates and terms. At year-end 1983, the ratio of long-term debt, including capital lease obligations, to total capitalization was 20.1 percent, a decrease in comparison with 21.1 percent and 20.5 percent at the end of 1982 and 1981, respectively.

At the end of 1983, consolidated working capital increased by $161 million to $457 million, compared with $296 million at the end of 1982. Cash and marketable securities increased $58 million and accounts and notes receivable were up $195 million which are the main reasons for the 1983 increase.

Financing activities by Union Oil Credit Corporation decreased significantly in 1983. At December 31, 1983, short-term notes payable stood at $149 million, down $258 million from the previous year's level. On December 31, 1982 and 1981, short-term notes payable were $407 million and $472 million, respectively.

With the decline in inflation in 1983 the company's operating and capital costs were not impacted as greatly as they were in prior years. Additionally, cost savings and productivity improvements were effected to minimize the increase. Selling prices, however, could not be increased in line with inflation due to market conditions, thus margins were reduced. Inflation adjusted data are shown on pages 38 and 39.

Accountants' Report

Coopers & Lybrand
Certified Public Accountants
1000 West Sixth Street, Los Angeles, CA 90017

To the Shareowners of Unocal Corporation:

We have examined the consolidated balance sheet of Unocal Corporation and its consolidated subsidiary, Union Oil Company of California, as of December 31, 1983 and 1982, and the related statements of consolidated earnings, consolidated shareowners' equity and changes in consolidated financial position for each of the three years in the period ended December 31, 1983. Our examinations were made in accordance with generally accepted auditing standards and, accordingly, included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the financial statements referred to above, which appear on pages 24 through 39 of this annual report, present fairly the consolidated financial position of Unocal Corporation and its consolidated subsidiary as of December 31, 1983 and 1982, and the results of their consolidated operations and changes in consolidated financial position for each of the three years in the period ended December 31, 1983, in conformity with generally accepted accounting principles applied on a consistent basis.

Coopers & Lybrand

February 14, 1984

Consolidated Earnings

(dollars in millions except per share amounts)

		1983	1982	1981
Revenues	Sales and operating revenues (including consumer excise taxes of $480.5 in 1983, $342.8 in 1982 and $358.0 in 1981)	**$10,546.1**	$10,733.2	$11,103.9
	Interest, dividends and miscellaneous income	**72.6**	105.2	119.3
	Equity in earnings of affiliated companies	**40.3**	17.7	18.5
	Gains on sales of assets	**31.5**	43.0	54.5
	Total revenues	**10,690.5**	10,899.1	11,296.2
Costs and Other Deductions	Cost of products sold and operating expense	**6,932.6**	6,804.7	7,224.2
	Selling, administrative and general expense	**440.1**	481.5	482.4
	Depreciation and amortization	**796.7**	723.8	585.0
	Dry hole costs	**252.2**	273.3	263.0
	Exploration operations expense	**158.1**	158.4	150.8
	Interest expense	**123.1**	130.3	109.8
	Excise, property and other operating taxes	**919.2**	920.3	1,058.2
	Earnings applicable to minority interests	**.1**	.3	.6
	Total costs and other deductions	**9,622.1**	9,492.6	9,874.0
	Earnings before taxes on income	**1,068.4**	1,406.5	1,422.2
	Federal and other taxes on income	**442.5**	602.5	630.8
Earnings	Net earnings	**$ 625.9**	$ 804.0	$ 791.4
	Net earnings per share	**$3.60**	$4.63	$4.56

See Notes to Consolidated Financial Statements.

Consolidated Balance Sheet

		December 31 1983	December 31 1982
		Millions of Dollars	
Assets	Current assets		
	Cash	$ 134.0	$ 179.1
	Marketable securities	203.2	100.4
	Accounts and notes receivable	925.0	730.5
	Inventories	611.1	608.6
	Prepaid expenses	23.1	26.3
	Total current assets	1,896.4	1,644.9
	Investments and long-term receivables		
	Affiliated companies	73.4	99.0
	Nonconsolidated subsidiary	81.1	105.2
	Other	61.7	54.7
	Properties—net	7,068.4	6,562.0
	Deferred charges	47.0	45.5
	Total assets	$9,228.0	$8,511.3
Liabilities	Current liabilities		
	Accounts payable	$1,033.7	$ 978.5
	Taxes payable	213.7	195.6
	Current portion of long-term debt and capital leases	103.1	88.8
	Other liabilities	89.1	85.7
	Total current liabilities	1,439.6	1,348.6
	Long-term debt	1,140.3	1,095.5
	Capital lease obligations	160.0	171.6
	Deferred income taxes	1,047.5	916.5
	Advances, etc. related to future production	32.1	30.9
	Other deferred credits	227.1	201.8
	Minority interests	1.3	1.3
	Total liabilities	4,047.9	3,766.2
Shareowners' Equity	Common Shares	173.7	361.8
	Capital in excess of par value of shares issued	352.2	162.8
	Foreign currency translation adjustment	(8.2)	—
	Retained earnings	4,662.4	4,220.5
	Total shareowners' equity	5,180.1	4,745.1
	Total liabilities and shareowners' equity	$9,228.0	$8,511.3

See Notes to Consolidated Financial Statements.

Changes in Consolidated Financial Position

		1983	1982	1981
		Millions of Dollars		
Funds Provided From Operations	Net earnings	$ 625.9	$ 804.0	$ 791.4
	Non-cash items in earnings			
	Depreciation and amortization	796.7	723.8	585.0
	Dry hole costs	252.2	273.3	263.0
	Deferred taxes	123.1	177.8	141.2
	Other	1.3	8.2	31.1
	Funds provided from operations	1,799.2	1,987.1	1,811.7
Sources/(Uses) of Other Funds Excluding Financing	Book value of assets sold	25.0	30.1	35.8
	Investments and long-term receivables	60.5	15.2	(16.0)
	Working capital changes			
	Accounts and notes receivable	(194.5)	37.2	283.3
	Inventories	(2.5)	(46.1)	(106.1)
	Prepaid expenses	3.2	1.9	(8.2)
	Current liabilities	76.7	(7.1)	(23.7)
	Other	9.2	7.9	18.0
	Funds available before financing	1,776.8	2,026.2	1,994.8
Financing Activities	Long-term borrowings	152.4	407.6	122.6
	Reduction of long-term debt	(90.3)	(289.4)	(25.6)
	Reduction of capital lease obligations	(14.6)	(14.9)	(23.2)
	Total funds provided	1,824.3	2,129.5	2,068.6
Utilization of Funds	Capital expenditures (including dry hole costs)	(1,592.9)	(1,917.3)	(1,810.6)
	Purchase of minority interest—Union Oil Company of Canada Limited	—	—	(110.9)
	Cash dividends declared	(173.7)	(173.7)	(156.3)
	Increase/(Decrease) in cash and marketable securities	$ 57.7	$ 38.5	$ (9.2)

See Notes to Consolidated Financial Statements.

Consolidated Shareowners' Equity

		1983	1982	1981
		Millions of Dollars		
Common Shares	Balance at beginning of year	$ 361.8	$ 361.7	$ 361.5
	Sale of Common Shares, etc.	.1	.1	.2
	Change in par value of Common Shares	(188.2)	—	—
	Balance at end of year	173.7	361.8	361.7
Capital in Excess of Par Value of Shares Issued	Balance at beginning of year	162.8	162.3	160.2
	Sale of Common Shares, etc.	1.2	.5	2.1
	Change in par value of Common Shares	188.2	—	—
	Balance at end of year	352.2	162.8	162.3
Foreign Currency Translation Adjustment	Balance at beginning of year	(4.9)	—	—
	Current year adjustment	(3.3)	—	—
	Balance at end of year	(8.2)	—	—
Retained Earnings	Balance at beginning of year	4,220.5	3,590.2	2,955.1
	Translation adjustment for foreign deferred taxes	(10.3)	—	—
	Adjusted balance at beginning of year	4,210.2	3,590.2	2,955.1
	Net earnings for year	625.9	804.0	791.4
	Total	4,836.1	4,394.2	3,746.5
	Cash dividends declared	(173.7)	(173.7)	(156.3)
	Balance at end of year	4,662.4	4,220.5	3,590.2
Shareowners' Equity	Total shareowners' equity	$5,180.1	$4,745.1	$4,114.2

On April 25, 1983, the shareowners approved a plan of reorganization whereby Union Oil Company of California became an operating subsidiary of a newly created company, Unocal Corporation. With the reorganization, 173.7 million shares of Common Stock, $2 1/12 par value, of Union Oil Company of California were converted into an equal number of shares of Common Stock, $1 par value, of Unocal Corporation. The difference of $188.2 million from the change in par value was credited to Capital in Excess of Par Value of Shares Issued.

See Notes to Consolidated Financial Statements.

Notes to Consolidated Financial Statements

Summary of Accounting Policies

Principles of Consolidation

For the purposes of this report, Unocal Corporation and its consolidated subsidiary, Union Oil Company of California, will be referred to as company.

The consolidated financial statements of Unocal Corporation include the accounts of Union Oil Company of California and its subsidiaries except Union Oil Credit Corporation, a wholly owned subsidiary engaged in financing certain accounts receivable, which is accounted for on the equity basis.

Investments in affiliates owned 50% or less are accounted for by the equity method. Investments in such companies are stated at cost plus the company's equity in undistributed earnings after acquisition. Income taxes estimated to be payable when undistributed earnings are distributed are included in deferred taxes.

Inventories

Inventories of crude oil and refined products are valued at cost under the last-in, first-out method. Other inventories are valued at cost using various methods.

Capitalized Leased Properties

Facilities and lands leased by the company under firm, long-term obligations are capitalized as assets and depreciated in the same manner as owned properties. Future minimum rental payments are discounted to a present value using the company's incremental borrowing rate in effect at the time of leasing and such value is recorded as a liability. Earnings are charged for depreciation of the properties and the imputed interest on the rental obligations in lieu of actual rental payments.

Oil and Gas Exploration and Development Costs

The company follows the successful efforts method of accounting for its oil and gas activities.

Acquisition costs of exploratory acreage are capitalized. Full amortization of the nonproductive portion of such costs is provided over the shorter of the exploratory period or the lease holding period. Costs of successful leases are transferred to proved properties.

Exploratory drilling costs are initially capitalized. When drilling is completed, dry hole costs are expensed.

Geological and geophysical costs and leasehold rentals are expensed as incurred.

Development costs of proved properties are capitalized.

Depreciation and Amortization

Depreciation and amortization related to proved oil and gas properties and estimated future abandonment and removal costs for offshore production platforms are calculated at unit of production rates based upon estimated proved recoverable reserves.

Mine development costs are capitalized and amortized on unit of production rates based on estimated proved recoverable reserves.

Depreciation of other properties is generally on a straight-line basis using various rates based on useful lives.

Maintenance and Repairs
Expenditures for maintenance and repairs are charged currently to earnings. In general, betterments are charged to the respective property accounts and such accounts are relieved of the cost of any property replaced.

Retirements and Disposals of Properties
Losses on retirement of facilities for which individual allowances are accumulated are charged to current depreciation expense and on retirements of other properties to accumulated allowances. Losses or gains on sales of properties are included in current earnings.

Investment and Energy Tax Credits
The allowable investment and energy tax credits are applied as a current reduction of income tax expense.

Business Segments

The company is engaged principally in petroleum, chemical, geothermal and metal operations. Petroleum involves the exploration, production, transportation and sale of crude oil and natural gas; and the manufacture, transportation and marketing of petroleum products. Chemicals involves the manufacture, purchase, transportation and marketing of chemicals for industrial and agricultural uses. Geothermal involves the exploration, production and sale of geothermal resources. Metals primarily involves the exploration, production and marketing of molybdenum, columbium and lanthanides (rare earths). Other operations include the development of oil shale; development of coal; and real estate development and sales.

Financial data by geographic areas of operations and business segments are shown in Selected Financial Data on pages 40 and 41.

Foreign Currency Translation

Effective January 1, 1983, the company adopted the Financial Accounting Standards Board's new statement on foreign currency translation. As permitted by the statement and due to immateriality, the financial statements for 1982 and 1981 have not been restated.

Marketable Securities

Marketable securities are carried at cost which approximates market.

Allowances for Losses

Accounts and notes receivable are stated net of allowances for losses of $25.5 million and $35.2 million at December 31, 1983 and 1982, respectively. Investments and long-term receivables are stated net of allowances for losses of $.6 million and $19.8 million at December 31, 1983 and 1982, respectively.

Inventories

	December 31	
	1983	1982
	Millions of Dollars	
Crude oil and condensate	$111.6	$101.0
Refined products	265.6	270.1
Chemicals	71.5	71.4
Metals	33.5	44.6
Real estate development	81.3	75.6
Supplies, merchandise, etc.	47.6	45.9
Total	$611.1	$608.6

Current cost of inventories exceeded the LIFO inventory value included above by $642.5 million and $740.1 million at December 31, 1983 and 1982, respectively.

Properties and Capitalized Leases

Investments in owned and capitalized leased properties at December 31, 1983 and 1982, are set forth below. Noncancellable agreements related to leased properties are for varying periods extending to the year 2053. A substantial portion of such properties includes land rights, purchase options or favorable renewal options.

	1983		1982	
	Gross	Net	Gross	Net
	Millions of Dollars			
Owned properties (at cost)				
Petroleum operations:				
Exploration				
United States	$ 966.6	$ 486.0	$ 914.8	$ 509.1
Foreign	149.7	77.4	191.7	124.2
Production				
United States	4,581.6	2,156.9	4,276.5	2,071.7
Foreign	1,827.1	907.1	1,459.1	733.5
Refining, marketing and transportation	2,331.8	1,258.1	2,160.1	1,158.2
Total	9,856.8	4,885.5	9,002.2	4,596.7
Chemical operations	764.3	480.6	670.9	466.3
Metal operations	469.0	289.2	428.8	258.2
Geothermal operations	403.5	239.4	346.0	227.9
Other and Unallocated	1,126.6	1,029.0	928.2	843.3
Total owned properties	12,620.2	6,923.7	11,376.1	6,392.4
Capitalized leased properties				
Refining, marketing and transportation	248.0	120.3	255.7	134.8
Chemical operations	.8	.2	56.3	14.5
Other and Unallocated	38.5	24.2	35.2	20.3
Total leased properties	287.3	144.7	347.2	169.6
Total	$12,907.5	$7,068.4	$11,723.3	$6,562.0

Contingent Liabilities

Civil antitrust actions brought by the attorneys general of five states and the City of Long Beach, California, are pending against the company and other major oil companies. The company is also a defendant in six antitrust cases involving its fertilizer operations in five states in the Pacific Northwest. In addition, there are two private antitrust actions pending against the company and other companies in the oil industry. These actions collectively seek treble damages, injunctive relief and divestiture of certain segments of the defendants' businesses. The company has denied the allegations of unlawful practices in these actions and believes the actions can be successfully defended. In view of the broad and largely undefined relief sought, however, an adverse decision could have a significant effect upon the scope and nature of the company's operations.

The company also has certain other contingent liabilities with respect to litigation, claims and contractual agreements arising in the ordinary course of business. In the opinion of management, such contingent liabilities will not result in any loss which would materially affect the company's financial position.

Long-Term Debt and Credit Agreements

Annual maturities of long-term debt during the next five years are (in millions of dollars): 1984—$89.7 (included in current liabilities), 1985—$222.3, 1986—$107.5, 1987—$101.7 and 1988—$117.8.

	December 31	
	1983	1982
	Millions of Dollars	
Bonds and debentures		
8⅝% Debentures due 1987 to 2006	$ 200.0	$ 200.0
5.5% to 10½% Industrial Development Revenue Bonds due 1987 to 2008	194.8	168.7
8⅜% Debentures due 1985	150.0	150.0
6⅝% Debentures due 1985 to 1998	102.6	103.6
4⅞% Debentures due 1985 to 1986	32.0	34.0
7½% Debentures due 1985 to 1987	11.1	14.9
Notes		
Floating rate notes due 1985 to 1991	180.0	220.0
Floating rate notes due 1986 to 1989	125.0	—
8.3% Notes due 1985 to 1997	54.6	63.3
3¾% Notes due 1985 to 1990	30.0	35.0
Floating rate notes due 1985 to 1986	29.2	60.0
4⅝% to 12% Notes due 1985 to 2000	17.6	25.6
8½% to 9¾% Notes due 1985 to 1986	10.2	17.0
Other miscellaneous debt	3.2	3.4
Total	$1,140.3	$1,095.5

Arrangements with various banks make available to the company and its subsidiaries lines of credit totaling $250 million that extend through June 1984 at commitment fees of ¼ of 1% on the unused funds.

Lease Rental Obligations

Minimum rental payments for capitalized leased properties, as well as the present value thereof computed by discounting future payments using the company's incremental borrowing rate in effect at the time of leasing and minimum rental obligations for operating leases are as follows:

	Capital Leases	Operating Leases
	Millions of Dollars	
1984	$ 26.9	$ 64.2
1985	25.9	56.0
1986	25.1	50.1
1987	51.2	45.4
1988	33.8	17.4
Balance	88.2	45.2
Total minimum rental obligations	$251.1	$278.3

After deduction of imputed interest of $77.7 million, the present value of capital lease obligations at December 31, 1983, totaled $173.4 million. The current portion of these obligations amounted to $13.4 million.

Total operating rental expense included in current earnings is as follows:

	1983	1982	1981
	Millions of Dollars		
Fixed amount rentals	$ 74.3	$ 68.0	$60.3
Contingent rentals (based on sales, usage, etc.)	42.6	35.0	32.5
Total	$116.9	$103.0	$92.8

Sublease rental income related to capital and operating leases amounted to $40.7 million in 1983, $37.8 million in 1982 and $35.1 million in 1981.

Common Shares

Authorized—260,000,000 Shares

	1983	1982	1981
	Thousands of Shares		
Outstanding at beginning of year	173,643	173,614	173,505
Sale of Common Shares, etc.	43	29	109
Outstanding at end of year	173,686	173,643	173,614
Par value per authorized share	$1.00	$2 1/12	$2 1/12

At December 31, 1983, 1,143,308 shares were reserved for issuance as follows: 16,167 shares for conversion rights of the 4¼% Convertible Debentures; 703,184 shares for future grants under options; and 423,957 shares for the exercise of options presently held by officers and employees, of which 290,743 shares were exercisable at year end. Options outstanding at December 31, 1983, which were granted at market value at the date of the grant, have an average purchase price of $27.21 per share and expiration dates ranging from October 28, 1984, to November 28, 1993. During 1983 options on 1,874 shares with an average purchase price of $7.70 per share were exercised, 7,928 shares were issued upon the exercise of stock appreciation rights, options on 22,468 shares were cancelled and options to purchase 239,786 shares were granted at an average purchase price of $29.49 per share.

Nonconsolidated Subsidiary

The financial position and results of operations of Union Oil Credit Corporation, a wholly owned nonconsolidated finance subsidiary of the company, which is accounted for on the equity basis, were as follows:

Financial Position	December 31	
	1983	1982
	Millions of Dollars	
Accounts receivable, etc.	$218.7	$498.7
Long-term receivables	11.7	13.6
Total assets	$230.4	$512.3
Short-term notes payable	$149.3	$407.1
Long-term debt due Union Oil Company	10.0	10.0
Shareowner's equity	71.1	95.2
Total liabilities and shareowner's equity	$230.4	$512.3

Statement of Earnings	1983	1982	1981
	Millions of Dollars		
Service charge income	$36.0	$84.6	$96.1
Interest income	1.2	1.4	1.6
Total income	37.2	86.0	97.7
Administrative and general expense	.2	.3	.2
Interest expense	24.8	57.3	65.2
Earnings before taxes on income	12.2	28.4	32.3
Provision for taxes on income	6.2	14.5	16.5
Net earnings	$ 6.0	$13.9	$15.8

Union Oil Credit Corporation had average short-term notes payable outstanding of $265.3 million in 1983, $435.4 million in 1982 and $399.0 million in 1981. The average interest rates for these notes were 8.8%, 12.1% and 16.2% in 1983, 1982 and 1981, respectively.

Service charge income paid by the company to Union Oil Credit Corporation is reported as selling, administrative and general expense. Equity in earnings of Union Oil Credit Corporation is included in miscellaneous income.

Affiliated Companies

Dividends received from affiliates totaled $21.6 million in 1983, $23.1 million in 1982 and $18.2 million in 1981.

Excise, Property and Other Operating Taxes

	1983	1982	1981
	Millions of Dollars		
Consumer excise taxes	$480.5	$342.8	$ 358.0
Windfall profit tax	246.8	378.7	522.8
Severance and other taxes on production	66.9	79.7	86.7
Real and personal property taxes	74.6	65.0	58.5
Other taxes and duties	50.4	54.1	32.2
Total	$919.2	$920.3	$1,058.2

In addition, social security and unemployment insurance taxes, which are charged principally to earnings and included with salaries and wages, totaled $38.0 million in 1983, $33.8 million in 1982 and $30.6 million in 1981.

Federal and Other Taxes on Income

	1983	1982	1981
	Millions of Dollars		
Federal			
Current	**$253.1**	$370.3	$408.8
Investment and energy tax credits	**(86.0)**	(115.7)	(95.7)
Deferred	**112.1**	140.0	113.9
Total	**279.2**	394.6	427.0
State			
Current	**47.3**	60.8	61.3
Deferred	**11.0**	16.0	13.5
Total	**58.3**	76.8	74.8
Foreign			
Current	**105.0**	109.3	115.2
Deferred	**—**	21.8	13.8
Total	**105.0**	131.1	129.0
Total	**$442.5**	$602.5	$630.8

Deferred taxes on income resulted from the following timing differences between financial and taxable income:

Accelerated depreciation for tax in excess of book provision	**$ 93.0**	$ 35.6	$ 23.4
Deductions for tax in excess of book provisions related to exploration and development costs	**32.0**	129.4	121.5
Other items	**(1.9)**	12.8	(3.7)
Total	**$123.1**	$177.8	$141.2

Reconciliation of the provision for taxes on income to the current Federal statutory rate is as follows:

Taxes on book earnings computed at statutory rate	**$491.5**	$647.0	$654.2
Foreign taxes in excess of the statutory rate	**6.9**	42.5	50.6
State taxes, net of U.S. tax effect	**31.5**	41.5	40.4
U.S. investment and energy tax credits	**(86.0)**	(115.7)	(95.7)
All other items	**(1.4)**	(12.8)	(18.7)
Total	**$442.5**	$602.5	$630.8

United States earnings before income taxes (net of corporate and unallocated expenses) were $855.2 million, $1,213.8 million and $1,251.8 million for 1983, 1982 and 1981, respectively. Foreign earnings before taxes were $213.2 million, $192.7 million and $170.4 million for 1983, 1982 and 1981, respectively.

No provision for U.S. taxes has been made related to the company's share of the undistributed earnings of foreign subsidiaries and affiliates which have been retained for reinvestment or when distributed are not expected to result in additional U.S. tax. Such undistributed earnings amounted to $231.9 million, $185.1 million and $150.0 million as of December 31, 1983, 1982 and 1981, respectively.

Earnings Per Share

Earnings per share are based on weighted average shares outstanding during each period.

Research and Development Costs

Charges to income for research and development were $56.0 million in 1983, $48.3 million in 1982 and $37.0 million in 1981.

Retirement Plans

The company and its subsidiaries have several non-contributory retirement plans covering substantially all employees. Essentially all of these plans are funded with insurance companies and a corporate trustee. Total costs for these plans were $54.1 million for 1983, $56.8 million for 1982 and $54.9 million for 1981.

Net assets of the retirement plans and the actuarial present value (based on a 7% discount factor) of accumulated plan benefits are:

	December 31	
	1983	1982
	Millions of Dollars	
Net assets available for benefits	**$809.4**	$714.2
Vested benefits	**$629.3**	$593.2
Non-vested benefits	**$ 31.0**	$ 31.1

Oil and Gas Financial Data

	1983		1982**		1981**	
	United States	**Foreign**	United States	Foreign	United States	Foreign
	Millions of Dollars except per unit amounts					
Results of Operations						
Sales						
To public	**$ 690.3**	**$368.0**	$ 948.6	$244.3	$ 952.4	$129.4
Intercompany	**1,418.1**	**331.1**	1,547.1	347.7	1,633.1	340.1
Other revenues	**33.2**	**28.9**	13.5	59.0	12.1	26.4
Total	**2,141.6**	**728.0**	2,509.2	651.0	2,597.6	495.9
Production costs	**661.4**	**168.8**	790.9	153.8	915.6	105.1
Exploration expenses	**183.3**	**192.1**	236.5	163.4	234.2	151.5
Depreciation and amortization	**350.1**	**221.6**	328.0	185.7	299.9	96.5
Other operating expenses	**32.4**	**17.3**	32.1	22.4	27.6	21.3
Net	**914.4**	**128.2**	1,121.7	125.7	1,120.3	121.5
Income tax expense	**435.5**	**84.9**	529.8	113.8	522.7	122.2
Results of operations for producing activities	**$ 478.9**	**$ 43.3**	$ 591.9	$ 11.9	$ 597.6	$ (.7)
Average sales price: (unaudited)						
Oil—per barrel	**$ 25.85**	**$26.06**	$ 27.87	$27.75	$ 31.57	$27.19
Gas—per MCF	**$ 2.15**	**$ 2.24**	$ 2.33	$ 2.10	$ 2.00	$ 1.97
Average production costs per barrel (unaudited)*	**$ 6.01**	**$ 5.18**	$ 6.32	$ 5.57	$ 7.09	$ 5.24
Costs Incurred						
Land acquisition	**$ 127.0**	**$ 3.5**	$ 173.6	$ 2.0	$ 192.2	$ 1.5
Exploration	**$ 197.7**	**$198.3**	$ 267.9	$220.7	$ 280.5	$176.5
Development	**$ 281.0**	**$354.6**	$ 430.5	$315.9	$ 530.4	$176.7

**The above average production expense per barrel is based on equivalent petroleum barrels including natural gas converted on a ratio of 5.3 MCF to one barrel of oil. Production expense includes lifting costs and windfall profit tax. It excludes exploration expense, dry hole costs, depreciation and amortization, administrative and general expense, and estimated income taxes.*

***Data have been restated where necessary to conform to new disclosure requirements applicable to 1983 data.*

Oil and Gas Reserve Data (Unaudited)

Estimated Underground Reserves*

	Crude Oil and Condensate (Millions of Barrels)		Natural Gas (Billion Cubic Feet)		Natural Gas Liquids*** (Millions of Barrels)	
	United States	Foreign	United States	Foreign	United States	Foreign
Proved developed and undeveloped reserves						
1983 Activity						
Estimated at 1/1/83	523	205	5,170	1,223	138	6
Revisions of estimates	10	6	(30)	114**	(1)	1
Improved recovery	11	—	5	—	—	—
Discoveries and extensions	39	4	205	39	6	—
Production	(56)	(27)	(301)	(60)	(8)	(1)
Estimated at 12/31/83	527	188	5,049	1,316	135	6
1982 Activity						
Estimated at 1/1/82	533	198	5,436	1,685	145	7
Revisions of estimates	18	17	(73)	(728)**	(2)	—
Improved recovery	3	—	—	—	—	—
Discoveries and extensions	24	15	210	318	6	—
Production	(55)	(25)	(403)	(52)	(11)	(1)
Estimated at 12/31/82	523	205	5,170	1,223	138	6
1981 Activity						
Estimated at 1/1/81	528	193	5,781	1,429	154	7
Revisions of estimates	6	10	(80)	15	(2)	1
Improved recovery	18	1	1	4	—	—
Discoveries and extensions	36	18	167	263	4	—
Production	(55)	(24)	(433)	(26)	(11)	(1)
Estimated at 12/31/81	533	198	5,436	1,685	145	7
Proved developed reserves						
Estimated at 12/31/83	421	150	3,575	513	95	5
Estimated at 12/31/82	405	157	3,636	494	97	5
Estimated at 12/31/81	410	131	3,737	780	100	6
Estimated at 12/31/80	388	134	3,880	299	104	5

**Includes net profits type agreements on a gross basis.*

***Includes reserve revisions for Thailand of 115 and (728) billion cubic feet of natural gas for 1983 and 1982, respectively.*

****Natural gas liquids reserves are on a leasehold basis. The United States information is derived from the natural gas reserves by applying a national average shrinkage factor obtained from the Department of Energy published statistics.*

Oil and Gas Reserve Data (Unaudited)

continued

Present Value of Future Net Cash Flow

	1983			1982		
	United States	Foreign	Total	United States	Foreign	Total
	Millions of Dollars					
Revenues	$26,048	$7,130	$33,178	$25,963	$7,577	$33,540
Development and production costs	8,984	3,331	12,315	7,682	3,098	10,780
Income tax expense	7,905	1,800	9,705	8,535	2,030	10,565
Net future cash flow	9,159	1,999	11,158	9,746	2,449	12,195
10% annual discount	4,642	627	5,269	4,377	921	5,298
Present value of future net cash flow	$ 4,517	$1,372	$ 5,889	$ 5,369	$1,528	$ 6,897

The above data are based on estimated production of proved developed and undeveloped reserves from present and planned future facilities, present prices of oil and gas and present costs of development and production.

Changes in Present Value of Future Net Cash Flow

	1983	1982	1981
	Millions of Dollars		
Present value at beginning of year	$6,897	$7,423	$5,274
Discoveries and extensions, net of estimated future costs	619	1,195	1,172
Revisions to prior estimates:			
Prices net of estimated changes in production costs	(791)	897	2,875
Quantity estimated	294	(491)	61
Production schedules, etc.	(2,062)	(2,403)	484
Interest factor	1,159	1,365	961
Development costs related to beginning of year reserves	676	397	451
Sales of oil and gas, net of production costs of $830 million in 1983, $945 million in 1982 and $1,021 million in 1981	(1,977)	(2,143)	(2,034)
Net change in income taxes	1,074	657	(1,821)
Present value at end of year	$5,889	$6,897	$7,423

The company cautions readers that the preceding data on the present value of future net cash flow of oil and gas reserves are based on many subjective judgments and assumptions. Different, but equally valid assumptions and judgments could lead to significantly different results. Additionally, estimates of physical quantities of oil and gas reserves, future rates of production and related prices and costs for such production are subject to extensive revisions and a high degree of variability as a result of economic and political changes. It is, therefore, the opinion of the company that these data can be highly misleading and may not be indicative of underground oil and gas reserves values.

Metals Reserve Data (Unaudited)

	1983	1982	1981	1980
Estimated Proved and Probable Ore Reserves at year end (million tons)				
Molybdenum				
Open pit operations	123	119	119	119
Average disulfide content (percent)	0.183	0.169	0.169	0.169
Underground operations	124	124	124	124
Average disulfide content (percent)	0.294	0.294	0.294	0.294
Lanthanides (rare earths)	42	43	44	44
Average oxides content (percent)	7.670	7.680	7.680	7.680
Average Sales Price (per pound)				
Molybdenum disulfide*	$4.23	$5.30	$8.55	$9.02
Lanthanides (rare earths) in concentrate	$ .94	$ .99	$ .93	$ .85

**Contains approximately 60% molybdenum by weight. Stated at equivalent market price.*

Supplementary Inflation Adjusted Data (Unaudited)

As required by the Financial Accounting Standards Board, the following supplementary financial information is presented to indicate the effects of general inflation and changes in specific prices on historical cost data. The Consumer Price Index—For All Urban Consumers has been used to estimate the effects of general inflation, while externally and internally developed indices, current prices, engineering estimates and appraisals have been used to estimate the effect of changes in specific prices.

	Adjusted For General Inflation	Adjusted For Changes in Specific Prices
	Millions of Dollars	
1983 Net earnings—historical cost basis	626	626
Adjustments to restate:		
Inventory withdrawals	(20)	(7)
Depreciation and amortization	(295)	(346)
1983 Net earnings—as adjusted	311	273
Purchasing power gain on net monetary liabilities not included above	98	

At December 31, 1983, inventories and net properties, adjusted for changes in specific prices, were $1.3 billion and $11.1 billion, respectively.

The adjustments to restate depreciation and amortization were calculated using historical cost lives and methods except for oil and gas producing properties. For those properties, the adjustment was calculated using the straight-line method and estimated average lives as compared to the unit of production method used for historical cost purposes. In accordance with the standards, income tax expense has not been restated.

The Board's standards also require the company to estimate and disclose cost increases/(decreases) due to changes in specific prices over/(under) general inflation for inventories and properties held during the year. This amount was determined as follows:

	Millions of Dollars
Estimated increase/(decrease) in specific prices of inventories and properties held during the year	(277)
Less estimated effect of increase in general price level	465
Estimated increase/(decrease) in specific prices over/(under) increase in general price level	(742)

Additional data adjusted for the effects of inflation, stated in average 1983 dollars, and the Consumer Price Index—For All Urban Consumers used for the years 1979 through 1983 are as follows:

	1983	1982	1981	1980	1979
	Millions of Dollars except per share amounts				
Sales and operating revenues (including consumer excise taxes)	10,546	11,074	12,164	12,542	10,941
Net earnings					
Adjusted for general inflation	311	509	556	467	319
Adjusted for changes in specific prices	273	388	426	302	170
Net earnings per share					
Adjusted for general inflation	1.79	2.93	3.20	2.69	1.84
Adjusted for changes in specific prices	1.57	2.23	2.45	1.74	.98
Shareowners' equity at year end					
Adjusted for general inflation	8,092	8,027	7,602	7,204	6,729
Adjusted for changes in specific prices	9,710	10,303	9,455	8,864	8,442
Increase/(decrease) in specific prices over/(under) increase in the general price level for inventories and properties	(742)	595	360	104	(104)
Purchasing power gain on net monetary liabilities	98	93	185	213	223
Dividends per common share	1.00	1.03	.99	.92	.90
Market price per common share at year end	31.10	27.18	39.90	51.52	29.05
Consumer Price Index—For All Urban Consumers	298.5	289.3	272.5	246.8	217.4

Supplementary Financial and Market Price Data (Unaudited)

	1983—Quarters			
	1st	2nd	3rd	4th
	Millions of Dollars except per share amounts			
Sales and operating revenues	2,446.9	2,781.3	2,707.3	2,610.6
Gross margin	238.9	286.0	349.8	280.6
Net earnings	128.3	139.4	180.2	178.0
Net earnings per share	.74	.80	1.04	1.02
Market price per share—high	34¼	37⅝	37¼	32⅛
—low	27	30¼	29⅞	27¼
Dividends paid per share	.25	.25	.25	.25

	1982—Quarters			
	1st	2nd	3rd	4th
	Millions of Dollars except per share amounts			
Sales and operating revenues	2,447.9	2,846.1	2,737.3	2,701.9
Gross margin	311.6	383.8	428.3	392.4
Net earnings	168.5	197.6	212.8	225.1
Net earnings per share	.97	1.14	1.22	1.30
Market price per share—high	37⅞	37½	32¼	34½
—low	27⅛	30⅝	21¼	24½
Dividends paid per share	.25	.25	.25	.25

Shares are listed on the New York, Pacific and Midwest Stock Exchanges.

Selected Financial Data

(dollars in millions except per share amounts)

		1983	1982	1981	1980	1979
Earnings and Funds Data	Sales and operating revenues	10,546.1	10,733.2	11,103.9	10,369.0	7,968.5
	Other revenues	144.4	165.9	192.3	103.5	121.5
	Total revenues	10,690.5	10,899.1	11,296.2	10,472.5	8,090.0
	Net earnings	625.9	804.0	791.4	647.0	500.6
	Per share	3.60	4.63	4.56	3.73	2.88
	Funds provided from operations	1,799.2	1,987.1	1,811.7	1,415.3	1,153.7
Share Data	Weighted average shares—thousands	173,677	173,636	173,589	173,452	173,786
	Cash dividends declared	173.7	173.7	156.3	132.3	112.6
	Per share	1.00	1.00	.90	.7625	.65
	Number of shareowners at year end	88,089	93,445	94,298	92,829	87,941
Balance Sheet Data	Total assets	9,228.0	8,511.3	7,592.8	6,772.1	6,013.1
	Working capital	456.8	296.3	138.4	444.1	820.4
	Ratio of current assets to current liabilities	1.3:1	1.2:1	1.1:1	1.3:1	1.7:1
	Long-term debt	1,140.3	1,095.5	876.5	945.1	995.2
	Capital lease obligations	160.0	171.6	185.4	207.9	224.6
	Shareowners' equity	5,180.1	4,745.1	4,114.2	3,476.8	2,956.9
	Return on average shareowners' equity	12.6%	18.2%	20.8%	20.1%	18.0%
Geographic Areas of Operations	Revenues:					
	United States	9,863.0	10,253.5	10,718.4	9,989.5	7,475.0
	Foreign	1,668.7	1,501.3	1,841.4	2,332.6	2,233.1
	Corporate and Unallocated	43.8	61.2	66.8	49.1	48.7
	Intersegment Eliminations*	(885.0)	(916.9)	(1,330.4)	(1,898.7)	(1,666.8)
	Total	10,690.5	10,899.1	11,296.2	10,472.5	8,090.0
	Net earnings:					
	United States	655.1	868.1	870.3	725.6	539.9
	Foreign	90.9	56.7	35.8	22.5	22.6
	Corporate and Unallocated	(120.1)	(120.8)	(114.7)	(101.1)	(61.9)
	Total	625.9	804.0	791.4	647.0	500.6
	Assets—December 31:					
	United States	7,206.1	6,819.3	6,096.4	5,516.4	4,901.6
	Foreign	1,468.9	1,216.0	1,012.6	870.1	710.5
	Corporate and Unallocated	553.0	476.0	483.8	385.6	401.0
	Total	9,228.0	8,511.3	7,592.8	6,772.1	6,013.1
General Data	Salaries, wages and employee benefits	785.9	751.3	633.3	577.1	486.3
	Number of regular employees at year end	20,304	20,035	19,399	18,539	17,460

All data are pro forma where applicable.

**Intersegment revenue eliminations essentially represent transfers from foreign countries to the United States at prices which approximate market.*

Segment Data

	1983	1982	1981	1980	1979
Revenues:					
Petroleum—Exploration and Prod.	3,633.6	3,719.5	3,640.4	2,553.5	1,676.6
—Refining, Mktg., Transp.	8,221.9	8,484.5	8,951.6	8,625.1	6,577.0
Chemicals	1,132.6	1,152.5	1,248.4	1,087.2	890.1
Geothermal	154.0	119.5	147.3	69.8	37.8
Metals	66.7	69.4	110.5	126.0	133.6
Other	47.7	66.0	42.6	38.7	22.9
Corporate and Unallocated	43.8	61.2	66.8	49.1	48.7
Intersegment Eliminations***	(2,609.8)	(2,773.5)	(2,911.4)	(2,076.9)	(1,296.7)
Total	10,690.5	10,899.1	11,296.2	10,472.5	8,090.0
Net earnings:					
Petroleum—Exploration and Prod.	522.2	603.8	596.9	486.2	329.4
—Refining, Mktg., Transp.	122.6	161.4	123.6	115.5	103.6
Chemicals	74.0	89.5	110.9	104.0	80.4
Geothermal	29.0	21.4	50.7	20.6	8.1
Metals*	(11.1)	(7.2)	3.2	26.7	32.7
Other	9.3	55.9	20.8	(4.9)	8.3
Corporate and Unallocated	(120.1)	(120.8)	(114.7)	(101.1)	(61.9)
Total	625.9	804.0	791.4	647.0	500.6
Assets—December 31:					
Petroleum—Exploration and Prod.	3,963.9	3,643.6	3,085.4	2,668.1	2,040.9
—Refining, Mktg., Transp.	2,376.4	2,314.4	2,325.7	2,373.1	2,491.3
Chemicals	699.3	671.0	701.4	688.2	645.6
Geothermal	271.4	253.6	236.7	199.2	160.4
Metals**	401.1	376.4	333.3	239.7	131.7
Other	962.9	776.3	426.5	218.2	142.2
Corporate and Unallocated	553.0	476.0	483.8	385.6	401.0
Total	9,228.0	8,511.3	7,592.8	6,772.1	6,013.1
Capital expenditures:					
Petroleum—Exploration and Prod.	1,024.6	1,272.1	1,223.7	1,106.3	680.9
—Refining, Mktg., Transp.	198.5	82.6	139.1	180.4	131.2
Chemicals	43.8	41.0	41.4	60.1	32.1
Geothermal	66.3	65.7	67.3	55.5	54.1
Metals	44.7	55.7	99.2	79.4	26.0
Other, Corporate and Unallocated	215.0	400.2	239.9	103.1	61.9
Total	1,592.9	1,917.3	1,810.6	1,584.8	986.2
Depreciation and amortization:					
Petroleum—Exploration and Prod.	571.7	513.7	396.4	296.2	182.1
—Refining, Mktg., Transp.	104.2	102.3	98.1	92.7	87.3
Chemicals	40.9	39.3	37.9	34.0	30.9
Geothermal	39.8	30.3	21.5	12.6	4.4
Metals	13.6	14.2	15.0	11.3	9.7
Other, Corporate and Unallocated	26.5	24.0	16.1	8.8	8.6
Total	796.7	723.8	585.0	455.6	323.0
*Includes equity in earnings of affiliates	4.6	8.4	10.4	6.6	4.1
**Includes equity in affiliates	55.1	57.1	59.4	62.0	28.8

****Intersegment revenue eliminations are mainly transfers from exploration and production operations to refining, marketing and transportation operations at prices which approximate market.*

Operating Summary

Energy Resources

	1983	1982	1981	1980	1979
Drilling					
Net exploratory wells completed:					
Oil	6	11	8	10	9
Gas	9	9	14	18	18
Geothermal	7	5	8	4	6
Net development wells completed:					
Oil	144	165	249	195	111
Gas	48	59	50	38	49
Geothermal	9	13	15	23	23
Net dry holes	53	67	66	69	77
Total net wells	276	329	410	357	293
Net producible wells at year end	10,346	10,411	10,478	10,116	9,784
Net reserves at year end:*					
Crude oil and condensate—million barrels					
United States	527	523	533	528	526
Foreign	188	205	198	193	283
Total	715	728	731	721	809
Natural gas—billion cubic feet	6,365	6,393	7,121	7,210	7,049
Geothermal—billion kilowatt hours	202	208	210	200	169
Geothermal—million equivalent oil barrels	304	312	315	301	253
Net daily production:*					
Crude oil and condensate—thousand barrels					
United States	152.9	151.3	147.9	152.3	156.5
Foreign	73.1	68.7	67.9	77.1	84.8
Total	226.0	220.0	215.8	229.4	241.3
Available to U.S. refineries					
United States	152.9	151.3	147.9	152.3	156.5
Foreign	39.1	28.6	25.0	24.1	28.6
Total	192.0	179.9	172.9	176.4	185.1
Natural gas—million cubic feet					
United States	817.4	1,035.8	1,133.4	1,165.0	1,201.2
Foreign	165.1	143.1	72.9	60.5	64.3
Total	982.5	1,178.9	1,206.3	1,225.5	1,265.5
Natural gas liquids—thousand barrels					
Plant	7.7	9.1	9.2	8.7	11.4
Leasehold**	9.8	11.0	11.1	12.4	9.8
Total	17.5	20.1	20.3	21.1	21.2
Geothermal—million kilowatt hours	16.0	13.7	12.7	10.1	6.1
Geothermal—thousand equivalent oil barrels	24.0	20.5	19.0	15.2	9.1
Average geothermal sales prices—dollars per thousand kilowatt hours	26.33	23.91	23.92	18.74	16.99

**Includes net profits type agreements on a gross basis.*
***Net of plant retention.*

		1983	1982	1981	1980	1979
Refining and Marketing	Refining—thousand barrels daily					
	Input to crude oil processing units					
	For Union—Crude oil	**355.6**	342.2	348.6	366.7	429.2
	—Other materials	**20.5**	14.0	15.1	14.2	17.5
	For others	**4.2**	7.7	8.7	10.6	10.7
	Total input	**380.3**	363.9	372.4	391.5	457.4
	Refinery production					
	Gasoline	**223.7**	213.1	228.8	234.8	260.0
	Kerosine, heating oil and diesel oil	**98.1**	96.6	99.1	102.8	122.9
	Fuel oil	**31.2**	23.9	16.7	16.5	22.2
	Other products	**73.1**	71.0	72.6	74.9	85.4
	Total production	**426.1**	404.6	417.2	429.0	490.5
	Crude oil purchases—thousand barrels daily	**365.4**	332.8	328.9	434.6	490.0
	Marketing—thousand barrels daily					
	Crude oil sales	**219.1**	189.2	175.4	253.5	284.8
	Natural gas liquids sales	**25.3**	24.0	28.5	27.5	33.3
	Natural gas sales—million cubic feet daily	**793.1**	982.3	1,022.7	1,036.7	1,084.2
	Petroleum product sales					
	Gasoline	**226.8**	212.1	217.7	252.9	268.0
	Kerosine, heating oil and diesel oil	**116.1**	116.6	114.8	128.9	144.7
	Fuel oil	**29.6**	23.2	18.4	19.8	25.3
	Other products	**13.5**	12.3	14.4	20.1	25.1
	Total products	**386.0**	364.2	365.3	421.7	463.1
Chemicals	Ammonia production—tons daily	**3,559**	3,730	3,772	3,706	3,627
	Processed coke production—tons daily	**1,370**	1,600	1,933	1,680	1,611
	Petrochemical sales—thousand gallons daily	**1,010**	954	968	897	1,063
Metals	Annual mine production—thousand pounds:					
	Molybdenum in concentrates	**619**	—	1,832	3,729	5,394
	Lanthanides (rare earths) in concentrates	**37,661**	38,582	37,660	35,244	36,410
	Annual roaster production—thousand pounds:					
	Molybdenum oxide	**492**	4,169	5,791	5,601	5,752
Sales Data	Sales—million dollars					
	Petroleum products	**5,249.4**	5,545.9	5,961.2	5,848.8	4,394.9
	Crude oil and condensate	**2,284.7**	2,138.8	2,049.7	1,826.7	1,320.1
	Chemicals	**1,116.2**	1,135.6	1,210.5	1,047.7	865.4
	Natural gas	**700.1**	903.1	812.9	598.2	458.2
	Natural gas liquids	**192.0**	169.1	213.2	183.9	152.9
	Geothermal	**153.7**	119.0	110.4	69.1	37.7
	Metals	**61.7**	60.8	103.6	119.5	129.8
	Other	**135.6**	133.3	127.0	92.9	85.4
	Consumer excise taxes	**480.5**	342.8	358.0	384.9	400.9
	Total sales	**10,373.9**	10,548.4	10,946.5	10,171.7	7,845.3

Administration

Directors

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Retired President and Chief Executive Officer, Beckman Instruments, Inc., Fullerton, California (Analytical instruments and components)

***Claude S. Brinegar, 1968**
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***Ray A. Burke, 1966**
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Personal Investments, Beverly Hills, California

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Dean, J. L. Kellogg Graduate School of Management, Northwestern University, Evanston, Illinois

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Peter O'Malley, 1976
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***Richard J. Stegemeier, 1980**
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Donn B. Tatum, 1977
Chairman of the Executive Committee, Walt Disney Productions, Burbank, California (Entertainment and recreational activities)

**Member of the Executive Committee.*

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Comptroller

K. G. Hanks
Assistant Comptroller

C. S. McDowell
Assistant Comptroller

W. D. Farr
Assistant Treasurer

S. H. Nosler
Assistant Treasurer and Assistant Secretary

J. R. Courtney
Assistant Secretary

R. E. Jenkins
Assistant Secretary

R. P. Van Zandt
Assistant Secretary

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Washington, D.C. Office
E. William Cole, Jr., *Vice President*

UNOCAL

UNOCAL Corporation
Union Oil Center, 461 South Boylston Street
Los Angeles, California 90017

ATTACHMENT I-1

Union 76 Division: Eastern Region

Union Oil Company of California
Chicago Refinery, Lemont, Illinois 60439
Telephone (312) 257-7761

union 76

A.J. Eliskalns
Manager, Chicago Refinery

December 14, 1984

Mr. Valdas Adamkas
Regional Administrator
United States Environmental
Protection Agency - Region V
Waste Management Branch
230 S. Dearborn
Chicago, IL 60604

Dear Sir:

Request for Approval in
Principle-Impoundment Closure

After discussion with the U.S. EPA and Illinois EPA, Union Oil of California (Union Oil) seeks clarification and "approval-in-principle" from both agencies for the closure of a surface impoundment which is part of its hazardous waste land treatment area, as described in its recently submitted Part B permit application.

This request, and the information contained herein, describes the approach proposed by Union Oil. This approach fully complies with the closure requirements of both Subparts G and K of 40 CFR 264 and will allow Union Oil to "close" the surface impoundment, and subsequently re-open the impoundment for winter storage of nonhazardous wastes. Our approach and rationale follow.

Description of Surface Impoundment Operations

Union Oil has recently submitted a Part B permit application to the U.S. EPA for the operation of a land treatment facility.

Within that permit application, Union Oil proposed to close the surface impoundment contained within the hazardous waste land treatment area, and to submit a closure plan by December 31, 1984. See Figure 1.

The surface impoundment, as shown in Figure 2, consists of 2 cells and encompasses an area with approximate dimensions of 700 feet by 200 feet. Sludges are emptied into the first cell and flow by gravity into the second cell. During winter storage, the freezing and subsequent thawing of the sludges results in dewatering. Released liquids are drawn off in the second cell and flow to the refinery's wastewater treatment system. Residual solids contained within the surface impoundment are removed using a front-end loader during the spring and summer period and are placed on the active land treatment plots. Hazardous wastes generated at the refinery are not placed in the surface impoundment, but rather are placed directly on the land treatment plots.

During late 1980 and early 1981, Union Oil stored a sludge mixture which contained API separator sludge (a listed hazardous waste) within the surface impoundment. The quantity of API separator sludge placed within the surface impoundment amounted to approximately 1% of the total waste mixture placed in the surface impoundment during that period, as shown on Table 1. Union Oil has not placed any other hazardous wastes in the surface impoundment since the API separator sludge, and has no need to do so in the future.

Since hazardous wastes were placed in the surface impoundment, current federal regulations require that the surface impoundment either be permitted under the Part B permit application or closed.

The surface impoundment serves a required function in the total operation of the land treatment facility in that nonhazardous wastes are stored in the impoundment during the winter operations when land treatment is impractical. Union Oil desires to continue to use the surface impoundment for this function. Consequently, Union Oil proposes to "close' the surface impoundment and immediately thereafter reopen the impoundment for winter storage of nonhazardous wastes and continue operation of the impoundment as a decant basin. Winter freezing of nonhazardous sludges placed within the impoundment promotes dewatering during the spring thaw and provides a more easily handled material for placement on the land treatment plots.

Closure

Closure will be initiated after the spring thaw and the removal of any materials contained in the surface impoundment. For purposes of monitoring the closure activities, however, it is proposed that the following schedule for implementation be adhered to:

1) It is anticipated that all sludges will be removed by the end of June, 1985.

2) Within 15 days (July, 1985) after removal of all winter stored nonhazardous wastes in the surface impoundment, Union Oil will proceed to implement the bottom soil testing program as described below.

3) Soil samples will be immediately transferred to a laboratory for total metals and EP toxicity metals. Laboratory turn-around is expected to be approximately six weeks (the end of August, 1985).

4) A report documenting the methods and procedures of soil sampling used, and the results of the analytical program, will be prepared after the laboratory data has been received and will be submitted to the Illinois EPA by the end of September, 1985.

5) Final closure will be completed within 30 days of approval.

When Union Oil implements closure, all procedures and methods will be documented. This documentation will be signed and dated by a Union Oil representative. Copies of all analytical results and any other pertinent comments will be made part of this certification.

An independent registered professional engineer will be utilized for inspection of the surface impoundment after all sludges have been removed and will obtain the bottom soil samples as previously described. A closure certification will be prepared by this independent engineer for submittal by Union Oil to the State of Illinois and EPA Region V

offices. This certification will complete the requirements of 40 CFR 264.115.

Soil Tests

It is proposed that soil borings be taken at the bottom of each of the cells at approximately the mid-point of each cell (shown on Figure 2). A total of six borings will be taken. Two composite soil samples will be obtained from each boring, one composite from the first two feet and one composite from the next two feet. Each boring will therefore be four feet in total depth and a total of twelve (12) soil samples will be obtained. Borings will be obtained from the flights down to the appropriate depth. Analyses will include total metals as well as EP toxicity metals. See Table 2 for analytical requirements

Groundwater Monitoring

The surface impoundment is located within the RCRA Part B permitted area. The groundwater monitoring system for the land treatment area will be utilized for post closure monitoring of the surface impoundment (264.228(b)(3)). Figure 1 shows the monitoring well locations in relation to the location of the surface impoundment. Existing well locations provide for both upgradient and downgradient monitoring of the surface impoundment.

Notification of past operations in property deeds will ensure that requirements of 40 CFR 264.120 are fully met. With the anticipated remaining operational life of the land treatment area at approximately 12 years, to be followed by 30 years of post closure monitoring of the land treatment area, monitoring for the surface impoundment will encompass a period greater then 30 years as required under 40 CFR 264.117(a)(1).

Summary

Union Oil proposes the following program:

1. Removal of surface impoundment sludges.

2. Soil testing by an independent contractor.

3. Certification of closure by the Company and an independent registered professional engineer.

4. Groundwater monitoring for a minimum of 30 years.

5. Re-opening the surface impoundment for storage of non-hazardous wastes.

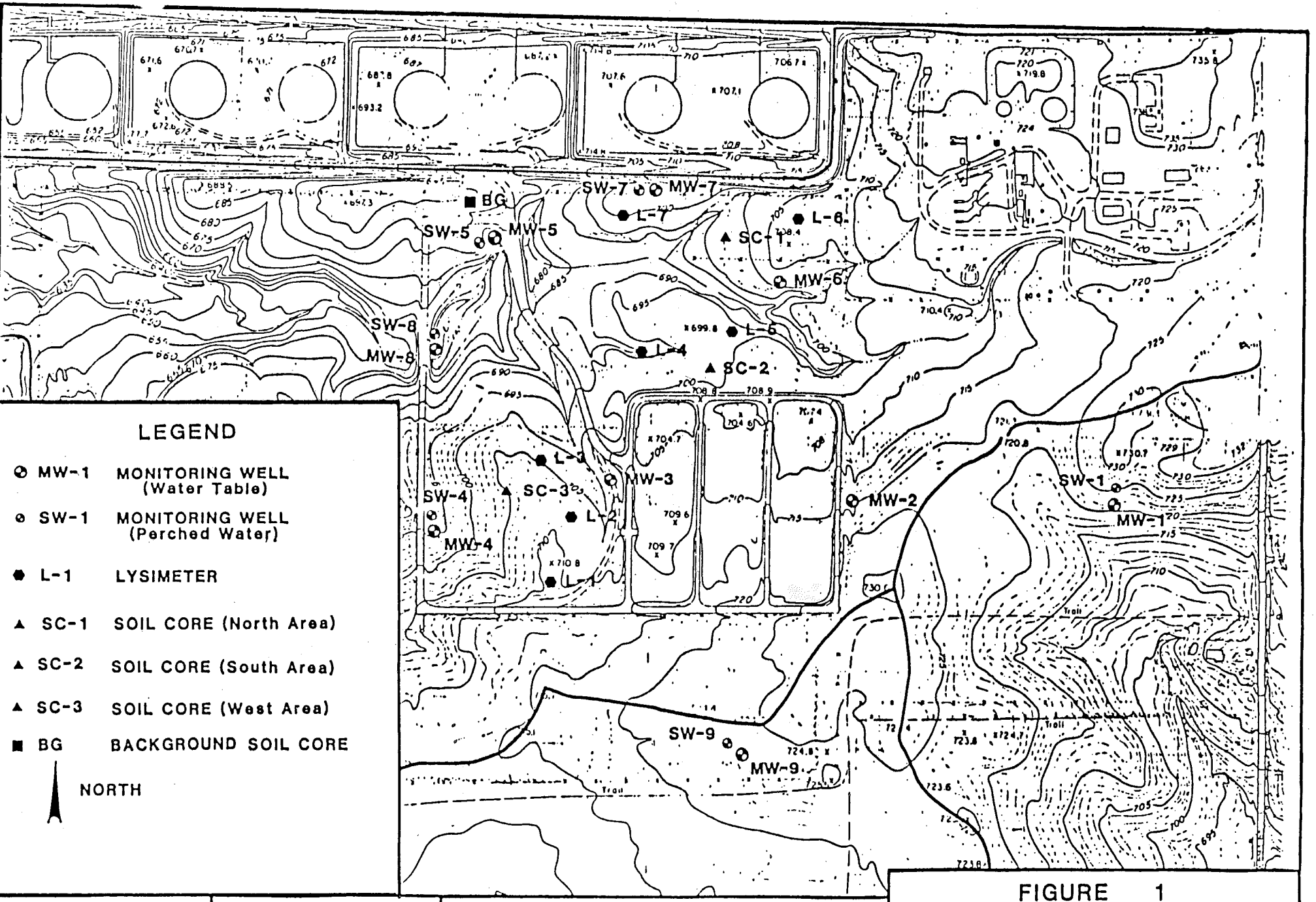
We would appreciate your earliest response to this request. If you have any questions, please contact Mr. L. D. Erchull at (312) 257-7761 for assistance.

Very truly yours,

D. W. Bruckert, Supervisor
Environmental Services

LDE:hw

cc: Mr. Lawrence Eastep-IEPA



UNION OIL OF CALIFORNIA
CHICAGO REFINERY
LAND TREATMENT AREA

T. M. GATES INC.

DATE OF AERIAL PHOTOGRAPHS: 1/25/73 | C. A. S. PROJECT NUMBER: CO 9456
CAMERA FOCAL LENGTH: 88.64 mm. | CONTOUR INTERVAL: 1 FOOT

FIGURE 1
MONITORING SYSTEM
FOR LAND TREATMENT AREA

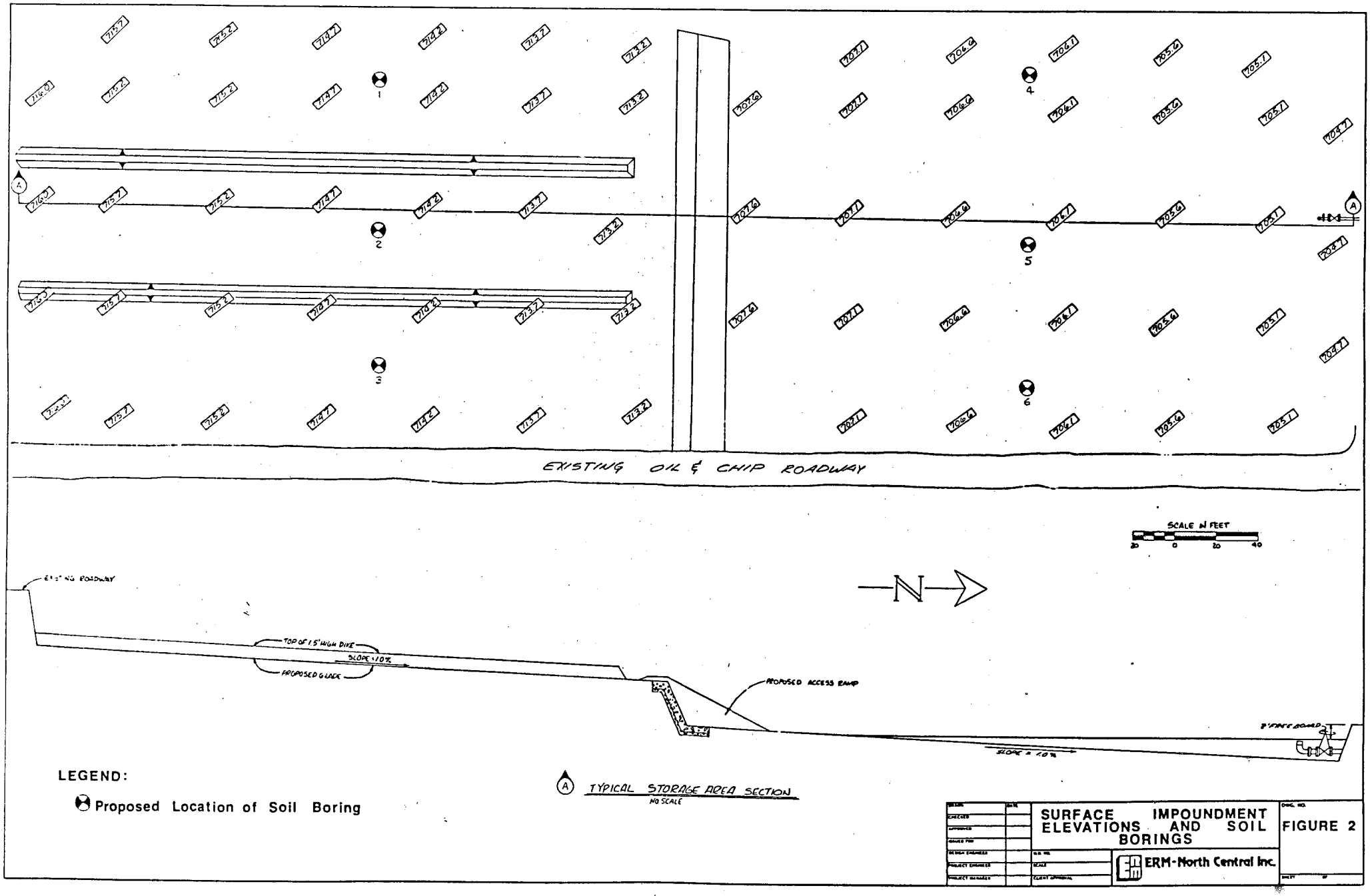

EXISTING OIL & CHIP ROADWAY
SCALE IN FEET
20 0 20 40
N
TOP OF 1.5' HIGH DIKE
SLOPE = 1.0%
PROPOSED GRADE
PROPOSED ACCESS RAMP
SLOPE = 1.0%
LEGEND:
Proposed Location of Soil Boring
TYPICAL STORAGE AREA SECTION
NO SCALE
SURFACE IMPOUNDMENT ELEVATIONS AND SOIL BORINGS
FIGURE 2
ERM-North Central Inc.

TABLE 1

HISTORIC LAND APPLICATION RECORD
(Dry Tons)

Waste	Year* 1983	1982	1981
API Separator Sludge			18**
Clear Well Sludge		200	
Cooling Tower Sludge	25		
Corrugated Plate Separator Bottoms			
Heavy Oil Sludge		10	
Slop Oil Emulsions			
Storm Water Pond Dredgings	1650	2328	
Tank Cleaning Waste			150
Water & Wastewater Sludge	2060	1444	1800
Totals	3735	3982	1968

* Records unavailable prior to 1981
** Estimated at 1% of Water & Wastewater Sludge

Note: Slop oil emulsions have not been generated as of this date.

SECTION J

OTHER FEDERAL LAWS

At this time, the land treatment area is the only operation under this Part B Permit. However, the Chicago Refinery has a number of other operations that have valid permits. These include air emission and wastewater discharge permits, all of which are administered by the State of Illinois.

At this time, the Chicago Refinery is either in full compliance with all federal and Illinois environmental requirements, or such requirements are not applicable to this facility. Federal laws not applicable to the Chicago Refinery include: Wild and Scenic Rivers Act; National Historic Preservation Act of 1966; Endangered Species Act; Coastal Zone Management Act; and, the Fish and Wildlife Coordination Act.

SECTION K

CERTIFICATION

"I certify under penalty of law that I have personally examined and am familiar with the information submitted in this document and all attachments and that, based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment."

Date 12-2-85 Signature: 12/2/85

Name and Title: A. J. Eliskains

Manager, Chicago Refinery

APPENDIX A

LITERATURE REVIEW

APPENDIX A

LITERATURE REVIEW

INTRODUCTION

The following sections are individual summaries of each pertinent article found in the literature review and previously referenced. Each article includes a summary of the waste types being treated, a review of the soils used for treatment, data on waste application and design rates, as well as the results of the studies. Pertinent tables and/or figures from each article have also been included when available.

For reference, the following listing shows author(s), title, and the page number on which each article summary starts.

LIST OF LITERATURE

Number	Reference	Page Number
1	Kincannon, C.B. "Oily Waste Disposal by Soil Cultivation Process." USEPA, Office of Research and Monitoring. Washington, D.C. December, 1972.	5
2	Dibble, J.T. and R. Bartha. "Effect of Environmental Parameters on Biodegradation of Oil Sludge." Applied and Environmental Microbiology. Volume 37, Number 4. 1979.	11
3	Dibble, J.T. and R. Bartha. "Leaching Aspects of Oil Sludge Biodegradation in Soil." Soil Science. Volume 127, Number 6. 1979.	25
4	Meyers, J.D. and Robert L. Huddleston. "Treatment of Oily Refinery Wastes by Landfarming." Proceedings of the 34th Industrial Waste Conference at Purdue University. May 8-10, 1979.	34
5	Deuel, Jr., L.E., and K.W. Brown. "Environmental Impact of Land Cultivation with Industrial Wastes." Disposal of Industrial and Oily Sludges by Land Cultivation. Resource Systems and Management Association. Northfield, New Jersey. 1980.	43
6	Raymond, R.L., J.O. Hudson, and B.W. Jamison. "Assimilation of Oil by Soil Bacteria." Disposal of Industrial and Oily Sludges by Land Cultivation. Resource Systems and Management Association. Northfield, New Jersey. 1980.	46
7	Norris, D.J. "Land Spreading of Oily and Biological Sludges in Canada." Proceedings of the 35th Industrial Waste Conference at Purdue University. May 13-15, 1980.	64

Number	Reference	Page Number
8	Weldon, R.A. "Atmospheric Emissions from Oil Waste Landspreading." Environmental Affairs Department, American Petroleum Institute. April, 1980.	73
9	Brown, K.W., K.C. Donelley, J.C. Thomas, and L.E. Deuel, Jr. "Factor's Influencing the Biodegradation of API Separator Sludges Applied to Soils." Land Disposal of Hazardous Wastes. Proceedings of the 7th Annual Research Symposium at Philadelphia, Pennsylvania. March 16-18. 1981.	84
10	Minear, R.A., J.L. Randall, and R.G. Weatherold. "Atmospheric Hydrocarbon Emissions from Land Treatment of Refinery Oily Sludges." American Petroleum Institute. May, 1981.	88
11	Huddleston, R.L. J.E. Rucker, R.W. Brown, and L.E. Deuel, Jr. "Evaluation of Subsurface Effects of Long-Term Landfarming." Land Disposal of Hazardous Waste, Proceedings of the 8th Annual Research Symposium at Fort Mitchell, Kentucky, March 8-10, 1982. EPA-600/9-82-002. March, 1982.	105
12	Brown, K.W., L.E. Deuel, Jr., and J.C. Thomas. "Land Treatability of Refinery and Petrochemical Sludges." Prepared for USEPA Office of Research and Development. PB 83-247148. August, 1983.	119
13	Habibafshar, A. "Determination of Volatile Hydrocarbon Emissions from Land Treatment of Petroleum Oily Sludges." A Dissertation to the University of Oklahoma. 1983.	156
14	Wetherold, R.G., J.L. Randall, and R.R. Williams. "Laboratory Assessment of Potential Hydrocarbon Emissions from Land Treatment of Refinery Oily Sludges, Phase II." American Petroleum Institute. June, 1983.	180

Number	Reference	Page Number
15	Environmental Research and Technology, Inc. "Land Treatability of Appendix VIII Constituents Present in Petroleum Industry Wastes." ERT Report No. B-974-220. Prepared for the American Petroleum Institute. February, 1984.	199

1). Kincannon, C. B., "Oily Waste Disposal By Soil Cultivation Process." USEPA, Office of Research and Monitoring. Washington, D.C.. December, 1972.

WASTES

The author studied three petroleum wastes: crude oil tank bottoms; a high molecular weight fuel oil (bunker C fuel oil or No. 6 fuel oil) which was high in olefinec and aromatic compounds; and, a waxy raffinate oil which was high in paraffinic compounds. Detailed analyses of these wastes were conducted.

SOILS

The soil to which these wastes were applied was a sandy-clay, loam soil. The soil had a history of oily waste application and had approximately 10% of the previously applied oil still present in it. The author added varying amounts of fertilizer to the soil. The soil was tilled approximately once every two weeks throughout the study period. Detailed soil analyses were made.

WASTE APPLICATION/DESIGN

All wastes were applied to the soil under field conditions. The wastes were applied to the soil in rates of up to 40 percent oil by weight in the top six inches of the soil. Three levels of fertilization were investigated: (a) no fertilizer; (b) an intermediate level of fertilizer; and, (c) a high level of fertilizer. All of the wastes were surface applied to the soil.

The study investigated the effect of a number of variables on the oil degradation rates, including: (a) degradation rates due to different wastes; (b) the effect of fertilizer additions on degradation rates of the wastes; and, (c) the effect of the oil levels present in the soil on the degradation rates.

RESULTS

- The differences in the degradation rates of the different wastes were minimal.

- The different wastes did cause differences in the numbers of microbes in the soils to which they were applied. No consistent pattern was apparent.

- Fertilizer additions increased the degradation rates of the oily wastes.

- Degradation rates of the oily wastes were proportional to the amount of oil present in the soil.

- The aromatic and saturated hydrocarbon fractions of the oily wastes were degraded to a greater extent than the resin and asphaltene fraction of the wastes.

- The study found that the waste increased the organic acids present in the soil although no organic acids were present in the waste. It

was also found that the fertilized soils to which wastes were added had greater amounts of organic acids present than in the unfertilized soils to which wastes were added.

- The addition of waste increased the number of microbes present in the soil, but not all of the microbial increase was due to hydrocarbon utilizing microbes. Fertilizer additions further increased the numbers of microbes found in the soil waste mixtures.

- The addition of waste to the soil changed the distribution of microbes in the soil. Nine months after the waste additions the predominant species was Anthrobacter, whereas before the waste addition the predominant species were Flavobacterium and Pseudomonas. The major microbial species present in the waste plots were Anthrobacter,

Corynebacterium, Flavobacterium, Nocardia, and Pseudomonas.

- When rainwater was immediately drained off the soil plots there was very little contamination present in the runoff. When rainwater was allowed to remain on the plots for a number of days and then drained, there was found to be 30 to 100 parts per million of oil present in the runoff. Most of the oils present were napthenic organic acids.

- Oil found in the extracts of the treatment plot soil at the end of the study were highly aromatic oils with substantial percentages of condensed multi-ring aromatic structures.

- It appeared that the soil organic acid increase was proportional to the reduction of long-chain paraffin groups in the applied oil.

- No vertial migration of metals or oil into the soil below the treatment zone was found.

- The maximum oil decomposition rate in the soil was 1.8 pounds of oil per cubic foot of soil per month. The average oil decomposition rates were 0.5 pounds of oil per cubic foot of soil per month without fertilizer additions, to 1 pound of oil per cubic foot of soil per month with fertilizer additions.

TABLES AND FIGURES

This article was reviewed on microfiche and, therefore, no Tables or Figures are included in this summary.

2). Dibble, J. T. and R. Bartha. "Effect of Environmental Parameters on Biodegradation of Oil Sludge." Applied and Environmental Microbiology. Volume 37, Number 4. 1979.

WASTES

The waste used in this study consisted of oil sludge collected from a waste storage pit at a refinery. The sources of the waste were: oil/water separators; storage tank bottoms; and, small spills on the refinery property. The sludge was air dried, and passed through a 3 millimeter screen before being stored at 4° Celsius for the study period. The air dried sludge contained 24% extractable hydrocarbons, 76% ash, and 4% water. The hydrocarbon composition of the sludge was found to be 57% saturated hydrocarbons, 29% aromatic hydrocarbons, and 14% asphaltic hydrocarbons.

SOILS

The soil used in this study was collected from a 20 centimeter depth and strained through a three millimeter

sieve. The soil was classified as a loam and mixed with an equal weight of washed sand passing a .5 millimeter sieve. Due to previous industrial use, this soil was innoculated with microbes by addition of a good quality agricultural soil preincubated with oil sludge hydrocarabons. The agricultural soil with oil sludge hydrocarbons was mixed into the test soil at 0.1 percent by weight.

WASTE APPLICATION/DESIGN

All of the work consisted of laboratory studies using respirometers. Waste application rates varied from 1.25 to 30 weight percent oil in the soil per application. All wastes were surface applied to the soils and mixed in.

The effect of soil moisture, soil pH, fertilizer additions, micronutrient additions, supplemental organic additions, waste loading rate, waste loading frequency, and temperature were all investigated relative to their effective on waste oil degradation.

RESULTS

- The overall degradation rate for extractable hydrocarbons found in the 180-day experimental period was 57%.

- The optimum moisture content for oil degradation was found in the range of 50 to 70 percent water holding capacity.

- It was found that higher pH values were correlated with greater amounts of oil degradation. The pH values investigated were 5.0, 6.0, 7.0, and 7.8.

- After 60 days of incubation CO_2 evolution essentially stopped.

- Both the degradation rate and the extent of hydrocarbon degradation were greater following the second application of waste (on day 103), than found following the initial waste application. It appeared that accumulation of toxic metabolities

had not occurred and that biodegradation of recalcitrant hydrocarbons from the first waste application were cometabolized during biodegradation of the second waste change.

- The percent of all hydrocarbons degraded were found to be greater than predicted from carbon dioxide evolution. This implied that some of the hydrocarbons were converted to cell material and products other carbon dioxide.

- The C:N ratio, after waste addition, of 60 to 1 was found to have the optimum degradation rate of the C:N ratios studied. The C:N ratios of 300 to 1 and 15 to 1 had greatly reduced degradation rates compared to a ratio of 60 to 1.

- Neither trace elements nor supplemental organics (yeast extract) were found to be of substantial value in increasing the degradation rates of waste oil. Sewage sludge at one percent by weight in the soil decreased degradation of the oil.

- Production of carbon dioxide increased with increasing waste loading rate up to 5 percent oil by weight in the soil.

- Application of wastes in excess of five percent oil by weight in the soil produced a reduction in of carbon dioxide evolution, relative to carbon dioxide production at five percent oil by weight in the soil.

- The greatest degradation of applied oil occurred at the lowest loading rate (1.25 weight percent by weight oil in the soil.)

- The authors felt that two loading of waste at five percent oil by weight in the soil per loading was the optimum loading rate considering efficient use of the land and adequate degradation of the wastes.

- The loading rate and application frequency of wastes to the soil affected degradation of the various hydrocarbon classes:

  - Saturated hydrocarbon degradation decreased with increasing waste loading rate for one and two waste applications during the study.

  - Loading rates of five percent oil by weight in the soil produced the greatest percent degradation of aeromatic hydrocarbons.

  - The asphaltic hydrocarbon group had the greatest percent degradation rate at a loading of 10 percent oil by weight in the soil for one waste application, and at a loading rate between 10 and 15 percent oil in the soil for 2 waste applications.

- A loading rate of five percent oil by weight in the soil produced a high hydrocarbon degradation rate while minimizing accumulation of asphaltic hydrocarbons.

- Small multiple loadings of waste (to the same total weight percent oil in the soil) produced greater degradation rates and greater total degradation of hydrocarbons then did a single loading of waste to the soil. Small multiple loadings were conjectured to keep the soil microbes in an active growth phase.

- Little or no increase in hydrocarbon degradation was found at temperatures exceeding 20° Celsius. Negligible biodegradation activity was found at 5° Celsius, and 13° Celsius produced a lag phase after which intermediate amounts of CO_2 evolution took place.

TABLES AND FIGURES

Tables and Figures from the study follow.

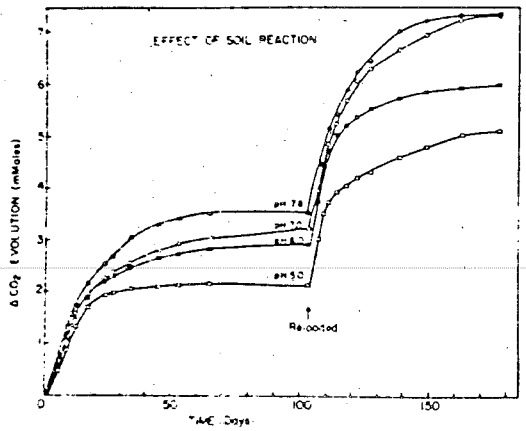


FIG. 1. *Effect of soil reaction on carbon dioxide evolution.*

Source: Dibble and Bartha, (2), page 731.

TABLE 1. *Effect of mineral nutrients on oil sludge biodegradation*

Mineral nutrient ratios	% Biodegradation as determined by:[a]					
	CO_2 evolution for days:			Residual hydrocarbon for days:		
	0-131	131-285	0-285	0-131	131-285	0-285
No nutrients added	13.5	22.1	17.8	26.1	35.1	30.0
C:N, 300:1; C:P, 4,000:1; C:K, 2,000:1	24.0	30.0	27.0	28.3	53.7	39.9
C:N, 60:1; C:P, 800:1; C:K, 400:1	23.3	38.5	30.9	33.2	59.6	45.2
C:N, 15:1; C:P, 200:1; C:K, 100:1	13.9	28.9	21.4	26.5	48.9	36.7

[a] Loadings were 0.5 g of oil sludge hydrocarbon each on days 0 and 131. The total biodegradation period was 285 days.

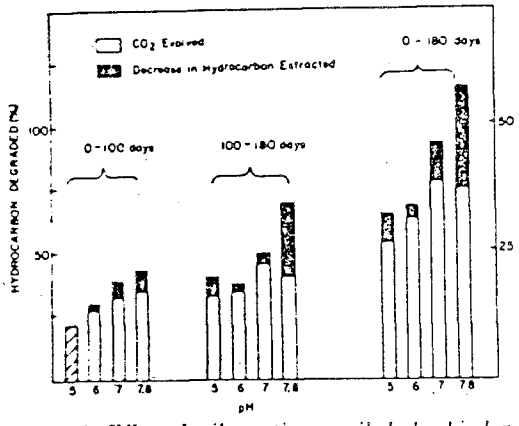


FIG. 2. *Effect of soil reaction on oil sludge biodegradation. The total height of the histograms represents hydrocarbon degradation; the white portion of the histograms represents CO_2 evolution as a percentage of the theoretical total. The CO_2 evolution and hydrocarbon degradation at 100 days and pH 5.0 were identical and are represented by the cross-hatched bar. The group of histograms on the right is on a different scale because of the reloading on day 103.*

Source: Dibble and Bartha, (2), page 732.

TABLE 2. *Effect of trace elements, yeast extract, and sewage sludge on oil sludge biodegradation*

Treatment	% Biodegradation as determined by:[a]	
	CO_2 evolution	Residual hydrocarbon
Control	19.0	34.4
Hoagland trace elements	22.1	33.2
Yeast extract	22.6	33.7
Sewage sludge	13.6	26.1

[a] Loading was 0.5 g of oil sludge hydrocarbon. The biodegradation period was 83 days. The control received oil sludge but no other additives. The data are corrected for CO_2 evolution from soil alone, from soil with yeast extract but no oil sludge, and from soil with sewage sludge but no oil sludge, respectively. Consequently, the CO_2 evolution data represent net CO_2 evolution from the oil sludge.

TABLE 3. *Effect of loading rate on oil sludge biodegradation*

Loading rate (g)	% Biodegradation as determined by:					
	CO_2 evolution for days:			Residual hydrocarbon for days:		
	0-131	131-285	0-285	0-131	131-285	0-285
3.00	6.3	8.7	7.5	12.0	20.5	14.5
2.00	11.7	14.5	13.1	20.4	26.0	22.4
1.00	23.7	26.3	25.0	34.5	48.8	40.4
0.50	23.3	38.5	30.9	36.0	56.9	45.2
0.25	32.0	48.0	40.0	36.0	60.7	48.7

[a] Grams of extractable hydrocarbon per 20 g of soil-sand mixture. The flasks were reloaded with equal antities on day 131, and the total biodegradation period was 285 days.

Source: Dibble and Bartha, (2), page 733.

TABLE 4. *Comparison of hydrocarbon biodegradation and residue at various loading rates*

Loading rate[a] (g)	No. of loadings	Amt of hydrocarbon biodegraded (g)	Amt of residual hydrocarbon (g)
3.00	2	0.88	5.12
2.00	2	0.90	3.10
1.00	2	0.81	1.19
0.50	2	0.45	0.55
0.25	2	0.24	0.26

[a] Grams of extractable hydrocarbon per 20 g of soil-sand mixture. The flasks were reloaded with equal quantities on day 131, and the total biodegradation period was 285 days.

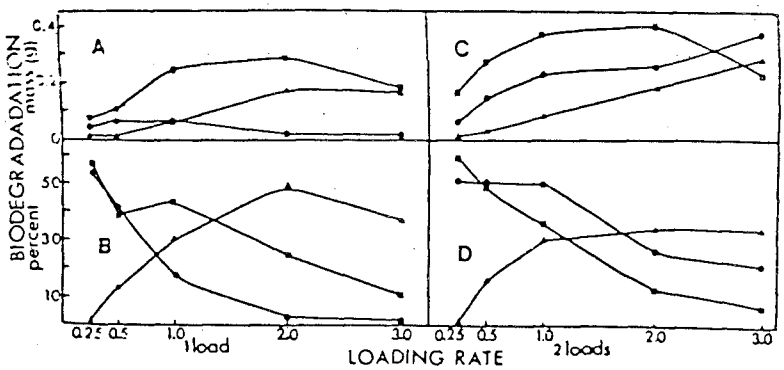


FIG. 3. *Effect of loading rates on the biodegradation of hydrocarbon classes. (A) Absolute amount (mass) of a class removed afer one loading; (B) percentage of a class removed after one loading; (C) absolute amount of a class removed after two loadings; (D) percentage of a class removed after two loadings. Loadings were at 0 and 131 days. The total biodegradation period was 285 days. Symbols: ■, saturated hydrocarbons; ●, aromatic hydrocarbons; ▲, asphaltic hydrocarbons.*

Source: Dibble and Bartha, (2), page 734.

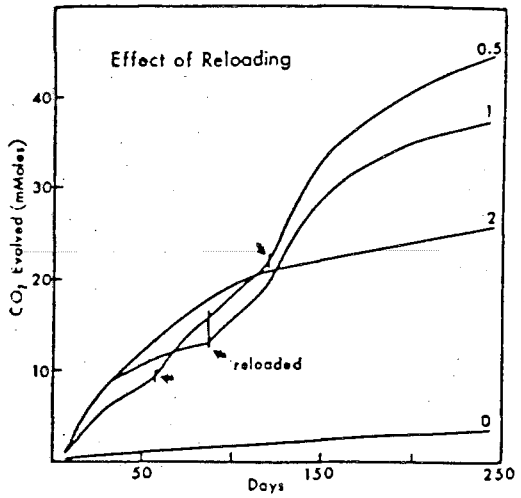


FIG. 4. *Effect of reloading on carbon dioxide evolution. Increment charge size, expressed as grams of hydrocarbon per loading, appears at the right. CO_2 evolution was determined at 1- to 10-day intervals as dictated by the rate of evolution. Because of their dense spacing, the data points were omitted.*

TABLE 5. *Effect of loading frequency on the biodegradation of oil sludge hydrocarbons*

Charge size (g)	No. of loadings	% Biodegradation as determined by:		% of the following hydrocarbon classes biodegraded:		
		CO_2 evolution	Residual hydrocarbon	Saturated	Aromatic	Asphaltic
2.0	1	17.9	24.5	17.7	34.8	31.9
1.0	2	25.8	33.1	35.1	33.8	24.5
0.5	4	30.8	45.5	54.0	40.7	22.0

Source: Dibble and Bartha, (2), page 735.

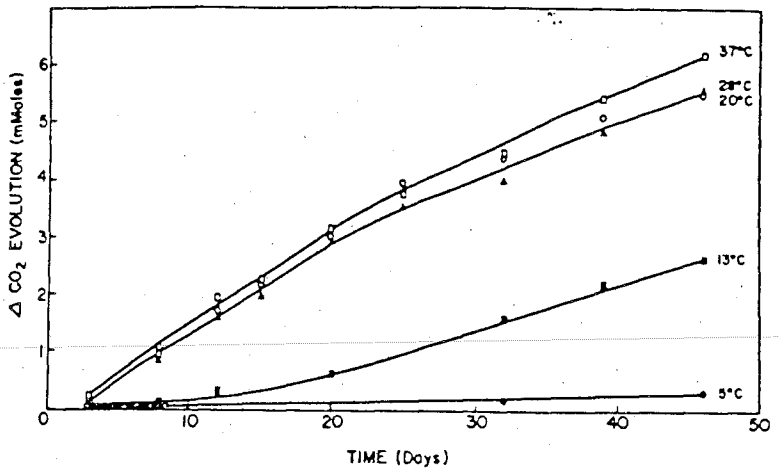


FIG. 5. *Effect of temperature on CO_2 evolution of oil sludge-treated soil. All curves were corrected for CO_2 evolution of untreated soil at the respective temperature; the curves represent net CO_2 evolution (Δ CO_2) from oil sludge.*

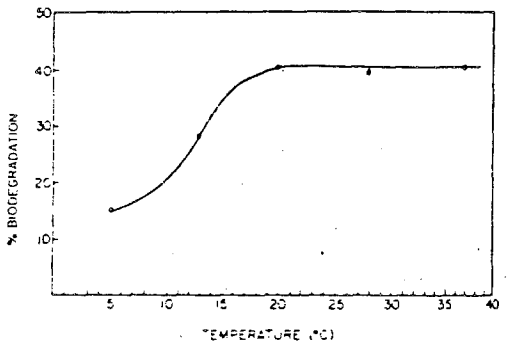


FIG. 6. *Effect of temperature on hydrocarbon biodegradation in oil sludge-treated soil.*

Source: Dibble and Bartha, (2), page 736.

3). Dibble, J. T. and R. Bartha. "Leaching Aspects of Oil Sludge Biodegradation in Soil." Soil Science. Volume 127, Number 6. 1979.

WASTES

The waste used in this study consisted of oil sludge collected from a waste storage pit at the refinery. The sources of the waste were: oil/water separators; storage tank bottoms; and, small spills on the refinery property. The sludge was air dried, and passed through a three millimeter screen before being stored at 4° Celsius for the study period. The air dried sludge contained 24% extractable hydrocarbons, 72% ash, and 4% water. The hydrocarbon composition was found to be 57% saturated hydrocarbons, 29% aromatic hydrocarbons, and 14% asphaltic hydrocarbons.

SOILS

The soil used in this study was collected from a potential landfarm site. The soil was collected from a 20 centimeter

depth, and screened through a 3 millimeter sieve. The soil contained 42% sand, 34% silt, and 24% clay. One part of this soil was mixed with nine parts of sand to produce drainage characteristics necessary for this study.

WASTE APPLICATION/DESIGN

This study consisted of laboratory work utilizing leaching columns (lysimeters). The columns were six centimeters in diameter and over 30 centimeters in height. A 15 centimeter drainage bed of sand was placed in the bottom of the column, over which the soil/sand mixture was placed. Wastes were incorporated into the 15 centimeters of soil/sand at 5 percent oil by weight in the soil. A large amount of sand with a small surface area and a low cation exchange capacity caused these results to be considered as worst case results.

Various forms of nitrogen and phosphorus were added to the columns to investigate leaching of the nutrients from the soil, as well as leaching of hydrocarbons. The forms of nitrogen investigated were: urea; urea paraffin; and, urea formaldehyde (slow release fertilizer). The forms of

phosphorus studied were octylphosphate and triple superphosphate. Potassium chloride was also added to the columns since it is a standard ingredient of agricultural fertilizer formulations. Periodically, 200 milliliters of distilled water was passed through the columns, collected, and frozen until analysis.

RESULTS

- Approximately 24 hours were required to pass the added water through the samples. Frequently, 90 to 95% of the distilled water poured onto the columns was collected as leachate.

- All of the nitrogen fertilizer formulations stimulated oil biodegradations. The urea paraffin formulation produced the highest oil degradation rate.

- Nitrogen was present in significant amounts in all leachates collected except from the urea

formaldehyde formulation, and from the control soil that received no fertilizer.

- The urea nitrogen formulation leached the greatest amount of nitrogen from the soil waste mixture. The urea paraffin formulation leached an intermediate amount of nitrogen, and the urea formaldehyde leached the smallest amount of nitrogen from the soil/waste mixture. The leaching of nitrogen from the soil/waste columns with urea formaldehyde were equivalent to nitrogen leaching from columns with no fertilizer additions.

- Nitrite was not present in the leachate of any soil/waste mixture, although it was present in the urea control plot that had no waste added.

- Nitrate was not present in any leachate in significant amounts except from the urea control column that had no waste added.

- No phosphate was found in any leachate from any column at the 0.2 milligrams per liter detection limit.

- Less TOC was leached from fertilized soil/waste columns then from unfertilized soil/waste columns.

- Solvent extractions of the sand drainage bed detected no oil from any treatment column. Oil did not leach below the area of waste incorporation, nor was oil present in any of the leachates collected.

- Water soluble organic compounds were found in higher concentrations in the leachate from soil/waste columns that from the leachate of control columns with no waste added. These organic compounds were not different from organic compounds leached from control columns receiving no waste.

TABLES AND FIGURES

Tables and Figures from the study follow.

TABLE 1

Effect of mineral nutrient formulations on oil sludge biodegradation[a]

Fertilizer formulation	% Biodegradation
Urea plus superphosphate	21
Urea-paraffin adduct plus octylphosphate	24
Urea formaldehyde plus superphosphate	20
Control without fertilizer	10

[a] Thirty grams hydrocarbon per 600 g soil (5 percent wt/wt) incubated for 120 days.

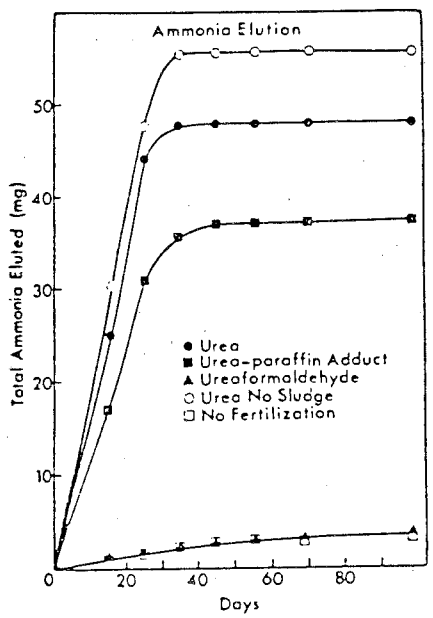


FIG. 2. Effect of nitrogen sources on ammonia elution during oil sludge biodegradation.

Source: Dibble and Bartha, (3), page 367.

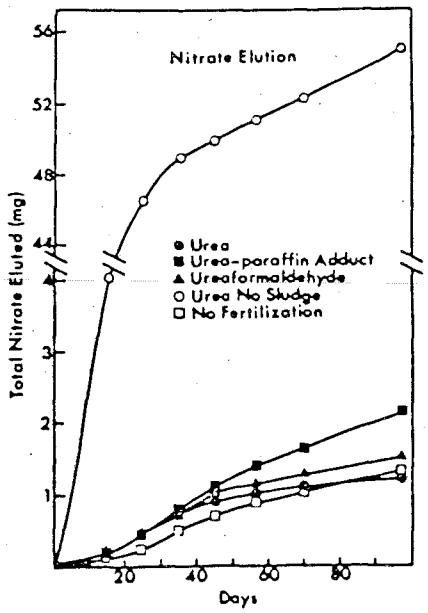


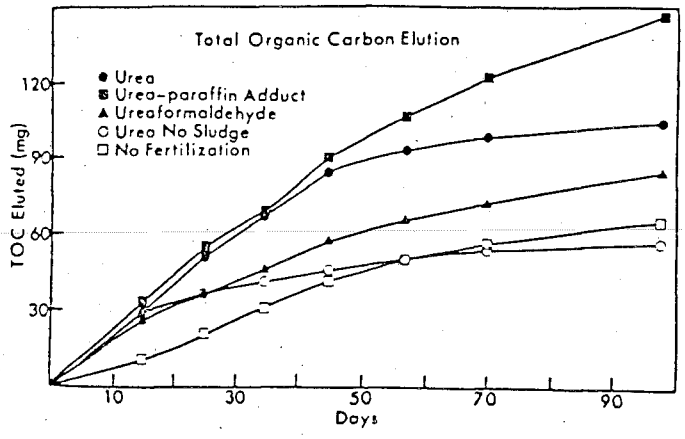
FIG. 3. Effect of nitrogen source on nitrate elution during oil sludge biodegradation.

Effect of nitrogen source on nitrogen elution

Nitrogen source	Total mineral nitrogen eluted, mg[a]
Urea	38.6
Urea-paraffin adduct	29.9
Urea formaldehyde	2.8
Urea control without oil sludge	67.1
Oil sludge control without fertilizer	2.7

[a] Eighteen milligrams N supplied by soil mixture; 150 mg N supplied by fertilizer. Cumulative elution in 120 days.

Source: Dibble and Bartha, (3), page 368.



Source: Dibble and Bartha, (3), page 369.

4). Meyers, J.D., and Robert L. Huddleston. "Treatment of Oily Refinery Wastes by Landfarming." Proceedings of the 34th Industrial Waste Conference at Purdue University. May 8-10, 1979.

WASTES

The authors investigated an oily waste that they felt was typical of refinery oily wastes. It had a high oil content, and a high metal content. No analyses of the waste were presented.

SOILS

The soil to which the waste was applied had no previous history of oily waste application. The authors raised the soil pH to 7.5 or greater with agricultural lime. The authors also added fertilizers to the soil to increase the nitrogen and phosphorus content of the soil. The soil was cultivated five times every two months with a rototiller during the study. No detailed soil analyses were available.

WASTE APPLICATION/DESIGN

This study was conducted under field conditions. The authors applied the wastes to different plots, various numbers of times. Some plots had waste applied only once, others twice, and still others had waste applied three times. The results of the plots having waste applied three times were not available. The authors applied 5 percent waste oil by weight to the soil in each application. These levels were calculated using the top eight inches of the soil. The waste was surface applied.

The authors investigated the effects of plot cover and waste application on oil degradation rates. The treatment plots were open or vegetated with either bermuda grass or wheat. The waste loads were low, moderate, or high depending on the number of applications of oily wastes made to the soil.

RESULTS

- Low waste loading rates showed no degradation rate variation with fertilizer levels, tilling frequency, or varying plot covers.

- The aromatic and paraffin hydrocarbon fraction had greater percentage degradations than the resin and asphaltene hydrocarbon fractions.

- Fifty percent of the TOC lost from the oil was found to be present in the soil but no longer as oil. The oil degradation had apparently increased the humus content of the soil.

- Leaching and vertical migration of cadmium, lead, and oil were not found at 10.5 inches below the soil surface. The surface layer of the soil had much higher concentrations of these contaminants than background soil levels.

- Plant growth was found to be difficult when more than one waste application had been made to the soil.

- Some plots exhibited an increase in the resin and asphaltene concentration greater than expected due to the waste application. This suggested that the aromatic and paraffin hydrocarbon fractions were partially degraded to resins and asphaltenes.

- Plowing appeared to be a very important aspect of the land treatment of oily wastes. The plots that had bermuda grass or wheat grown on them showed much lower degradation rates than the plots that had no cover and were plowed more frequently.

- After twenty months a 2.02 weight percent decrease of the oil in the soil was found. This is equivalent to degradation of approximately 40% of the oil applied.

TABLES AND FIGURES

Tables and Figures from the study follow.

Table II. Experimental Plot Types

Plot Status	Plot Cover	Fertilization Level	Plots in Category
Control	Bermuda Grass	Low	3
Control	Tilled	Low	3
Control	Wheat	Low	3
Waste	Bermuda Grass	Low	3
Waste	Bermuda Grass	High	3
Waste	Tilled	Low	3
Waste	Tilled	High	3
Waste	Wheat	Low	3
Waste	Wheat	High	3

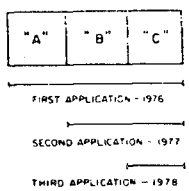


Figure 1. Waste application scheme.

Source: Meyers and Huddleston, (4), page 688.

Table III. Analytical Determinations for Plow-Zone Samples

Routine		
Moisture Content	Total Organic Carbon (TOC)	Nitrate Nitrogen
pH	Extractable Hydrocarbon (Oil)	Ammonia Nitrogen
Conductivity	Paraffin, Aromatic, and Resin and Asphaltic Fractions	Orthophosphate

Intermittent	
Selected Metals	Water Holding Capacity

Table IV. Selected Parameters Used for Field Leaching/Migration Analysis

Total Organic Carbon	Calcium	Lead	Nickel
Extractable Hydrocarbon	Chromium	Magnesium	Sodium
Barium	Copper	Mercury	Zinc
Cadmium			

Source: Meyers and Huddleston, (4), 689.

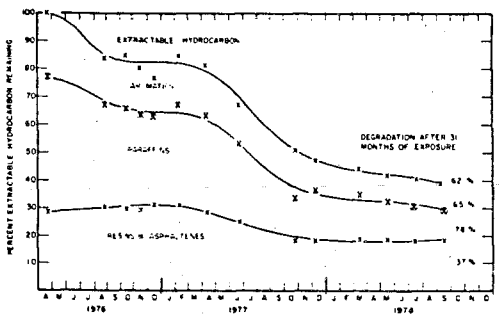


Figure 2. Distribution/degradation curves for extractable hydrocarbon and fractions– initial waste application.

Source: Meyers and Huddleston, (4), page 690.

Table V. Landfarm Oil Loss Summary: Moderate Waste Loa

	Average % Degradation		Average Tons/Acre Degraded	
	Wheat and Burmuda Cover	Tilled (No Cover)	Wheat and Burmuda Cover	Tilled (No Cover)
Overall 25-Month Period				
Oil	30	43	56	81
Paraffins	44	50	36	42
Aromatics	29	44	14	22
Resins and Asphaltenes	12	30	6	17
First 15 Months of Exposure (5-wt % Oil Addition Only)				
Oil	36	36	22	22
Paraffins	48	48	15	15
Aromatics	30	30	4	4
Resins and Asphaltenes	18	18	3	3
Remaining 10 Months of Exposure (After Second 5-wt % Application Made)				
Oil	27	47	34	59
Paraffins	42	52	21	27
Aromatics	29	50	10	18
Resins and Asphaltenes	9	36	3	14

Table VI. Landfarm Oil Loss Summary: Low Waste Loading

	Months of Waste Exposure							
Fraction	6	12	18	25	6	12	18	25
	(Avg. % Degradation)				(Avg. Tons/Acre Degraded)			
Oil	17	22	49	58	10	14	31	37
Paraffins	27	34	58	71	8	11	18	22
Aromatics	21	25	47	58	3	3	7	8
Resins and Asphaltenes	-7[a]	0	35	37	-1[a]	0	6	7

[a]An increase at six months over the amount added.

Source: Meyers and Huddleston, (4), page 691.

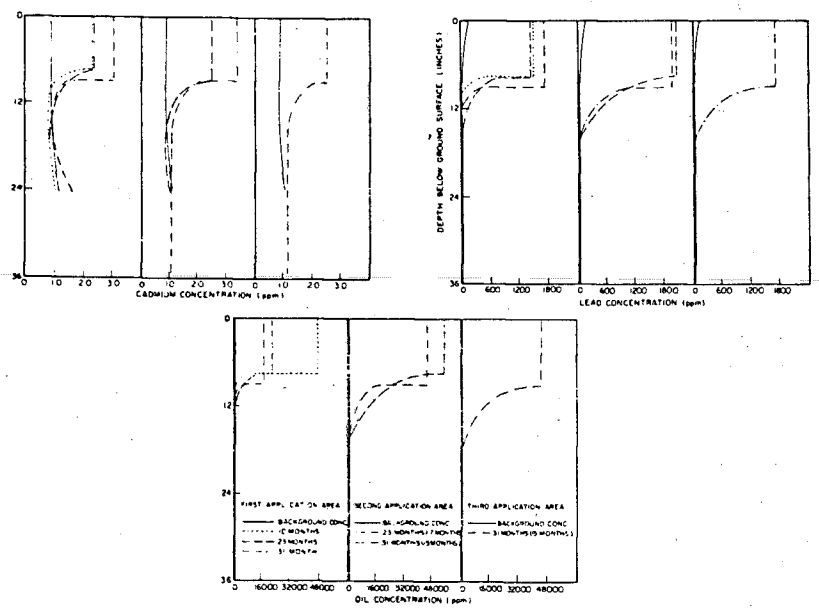


Figure 3. Field leaching analysis: time since application (reapplication).

Source: Meyers and Huddleston, (4), page 692.

5). Deuel, L. E., and K. W. Brown. "Environmental Impact of Land Cultivation with Industrial Wastes." Disposal of Industrial and Oily Sludges by Land Cultivation. Resource Systems and Management Association. Northfield, New Jersey. 1980.

PURPOSE

This article related some of the problems, shortcomings, and concerns of land treatment of all industrial wastes.

RESULTS

- Soils have a substantial capacity to absorb gaseous atmospheric pollutants, but this ability varies significantly with soil types.

- Incorporation of oily wastes into soil will significantly reduce or eliminate release of atmospheric pollutants due to the adsorption of pollutants to soil. Further, once oily wastes have been incorporated into the soil, all atmospheric losses must first diffuse through the

soil and this gives increased contact time with the soil for biological degradation.

- Foul odors from land treatment systems are associated with overloading the soil, which produces anaerobic, and reducing, conditions.

- Metals are more mobile under reducing conditions, and metal organic complexes may be more soluble and mobile than ionic metals.

- Negatively charged clays repel anions, and may cause anion breakthrough before wetting front breakthrough.

- Loading rates of wastes to soil are probably the most important parameter for successful operation of land treatment systems.

TABLES AND FIGURES

This article was reviewed on microfiche and, therefore, no Tables or Figures are included in this summary.

6). Raymond, R. L., J. O. Hudson, and B. W. Jamison. "Assimilation of Oil by Soil Bacteria." Disposal of Industrial and Oily Sludges by Land Cultivation. Resource Systems and Management Association. North Field, New Jersey. 1980.

WASTES

The wastes investigated in this study were: used crankcase oil from cars; used crankcase oil from diesel trucks; Arabian heavy crude oil; gulf coast mixed crude oil; home heating oil (No. 2 fuel oil); and, residual fuel oil (No. 6 fuel oil).

SOILS

This study included three different sites, however, no soil data was presented. The different sites were located in: Corpus Christi, Texas; Marcus Hook, Pennsylvania; and Tulsa, Oklahoma. Fertilizers were added to the soil at all of the sites. The sites were tilled once a month for the first three months of the study and once every three months for the remaining nine months of the study.

WASTE APPLICATION/DESIGN

All work consisted of field studies. The waste application rates varied with each waste; however, all of the rates were from 1.6 to 3.4 percent oil by weight in the top six inches of the soil. All of the sites were fertilized to the same carbon, nitrogen, and phosphorus ratios. All of the wastes were surface applied to the soil.

The authors studied: differences in degradation rates exhibited by the different wastes; contamination present in the leachate from each site; contamination present in the runoff from each site; and, differences that geographical locations had on degradation rates.

RESULTS

- The authors found that addition of any of the wastes to the soil increased the total number of microbes present in any of the soils, as well as increasing the numbers of hydrocarbon utilizing bacteria.

- All of the oils were found to be degradable in soil. No major differences in degradation rates were found for the wastes studied.

- Leachate was collected at only one site; Marcus Hook, Pennsylvania. The leachate had acidic organic water soluble compounds present one foot below the soil surface. No oil or metals were present in the leachate.

- Runoff was collected at Marcus Hook, Pennsylvania and Tulsa, Oklahoma. No oil contamination was present in the runoff.

- Relatively minor differences were found in the degradation rates of the different oils at the different geographical sites.

- Degradation rates of the different wastes were: a) crank case oils, 67.9% of the applied oil degraded in one year, b) crude

oil, 61.9% of the applied oils were degraded in one year, c) home heating oil (No. 2 fuel oil), 87.3% of the applied oil was degraded in one year, and d) residential fuel oils (No. 6 fuel oil), 57.8% of the applied oil was degraded in one year.

TABLES AND FIGURES

Tables and Figures from the study follow.

TABLE 1

PROPERTIES OF OILS
USED IN BIODEGRADATION STUDY

	Arabian Heavy Crude Oil	Gulf Coast Mix Crude Oil	Home Heating Fuel Oil (#2)	Residual Fuel Oil (#6)
Gravity, API/60°F	27.4	23.6	35.0	16.0
Vis., SUS/77°F	164.0	324.0		
Vis., SUS/100°F	103.0	161.0		
Vis.,KV/100°F cs			2.4	
Vis., SFS/122°F				160.0
Flash - PM, °F	<40.0	88.0	140.0	200.0
Pour Point, °F	+10.0	<−50.0	−20.0	+55.0

TABLE 2

CHARACTERIZATION OF OILS
APPLIED TO EXPERIMENTAL PLOTS

	TYPE OF OIL				
Silica Gel Fraction	Crankcase	Heavy Arabian	Coastal Mix	#2	#6
Paraffinic	70.5*	45.8	53.6	52.0	37.1
Cycloparaffinic	9.5	13.3	9.7	3.2	11.2
Aromatic	8.6	26.4	22.8	34.7	35.0
NSO	11.3	14.4	13.8	10.1	16.7
Sulfur	0.3	3.01	0.38	.15	.66

* per cent

Source: Raymond, et al, (6), page 58.

TABLE 3

METALS IN OILS

(ppm)

	Used Crankcase Oil (car)	Used Crankcase Oil (truck)	Arabian Heavy Crude	Gulf Coast Crude	#6 Oil
CA	700	780	–	21	17
BA	480	36	–	–	–
P	1400	1350	–	–	–
ZN	1500	1300	21	17	12
MG	1600	1100	–	–	21
B	10	–	–	–	–
AL	22	10	–	–	–
NI	–	–	23	2	13
PB	7500	75	–	–	–
SN	5	3	–	–	3
CU	17	18	–	–	–
FE	260	180	3	5	18
CR	21	3	–	–	1
AG	–	–	–	–	–
SI	18	8	–	–	–
NA	51	39	–	9	27
MO	10	4	–	–	–
V	–	–	65	–	38
MN	3	–	–	–	2

Source: Raymond, et al, (6), page 59.

TABLE 4

PERCENTAGE REDUCTION IN OIL CONCENTRATION AFTER ONE YEAR

	LOCATION OF FIELD SITES			
Type of Oil	Marcus Hook, Pa.	Tulsa, Okla.	Corpus Christi, Texas	Average
Used Crankcase oils	69.2	73.8	60.8	67.9
Crude oils	54.2	77.5	54.2	61.9
Home heating oil (#2)	86.0	90.0	86.0	87.3
Residual oil (#6)	48.5	65.5	59.4	57.8

Source: Raymond, et al, (6), page 60.

TABLE 5

OIL IN RUN-OFF WATER

FROM CONTROL AND OIL-TREATED SOIL PLOTS

MARCUS HOOK, PA.

Dates –	12/73	3/74	4/74	5/74	9/74	11/74
Soil Plot						
Control #1	4.3*	2.8	0.6	3.7	1.7	2.4
CC**	–	1.9	0.5	3.6	1.3	1.7
CC + F	7.8	3.1	1.6	1.8	2.5	2.1
DC	–	0.9	1.6	1.7	1.3	2.0
DC + F	5.9	2.7	1.4	2.5	1.6	1.4
HAC	–	1.5	1.6	1.9	1.6	1.2
HAC + F	6.8	3.5	2.4	2.7	3.0	1.3
CLC	–	2.6	1.8	3.1	4.0	1.9
CLC +F	3.9	2.4	1.8	3.1	3.1	1.4
#2	–	1.7	1.1	5.4	1.2	2.3
#2 + F	6.6	3.5	1.6	2.8	1.1	1.7
#6	–	1.8	1.4	3.3	2.3	1.6
#6 + F	3.0	6.4	2.5	3.5	2.4	1.5
Control #2	4.3	2.0	2.1	3.3	2.8	1.8

* Values in ppm

** CC - car crankcase oil; CC + F - with fertilizer; DC- diesel truck crankcase oil; HAC - Arabian heavy crude oil; CLS - coastal oil; #2 - home heating oil (#2); #6 - residual oil (#6).

Source: Raymond, et al, (6), page 61.

TABLE 6

OIL IN LEACHATE WATER FROM CONTROL AND OIL-TREATED SOIL PLOTS

MARCUS HOOK, PA.

Dates —	3/74	4/74	5/74	9/74	11/74
Soil Plot					
Control #1	1.8	4.0	–	4.5	7.3
CC*	5.4	1.9	–	5.0	8.0
CC + F	–	–	–	–	–
DC	3.7	6.0	8.4	5.8	7.4
DE + F	2.7	3.6	7.5	10.1	14.7
HAC	3.2	5.1	6.8	14.0	7.0
HAC + F	–	–	–	–	–
CLC	–	–	–	–	–
CLC + F	2.4	8.9	18.2	15.9	3.7
#2	4.1	7.5	8.6	11.3	6.6
#2 + F	4.9	5.9	36.0	3.9	3.9
#6	2.9	4.9	7.1	3.9	3.9
#6 + F	3.2	2.4	8.7	40.0	17.7
Control #2	3.3	2.2	21.0	4.1	3.6

*See Table 5

Source: Raymond, et al, (6), page 62.

TABLE 7

ETHER EXTRACTABLES IN LEACHATE WATER
FROM CONTROL AND OIL-TREATED SOIL PLOTS

MARCUS HOOK, PA.

Dates –	3/74	4/74	5/74	9/74	11/74
Soil Plot					
Control #1	36.5	13.0	–	10.0	153.0
CC*	30.5	26.6	–	61.0	164.0
CC + F	–	–	–	–	–
DC	50.2	23.0	37.5	58.5	172.0
DC + F	73.0	21.5	95.5	180.0	351.5
HAC	32.0	26.5	28.5	126.5	282.0
HAC + F	–	–	–	–	–
CLC	–	–	–	–	–
CLC + F	53.0	73.2	149.5	251.5	1339.0
#2	55.0	70.5	104.5	154.5	2019.5
#2 + F	32.0	87.0	34.0	107.0	1336.0
#6	18.5	23.0	36.0	105.5	49.5
#6 + F	42.0	53.0	82.0	121.0	201.0
Control #2	12.0	12.5	23.3	95.0	148.5

*See Table 5

Source: Raymond, et al, (6), page 63.

TABLE 8

DISTRIBUTION OF LEAD IN SOIL PLOTS
FOLLOWING APPLICATION OF USED CRANKCASE OILS
MARCUS HOOK, PA.

Date	Recovered Oil		Soil			Leachate		
	Car	Truck	Control	Car	Truck	Control	Car	Truck
11/73	90*	0	34	448	31			
3/74	33	7	125	325	53	0.2	0.2	0.2
4/74	0	0	100	221	50	0.2	0.0	0.0
5/74	0	0	190	320	110	0.0	0.0	0.0
9/74	7	2	135	295	52	0.2	0.4	1.4
11/74	102	100	100	275	55	0.6	0.0	0.3

*Values in ppm

TABLE 9

DISTRIBUTION OF LEAD IN SOIL PLOTS
FOLLOWING APPLICATION OF USED CRANKCASE OILS
TULSA, OKLAHOMA

Date	Recovered Oil		Soil			Run-Off Water		
	Car	Truck	Control	Car	Truck	Control	Car	Truck
12/73	495*	160	14	198	9			
1/74	580	<10	20	128	6	0.3	0.2	0.1
2/74	586	40	25	338	5			
3/74	493	24	9	313	23			
6/74	676	<10	50	155	10			
9/74	–	–	50	162	35	0.8	1.2	0.3
12/74	525	49	27	147	8	0.03	0.03	0.03

*values in ppm

Source: Raymond, et al, (6), page 64.

TABLE 10

DISTRIBUTION OF LEAD IN SOIL PLOTS
FOLLOWING APPLICATION OF USED CRANKCASE OILS

CORPUS CHRISTI, TEXAS

	Recovered Oil		Soil		
Date	Car	Truck	Control	Car	Truck
12/73	600*	43	2	325	47
1/74	830	35	25	280	63
2/74	480	98	55	288	90
4/74	12	0	25	62	62
6/74	23	16	45	110	130
10/74	0	4	50	215	70
12/74	41	12	21	268	63

* values in ppm

TABLE 11

CONCENTRATION OF LEAD IN SOIL
AT VARIOUS DEPTHS

MARCUS HOOK (2/21/75)

Depth in Inches	Control Plot	Used Crankcase Oil & Fertilizer Plot
		ppm
0 - 4	108	247
4 - 8	108	94
8 - 12	69	42

Source: Raymond, et al, (6), page 65.

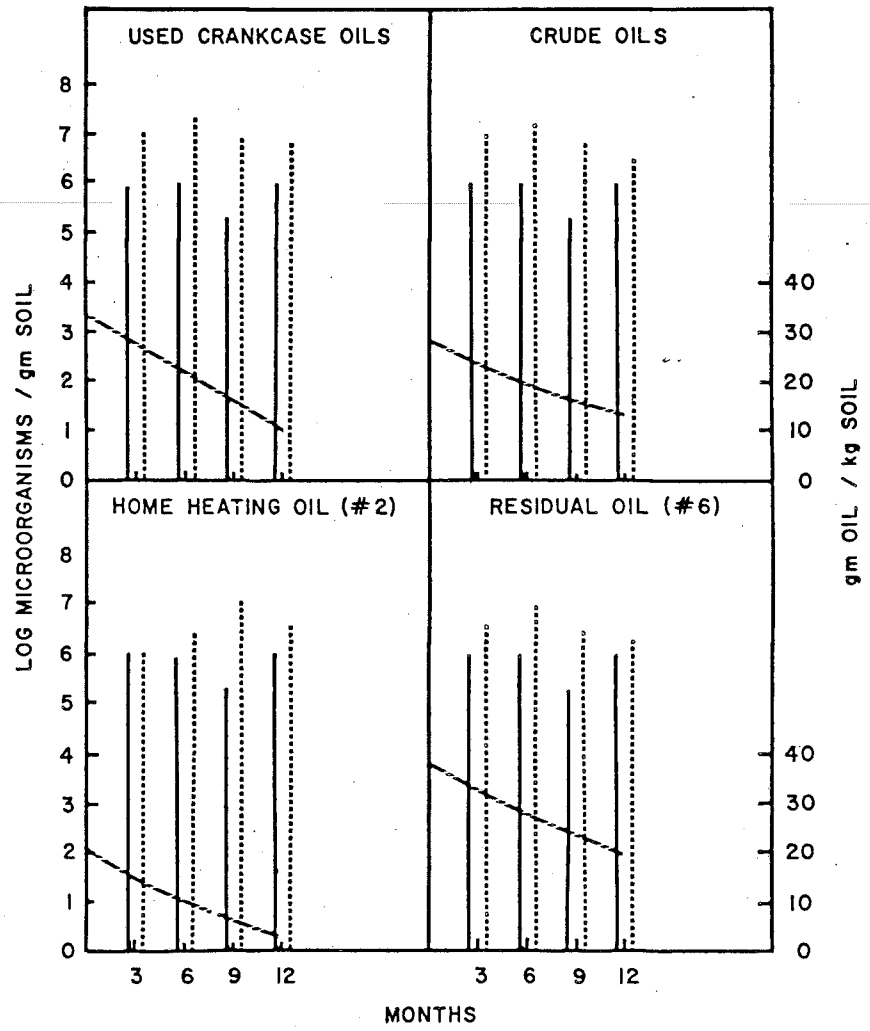


FIGURE 7

Numbers of hexadecane-utilizing microorganisms and residual oil concentrations in Marcus Hook, Pa. experimental plots. Numbers in control plots ———— . Numbers in treated plots -·-·-·-. Oil concentration ..... The values are averages of both unfertilized and fertilized plots.

Source: Raymond, et al, (6), page 70.

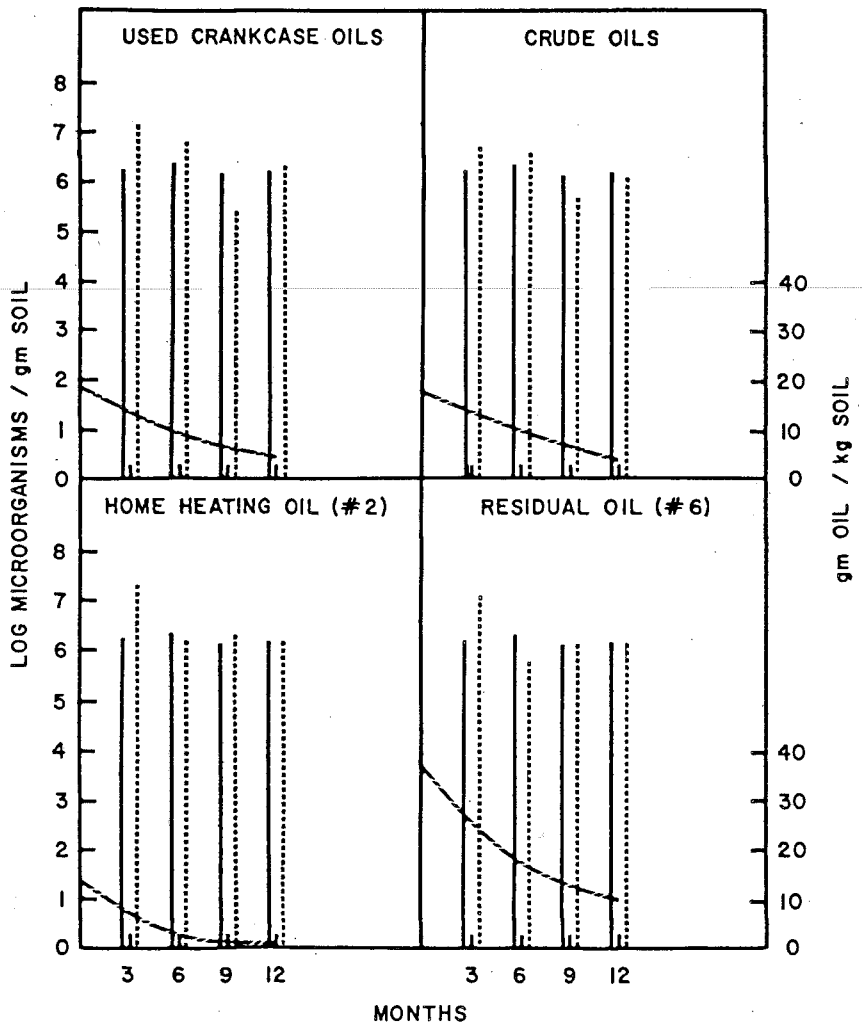


FIGURE 8

Numbers of hexadecane-utilizing microorganisms and residual oil concentration in Tulsa, Okla. experimental plots. See Figure 7 for explanation of symbols.

Source: Raymond, et al, (6), page 71.

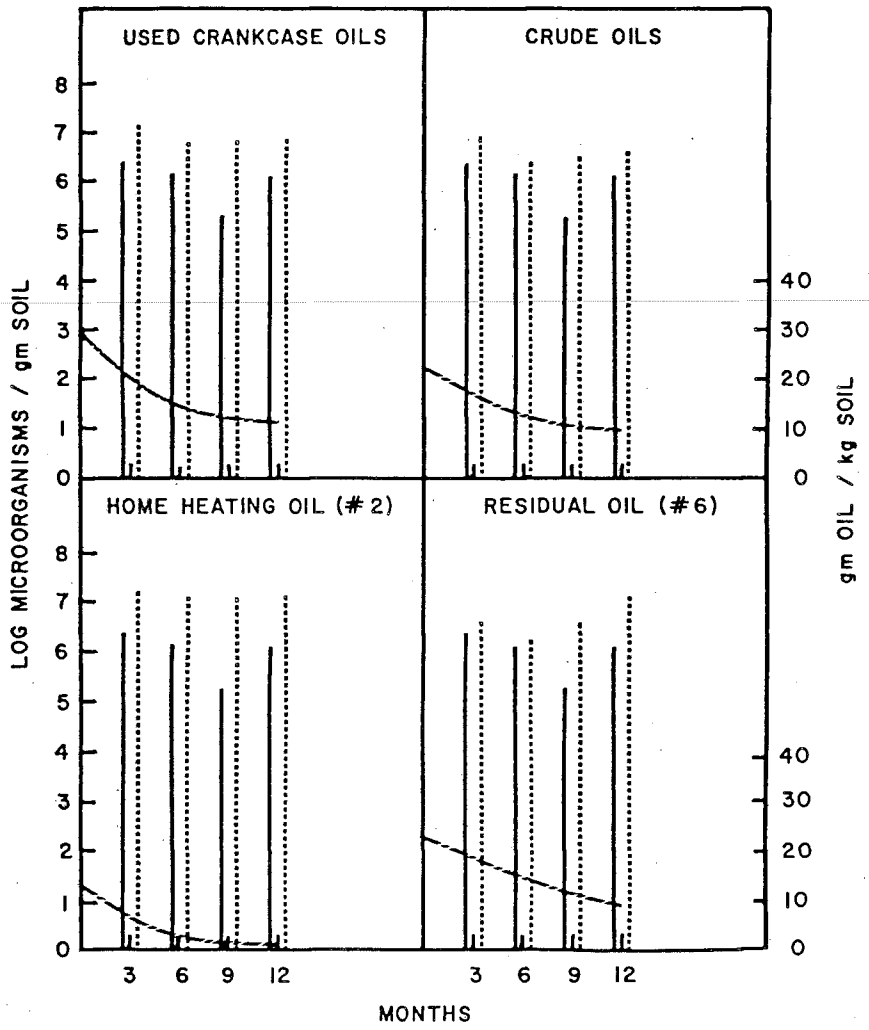


FIGURE 9

Numbers of hexadecane-utilizing microorganisms and residual oil concentration in Corpus Christi, Tex. experimental plots. See Figure 7 for explanation of symbols.

Source: Raymond, et al, (6), page 72.

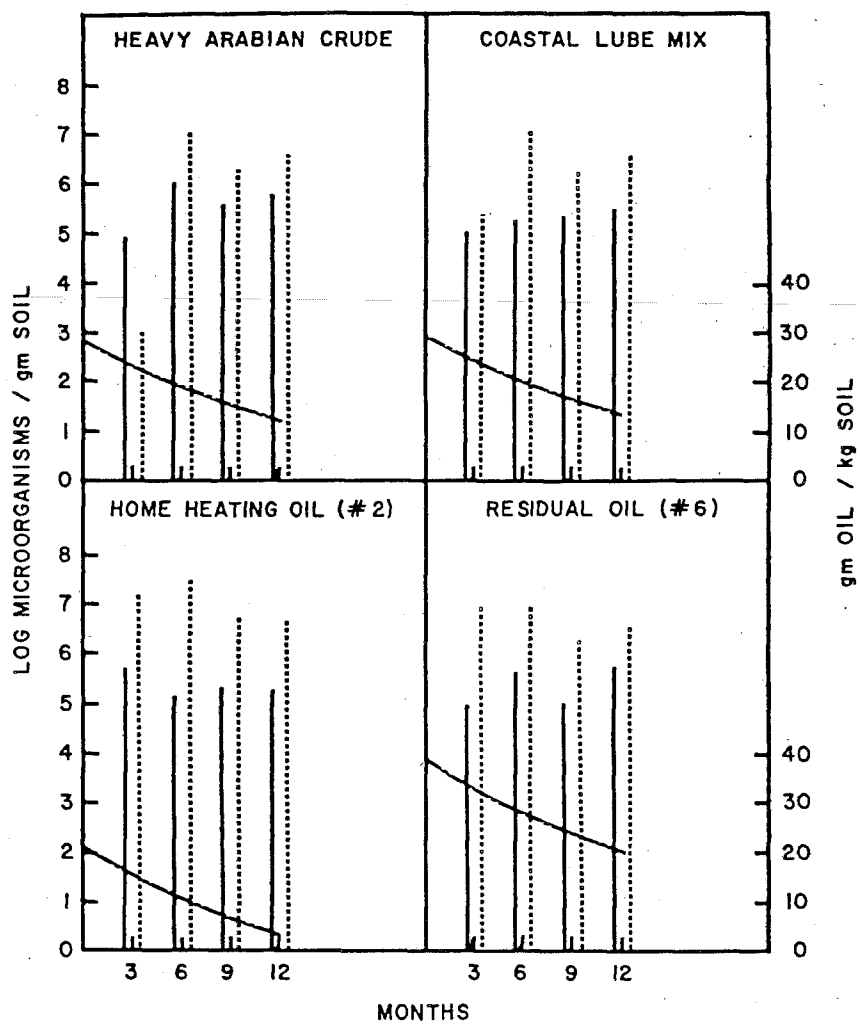


FIGURE 10

Numbers of oil-utilizing microorganisms and residual oil concentration in Marcus Hook Pa. experimental plots. See Figure 7 for explanation of symbols.

Source: Raymond, et al, (6), page 73.

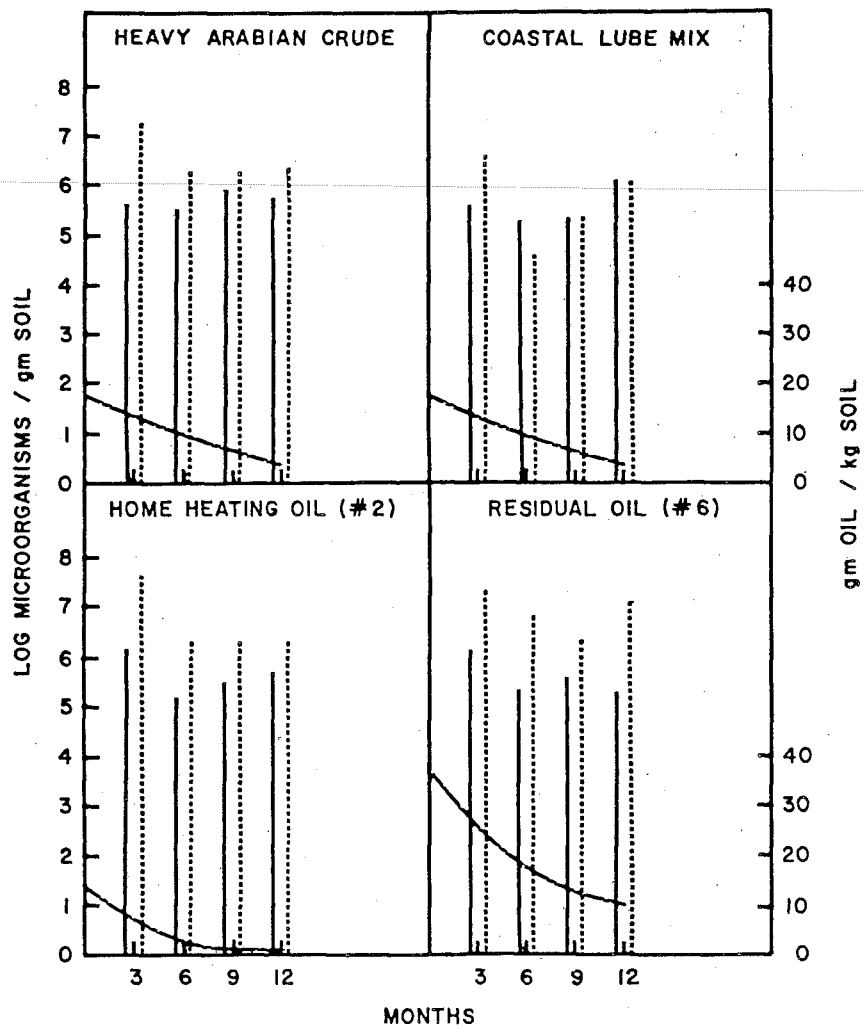


FIGURE 11

Numbers of oil-utilizing microorganisms and residual oil concentration in Tulsa, Okla., experimental plots. See Figure 7 for explanation of symbols.

Source: Raymond, et al, (6), page 74.

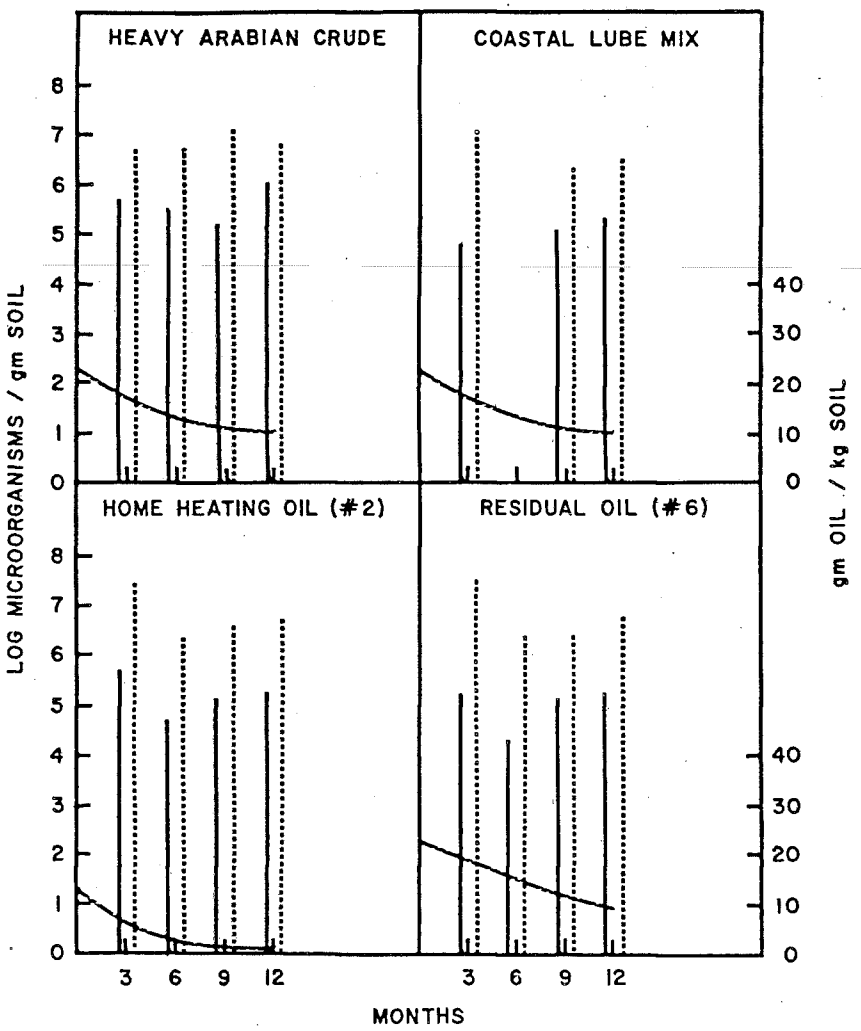


FIGURE 12

Numbers of oil-utilizing microorganisms and residual oil concentration in Corpus Christi, Texas experimental plots. See Figure 7 for explanation of symbols.

Source: Raymond, et al, (6), page 75.

7). Norris, D. J. "Land Spreading of Oily and Biological Sludges in Canada." Proceedings of the 35th Industrial Waste Conference at Purdue University. May 13-15, 1980.

WASTES

The waste investigated in this study was a mixture of petroleum refining oily wastes, consisting of an oily sludge and a waste activated sludge. The oily sludge consisted of a mixture of filter backwash, DAF froth, API separator sludge and tank cleanings.

SOILS

The land to which these wastes were applied consisted of two flat clay sites and one site with a sloped, fine silt soil. All of the sites were in Canada. The sites were near the cities of Sarnia, Montreal, and Dartmouth. All of the soils were fertilized and cultivated bi-weekly or monthly depending on the soil conditions.

WASTE APPLICATION/DESIGN

All work consisted of field work. The waste application rates varied depending on the degradation of the wastes, however, the waste loading never exceeded 10% oil by weight in the top six inches of the soil. All of the wastes were surface applied to the soil.

The study was initiated to determine if significant differences in degradation rates occurred at the different sites, and whether or not waste migration was taking place.

RESULTS

- The waste degraded at a rate of about 230 cubic meters of oil per hectare per year.

- Few major differences were found in degradation rates between the sites.

- No contamination of the ground water with oils or phenols were found at any sites studied.

- There was a slight increase in oil content of the soil one foot below the soil surface at the Sarnia site (a clay soil site). No oil increases were found in the soil below the other sites.

TABLES AND FIGURES

Tables and Figures from the study follow.

Table I. Sludge Characteristics

	Oily Sludge[a]	Waste Activated Sludge
Oil Content (wt%)	1-30	<0.01
Solids Content (wt%)	1-20	1-10
Water Content (wt%)	50-98	90-99
Trace Metals (mg/kg solids)	1-10,000[b]	1-10,000[b]

[a]Primarily from fine oil removal (filter backwash, DAF froth, etc.), separator cleanings and tank cleanings.

[b]Depending on the metal. Aluminum and zinc are among the highest, cadmium and molybdenum are among the lowest.

Source: Norris, (7), page 10.

Table II. Site Characteristics

	Sarnia	Montreal	Dartmouth
Climate			
Frost-Free Days	235	213	237
Rainfall, May-Oct (cm)	45	50	60
Rain Free Days, May-Oct	130	115	123
Topography	Flat	Flat	6-8% Slope
Soil Type	Clay	Clay	Silt
Permeability (cm/s)	$<10^{-8}$	$3x10^{-8}$	10^{-5}-10^{-8}
CEC (meq/100 g)	30	15-30	4
pH	7-7.5	7-7.5	4.5-5
Depth to Bedrock (m)	>15	1.5-7.5	>30
Depth to Groundwater (m)	$\sim$15	<1	1-2

Source: Norris, (7), page 11.

Table III. Site Preparations

Sarnia	Montreal	Dartmouth
Drainage Tiles	Tank Removal	Tree Removal
Roadways/Dikes	Drainage System	Rock Removal
Clay-Lined Storage Basins	Contouring	Contouring
Monitoring Wells	Topsoil Addition	Dikes
	Monitoring Wells	Monitoring Wells
	Storage Tank Modifications	Concrete Storage Basin
		Soil pH Adjustment

Source: Norris, (7), page 12.

Table IV. Parameters Monitored

Surface and Subsurface Soil	Groundwater
Oil Content	Oil
pH	Total Organic Carbon
Trace Metals	Phenol
Total Nitrogen and Phosphorous	Polyaromatic Hydrocarbons
	Trace Metals
	Nitrate, Ammonia, Phosphate
	Chloride, Sulfate, Conductivity
	Total Inorganic Carbon
	pH

Source: Norris, (7), page 13.

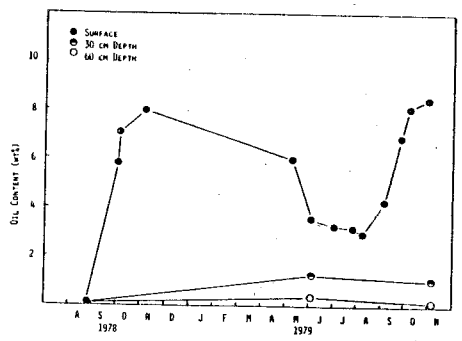


Figure 1. Oil content of soil at Sarnia land-spreading site.

Source: Norris, (7), page 14.

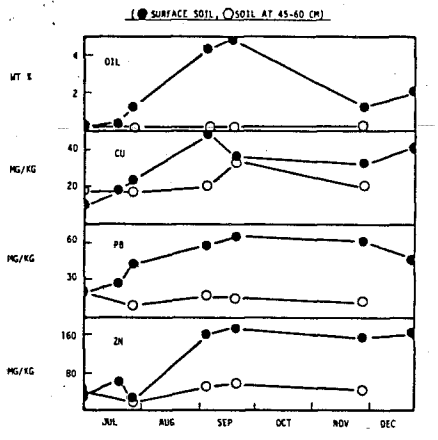


Figure 2. Oil and trace metals at Dartmouth landspreading site.

Table V. Groundwater Quality at Sarnia

	Oil (ppm)		Phenol (ppb)		Nitrate-N (ppm)	
	Avg	Range	Avg	Range	Avg	Range
Before Spreading	0.9	<0.1-3.8	11	<2-20	1.2	<0.05- 3.0
After Spreading						
Shallow Wells	0.5	<0.1-2.5	5	<2-15	3.8	<0.05-10
Deep Well	0.3	<0.1-1.3	6	<2-16	1.3	<0.05- 5.5

Source: Norris, (7), page 15.

8). Weldon, R. A. "Atmospheric Emissions from Oil Waste Landspreading." Environmental Affairs Department, American Petroleum Institute. April, 1980.

WASTES

The petroleum refining wastes investigated in this study were API separator sludge and a centrifuge dewatering sludge containing oily sludge from refinery operations. The types of components in the oily sludge were: wastewater treatment sludge; API separator sludge; and other sludges from the refinery operations.

SOILS

The soils to which these wastes were applied were not analyzed. Wastes were applied to relatively small areas and the soils were considered to be similar. The soil had a history of oily waste landfarming. There was approximately a 3.2 percent oil fraction by weight in the soil at the beginning of the study.

WASTE APPLICATION/DESIGN

All wastes and conditions were investigated in field tests. The API separator sludge was applied to two plots in one application. The centrifuge sludge was applied to only one plot in one application. An additional 0.7 percent oil by weight of the API separator sludge and 1.3 percent oil by weight of the centrifuge sludge were added to the experimental plots. All of the wastes were surface applied.

The variables effecting volatile emissions investigated were: different wastes; temperature variations; and, differences due to tilling of the soil.

RESULTS

- Up to approximately 14 percent of the API separator sludge oils applied to the soil volatilized in the first 30 days after waste application.

- Approximately 5.2 percent of the centrifuge sludge oils applied to the soil volatilized in the first 13 days after waste application.

- A positive correlation was found for each waste/soil mixture between temperature and emissions of volatile organics.

- Positive correlations were found between tilling of the wastes/soil mixture and concentrations of hydrocarbons in the emissions. The author felt that the total hydrocarbons emitted were approximately the same whether or not tilling took place.

- Hydrocarbon emission concentration peaks occurred when the waste was initially applied to the soil and when the soil/waste mixture was tilled.

TABLES AND FIGURES

Tables and Figures from the study follow.

TABLE 1

WASTE APPLICATIONS DURING API CREC 6.28 STUDY

PLOT	TOTAL APPLICATIONS	LAST APPLICATION	TOTAL SLUDGE APPLIED BBLS/ACRE	TOTAL OIL IN SLUDGE APPLIED BBLS/ACRE	DEPTH OF INCORPORATION INCHES	FINAL OIL CONCENTRATION IN THE SOIL ON 12/4/78, WT. %
A	13	11/10/78	11,000	1,650	8	4.3
B	14	11/14/78	13,000	1,550	8	3.0

Source: Weldon,(8), page 10.

TABLE 2

OILY WASTE CHARACTERISTICS

	API SEPARATOR SLUDGE	CENTRIFUGE SLUDGE
Hydrocarbon Fraction, Wt. %	5.2	8.1
Water Fraction, Wt. %	85.2	72.1
Solids Fraction, Wt. %	9.6	19.8
	100.0	100.0
Flash Point (Setaflash tester) <140°F	None	None
Flash Point (Setaflash tester) >140°F	(1)	(1)
Simulated Distillation of Hydrocarbon Fraction, °F		
IBP	230.7	228.7
5 Vol. %	321.7	332.3
10	368.3	362.3
15	405.4	398.5
20	443.8	432.6
25	480.0	444.4
30	485.9	478.0
35	506.1	489.7
40	516.8	509.0
45	544.7	519.0
50	560.1	534.6
55	583.9	551.7
60	612.3	562.0
65	637.0	586.5
70	645.7	609.1
75	677.5	632.7
80	711.5	653.4
85	749.8	685.1
90	803.9	731.4
95	883.4	814.2
FBP	1087.1	1026.2

(1) Water vapor released from sample extinguished flame.

Source: Weldon, (8), page 11.

TABLE 3

ATMOSPHERIC VOC EMISSIONS FROM LANDFARMING OILY WASTES

Test No.	1979 Date	Length Of Run, Days	Sludge Spread Lbs/ Ft^2	Sludge Spread Tons/ Acre	Sludge Spread Bbls/ Acre	Hydrocarbon Content Of Sludge Wt. %	Oil Spread Lbs/ Ft^2	Oil Spread Lbs/ Acre	Oil Spread Bbls/ Acre	Hydrocarbon Emissions(3) Total Lbs/ Acre	Hydrocarbon Emissions(3) Avg. Rate Lbs/ Acre-Day	Wt. % Of Sludge Hydrocarbon Phase Evaporated	Collector Box Avg. Daily Temp., °F Max.	Collector Box Avg. Daily Temp., °F Min.
PHASE II: CENTRIFUGE SLUDGE, PLOT A														
4	5/30-31	0.94	7.9	172	894	8.1	0.64	27900	88.5	18	19.2	0.06		
5	5/31-6/1	0.83	8.0	174	905	8.1	0.65	28300	89.7	32	38.6	0.11		
6(1)	6/5-18	12.8								494	40.9	1.9		
5 & 6										526		2.0	90	61
PHASE III: API SEPARATOR SLUDGE (WEATHERED), PLOT B														
7	6/18-7/14	25.8	8.0	174	905	5.2	0.42	18100	57.6	1963	76.1	10.9	85	59
8	9/11-17	5.1	6.8	147	764	5.2	0.35	15300	48.6	507	99.4	3.3		
9(2)	9/17-10/9	21.7								1596	95.1	10.2		
8 & 9										2103		13.8	86	50

(1) Test 6 followed rototilling at the end of Run 5 on same ground area.
(2) Test 9 followed rototilling at the end of Run 8 on same ground area.
(3) Hydrocarbons-less-methane expressed as hexane. Hydrocarbons in background air have been backed out.

Source: Weldon, (8), page 23.

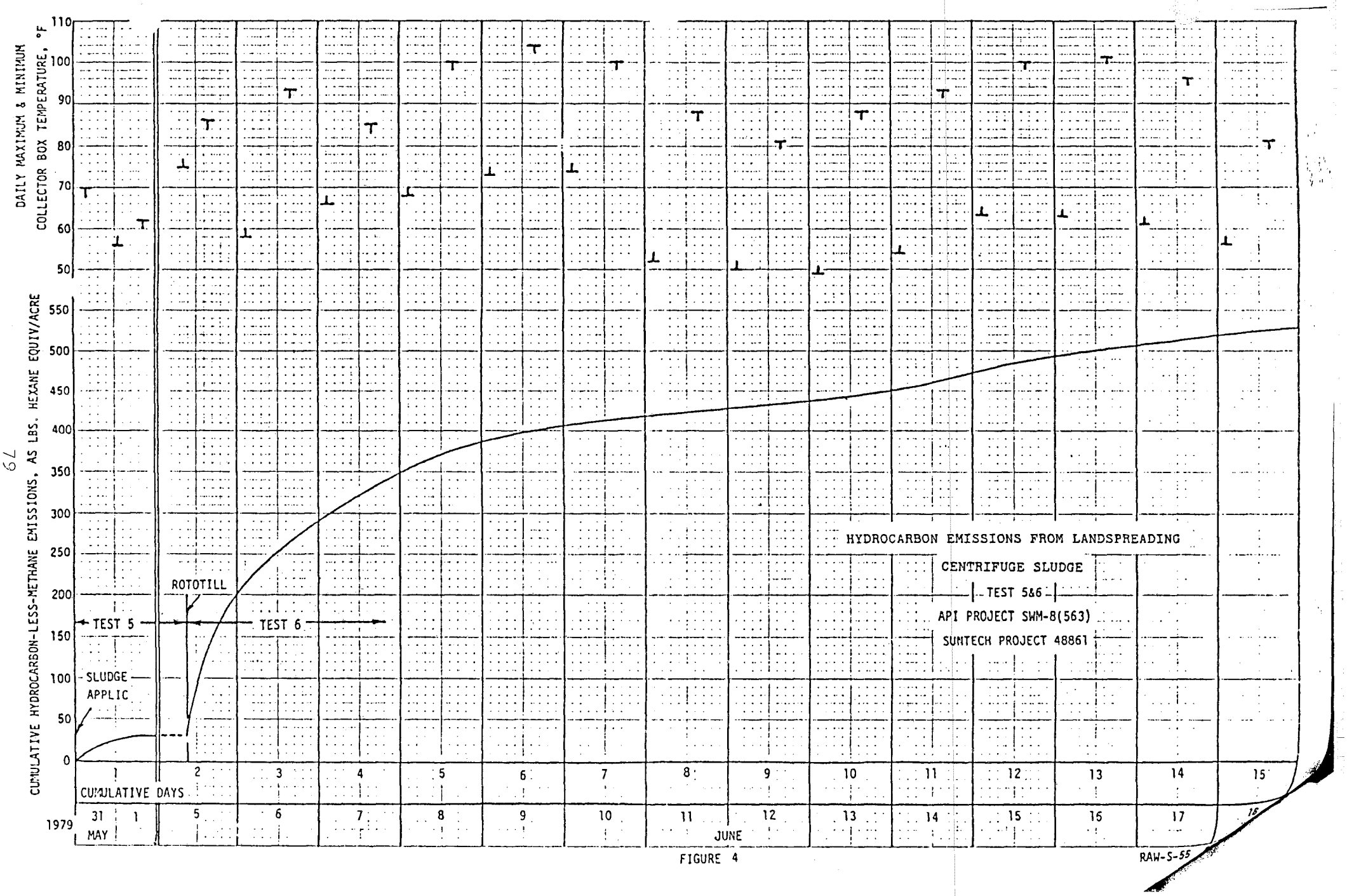
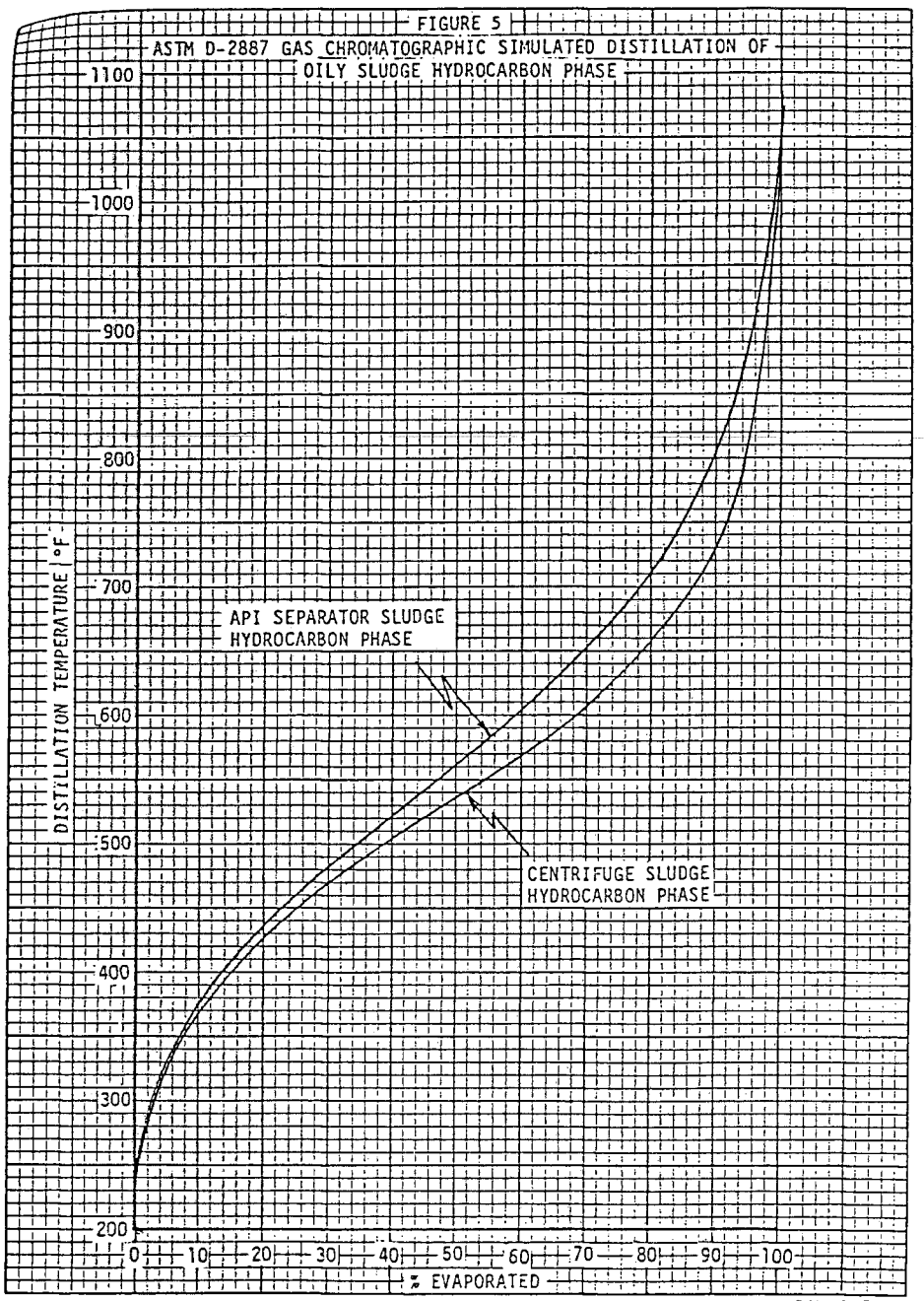


FIGURE 4

Source: Weldon, (8), page 24.



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Source: Weldon, (8), page 25.

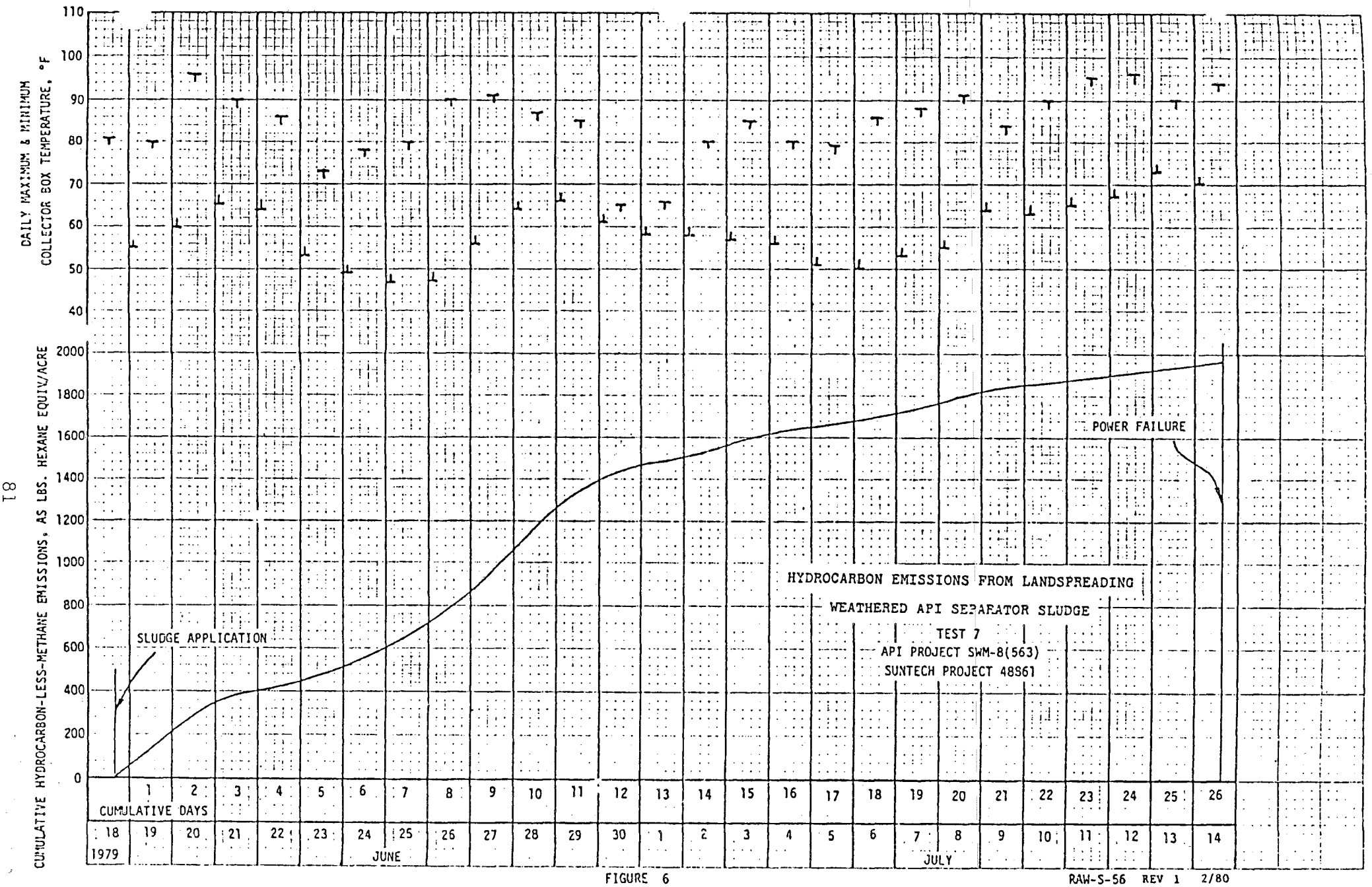

FIGURE 6

RAW-S-56 REV 1 2/80

Source: Weldon, (8), page 27.

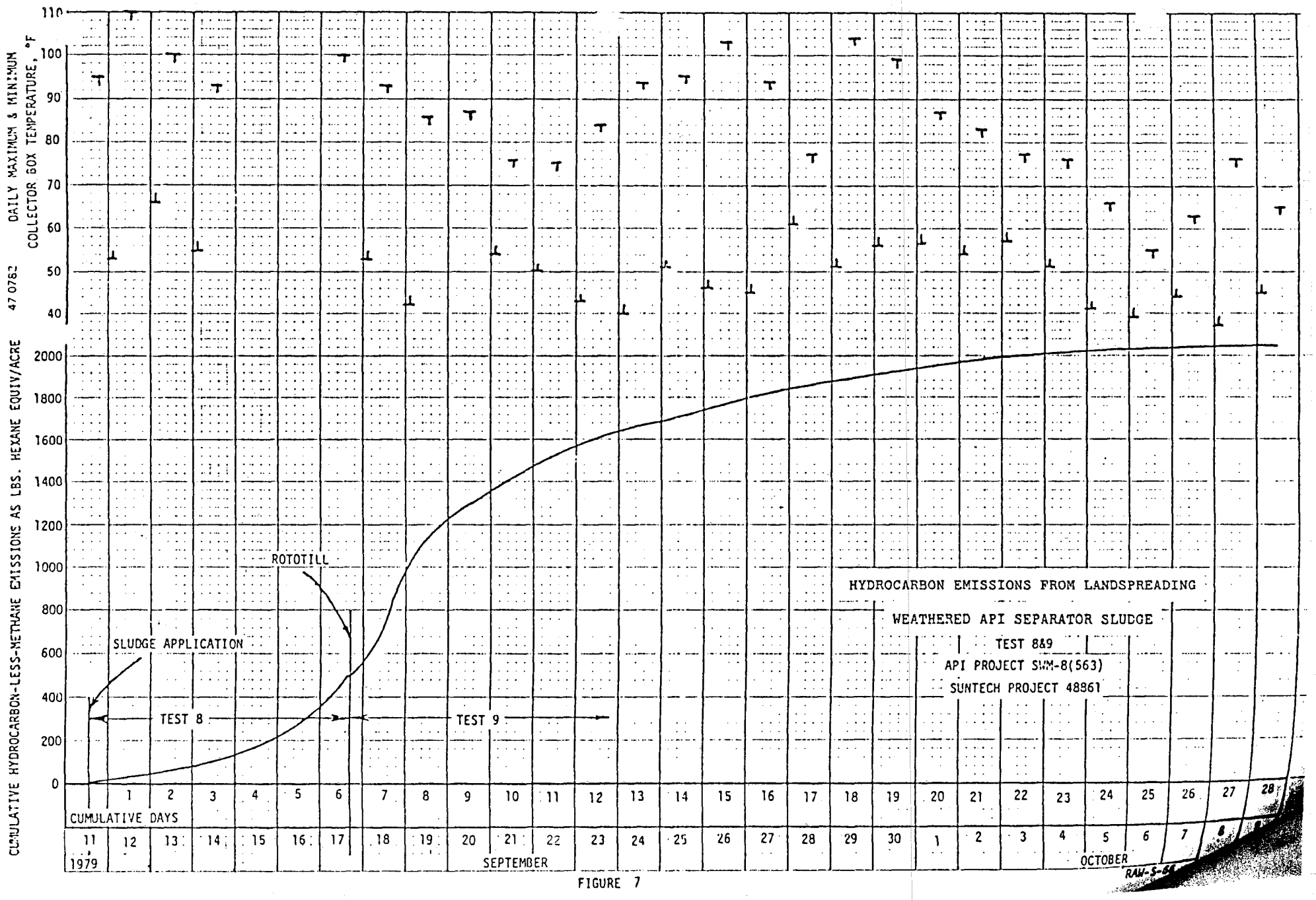

FIGURE 7

Source: Weldon, (8), page 28.

TABLE 5

BACKGROUND HYDROCARBON LEVELS

	(HC-CH_4) CONCENTRATION EXPRESSED AS VPPM CH_4	METHANE, VPPM	LENGTH OF TEST HOURS
Plot (C) Control Test 1	1.5 (1)	0.0	18
Plot (A) Test 2	< 1.0	< 1.0	22
Plot (B) Test 3	< 1.0	< 1.0	9
Ambient Air:			
5/23/11:00 AM	1.3	1.3	
6/5/9:20 AM	5.5 (2.3-8.8)	1.8	
6/8/1:00 PM	2.0	1.5	
6/18/5:00 PM	1.3	1.6	
6/26/3:00 PM	3.5	1.6	
6/27/1:30 PM	3.8	2.0	
9/11/1:45 PM	0.5	1.0	
10/10/1:10 PM	1.3	0.9	

(1) Power to system was supplied by propane generator at the site.

Source: Weldon, (8), page 31.

9). Brown, K. W., K. C. Donelley, J. C. Thomas, and L. E. Deuel, Jr. "Factor's Influencing the Biodegradation of API Separator Sludges Applied to Soils." Land Disposal of Hazardous Wastes. Proceedings of the 7th Annual Research Symposium at Philadelphia, Pennsylvania. March 16-18, 1981.

WASTES

The wastes investigated in this study were refinery API separator sludge and petrochemical plant API separator sludge.

SOILS

A variety of soils were investigated and ranged from a clay soil to a sandy clay soil. Detailed soil analyses were conducted.

WASTE APPLICATION/DESIGN

All of the work consisted of laboratory investigations using respirometers. The refinery sludge contained 10% extractable carbon. The authors applied the waste sludges

at up to 10% waste sludge in the soil. The authors also investigated different levels of fertilizer applications. The wastes were surface applied to the soil.

The variables investigated in this study were: temperature levels; soil moisture levels; fertilizer application levels; waste application rates; waste application frequency; and, soil types.

RESULTS

- A broad range of temperatures suitable for oil degradation existed. Thirty degrees Celsius exhibited the maximum degradation rate for refinery sludge of the temperatures investigated.

- The authors found that a broad acceptable range of soil moisture levels for oil degradation existed. The maximum degradation rate for refinery sludges was found at field capacity for the soils studied.

- Fertilizer applications were found to have no effect on the refinery sludge degradation rates.

- Frequent small additions of small amounts of waste increased degradation rates.

- The best waste loading rate for the refinery sludge appeared to lay somewhere between 1 and 5 percent of waste sludge by weight in the soil.

- The sandy clay soil had the greatest degradation rate of the soils studied for the refinery sludge.

- The clay soil had the smallest degradation rate of the soils studied for the refinery sludge.

- Addition of fertilizers to the soil increased the number of microbes present in the soil.

- Addition of waste to the soil had varying effects on the population of microbes in the soil. At 1.0 percent waste sludge by weight in the soil, the largest microbial populations were found. At 10 percent waste sludge by weight in the soil the microbial populations were lower than in unamended soils.

- The average half-life of the refinery wastes in the soils were calculated at 141 days.

TABLES AND FIGURES

This study was reviewed on microfiche and, therefore, no Tables or Figures are included in this summary.

10). Minear, R. A., J. L. Randall, and R. G. Weatherold. "Atmospheric Hydrocarbon Emissions from Land Treatment of Refinery Oily Sludges." American Petroleum Institute. May, 1981.

WASTES

The petroleum refinery wastes studied were two API separator sludges and one sample of tank bottoms.

SOILS

Two types of soil were investigated in this study, however, differences and similarities of the soils were not presented.

WASTE APPLICATION/DESIGN

All work consisted of laboratory investigations lasting approximately 30 minutes. Waste applications were made at rates varying anywhere from 27.2 to 1707 grams of oil per square foot of soil (the soil was four inches deep). Additions of fertilizer and their effects on hydrocarbon emissions were not investigated. The wastes were applied

evenly to the soil surface except for some trials involving subsurface injection. A number of variables and their effects on hydrocarbon emissions from the soil/waste mixtures were investigated in this study. The variables consisted of: sludge volatility; soil moisture content; wind speed; relative humidity; air and soil temperature; sludge loading to the soil; and, sludge applications techniques.

RESULTS

- The volatile organic carbon emissions varied from 0.09 to 7.5 percent of the total applied oil by weight. These emissions took place in the first 30 minutes after application of the waste to the soil.

- Greater sludge volatility, as based on stripping tests, was positively correlated with greater total volatile organic carbon emission from the land treatment plots.

- The volatility of waste sludges decreased when the waste was added to the soil. However, a sludge/gasoline mixture added to soil had greater total emissions than the raw waste itself. No explanation was provided.

- Stripping tests run on the raw wastes tended to have the highest volatile organic carbon concentrations in emissions shortly after stripping began. An exponential decay of concentrations with time was found for the 30 minute study period.

- The highest volatile organic carbon emissions were found shortly after applying the wastes to the soil. These concentrations decreased with time.

- Experimental runs on soil/waste mixtures indicated that increased soil moisture contents were positively correlated with greater hydrocarbon emissions to the air.

- Wind speeds between 1 and 3 miles per hour were studied. Concentrations of volatile organic carbons in the air fell with increasing wind speed over the soil/waste plots. However, total mass emissions of volatile organic carbons were approximately the same in the wind speed range studied.

- Experimental runs on soil/waste mixtures indicated that increased relative humidity in the air was correlated with higher hydrocarbon emissions from the soil/waste plots.

- One run indicated that lower temperatures of the soil and the air were associated with decreased hydrocarbon emissions from the soil/waste plots when compared with higher temperatures.

- No consistent relationship was found between the weight percent of oil in the soil/waste mixture and hydrocarbon emissions.

- It was found that subsurface injection of wastes significantly decreased volatile organic carbon emissions. When the wastes were not allowed to bubble to the surface after injection, no emissions were found. The longer the wait before tilling the soil/waste mixture after subsurface injection, the lower the total volatile organic carbon emissions.

TABLES AND FIGURES

Selected Tables and Figures from the study follow.

Tables 3 and 4.

Table 3 Physical Tests Run on the Oily Sludges

1. Total solids
2. Total volatile solids
3. Total suspended solids
4. Total volatile suspended solids
5. Weight loss on heating
6. Centrifugation

Table 4 Chemical Tests Run on the Sludge and Soil Samples

Tests	Methods
1. Oil and grease content of sludges	Extraction with freon and infra-red adsorption
2. Volatile organics on soils and sludges	Gas chromatography Mass spectrometry (GC/MS)
3. Volatile organics on soil	High temperature (GC/MS)

Source: Minear, et al, (10), page 10.

Table 5 Physical Characteristics of Land Treatment Sludges[2]

Sludge sample**	Oil* and grease by IR (mg/l)	Oil* and grease by gravimetric (mg/l)	Total solids (mg/l)	Total volatile solids mg/l	Total volatile solids (%)	Total suspended solids (mg/l)	Total volatile suspended solids mg/l	Total volatile suspended solids (%)
T-A		159,600	82,200	66,700	81			
T-B						93,400	32,400	35
T-C	80,500	110,000				790,000	94,000	12
T-D	38,400	66,000				410,000	100,000	25
S3-A		82,500	74,400	54,200	73			
S3-B						12,500	4,300	35
S3-C	142,000	150,000				21,000	16,000	76
S3-D	177,000	340,000				11,000	6,000	55
S1-A		726,800	196,200	153,600	78			
S1-B						1,100	1,070	97
S1-C	598,000	800,000				2,900	2,700	93
S1-D	619,000	820,000				2,000	1,900	94
Average Values								
T Avg	59,500	111,900	82,200	66,700	81	431,000	75,500	18
S3 Avg	159,500	191,000	74,400	54,200	73	14,800	8,800	59
S1 Avg	608,500	782,000	196,200	153,600	78	2,000	1,890	95

*Reference oil contained 37.5% Isoctane, 37.5% hexadecane, and 25.0% benzene.

**S1 = Tank bottoms
S3 = API separator sludge
T = API separator sludge

Source: Minear, et al, (10), page 11.

Table 6 Results of Centrifugation of Sludge Samples[2]

Sample*	Centrifugation time (min)	Solids (Vol %)	Water (Vol %)	Oil (Vol %)
T-A	15	40	50	10
T-B	15	40	50	10
S3-A	15	15	79	6
S3-B	15	15	79	6
S1-A	15	6	0	94
S1-B	15	6	0	94

*S1 = Tank bottoms
S3 = API separator sludge
T = API separator sludge

Source: Minear, et al, (10), page 12.

Table 7 Chemical Composition of Sludge and Soil Samples[2]

RT(min)	Compound (M/E)	Concentration, PPM* API separator sludge S3	Tank bottoms S1	API separator sludge T	S Soil	T Soil
9.2	Benzene (78)	1,400	1,800	N.D.	0.0085	0.55
15.2	Toluene (92)	5,600	9,300	0.02	0.0075	0.50
18.1	Ethylbenzene (106)	4,300	5,200	0.46	0.0065	1.8
20.5	M,P-Xylene (106)	15,000	23,000	1.2	0.012	5.5
21.2	O,Xylene (106)	32,000	42,000	0.55	0.016	5.0
23.2	Saturated Hydrocarbon (85)	24,000	4,000	5.0	N.D.	6.5
26.2	Indane (118)	28,000	34,000	9.2	N.D.	1.6
25.4	C_3-Benzene (120)	160,000	220,000	7.9	N.D.	12.0
24.0	Dimethylpentene (98)	1,900	2,200	5.0	N.D.	5.0
24.8	Saturated Hydrocarbon (57)	5,200	6,200	6.6	N.D.	13.0
	TOTAL	277,400	347,700	35.9		

*Compounds with retention times up to 21 minutes were quantitated based on actual response factors and compounds with retention times above 21 minutes were quantitated with a response factor of 1.

Source: Minear, et al, (10), page 13.

Table 8 Stripping Test Results[2]

Stripping time, minutes	Hydrocarbon concentration, ppmw/µl		
	Sludge T*	Sludge S3*	Sludge S1*
0	91	1900	6100
4	15	140	310
8	8.2	72	150
12	5.2	39	170
16	3.7	27	150
20	3.0	21	140
24	2.4	16	-
28	1.9	13	120
32	1.6	10	110
36	1.4	8.9	100
40	1.2	7.6	100
44	1.0	6.5	96
48	.91	5.8	92
52	.80	5.0	87
56	.69	4.7	84
60	.63	4.5	80
64	.62	4.0	74
68	.56	3.6	76
72	.54	2.8	71
76	.44	2.6	70
Bag sample, 0-36 minutes	17	23	140
Sample size, µl	20	5	1

* S1 = Tank bottoms
S3 = API separator sludge
T = API separator sludge

Source: Minear, et al, (10), page 15.

Table 9 Matrix of Experimental Conditions for Land Treatment Simulation Runs[2]

Run No.	Waste Material**	Waste Loading (lb/ft^2)***	Soil Type	Soil Moisture (wt%)	Soil/Air Temperature (°F/°F)	Air Velocity (mph)	Relative Humidity (%)	Spreading Mechanism	Remarks
1	Hexane	1.0	None	NA	NA/100	3	Amb*	Pour	
2	Hexane	1.0	S	10.7	120/100	3	Amb*	Surface	
3	Gasoline	1.0	None	NA	NA/100	3	Amb*	Pour	
4	Gasoline	1.0	S	10.7	120/100	3	Amb*	Surface	
5	S1	2.5	None	NA	NA/100	3	Amb*	Pour	
6	S1	2.5	S	10.7	120/100	3	Amb*	Surface	Base case
7	S1	2.5	S	10.7	120/100	3	Amb*	Surface	Repeat of base case
8	S1	2.5	S	10.7	120/100	1	Amb*	Surface	
9	S1	2.5	S	10.7	100/80	3	40	Surface	
10	S1	1.0	S	10.7	120/100	3	Amb*	Surface	
11	S1	1.0	S	10.7	120/100	3	Amb*	Surface	Repeat of Run 10
12	S1	2.5	T	4.7	120/100	3	Amb*	Surface	
13	S1	2.5	S	20.7	120/100	3	Amb*	Surface	
14	S1	2.5	S	10.7	120/100	3	75	Surface	
15	T	2.5	S	10.7	120/100	3	Amb*	Surface	
16	S1	2.5	S	10.7	120/100	3	Amb*	Surface	
17	S1	4.0	S	10.7	120/100	3	Amb*	Surface	
18	S1	0.5	S	10.7	120/100	3	Amb*	Surface	
19	S1	2.5	S	10.7	120/100	3	Amb*	Surface	Heat sludge to 140°F
20	S3	1.0	S	10.7	120/100	3	Amb*	Surface	
21	S3	2.5	S	10.7	120/100	3	Amb*	Surface	
22	S3	4.0	S	10.7	120/100	3	Amb*	Surface	
23	S3	1.0	T	4.7	120/100	3	Amb*	Surface	
24	S3	4.0	T	4.7	120/100	3	Amb*	Surface	
25	S3	2.5+	S	10.7	120/100	3	Amb*	Surface	Spike sludge with 0.5 lb of gas
26	S3	2.5+	S	10.7	120/100	3	Amb*	Surface	Spike sludge with 1.5 lb of gas
27	S3	2.5+	S	10.7	120/100	3	Amb*	Surface	Spike sludge with 1.5 lb of H_2O
28	S1	2.5	S	10.7	120/100	3	Amb*	Sub-surface	Till soil after spreading
29	S1	2.5	S	10.7	120/100	3	Amb*	Sub-surface	Use deeper injection

*Amb = ambient humidity was typically 50% at room temperature but measured <<30% at 100°F.
**Sludge S1 = Tank Bottoms
Sludge S3 = API Separator Sludge
Sludge T = API Separator Sludge
***Loading of 2.5 lb/ft^2 is equivalent to approximately 300 barrels/acre.

Source: Minear, et al, (10), page 16.

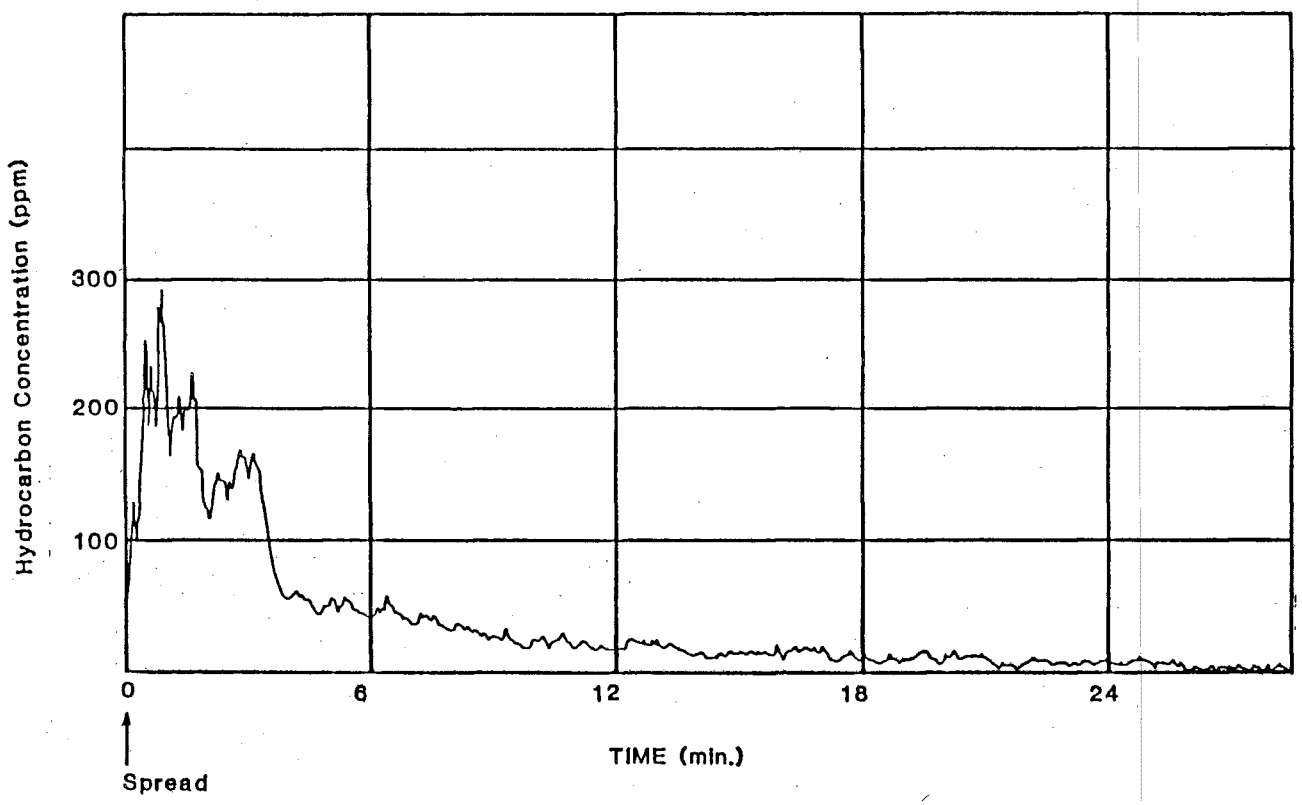

Figure 2 Typical chart trace from THC monitor[2]

Source: Minear, et al, (10), page 18.

Table 10 Results of Simulation Runs[2]

Run No.	Variable[1]	Maximum hydrocarbon concentration (ppm)	Integrated area In 6 Min.	Integrated area in 30 min.	Remarks
1	Pure hexane (false bottom)	>10,000	2,460	7,980	Total area at dryness was 8580
2	Pure hexane	>10,000	3,900	5,500	
3	Gasoline (false bottom)	> 5,000	690	1,810	Total area at zero hydrocarbon
4	Gasoline	>10,000	1,750	2,470	concentration was 2400
5	S1 (false bottom)	400	43	342	
6	Base case	215	21	78	
7	Base case (repeat)	200	22	62	
8	Air velocity decreased to 1 mph	310	57	231	
9	Air/soil temperature decreased	260	23	53	
10	Loading decreased	325	49	143	
11	Loading decreased (repeat of 10)	200	31	136	
12	Soil T used	485	86	230	
13	Moisture in soil increased	> 500	85	263	
14	Moisture in air increased	> 500	68	116	
15	Waste T used	35	1	1	
16	Base Case in a deeper box	350	27	71	
17	Loading increased	425	33	81	
18	Loading decreased drastically	250	31	61	
19	Waste heated before spreading	350	45	74	
20	Waste S3 at low loading	23	4	10	
21	Waste S3 used	15	1.5	5	
22	Waste S3 at high loading	25	4	16	
23	Waste S3 low load on T soil	17	2	5	
24	Waste S3 high load on T soil	34	4	12	
25	Waste S3 with low gas spike	7,000	480	760	
26	Waste S3 with high gas spike	>10,000	760	1,360	
27	Waste S3 cut with water	25	5	8	
28	Sub-surface injection	300	17	114	
28A	Tilling of 28	375	29	68	Tilled 80 min. after spreading
29	Sub-surface deep injection	0	0	0	
29A		225	15	15	Tilled 4 days after spreading
29B		50	3	3	Tilled 6 days after spreading

[1]Variable changes from the base case conditions of Runs 6 and 7. All other variables remained as in Runs 6 and 7.

Source: Minear, et al, (10), page 19.

Table 11 Estimated Emissions from Sludge Applied to Soil in Land Treatment Simulation Tests[2]

Run/Sludge	Area 30	Grams volatilized*	Weight Sludge applied, g	% Total Sludge volatilized	Weight Oil applied**	% volatilized	Weight Oil applied, g#	% Oil volatilized
6/S1	78	7.9	1135	0.70	1067	.74	999	.79
7/S1	62	6.3	1135	0.56	1067	.59	999	.63
9/S1	53	5.4	1135	0.48	1067	0.51	999	0.54
10/S1	143	14.5	454	3.2	427	3.4	400	3.6
11/S1	136	13.8	454	3.0	427	3.2	400	3.5
12/S1	230	23.3	1135	2.1	1067	2.2	999	2.3
13/S1	263	26.7	1135	2.4	1067	2.5	999	2.7
14/S1	116	11.8	1135	1.0	1067	1.1	999	1.2
15/T	1	0.10	1135	0.009	114	0.88	110	0.90
16/S1	71	7.2	1135	0.63	1067	.67	999	.72
17/S1	81	8.2	1816	0.45	1707	.48	1590	.52
18/S1	61	6.2	227	2.7	213	2.9	200	3.1
19/S1	74	7.5	1135	0.66	1067	.70	999	.75
20/S3	10	1.0	454	0.22	27.2	3.7	91	1.1
21/S3	5	0.51	1135	0.045	68.1	0.75	227	0.22
22/S3	16	1.6	1816	0.088	109	1.5	363	.44
23/S3	5	.51	454	.11	27.2	1.9	91	.56
24/S3	12	1.2	1816	0.066	109	1.1	363	.33
27/S3	8	.81	1135	0.071	68.1	1.2	227	.36

* Based on Figure D response factor.
** Based on % oil data of Table 4.
\# Based on gravimetric oil and grease data of Table 5.
*** S1 = Tank bottoms
S3 = API separator sludge
T = API separator sludge

Source: Minear, et al, (10), page 21.

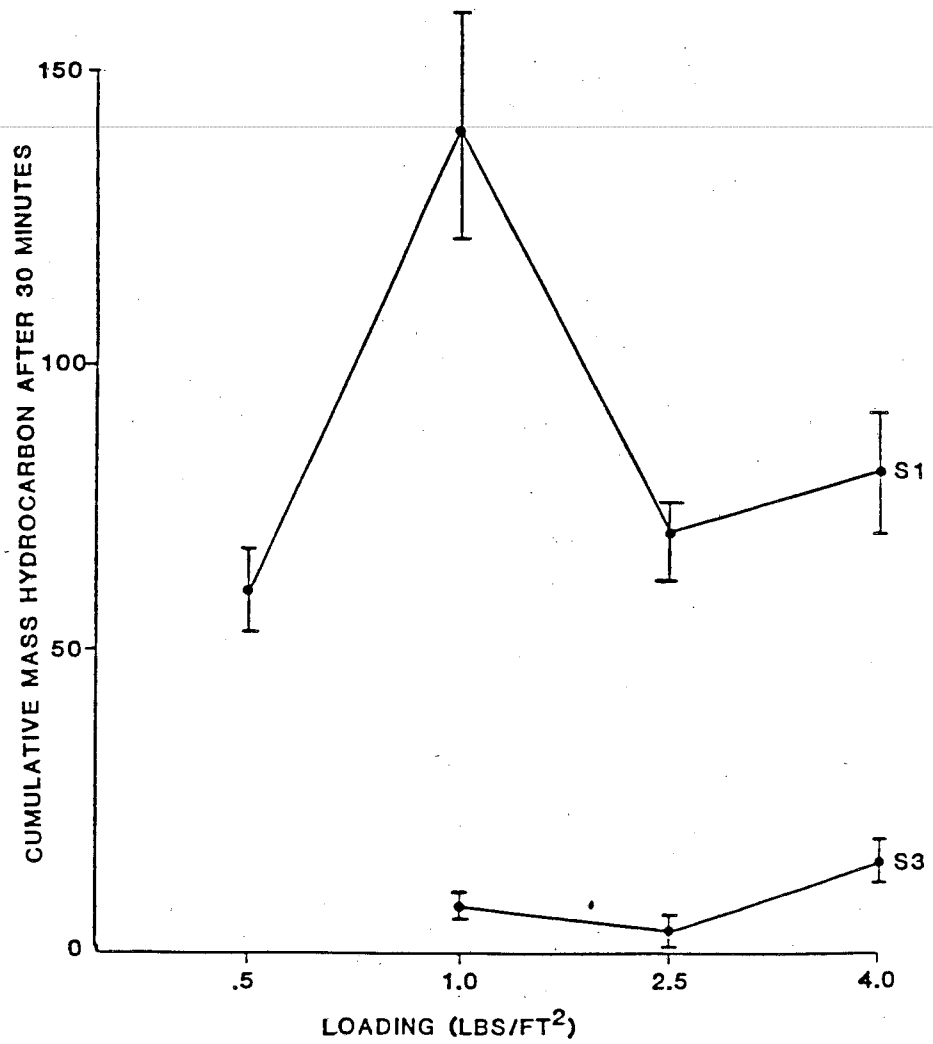

Figure 3 Effect of loading on emissions from simulated land treatment[2]

Source: Minear, et al, (10), page 22.

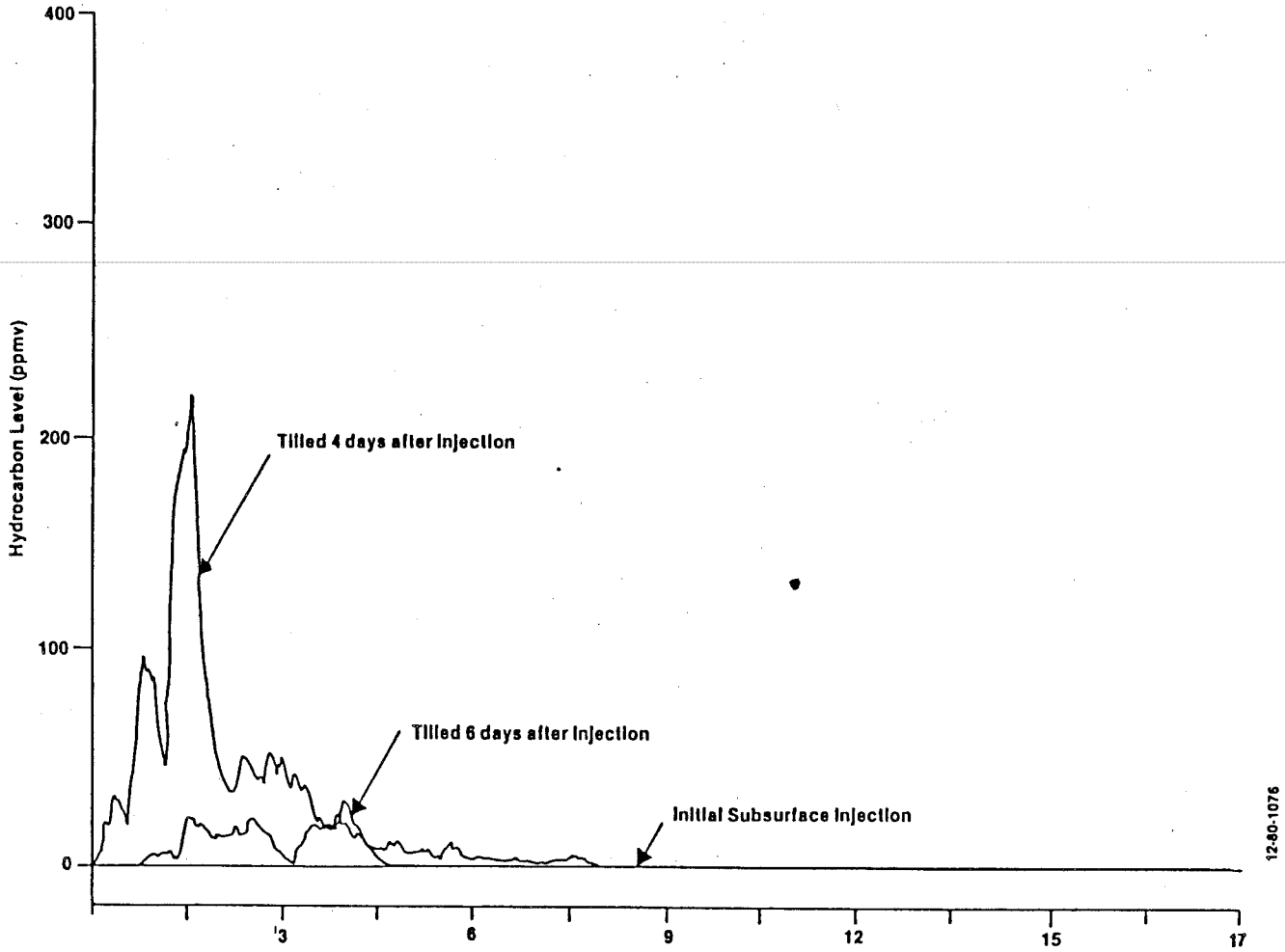

Figure 20. Effect of resting time before tilling on emissions after subsurface injection.

Source: Minear, et al, (10), page 74.

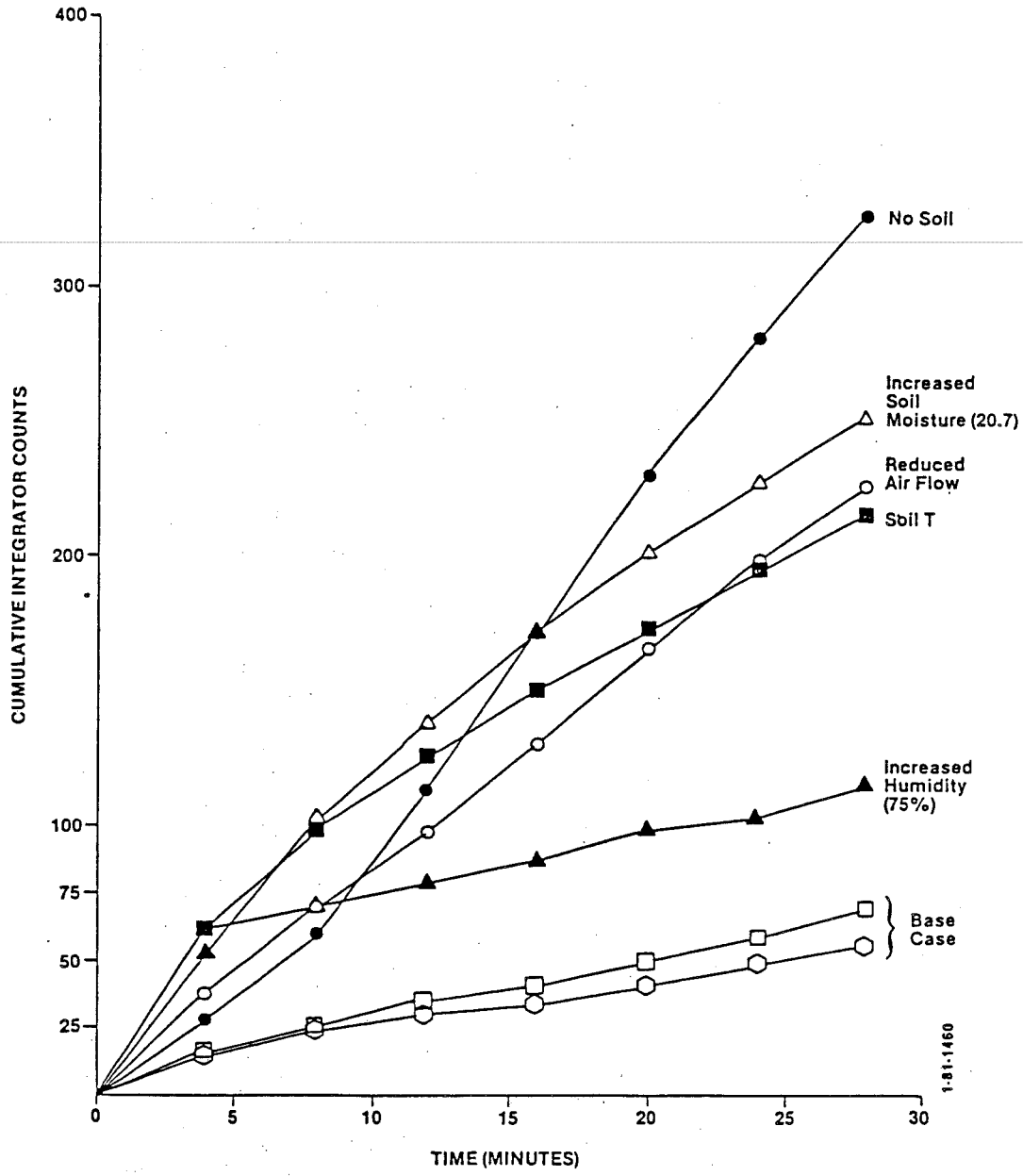

Figure 21. Effect of moisture, loading, and air flow on emissions.

Source: Minear, et al, (10), page 75.

11). Huddleston, R. L., J. E. Rucker, F. W. Brown, and L. E. Deuel, Jr. "Evaluation of Subsurface Effects of Long-Term Landfarming." Land Disposal of Hazardous Waste, Proceedings of the 8th Annual Research Symposium at Fort Mitchell, Kentucky, March 8-10, 1982. EPA-600/9-82-002. March, 1982.

WASTES

The long term migration potential of landfarming petroleum wastes were investigated by soil analyses at five previously used landfarming sites. Specific wastes treated at the sites were not listed.

SOILS

The sites investigated were used for treatment of petroleum wastes for at least five years. The soils ranged from sands to clays.

WASTE APPLICATION/DESIGN

The previously utilized sites were sampled through soil cores extending to a depth of twelve feet. Multiple soil

cores were taken at each site and composited with respect to a given depth. All analyses were run on these composite soil samples. Background soil samples were also taken at each site.

RESULTS

- Chromium and lead were present in the surface layers of the landfarm soils in concentrations higher than found in the background soil. These contaminants attenuated to background levels within six feet of the soil surface.

- There was no evidence of migration of any metals downward out of the treatment zone.

- The upper six feet of soil treated with petroleum wastes had a slightly lower pH when compared to background soils. The authors felt that this was due to the acidic degradation products of the wastes.

- No significant differences were found at two sites for surface soil oil and grease concentrations, when compared to background soils.

- Oil and grease concentrations at all treated soil plots attenuated to background levels within two feet of the surface soil.

- Some of the previously utilized sites had cation exchange capacities significantly higher than their background soils. The authors attributed this to the build-up of organic substances in the soil from the wastes.

- All sites appeared to have accomplished waste degradation without migration of the wastes or the degradation products of the wastes.

TABLES AND FIGURES

Tables and Figures from the study follow.

Table 22 . Mean Cl^-, $SO_4^=$, and NO_3^- Values Averaged Over Depth for Both Treated and Untreated Soils.

Site	Anion Cl^-	$SO_4^=$	NO_3^-
	meq/liter		
A-Untreated	1.91	272	0.95
A-Treated	3.38	258	0.76
B-Untreated	0.67	9.54	0.54
B-Treated	2.51	31.6	1.08
C-Untreated	40.3	8.58	2.24
C-Treated	40.4	41.2	1.71
D-Untreated	60.8	13.7	9.01
D-Treated	29.5	12.8	16.8
E-Untreated	1.48	4.25	0.25
E-Treated	6.00	6.68	0.31

Source: Huddleston, et al, (11), page 434.

TABLE 23. TOTAL METAL CONTENTS WITH DEPTH FOR UNTREATED AND TREATED SOIL AT SITE A IN PPM

Site	Depth (cm)	Depth (in.)	As	Cd	Cr	Hg	Pb	Se	Ni	V
A-Untreated Soil	0-15	0-6	1.2	1.8	29.4	0.6	23.5		17.6	67.6
	15-23	6-9	9.2	2.4	32.3	0.6	29.4		23.5	67.6
	23-30	9-12	8.3	1.9	27.8	0.6	27.8		22.2	63.9
	30-53	12-21	1.6	2.2	25.0	0.6	27.8		19.4	77.8
	53-76	21-30	0.9	2.2	28.1	0.6	31.3		21.9	71.9
	76-102	30-40	3.7	1.8	29.4	1.2	29.4		23.5	58.8
	102-127	40-50	4.6	1.8	26.5	1.2	29.4		20.6	52.9
	127-152	50-60	1.2	1.7	25.0	0.6	22.2		19.4	55.6
A-Treated Soil	0-15	0-6	1.7	2.1	182.4	1.2	50.0		11.8	44.1
	15-23	6-9	1.2	2.1	44.1	1.2	29.4		17.6	58.8
	23-30	9-12	3.7	1.8	26.5	0.6	29.4		17.6	58.8
	30-53	12-21	8.8	2.1	26.5	1.8	29.4		17.6	67.6
	53-76	21-30	0.2	2.2	28.1	0.6	31.3		15.6	62.5
	76-102	30-40	1.1	2.1	42.1	1.1	31.6		15.8	65.8
	102-127	40-50	6.3	2.3	41.9	1.1	28.8		23.6	78.5
	127-152	50-40	6.9	2.0	31.9	1.2	28.9		17.3	57.8

Source: Huddleston, et al, (11), page 436.

TABLE 24. TOTAL METAL CONTENTS WITH DEPTH FOR UNTREATED AND TREATED SOIL AT SITE B IN PPM

Site	Depth (cm)	Depth (in.)	As	Cd	Cr	Hg	Pb	Se	Ni	V
B-Untreated Soil	0-15	0-6	1.6	2.1	35.5	< 0.5	17.7		28.4	106.4
	15-30	6-12	< 0.2	1.3	19.1	< 0.5	12.7		22.3	95.5
	30-46	12-18	0.9	0.9	20.7	< 0.5	6.0		20.9	119.7
	46-61	18-24	< 0.2	1.2	20.4	< 0.5	5.8		23.4	117.0
	61-76	24-30	< 0.2	0.9	23.1	< 0.5	5.8		23.1	86.7
	76-91	30-36	1.7	2.1	18.1	< 0.5	6.0		24.1	120.5
	91-122	36-48	< 0.2	1.2	12.2	< 0.5	6.1		21.3	91.5
	122-152	48-60	3.7	1.5	25.4	< 0.5	10.2		35.5	152.3
	152-183	60-72	2.6	1.3	33.0	< 0.5	10.2		35.5	101.5
	183-244	72-96	1.5	1.5	32.8	< 0.5	12.6		30.3	126.3
	244-305	96-120	1.5	1.0	22.7	< 0.5	10.1		30.3	75.8
	305-366	120-144	1.1	1.3	27.8	< 0.5	10.1		32.8	75.8
B-Treated Soil	0-15	0-6	4.3	2.1	191.0	10.6	67.6		41.1	117.6
	15-30	6-12	2.7	2.2	186.3	11.2	71.4		40.4	124.2
	30-46	12-18	4.8	1.6	78.9	3.3	36.2		32.8	131.6
	46-61	18-24	1.9	1.3	44.9	1.9	16.0		28.8	128.2
	61-76	24-30	2.0	1.1	44.9	1.1	14.0		28.1	84.3
	76-91	30-36	2.6	1.5	73.9	0.9	14.8		35.5	88.8
	91-122	36-48	1.4	2.0	37.4	0.6	11.5		25.9	86.2
	122-152	48-60	3.4	1.5	40.7	< 0.5	11.6		26.2	87.2
	152-183	60-72	2.3	1.5	25.8	< 0.5	12.9		30.9	103.1
	183-244	72-96	0.7	1.8	27.9	< 0.5	12.7		35.5	101.5
	244-305	96-120	< 0.2	2.6	33.2	< 0.5	20.4		38.3	127.6
	305-366	120-144	3.0	1.8	30.6	< 0.5	17.9		40.8	102.0

Source: Huddleston, et al, (11), page 437.

TABLE 25. TOTAL METAL CONTENTS WITH DEPTH FOR UNTREATED AND TREATED SOIL AT SITE C IN PPM

Site	Depth (cm)	Depth (in.)	As	Cd	Cr	Hg	Pb	Se	Ni	V
C-Untreated Soil	0-15	0-6	7.8	2.4	21.0	1.6	34.2		13.1	34.2
	15-30	6-12	4.1	1.4	19.2	1.6	32.8		10.9	27.4
	30-46	12-18	3.5	0.5	18.4	1.6	13.2		2.6	26.3
	46-61	18-24	3.1	1.8	15.0	1.6	18.0		6.0	24.0
	61-76	24-30	3.5	1.1	13.1	1.1	13.1		5.3	21.0
	76-91	30-36	3.5	1.1	10.6	1.6	5.3		10.6	79.4
	91-122	36-48	3.1	1.3	13.2	1.1	< 5.0		7.9	52.9
	122-152	48-60	3.5	1.6	16.0	1.1	5.3		8.0	53.2
	152-183	60-72	2.8	1.3	13.4	2.1	5.3		8.0	53.5
	183-244	72-96	4.0	1.9	16.3	1.6	5.4		13.6	54.3
	244-305	96-120	3.6	1.1	16.0	3.2	10.6		8.0	53.2
	305-366	120-144	3.4	1.0	7.7	1.6	5.1		5.1	25.6
C-Treated Soil	0-30	0-12	16.3	2.6	109.4	1.6	57.3		31.3	78.1
	30-46	12-18	8.4	0.8	16.9	1.1	14.1		11.2	56.2
	46-61	18-24	3.7	1.1	10.9	0.5	13.7		8.2	27.3
	61-76	24-30	2.8	1.1	13.4	1.1	10.7		8.1	53.8
	76-91	30-36	2.8	1.3	16.1	0.5	5.4		8.1	53.8
	91-122	36-48	2.4	1.1	13.6	0.5	5.4		8.1	54.3
	122-152	48-60	2.0	1.1	16.3	0.5	10.9		5.4	54.3
	152-183	60-72	2.0	0.8	13.8	0.5	11.0		5.5	55.2
	183-244	72-96	4.0	0.9	11.9	0.6	5.9		5.9	29.8
	244-305	96-120	3.2	1.4	13.6	0.5	10.9		8.1	54.3
	305-366	120-144	2.4	1.4	16.2	1.1	10.8		8.1	54.1
	366-427	144-168	3.6	1.1	5.3	0.5	10.6		5.3	26.6

Source: Huddleston, et al, (11), page 438.

TABLE 26. TOTAL METAL CONTENTS WITH DEPTH FOR UNTREATED AND TREATED SOIL AT SITE D IN PPM

Site	Depth (cm)	Depth (in.)	As	Cd	Cr	Hg	Pb	Se	Ni	V
D-Untreated Soil	0-10	0-4	< 0.2	1.3	12.9	0.5	18.1		2.6	25.9
	10-20	4-8	0.6	1.0	7.7	0.5	18.0		5.2	25.8
	20-30	8-12	< 0.2	1.4	17.1	1.1	20.0		8.6	57.1
	30-46	12-18	< 0.2	1.9	19.5	1.1	26.0		13.0	65.1
	46-61	18-24	< 0.2	1.9	19.3	1.1	27.6		13.8	55.2
	61-76	24-30	< 0.2	1.9	16.2	1.1	27.0		13.5	54.0
	76-91	30-36	< 0.2	0.8	16.7	1.1	14.0		11.2	36.3
	91-122	36-48	< 0.2	1.1	16.0	1.6	13.4		10.7	53.4
	122-152	48-60	< 0.2	1.1	13.4	1.1	13.4		8.0	34.7
	152-183	60-72	< 0.2	1.1	16.0	1.1	13.4		8.0	34.7
	183-244	72-96	< 0.2	1.9	10.8	1.1	18.9		10.8	34.7
	244-305	96-120	< 0.2	1.3	10.7	1.1	13.4		8.1	34.7
	305-366	120-144	< 0.2	1.8	7.9	1.1	21.2		2.6	13.2
D-Treated Soil	0-10	0-4	< 0.2	1.6	31.6	3.7	63.2		13.2	34.2
	10-20	4-8	1.1	1.6	18.4	3.2	34.2		13.2	26.3
	20-30	8-12	< 0.2	1.6	13.2	1.6	21.1		10.5	26.3
	30-46	12-18	3.0	0.3	15.8	1.1	21.1		15.8	26.3
	46-61	18-24	< 0.2	1.6	15.8	1.1	26.3		10.5	26.3
	61-76	24-30	< 0.2	1.8	15.8	1.1	34.2		7.9	21.1
	76-91	30-36	< 0.2	1.8	10.5	2.1	26.3		7.9	21.1
	91-122	36-48	< 0.2	1.6	15.8	1.1	26.3		7.9	34.2
	122-152	48-60	< 0.2	1.8	15.8	1.1	26.3		7.9	34.2
	152-183	60-72	< 0.2	1.6	10.5	2.1	15.8		7.9	34.2
	183-244	72-96	< 0.2	0.3	16.7	1.1	16.7		1.4	27.8
	244-305	96-120	< 0.2	0.5	10.5	1.1	15.8		1.3	13.1
	305-366	120-144	< 0.2	1.6	7.9	1.1	21.1		1.3	7.9

Source: Huddleston, et al, (11), page 439.

Table 27. . Total Metal Contents with Depth for Untreated and Treated Soil at Site E in ppm.

Site	Depth (cm.)	Depth (in.)	As	Cd	Cr	Hg	Ni	Pb	V
E-Untreated Soil	0-30	0-12	4.8	2.7	41.0	1.1	30.0	95.6	109.3
	30-46	12-18	5.7	2.4	29.9	1.1	21.7	35.3	108.7
	46-61	18-24	3.8	2.7	41.2	1.6	30.2	38.5	137.4
	61-76	24-30	3.4	2.5	38.5	1.1	30.2	38.5	137.4
	76-91	30-36	6.3	2.5	41.9	1.1	36.3	47.5	139.7
	91-122	36-48	2.9	2.5	47.0	1.1	35.9	47.0	193.4
	122-152	60-72	4.8	2.5	27.6	0.6	22.1	27.6	110.5
	152-183	60-72	6.3	2.5	44.4	0.6	30.6	44.4	194.4
	183-244	72-96	<0.2	3.0	38.7	0.6	33.1	38.7	138.1
	244-305	96-120	4.8	3.6	35.5	0.6	27.3	38.3	164.9
	305-366	120-144	7.1	3.9	24.9	1.1	33.1	38.7	138.1
E-Treated Soil	0-30	0-12	6.3	2.8	113.9	0.6	30.6	19.4	111.1
	30-46	12-18	4.7	2.1	37.4	0.5	24.1	37.4	133.7
	46-61	18-24	5.6	2.7	37.8	1.6	29.7	37.8	135.1
	61-76	24-30	5.6	2.7	32.2	0.5	29.6	37.6	134.4
	76-91	30-36	5.2	2.5	43.7	0.5	35.5	43.7	136.6
	91-122	36-48	4.7	3.2	32.2	<0.5	32.0	43.0	80.6
	122-152	48-60	5.8	2.1	37.8	0.5	29.7	29.7	108.1
	152-183	60-72	<0.2	2.2	38.5	<0.5	27.5	35.7	137.4
	183-244	72-96	6.8	3.1	39.3	<0.5	30.9	36.5	140.4
	244-305	96-120	5.3	3.0	35.7	1.1	32.9	30.2	109.9
	305-366	120-144	4.7	3.3	29.9	1.6	29.9	35.3	108.7

Source: Huddleston, et al, (11), page 440.

TABLE 28. TOTAL ORGANIC CARBON AND EXTRACTABLE OIL AND GREASE FOR SOILS FROM SITE A GIVEN IN PERCENTAGE

Depth (cm)	Depth (in.)	UNTREATED SOIL Total Organic Carbon	UNTREATED SOIL Oil and Grease	TREATED SOIL** Total Organic Carbon	TREATED SOIL** Oil and Grease
0-15	0-6	0.65	0.05	4.6	5.55 a
15-23	6-9	0.35	0.01	1.0	0.66 b
23-30	9-12	0.28	0.06	0.31	0.07 c
30-53	12-21	0.27	0.12	0.17	0.05 c
53-76	21-30	0.17	0.02	0.18	0.02 c
76-102	30-40	0.18	0.02	0.15	0.17 c
102-127	40-50	0.15	0.04	0.47	0.20 c
127-152	50-60	0.08	0.01	0.07	0.08 c

**Treated soil hydrocarbon level differs significantly from untreated soil

LSD at 0.05 = 0.28 Oil and grease values with different letter subscripts are significantly different at the 0.05 level.

Source: Huddleston, et al, (11), page 441.

TABLE 29. TOTAL ORGANIC CARBON AND EXTRACTABLE OIL AND GREASE FOR SOILS FROM SITE B GIVEN IN PERCENTAGE

Depth (cm)	Depth (in.)	UNTREATED SOIL		TREATED SOIL**	
		Total Organic Carbon	Oil and Grease	Total Organic Carbon	Oil and Grease
0-15	0-6	4.1	0.24	6.0	5.49 a
15-30	6-12	1.5	0.05	6.5	3.98 b
30-46	12-18	0.58	0.16	6.5	1.63 c
46-61	18-24	0.37	0.06	< 0.01	0.71 d
61-76	24-30	0.37	0.03	1.10	0.38 d
76-91	30-36	0.27	0.04	1.6	0.62 d
91-122	36-48	0.37	0.05	0.35	0.08 d
122-152	48-60	0.25	0.04	0.60	0.18 d
152-183	60-72	0.19	0.04	0.12	0.13 d
183-244	72-96	< 0.01	0.04	0.24	0.07 d
244-305	96-120	0.47	0.04	< 0.01	0.06 d
305-366	120-144	0.20	0.01	0.46	0.06 d

**Treated soil hydrocarbon level differs significantly from untreated soil.

LSD at 0.05 = 0.86 Oil and grease values with different letter subscripts are significantly different at the 0.05 level.

Source: Huddleston, et al, (11), page 442.

TABLE 30. TOTAL ORGANIC CARBON AND EXTRACTABLE OIL AND GREASE FOR SOILS FROM SITE C GIVEN IN PERCENTAGE

Depth (cm)	Depth (in.)	UNTREATED SOIL		TREATED SOIL	
		Total Organic Carbon	Oil and Grease	Total Organic Carbon	Oil and Grease
0-15	0-6	4.0	2.71	5.5	7.86 a
15-30	6-12	2.3	0.16	1.3	2.60 b
30-46	12-18	1.9	0.96	0.75	0.59 c
46-61	18-24	2.2	1.49	1.2	0.79 c
61-76	24-30	1.6	2.12	0.79	0.49 cd
76-91	30-36	0.5	0.42	0.61	0.44 cd
91-122	36-48	< 0.01	0.04	0.58	0.06 d
122-152	48-60	< 0.01	0.11	0.53	0.49 cd
152-183	60-72	0.08	0.10	0.33	0.33 cd
183-244	72-96	< 0.01	0.01	0.06	0.02 d
244-305	96-120	< 0.01	0.01	< 0.01	0.08 d
305-366	120-144	0.66	0.01	< 0.01	0.05 d

Treated soil hydrocarbon level did not differ significantly from untreated soil level.

LSD at 0.05 = 0.49 Oil and grease values with different letter subscripts are significantly different at the 0.05 level.

Source: Huddleston, et al, (11), page 443.

TABLE 31. TOTAL ORGANIC CARBON AND EXTRACTABLE OIL AND GREASE FOR SOILS FROM SITE D GIVEN IN PERCENTAGE

Depth (cm)	Depth (in.)	UNTREATED SOIL		TREATED SOIL *	
		Total Organic Carbon	Oil and Grease	Total Organic Carbon	Oil and Grease
0-10	0-4	1.4	0.19	6.0	3.43 a
10-20	4-8	0.58	0.31	2.0	1.05 b
20-30	8-12	0.67	0.04	0.20	0.14 c
30-46	12-18	0.59	0.04	0.21	0.06 c
46-61	18-24	0.47	0.07	< 0.01	0.05 c
61-76	24-30	0.13	0.06	0.10	0.07 c
76-91	30-36	< 0.01	0.31	< 0.01	0.06 c
91-122	36-48	0.06	0.08	0.10	0.07 c
122-152	48-60	< 0.01	0.08	< 0.01	0.10 c
152-183	60-72	0.07	0.01	< 0.01	0.06 c
183-244	72-96	< 0.01	0.02	< 0.01	0.07 c
244-305	96-120	0.05	0.12	< 0.01	0.04 c
305-366	1 -144	< 0.01	0.28	0.19	0.07 c

*Treated soil hydrocarbon level differs significantly from untreated soil.

LSD at 0.05 = 0.36 Oil and grease values with different letter subscripts are significantly different at the 0.05 level.

Source: Huddleston, et al, (11), page 444.

TABLE 32. TOTAL ORGANIC CARBON AND EXTRACTABLE OIL AND GREASE FOR SOILS FROM SITE E GIVEN IN PERCENTAGE

		UNTREATED SOIL		TREATED SOIL	
Depth (cm)	Depth (in.)	Total Organic Carbon	Oil and Grease	Total Organic Carbon	Oil and Grease
-0-30	0-12	4.0	0.10	3.3	0.46
30-46	12-18	2.4	0.33	1.0	0.44
46-61	18-24	1.9	0.43	0.86	0.12
61-76	24-30	1.8	0.42	1.0	0.06
76-91	30-36	2.0	0.11	0.51	0.40
91-122	36-48	1.5	0.11	0.36	0.12
122-152	48-60	0.5	0.07	0.20	0.03
152-183	60-72	1.0	0.11	0.20	0.13
183-244	72-96	0.21	0.38	0.07	0.06
244-305	96-120	0.10	0.04	< 0.01	0.02
305-366	120-144	0.10	0.31	0.14	0.04

Source: Huddleston, et al, (11), page 445.

12). Brown, K. W., L. E. Deuel, Jr., and J. C. Thomas. "Land Treatability of Refinery and Petrochemical Sludges." Prepared for USEPA Office of Research and Development. PB 83-247148. August, 1983.

WASTES

Two oily sludges were used, one from a petroleum refinery and one from a petrochemical plant. Both of the sludges originated in oil/water separators. Detailed analyses of the wastes were conducted.

SOILS

The soils used in this study varied from a sandy loam soil to a clay soil. Detailed soil analyses were carried out.

WASTE APPLICATION/DESIGN

This research was carried out to investigate land treatment of two wastes. In particular, the sludges were studied with respect to phytotoxicity, biodegradability, water soluble constituents, and field mobility. The research methods

consisted of greenhouse, laboratory, and field lysimeter experiments.

The sludges were applied to the soil at up to 10% on a total weight basis. The refinery sludge contained approximately 10% total extractable carbon. The wastes were surface applied to the soil and immediately mixed in.

RESULTS

- Loading rates as high as 20 percent refinery sludge by weight in the soil had no adverse impact on ryegrass emergence. However as little as 5 percent of petrochemical sludge by weight significantly decreased ryegrass emergence. Emergence from successive plantings increased until reaching the control levels.

- Yield depressions from the first ryegrass harvests were proportional to the amount of sludge applied. Average yields at a given loading rate continued to be less then those from the controls for about

five months; subsequently, the yields increased to a level dependent on the amount of slowly degradable oily materials present.

- Sludge treated soils exhibited increased water adsorption times which indicated impaired plant soil water relations.

- The addition of either wastes to soil increased the number of soil bacteria above the number present in unamended soil plots. Both total soil bacteria and hydrocarbon utilizing bacteria were stimulated by the addition of the waste oil, but the increase in numbers was greater for hydrocarbon utilizing bacteria.

- The addition of one percent sludge by weight to the soil produced the greatest increase in soil bacteria for either waste. Additions of five or ten percent of either sludge by weight to the soil resulted in slightly lower numbers of soil bacteria. The addition of ten percent refinery

sludge by weight was found to cause a decrease in hydrocarbon utilizing bacteria below the numbers found in unamended soil plots.

- Biodegradation rates of both the refinery and petrochemical sludges in soil were soil dependent. At field capacity, maximum biodegradation occurred in the sandy clay soil, and minimum degradation occurred in the sandy clay loam soil.

- The average half life of the refinery sludge was 130 days based on carbon dioxide evolution, and 143 based on extractable hydrocarbons. The average half life of the petrochemical sludge was 600 days based on carbon dioxide evolution, and 264 days based on extractable hydrocarbons.

- Biodegradation rates were not correlated with soil pH in the range studied (5.6 to 7.7).

- Field capacity was the optimum moisture content for the degradation of the refinery sludge, while

an optimum moisture content for degradation was not found for the petrochemical sludge. Both sludges had a broad range of moisture contents that had little influence on the rate of biodegradation. Biodegradation rates decreased when the soil moisture approached saturation or extremely dry conditions.

- The CO_2 evolution rates of both sludges increased with increasing application rates. Smaller increases in biodegradation rates per amount of sludge applied between 5 and 10 percent sludge by weight in the soil were found.

- Biodegradation of the sludges in soil increased through 30° Celsius and decreased slightly at 40°Celsius. The biodegradation rate at 10° Celsius was approximately half of that found at 30° Celsius.

- Small, frequent applications of both wastes yielded higher respiration rates per unit of waste applied then did a single equivalent application.

- The petrochemical sludge that had a C:N ratio of 380 to 1 exhibited the greatest degradation rate at a C:N ratio of 124 to 1. But the refinery sludge, which contained a C:N ratio of 78 to 1, showed the greatest increase in biodegradation rate when the C:N ratio was adjusted to 9 to 1.

- Additions of phosphorus and potassium either alone or with nitrogen did not greatly effect the rates of biodegradation of either waste. Field data did confirm increased biodegradation resulting from nitrogen fertilization.

- The water soluble fraction of the API separator sludges was predominantly composed of aromatic compounds, mostly mono- and diaromatics such as phenols and napthalenes.

- The water soluble organic compounds in the sludges were found to move on soil-thin layer chromatography plates as a group, with mobilities relative to water of one for all

groups studied except the higher molecular weight phthalates. Mobilities may have resulted from the application exceeding the adsorption capacities of the soil.

- Degradation of refinery and petrochemical sludges applied to soils in lysimeters under field conditions showed that degradation was greatest over the summer months, June to August. Degradation did continue over the winter months, December to February, but at reduced rates. Soil temperatures at 6.4 centimeters from the soil surface were 25 to 30° Celsius in the summer, and 5 to 10° Celsius in the winter.

- Gas liquid chromatographic scans showed materials resolved as peaks to be more rapidly degraded than more complex, higher molecular weight materials chromatographed as an unresolved cone. Peaks represented primarily saturates and di- and tri-aromatics while the conical area was mainly composed of higher condensed polynuclear aromatics

with moculear weights over 250 grams per mole and carbon numbers in excess of 19.

- While the majority of organics applied to the soil were degraded or retained within the zone of incorporation, measurable levels of organics (greater then 1 milligram per kilogram) migrated below the zone of incorporation.

- Mobility of organic constituents was greatest in the sandy loam textured soil and least in the clay textured soil.

- Leachate samples collected 160 centimeters below the zone of incorporation were free of detectable organic or hydrocarbon contaminants.

TABLES AND FIGURES

Tables and Figures from the study follow.

TABLE 1. PHYSICAL PROPERTIES OF SOILS UTILIZED IN GREENHOUSE STUDY

Soil	Sand %	Silt %	Clay %	Texture USDA	Bulk Density ($g\ cm^{-3}$)			Percent Water Retention (v/v)			CEC[α] Meq/100g	Carbon %	pH
					FC*	WP+	OD=	SAT♦	FC	WP			
Bastrop	60.3	10.0	29.7	SCL	1.49	1.67	1.76	37.0	30.4	10.9	27.4	1.0	6.9
Lakeland	81.1	4.5	14.4	SL	1.38	1.39	1.39	43.6	10.0	2.8	0.3	0.4	6.5
Nacogdoches	41.8	12.9	45.3	C	1.4						17.2	1.3	5.6
Norwood	48.2	15.2	36.6	SC	1.44	1.48	1.49	40.0	31.8	10.8	19.6	1.4	7.7

* FC = Field capacity

\+ WP = Wilting point

= OD = Oven dry

♦ SAT= Saturated

α CEC= Cation exchange capacity

Source: Brown, et al, (12), page 14.

TABLE 2. CHARACTERISTICS OF THE TWO API PIT WASTE MATERIALS

	Refinery	Petrochemical
Density	1.22g cm^3	1.15g cm^3
Cd	3.3 ppm	4.5 ppm
Cr	51.0 ppm	134.2 ppm
Cu	227.7 ppm	35.8 ppm
Pb	14.1 ppm	20.9 ppm
Ni	14.1 ppm	924.4 ppm
Se	9.2 ppm	9.7 ppm
Na	1,734.8 ppm	1,252.4 ppm
Va	6.5 ppm	14.9 ppm
Zn	555.2 ppm	656.0 ppm
Percent H_2O	46.0 %	12.0 %
Pentane extractable	72.0 %	63.0 %
Benzene extractable	22.0 %	36.0 %
CH_3Cl_2 extractable	6.0 %	1.0 %
Residue	49.3 %	42.8 %
Ash	41.0 %	25.0 %
Sulfur	0.9 %	0.4 %
Total N	0.1 %	0.11%
Total extractable C	10.0 %	62.0 %
Total Carbon	7.3 %	42.4 %

Source: Brown, et al, (12), page 15.

TABLE 4. RELATIVE YIELDS OF SLUDGE AMENDED SOILS FROM THE FIRST HARVEST (34 DAYS FOLLOWING APPLICATION) AND THE 8TH HARVEST (437 DAYS FOLLOWING APPLICATION)

Percent Waste	Bastrop		Lakeland		Nacogdoches		Norwood	
	Day 34	Day 437	Day 34	Day 437	Day 34	Day 437	Day 37	Day 437
REFINERY								
0	100a *	100a	100a	100a	100a	100a	100a	100a
5	49b	91ab	78ab	80ab	64ab	107a	65b	81a
10	30c	77b	35b	87a	37bc	78b	45c	93a
20	22c	74b	23b	85a	13c	67b	22d	103a
PETROCHEMICAL								
0	100a	100a	100a	100a	100a	100a	100a	100a
5	27b	87ab	55ab	101a	29b	104a	2b	56ab
10	3c	55b	1b	97a	1c	77b	0b	44b
20	0c	54b	0b	60b	0c	46c	0b	24b

* Values in a given column followed by the same letter do not differ significantly at the 5% level.

Source: Brown, et al, (12), page 20.

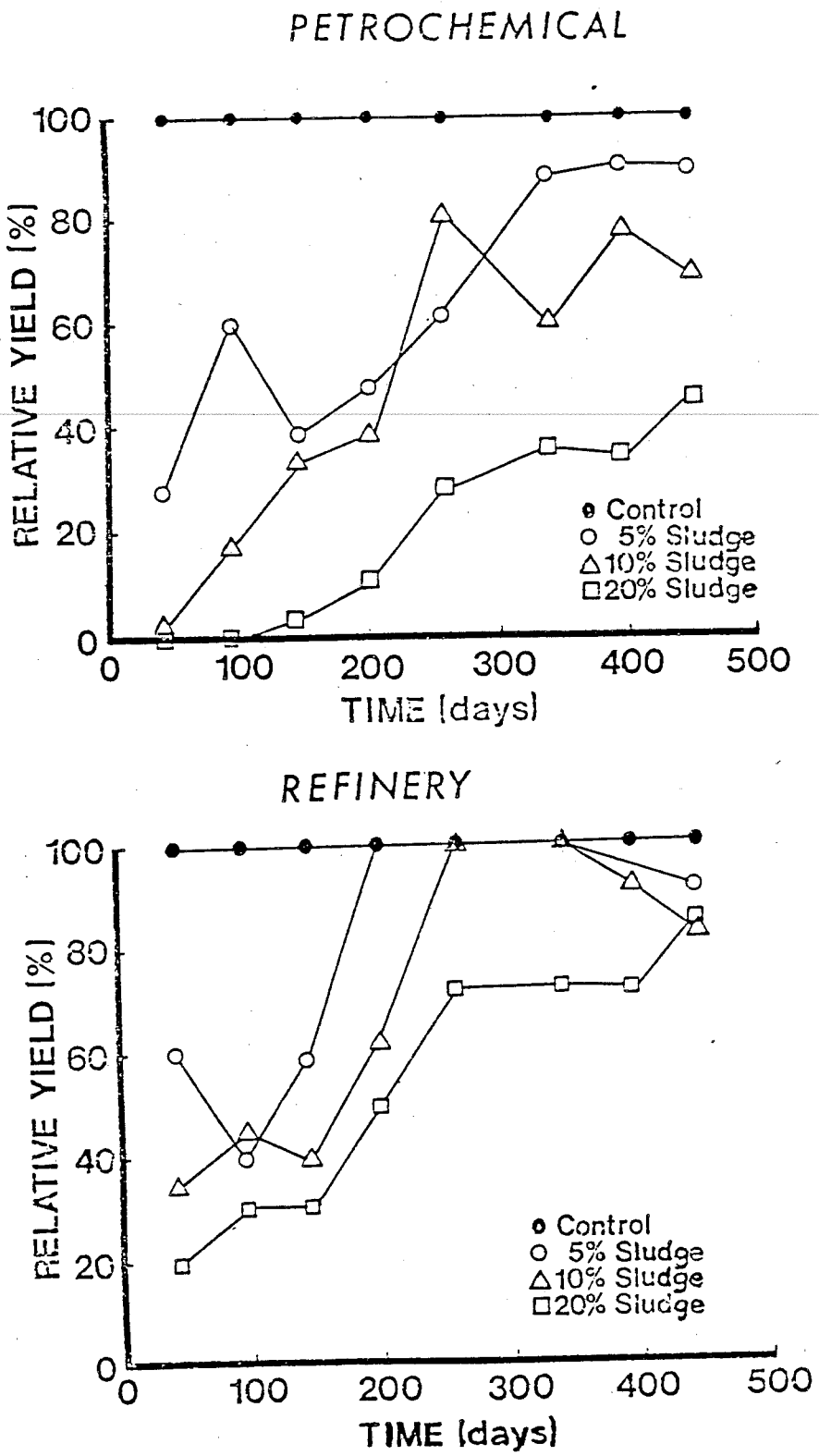

Figure 2. Relative Yields of Ryegrass with Time from Refinery and Petrochemical Sludge Amended Soils.

Source: Brown, et al, (12), page 22.

TABLE 6. AVERAGE ABSORPTION TIME OF WATER DROPLETS APPLIED TO SLUDGE-AMENDED SOILS MEASURED 291 AND 350 DAYS FOLLOWING SLUDGE APPLICATION (VALUES REPORTED ARE AVERAGES OVER ALL SOILS)

	ABSORPTION TIME (SEC)			
	Refinery Waste		Petrochemical Waste	
Loading Rate (%)	Day 291	Day 350	Day 291	Day 350
0	0.6c*	0.6c	1.3b	0.7d
5	8.2bc	16.4bc	27.1b	36.8c
10	35.4b	37.6b	124.1a	80.6b
20	75.8a	66.8a	149.8a	107.2a

* Values in a given column followed by the same letter do not differ significantly at the 5% level.

Source: Brown, et al, (12), page 24.

TABLE 7. CHEMICAL CHARACTERISTICS OF SOILS UTILIZED IN BIODEGRADATION EXPERIMENTS

Soil Series	N	P	K	Ca	Mg
	ppm				
Bastrop	160	25	200	2,920	385
Lakeland	42	20	200	600	100
Nacogdoches	47	3	164	1,280	400
Norwood	70	94	312	>4,000	485

Source: Brown, et al, (12), page26.

TABLE 10. THE INFLUENCE OF TEMPERATURE ON CO_2 EVOLUTION FROM SLUDGE-AMENDED SOIL

Waste	Total Carbon Applied (g)	Analytical Method	Biodegradation Percent of Waste Applied		
			10°C	30°C	40°C
Refinery	0.07	CO_2 evolution	36	59	42
		Residual C	25	62	49
Petrochemical	0.42	CO_2 evolution	9	18	13
		Residual C	12	26	21

Source: Brown, et al, (12), page 38.

TABLE 11. THE INFLUENCE OF LOADING RATE ON THE BIODEGRADATION OF BOTH WASTES APPLIED TO NORWOOD SOIL AND INCUBATED AT 30 AND 40 C AT 18% MOISTURE FOR 180 DAYS

Waste	Loading Rate (%)	Carbon Applied (mg)	% Biodegradation as Determined by Evolved CO_2-C	Average Biodegradation Rate µg CO_2/g/day
Refinery Waste				
1 Loading	0.1	7	15	40
"	0.5	35	85	101
"	1.0	70	51	114
"	5.0	350	60	436
"	10.0	700	41	575
Petrochemical Waste				
1 Loading	0.1	42	10	31
"	0.5	210	9	10
"	1.0	420	16	173
"	5.0	2100	15	524
"	10.0	4200	9	696

Source: Brown, et al, (12), page 42.

TABLE 12. BIODEGRADATION OF TWO WASTES APPLIED TO NORWOOD SOIL AT DIFFERENT FREQUENCIES. ALL SOILS WERE MAINTAINED AT FIELD CAPACITY AND 30 C.

Rate (%)	Numbers of Applications	Total Carbon Applied (mg)	% Biodegradation as Determined by CO_2 Evolution	% Biodegradation as Determined by Residual Carbon
Refinery Waste				
5	1	350	63	63
5	2	700	47	46
10	1	700	46	24
5	4	1400	27	34
Petrochemical Waste				
5	1	2100	15	34
5	2	4200	12	32
10	1	4200	9	18
5	4	8400	9	21

Source: Brown, et al, (12), page 45.

TABLE 14. THE EFFECT OF MINERAL NUTRIENTS ON RESIDUAL CARBON IN WASTE AMENDED SOIL AFTER 161 DAYS INCUBATION

Mineral Nutrients		Residual Hydro-carbon (gm)	% Biodegradation as Determined by	
			Residual Hydro-carbon	CO_2 Evolution
Refinery Sludge: Total carbon applied 0.35 g				
None	78:1	0.18	63	60
C:P	40:1	0.12	76	71
C:NPK	40:1	0.14	72	74
C:N	9:1	0.10	80	82
Petrochemical Sludge: Total carbon applied 2.1 g				
None	380:1	2.06	34	15
C:P	124:1	1.76	43	13
C:NPK	124:1	1.56	50	18
C:N	23:1	1.76	43	13

Source: Brown, et al, (12), page 48.

TABLE 15. MICROBIAL POPULATION IN THE NORWOOD SOIL 180 DAYS FOLLOWING WASTE APPLICATION OF DIFFERENT AMOUNTS OF TWO OIL WASTES.

Waste Applied %	g. Hydroc./ 100g Soil	Total Viable Soil Bacteria CFU/g x 10^5	Total Viable Hydrocarbon Utilizing bacteria x 10^5	H.U.B./ x 100/ /TVH %	Total Soil Fungi (CFU/g) x 10^4	Hydrocarbon Utilizing Fungi (CFU/g) x 10^4	Total Soil F/ H.U.F. %
Refinery							
0	0	4.1	0.46	11	7.9	0.63	8
1	0.10	10.9	1.50	14	13.0	5.70	44
5	0.50	6.2	1.10	18	-	-	-
10	1.00	6.0	0.29	5	2.1	0.21	10
Petrochemical							
0	0	4.1	0.05	1	7.9	0.50	6
1	0.62	80.0	4.30	5	4.2	2.10	50
5	3.10	79.0	5.20	7	6.3	1.40	22
10	6.20	62.0	1.20	2	0.13	0.10	77
Refinery Waste		0.94	0.83	88	0.01	0.01	100
Petrochemical Waste		0.10	0.05	50	0.43	0.03	6

Source: Brown, et al, (12), page 50.

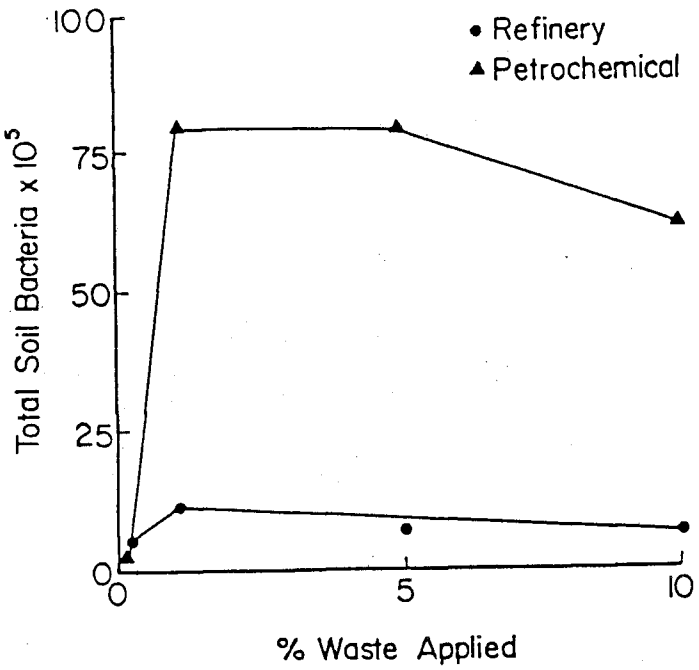

Figure 19. Total soil bacteria in Norwood soil amended with different amounts of both wastes after incubation at 40 C and 18% moisture for 180 days.

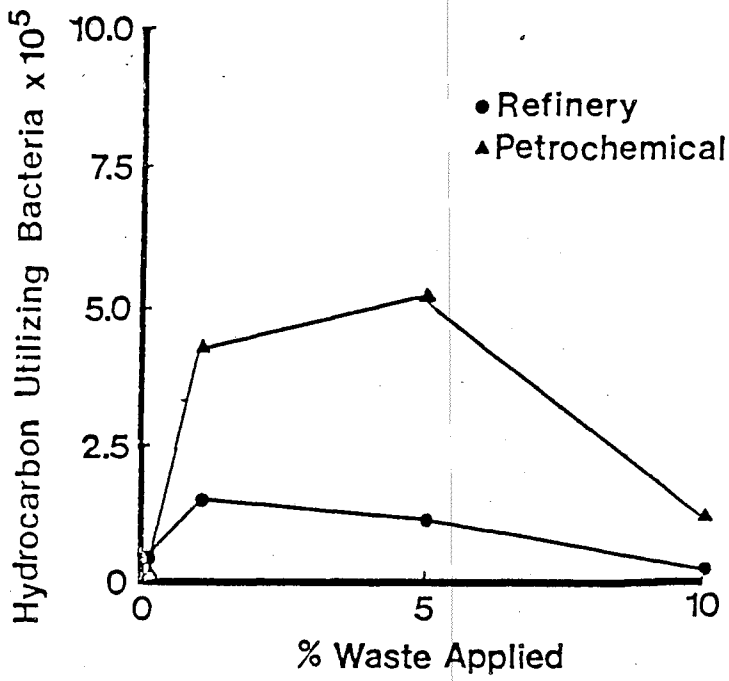

Figure 20. Total hydrocarbon utilizing bacteria in Norwood soil amended with different amounts of both wastes after incubation at 40 C and 18% moisture for 180 days.

Source: Brown, et al, (12), page 51.

TABLE 16. CHARACTERISTICS OF WASTE BEFORE AND AFTER 180 DAYS INCUBATION AT 30 C AT AN APPLICATION RATE OF 5% (WT/WT) TO A NORWOOD SOIL

		Extractable Hydrocarbons (mg)				
		Total	Petroleum Ether	Petroleum Ether: Dichloromethane	Dichloro-methane	Cumulative CO_2 - C Evolved
Refinery Waste	Carbon applied	500	396	121	33	350
	Carbon residual	183	90	66	27	240
	% Carbon degraded	63	77	45	18	69
Petrochemical Waste	Carbon applied	3,100	1,953	1,085	62	2,100
	Carbon residual	2,060	1,188	827	45	310
	% Carbon degraded	34	39	24	27	15

Source: Brown, et al, (12). page 53.

TABLE 17. HALF-LIFE OF ORGANIC SUBFRACTIONS OF BOTH WASTES

	Half-life (Days)				
	CO_2 - C Evolved	Extractable Hydrocarbons (Total)	Petroleum Ether (Saturate)	Petroleum Ether: Dichloromethane (Aromatic)	Dichloromethane (Condensed Ring)
Refinery Waste	130	143	116	119	500
Petroleum Waste	600	264	231	375	333

Source: Brown, et al, (12), page 54.

TABLE 18. WATER SOLUBLE FRACTIONS FROM VARIOUS PETROLEUM STOCKS

Crude oil†	Crude, fuel, and crankcase oils§	Gas oil¶	Bunker fuel oil#
benzene	benzenes	methylbenzenes	naphthalene
alkylated benzenes	naphthalenes	ethylbenzenes	methylnaphthalenes
naphthalene	phenols	naphthalenes	phenol
alkylated naphthalene	biphenyls	methylnaphthalenes	o- and p-cresol
monomethyl-naphthalene	indans	tetrahydronaphthalene	xylenols
tetrahydro-naphthalene	tetralins	propylbenzenes	acetophenone
phenol	anilenes	butylbenzenes	2-phenyl-2-propanol
m- or p-cresol	quinolenes	ethyl-methylbenzenes	
low m.w. paraffins	indoles	indan	
high boiling unresolved	benzothiophes		
	phthalides		
	benzaldehydes		
	aromatic ketones		

† Duffy et al. (1977) and Larson and Weston (1976)
§ Winters and Parker (1977)
¶ Kappeler and Wuhrmann (1978)
# Guard et al. (1975)

Source: Brown, et al, (12), page 60.

TABLE 22. WATER SOLUBLE FRACTION OF AN API OIL-WATER SEPARATOR SLUDGE. THE THREE EXAMPLES WERE ADJUSTED WITH HCl, NOT ADJUSTED, AND ADJUSTED WITH NaOH, RESPECTIVELY, BEFORE PARTITIONING INTO BENZENE

Retention time (min)	Molecular weight	pH 2	pH 7.6	pH 12
8.6	128	naphthalene		
10.9	134		2,3-benzothiophene	
12.5	142	n-methylnaphthalene	n-methylnaphthalene	
15.2	148	methylbenzothiophene	methylbenzothiophene	
19.0	156	n,n'-dimethylnaphthalene	n,n'-dimethylnaphthalene	
19.0	132	indan-1-one	indan-1-one	indan-1-one
20.2	94	phenol		
20.7	108	cresol		
22.7	170	trimethylnaphthalene	trimethylnaphthalene	
22.7	154	acenaphthene	acenaphthene	
22.7	134	dimethylbenzaldehyde	dimethylbenzaldehyde	dimethylbenzaldehyde
23.7	122	xylenol	xylenol	
26.6	122	methyl p-cresyl ether		
27.9	136		methyl-ethyl phenol	

Source: Brown, et al, (12), page 71.

TABLE 22. (CONTINUED)

Retention time (min)	Molecular weight	pH 2	pH 7.6	pH 12
28.5	168		n-methyl-biphenyl	
29.6	136	trimethyl-phenol	trimethyl-phenol	trimethyl-phenol
43.9	178		phenanthrene	
47.7	278	dibutyl phthalate	dibutyl phthalate	dibutyl phthalate
64.5	167	carbazole		carbazole
64.5	181	methylcarbazole		methylcarbazole
65.0	390		di-2-ethylhexyl-phthalate	di-2-ethylhexyl-phthalate
70.9	390		bis-(oct-n-yl)-phthalate	bis-(oct-n-yl)-phthalate

Source: Brown, et al, (12), page 72.

TABLE 26. COMPOSITION OF REFINERY SLUDGE (RS) IN PERCENT OF WET WEIGHT

Parameter	Percent of* Bulk Sludge (w/w)
Water	45.7
Soxhlet Extractable (Total)	9.93
Pentane fraction	7.17
Benzene fraction	2.20
Dichloromethane fraction	0.56
Residue	
Air dry	40.6
Stable to 750 C	37.8
Sulfur	0.88
Nitrogen	0.09
Carbon (wet combustion)	7.3

* Average of multiple determinations.

Source: Brown, et al, (12), page 101.

TABLE 27. COMPOSITION OF PETROCHEMICAL SLUDGE (PS) IN PERCENT OF WET WEIGHT

Parameter	Percent of* Bulk Sludge (w/w)
Water	11.9
Soxhlet Extractable (Total)	62.0
Pentane fraction	39.4
Benzene fraction	21.9
Dichloromethane fraction	0.7
Residue	
Air dry	25.1
Stable to 750 C	8.2
Sulfur	0.39
Nitrogen	0.11
Carbon	42.4

* Average of multiple determinations.

Source: Brown, et al, (12), page 102.

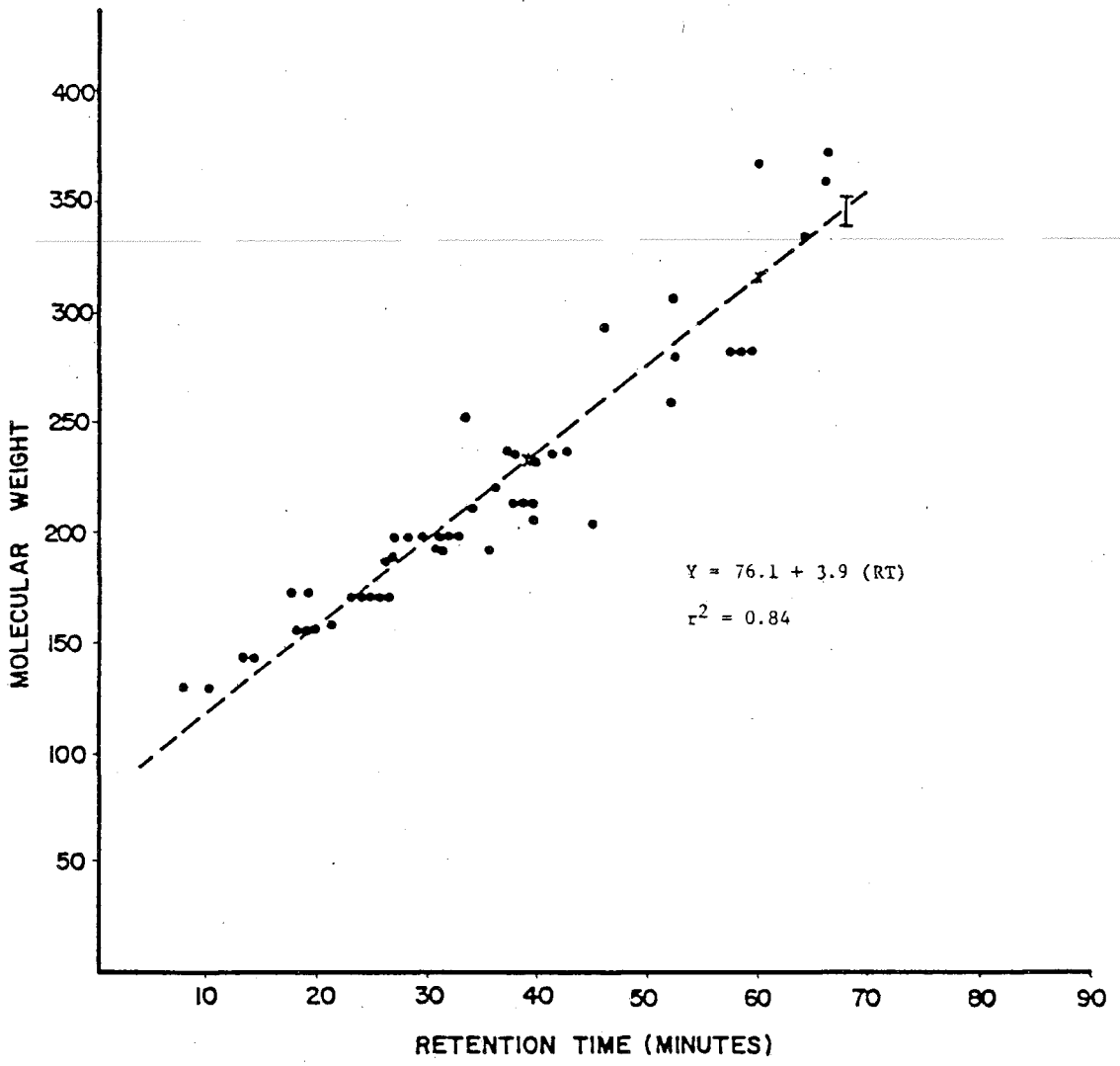

Figure 38. Relationship between retention time and molecular weight of known compounds.

Source: Brown, et al, (12), page 110.

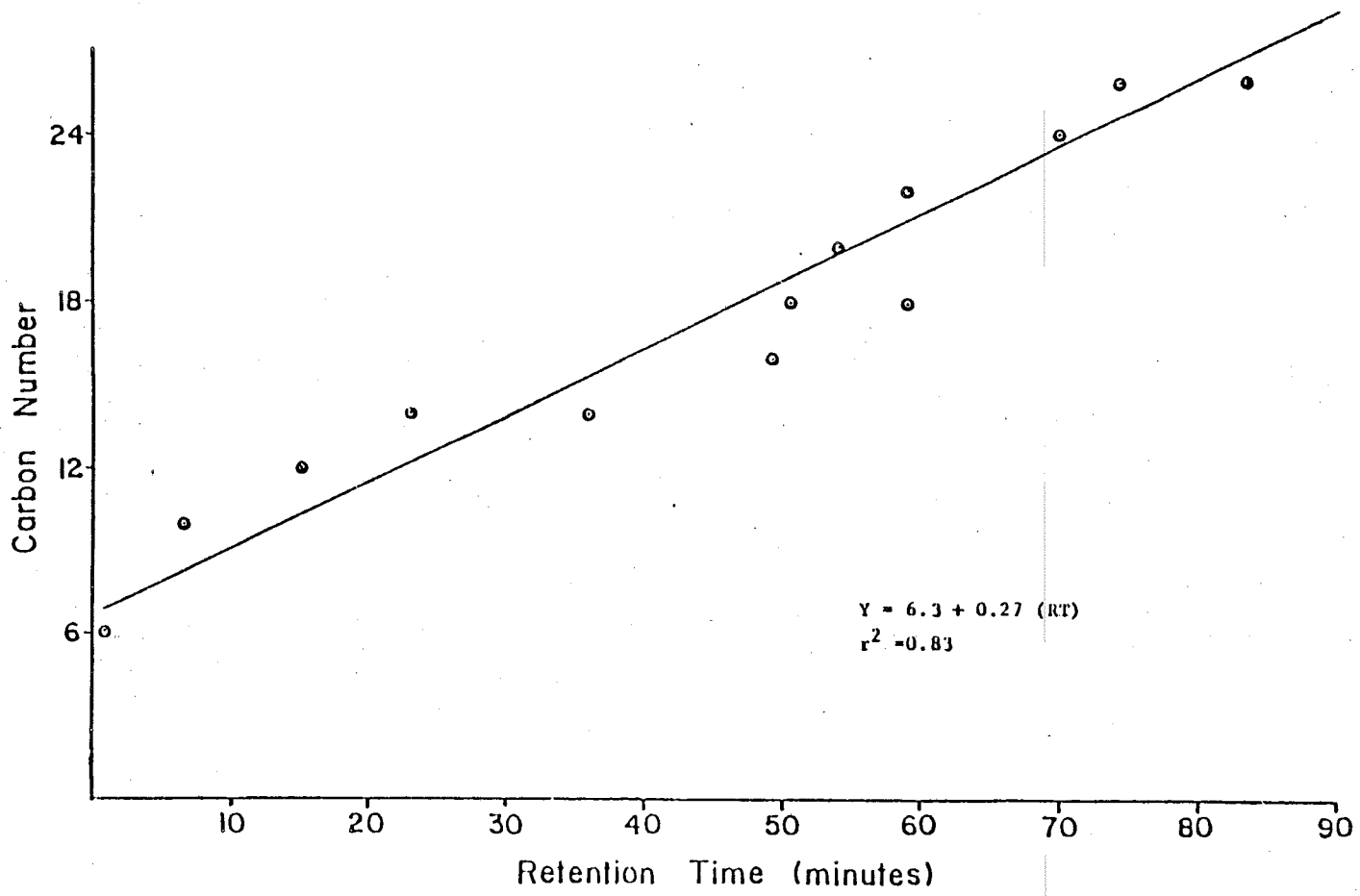

Figure 39. Relationship Between Retention Time and Carbon Number of Known Compounds.

Source: Brown, et al, (12), page 112.

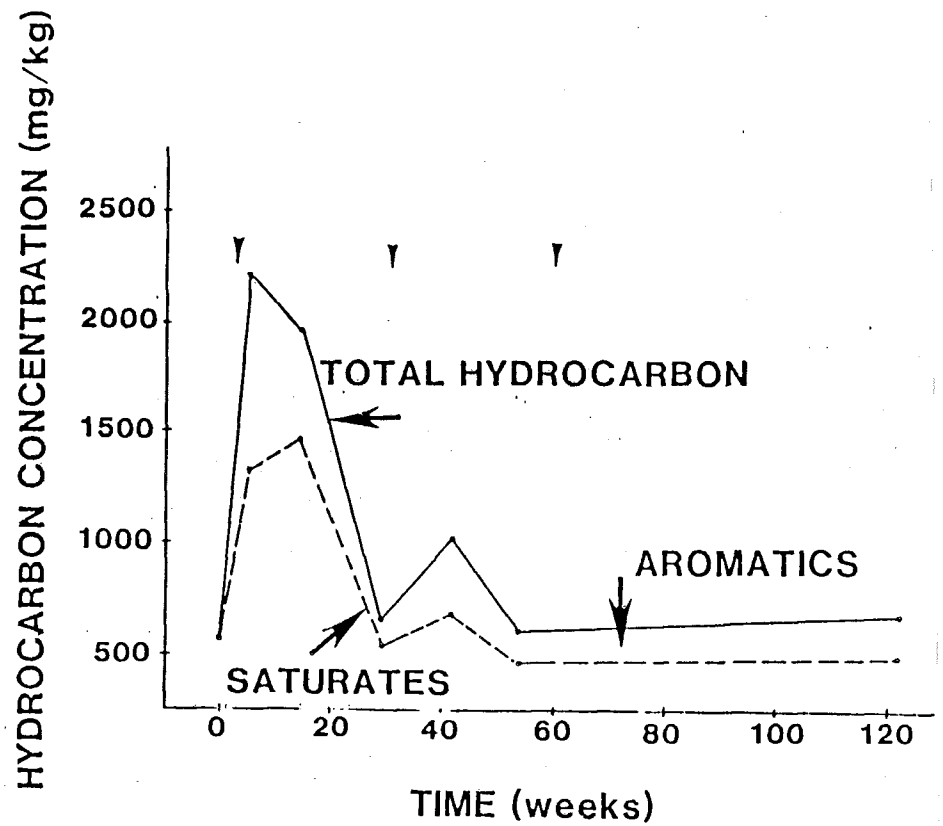

Figure 42. Hydrocarbon distribution with time for refinery sludge amended Nacogdoches soil.

Source: Brown, et al, (12), page 130.

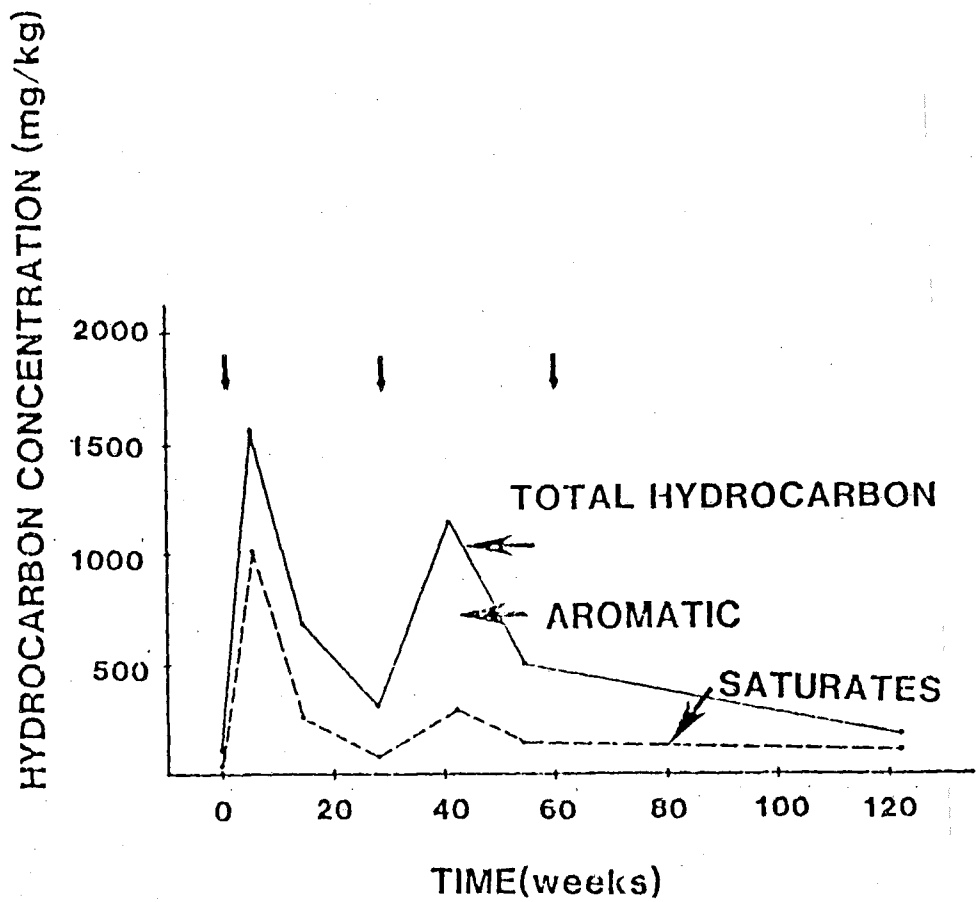

Figure 43. Hydrocarbon distribution with time for refinery sludge amended Lakedland soil.

Source: Brown, et al, (12), page 131.

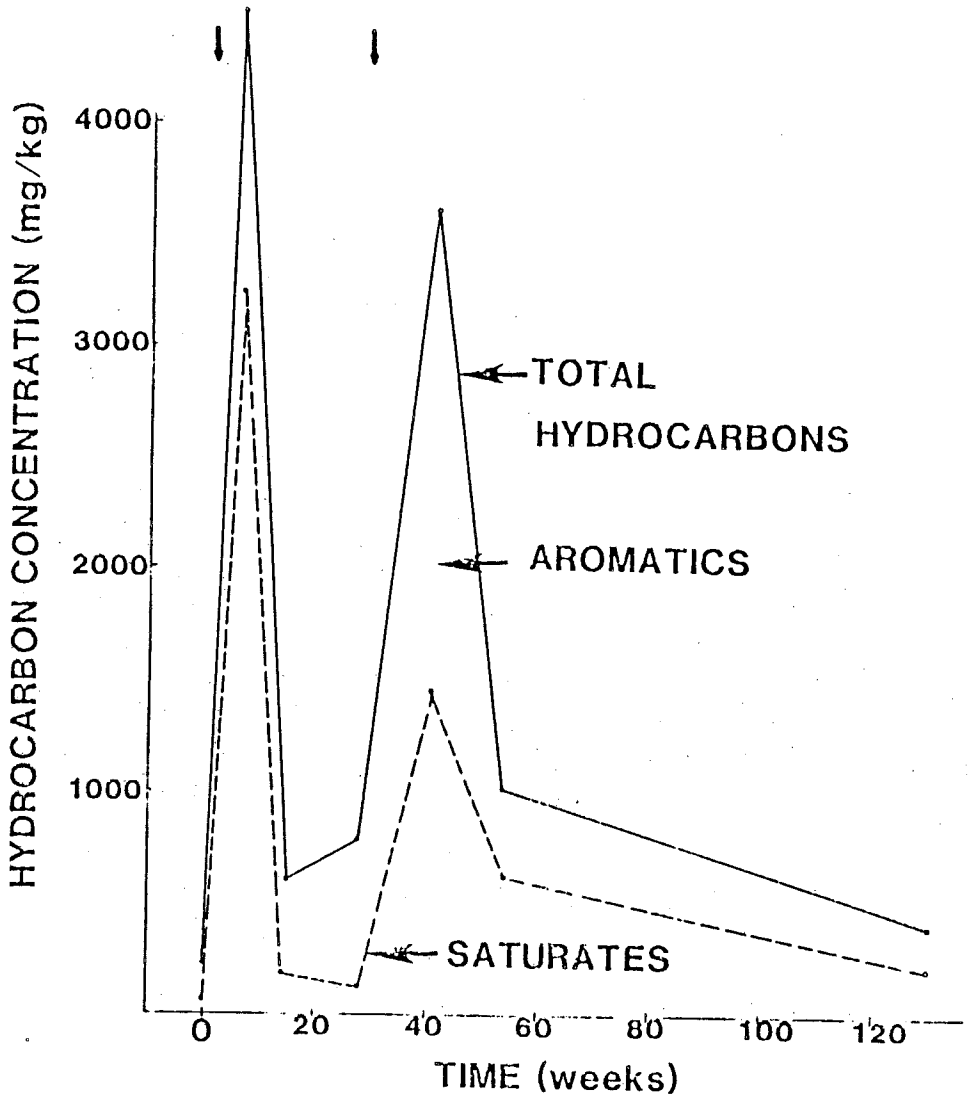

Figure 44. Hydrocarbon distribution with time for refinery sludge amended Norwood soil.

Source: Brown, et al, (12), 132.

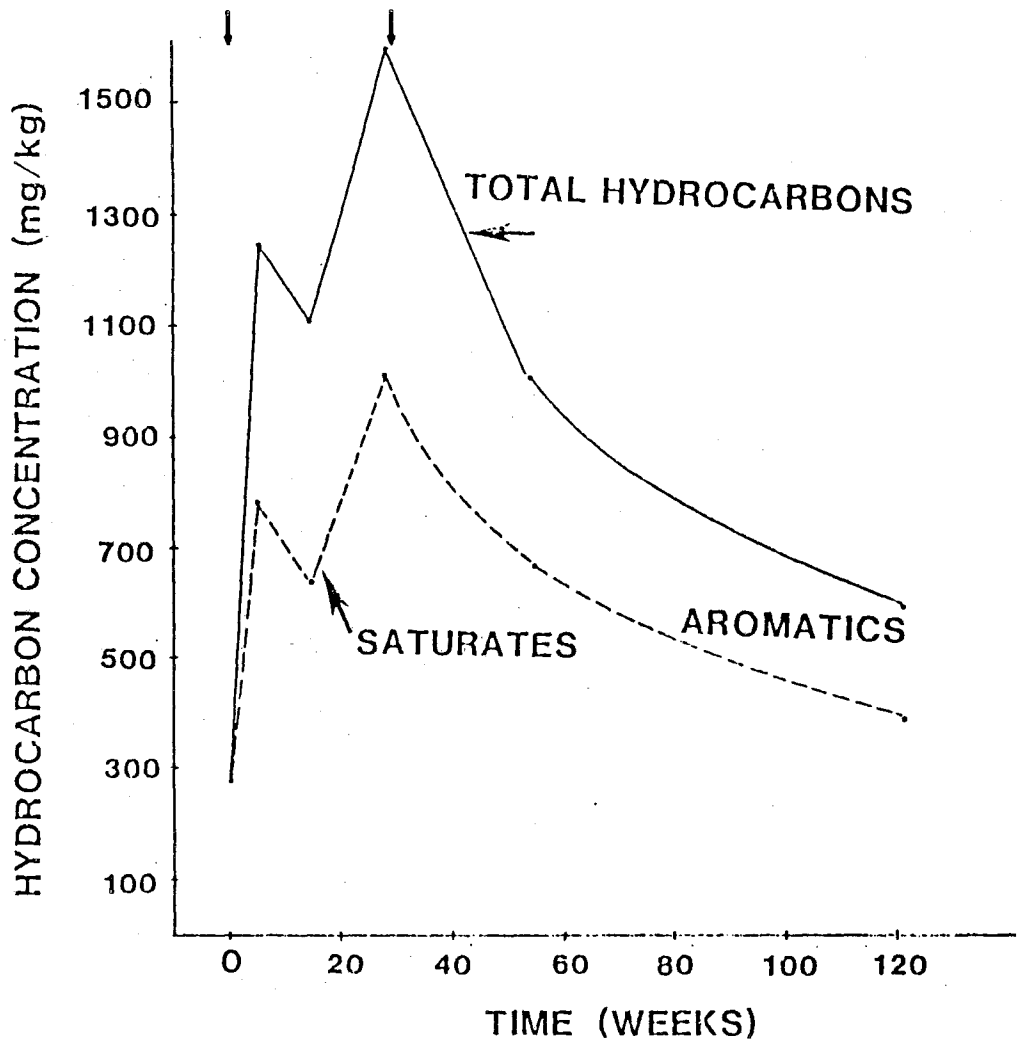

Figure 45. Hydrocarbon distribution with time for refinery sludge amended Bastrop soil.

Source: Brown, et al, (12), page 133.

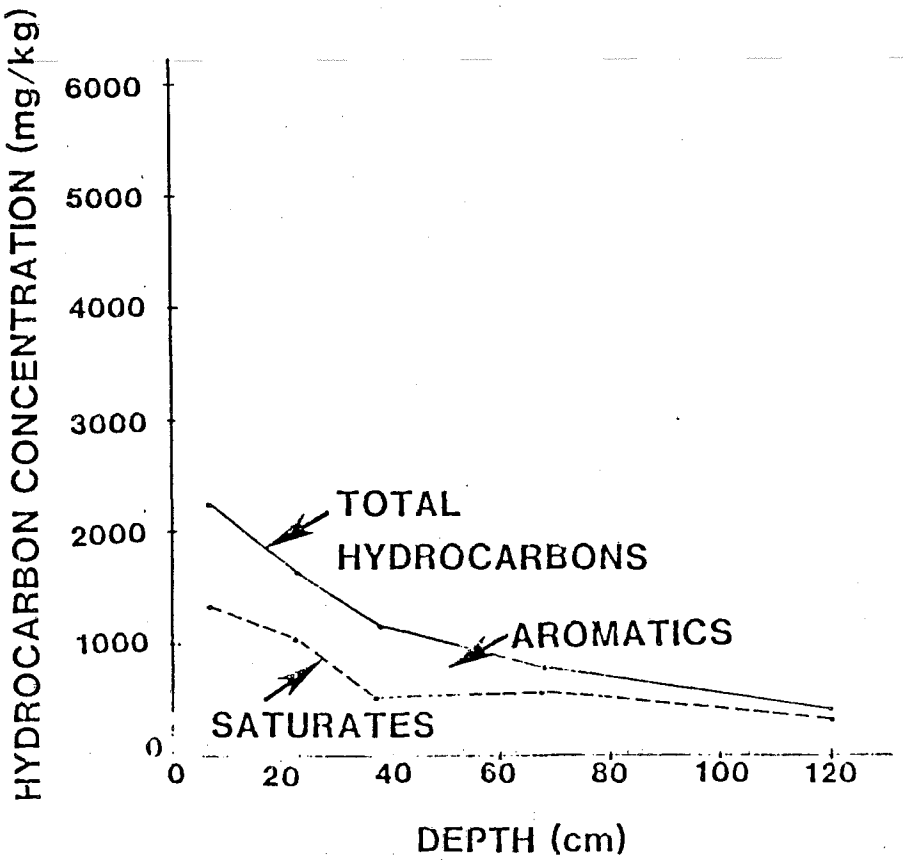

Figure 46. Hydrocarbon distribution with depth for refinery sludge amended Nacogdoches soil.

Source: Brown, et al, (12), page 134.

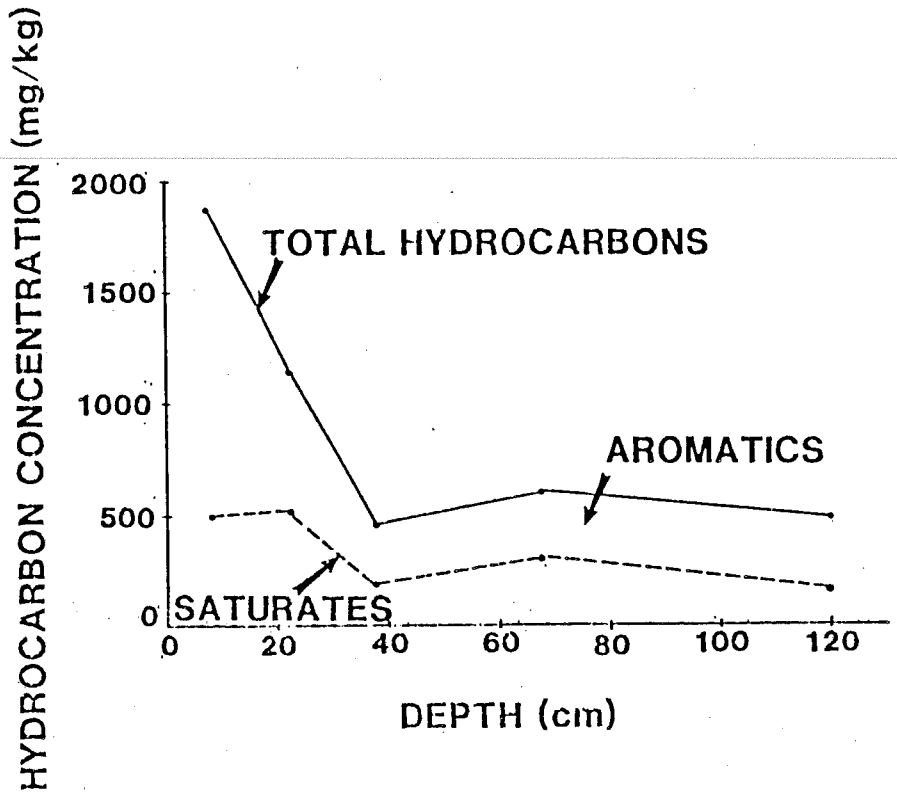

Figure 47. Hydrocarbon distribution with depth for refinery sludge amended Lakeland soil.

Source: Brown, et al, (12), page 135.

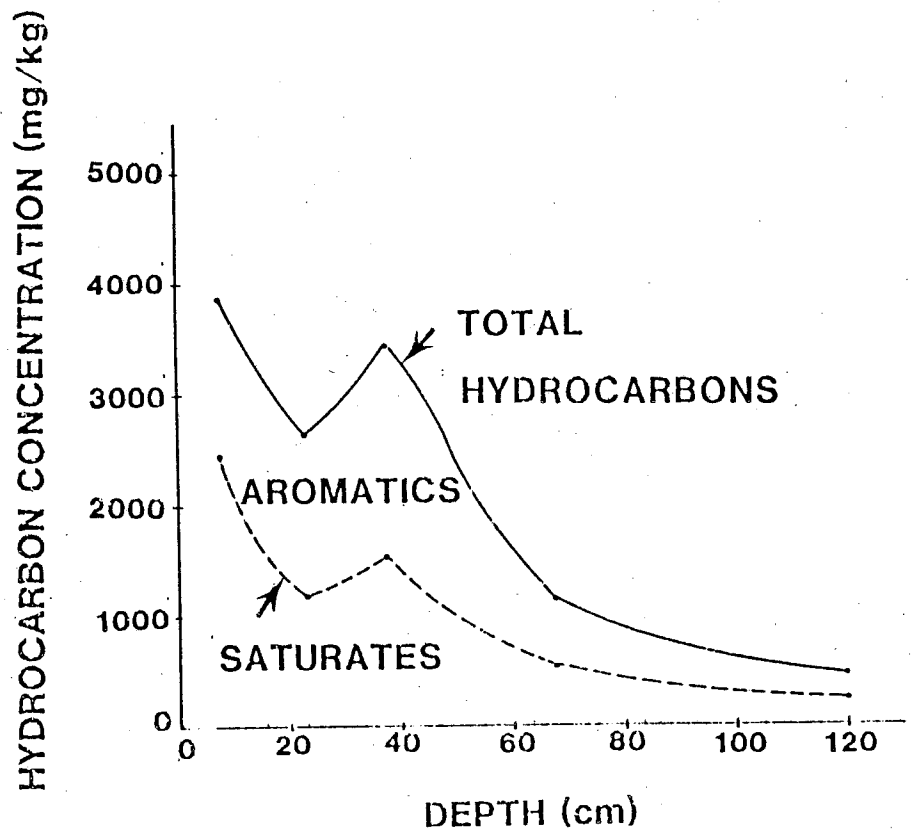

Figure 48. Hydrocarbon distribution with depth for refinery sludge amended Norwood soil.

Source: Brown, et al, (12), page 136.

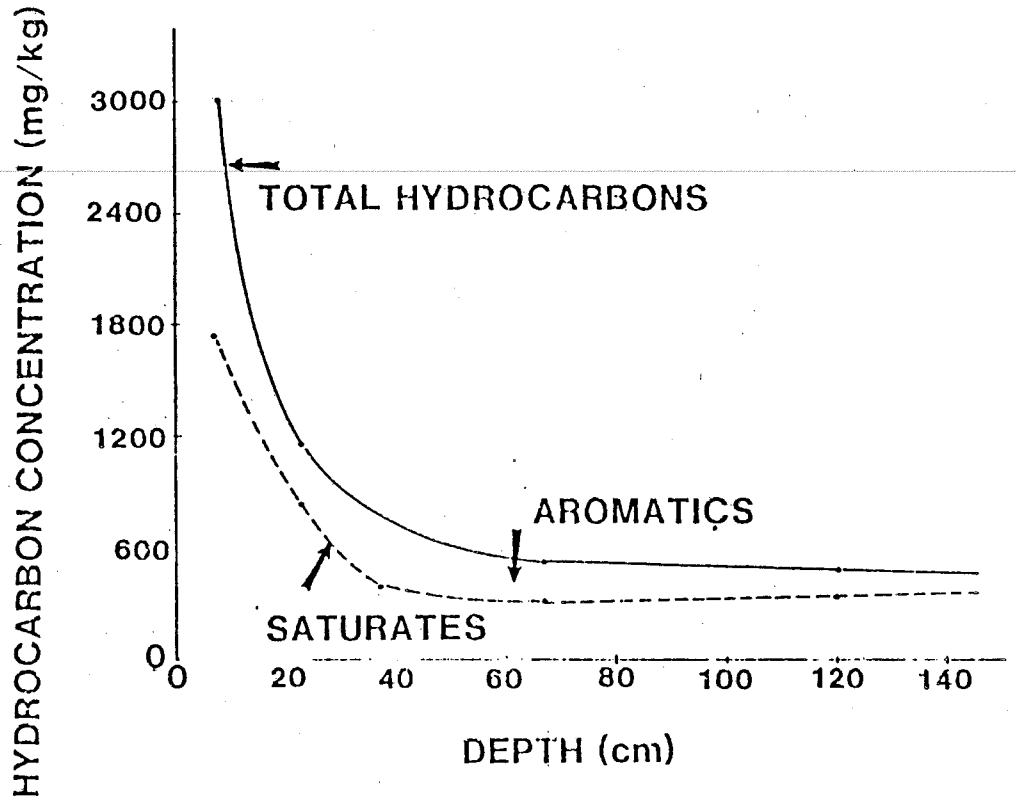

Figure 49. Hydrocarbon distribution with depth for refinery sludge amended Bastrop soil.

Source: Brown, et al, (12), page 137.

13). Habibafshar, A. "Determination of Volatile Hydrocarbon Emissions from Land Treatment of Petroleum Oily Sludges." A Dissertation to the University of Oklahoma. 1983.

WASTES & SOILS

The wastes investigated were all API separator sludges, although from different refineries. Only one soil was used in this study, but soil type was not reported.

WASTE APPLICATION/DESIGN

This study consisted of both laboratory and field work. Waste applications to the soil were made in four different numbers of applications. The first application rate was a single application giving 3 percent oil by weight in the soil. The second application rate had two applications of oil to give 6 percent oil by weight in the soil on a weight basis. The third application rate involved six applications of oil to give 10 percent of oil by weight in the soil. The fourth application rate consisted of 12

applications of the waste to give 13 percent by weight oil in the soil.

The following variables were studied to determine their effect on volatile emissions from the wastes: volatility of the sludges; loading rate of the sludges to the soil; soil temperature; soil moisture content; relative humidity; and, effects of tilling.

RESULTS

- A positive correlation was found between sludge volatility based on stripping tests, and volatile emissions from the land treatment areas. The sludge volatility was found to be the most important parameter in predicting volatile emissions from land treatment plots.

- A positive correlation was found between the loading rate of the sludge to the soil and

volatile emissions from the land treatment areas.

- Volatile emissions were higher at higher ambient temperatures.

- A positive correlation was found between soil moisture content and volatile emissions.

- Relative humidity had an inverse correlation to volatile emissions.

- Tilling was found to increase the volatile emissions for short periods of time, however, the author believed that tilling ultimately decreased the volatile emissions. No explanation was given.

- No more than 6.5 percent of the total applied oil to the soil was volatilized in any of the field study plots during the six month study period.

- Statistically valid empirical relationships were developed to predict volatile organic carbon emissions from surface application of the wastes under many conditions.

- Most trial runs exhibited an initial peak concentration of volatile emissions immediately after application to the soil, followed by an exponential decay in concentrations. Some experimental runs exhibited an initial high concentration, a decrease, and then a higher peak concentration followed by an exponential decay.

- Fourteen specific organic pollutants were found to account for 8.6 to 32% of the volatile organic emissions in the laboratory tests. These fourteen compounds were: pentane, cyclopentane, hexane, methylcyclopentane, benzene,

2,4-dimethylpentane, cyclohexane, 3-methylhexane, methylcyclohexane, 2,5-dimethylhexane, 2,3,4-trimethylpentane, 3-methylheptane, 2,2,5-trimethylhexane, 1,4-dimethylbenzene.

- Other organic compounds were identified but not quantified in the volatile emissions from the soil plots. These compounds were: propanol, 2-propanone, 2-butanone, 2-pentanone, cyclohexanol, ethylcyclopentane, 2-methyl-1-pentanol, and 1,1-dimethylcyclopentane.

TABLES AND FIGURES

Tables and Figures from the study follow.

Table 18 Stripping Test Results*

Stripping Time (min.)	Reading from sniffer Direct (ppm)	Reading from sniffer Calculated (mg/min.)	Area Count	Mass of Volatiles (mg)	Cumulative Mass (mg)	Wt** Loss (mg)	Cumulative Wt. Loss (mg)
<1	3200	22.76					
5	2000	14.23					
10	1500	10.67	37	148	148	278.4	278.4
15	1200	8.54					
20	1000	7.11	20.5	82	230	169.3	447.7
25	900	6.40					
30	600	4.27	14.5	58	288	154.8	602.5
40	380	2.40	9.0	36	324	87.3	689.8
45	310	2.21					
50	300	2.13	5.5	22	346	85.3	775.1
55	230	1.63					
60	190	1.35	4.0	16	362	65.0	840.1
65	140	.99					
70	110	.78	3.0	12	374	61.7	901.8
80	80	.57	1.9	7.6	381.6	36.7	938.5
90	30	.21	1.0	4.0	385.6	8.3	946.8
100	20	.14	.7	2.5	388.1	4.5	951.3
110			.2	.1	388.1	3.9	955.2

* Air flow through the sludge = 2.02 l/min.

** Initial wt. of sludge = 11045.3 gr.

% wt. loss of sludge = 8.5

Source: Habibafshar, (13), page 63.

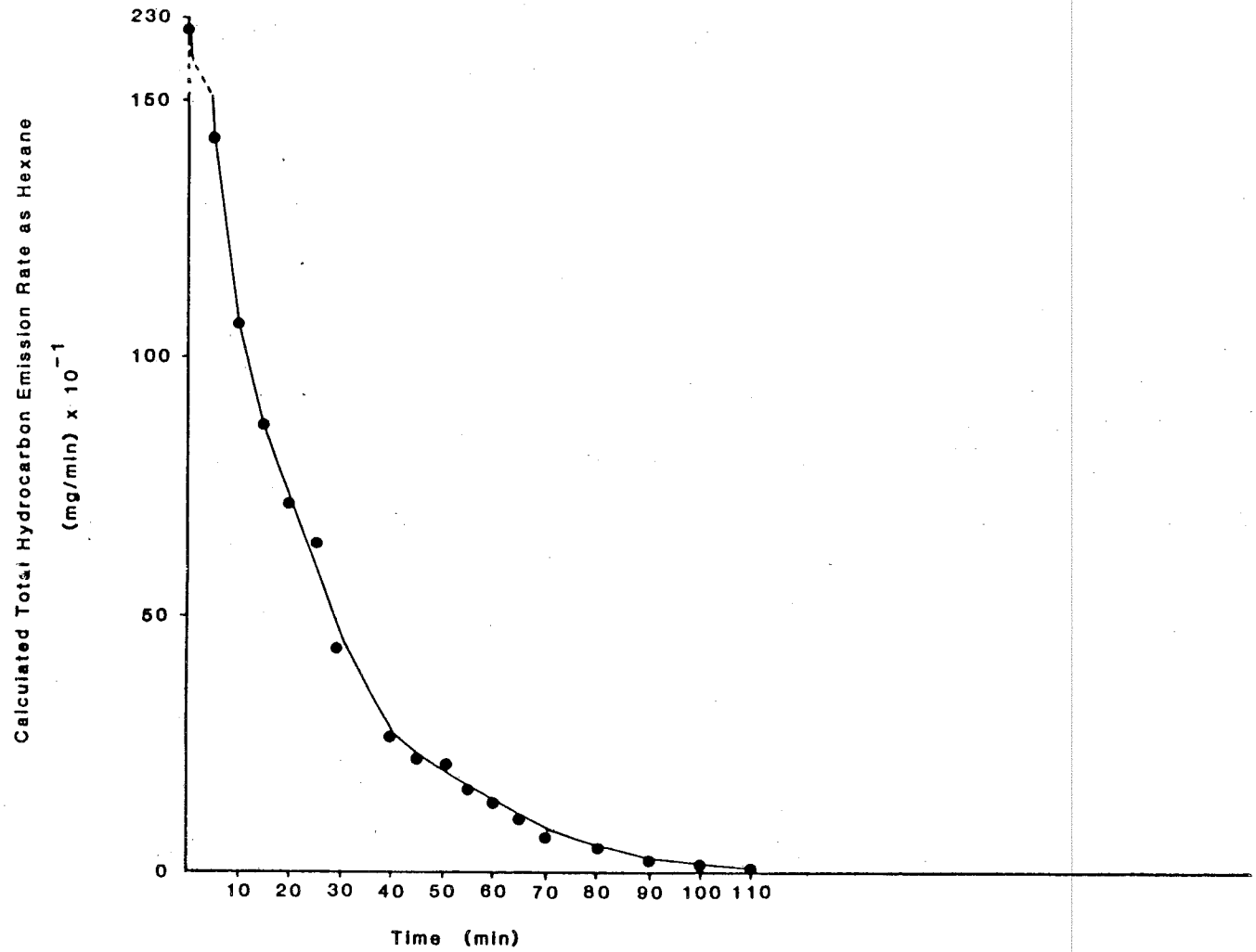

Figure 11 Calculated Total Volatile Emission of Sludge Sample vs Time

Source: Habibafshar, (13), page 64.

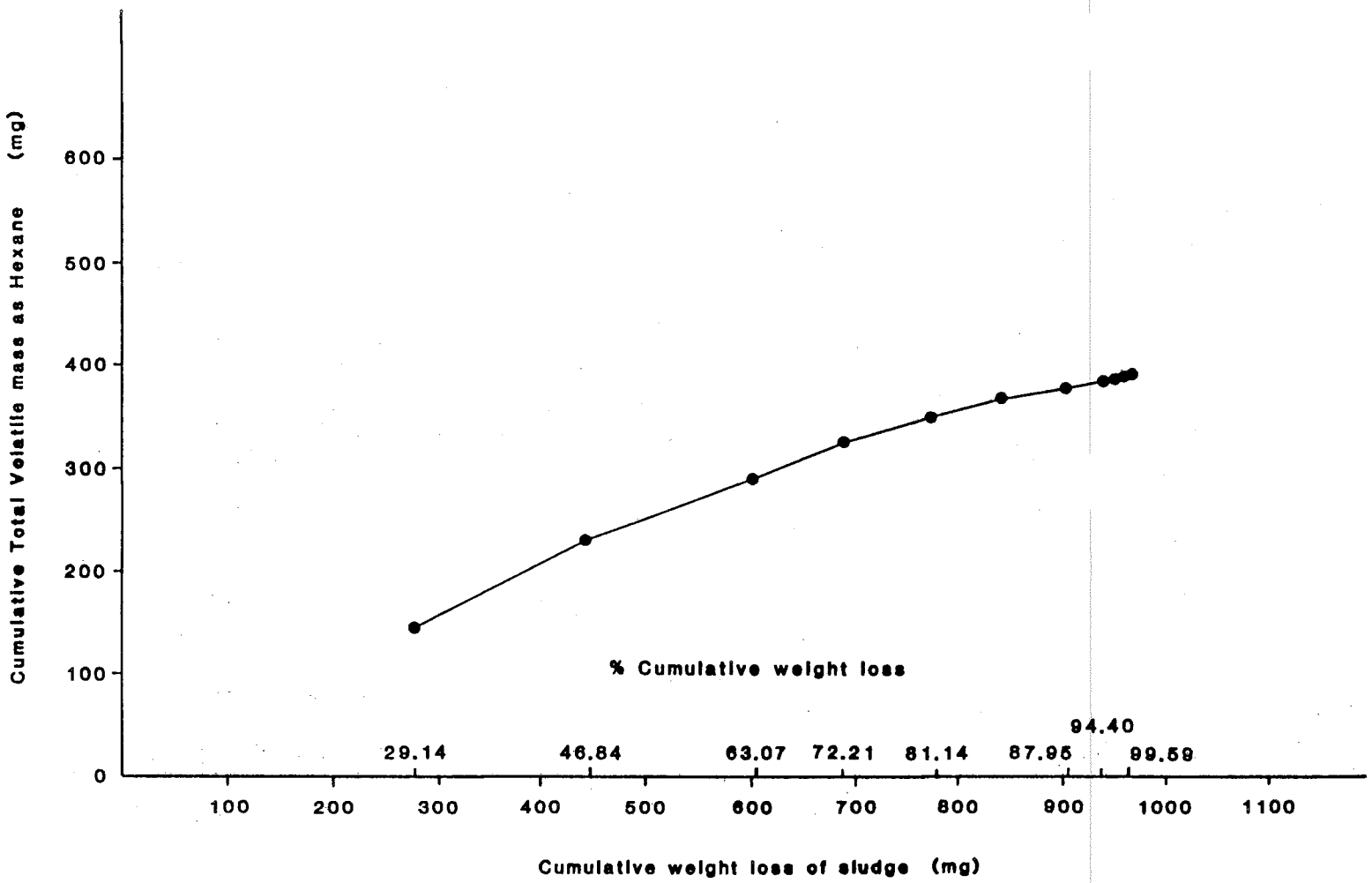

Figure 12 Relationship Between Cumulative Total Volatile Mass and Sludge Weight Loss

Source: Habibafshar, (13), page 65.

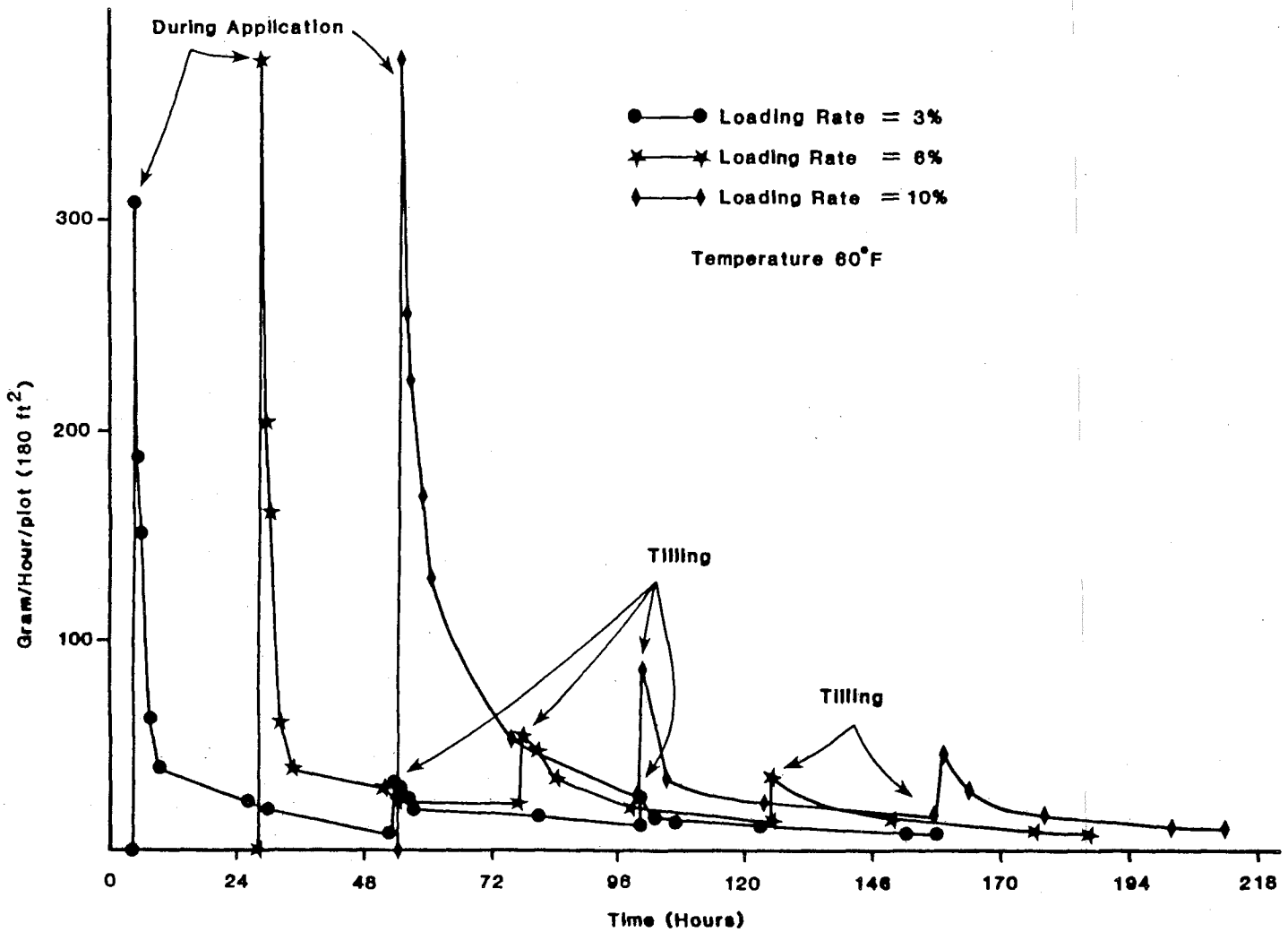

Figure 13 The Effect of Loading Rate and Tilling Frequency on Emission in Laboratory Experiments at 60°F

Source: Habibafshar, (13), page 67.

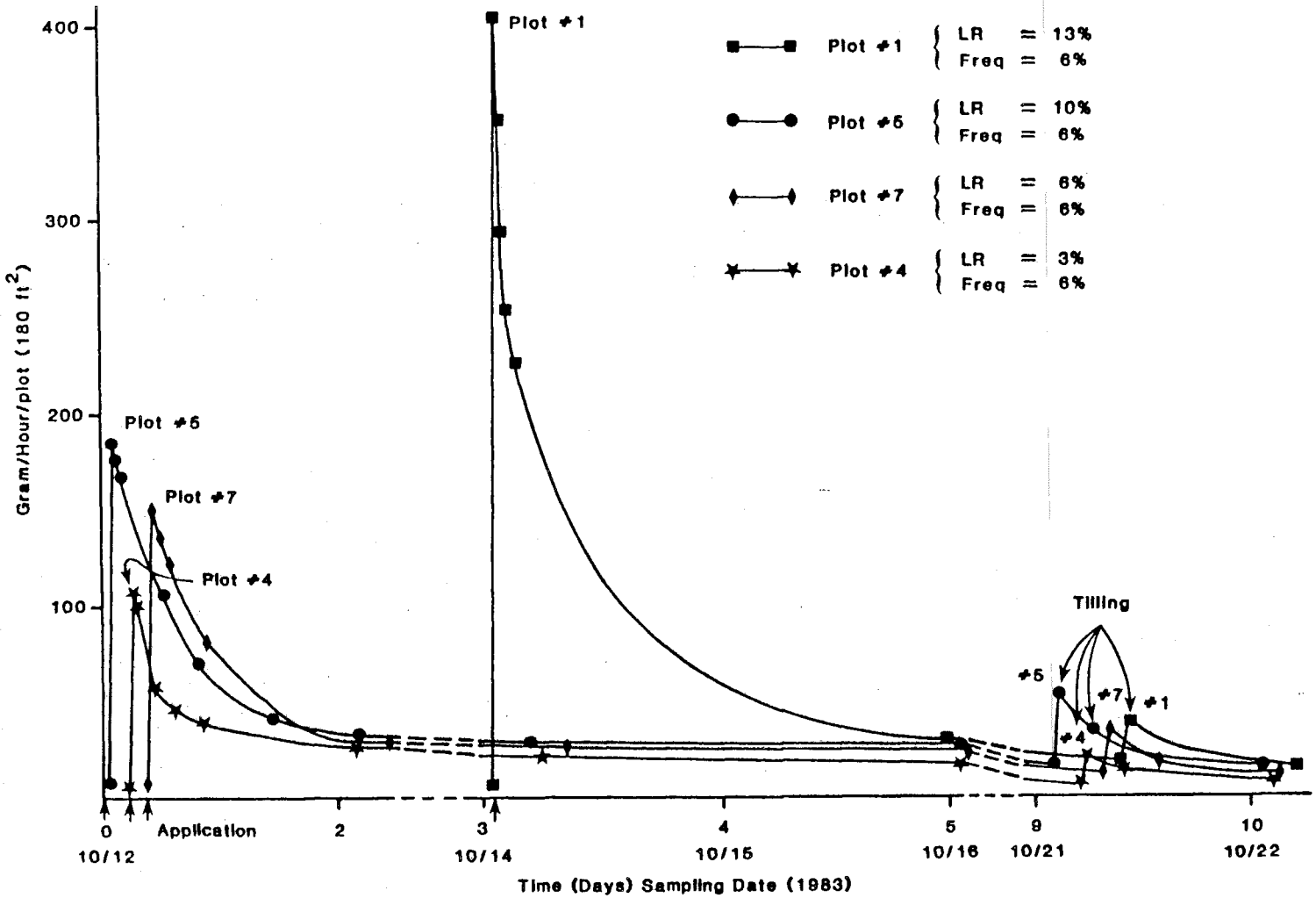

Figure 14 The Effect of Loading Rate and Tilling on Total Hydrocarbon Loss in Field Studies

Source: Habibafshar, (13), page 68.

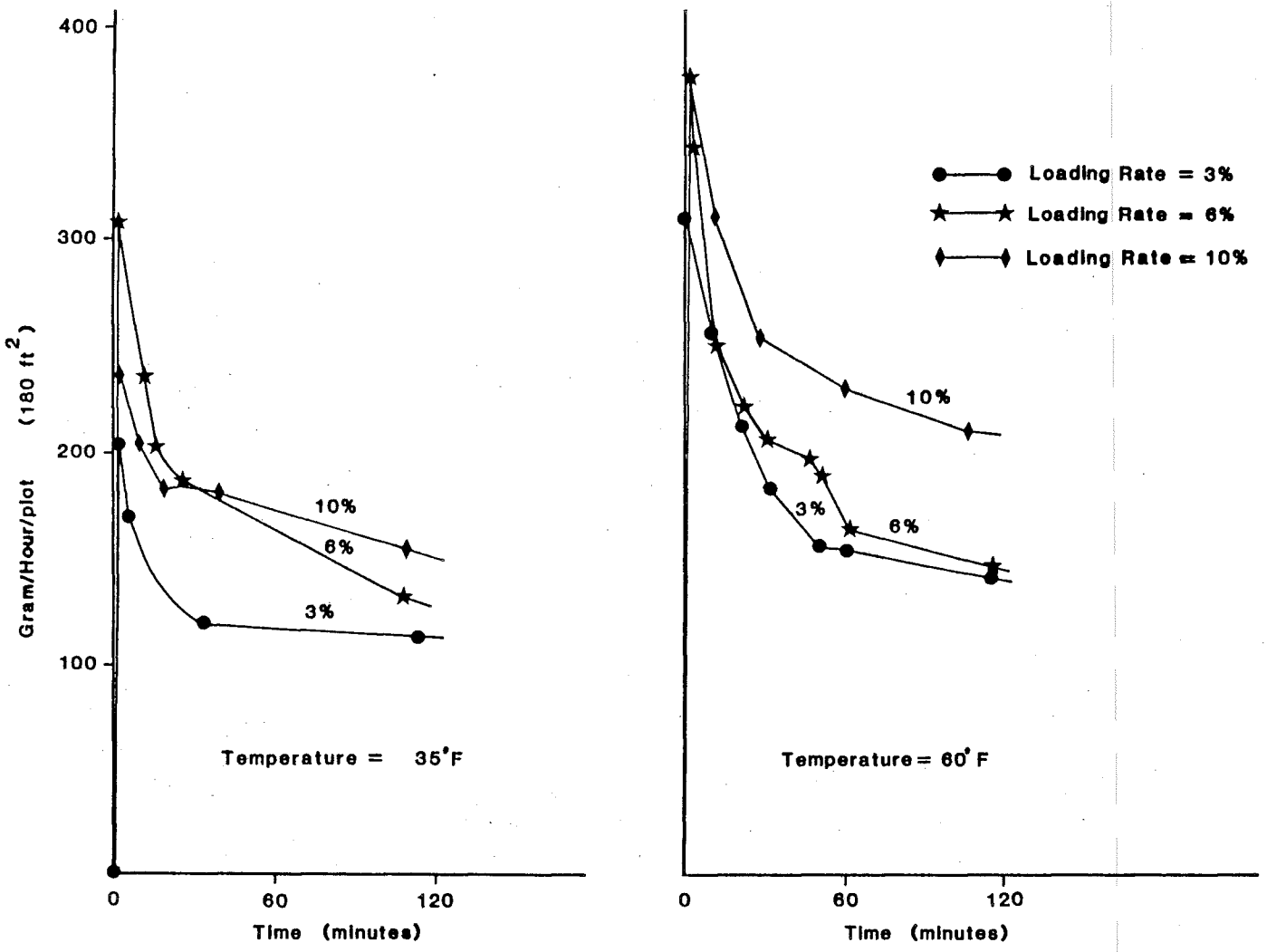

Figure 15 Rate of Emission of Volatiles in First Two Hours After Application of Temperature 35°F and 60°F

Source: Habibafshar, (13), page 70.

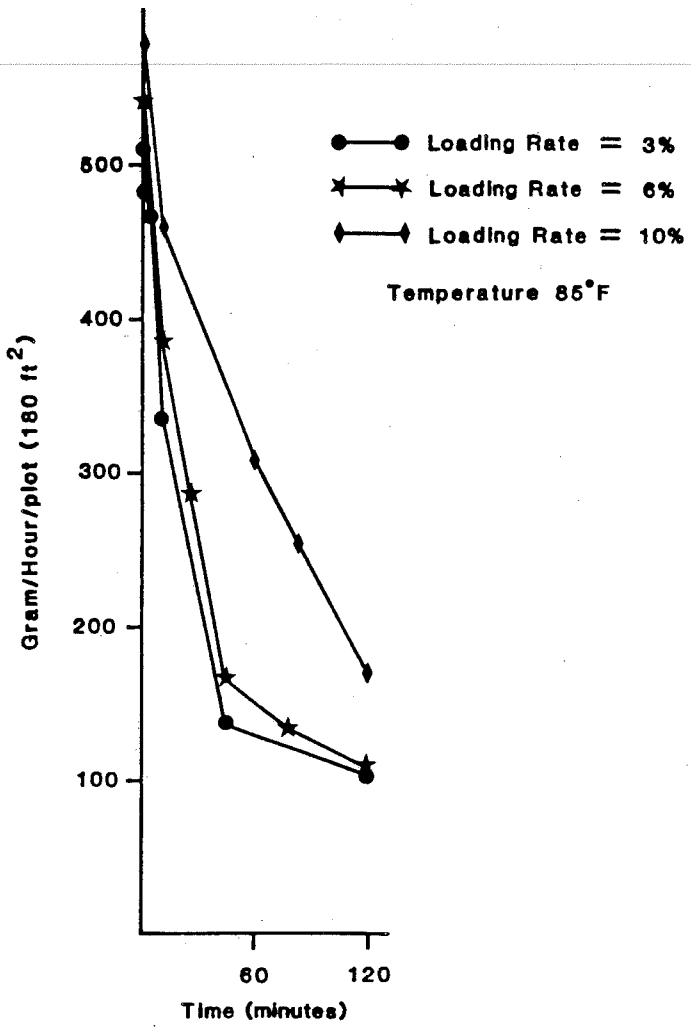

Figure 16 Rate of Emission of Volatiles in First Two Hours After Application at Temperature 85°F

Source: Habibafshar, (13), page 71.

Table 19 Total Volatile Loss from Field Data

Date of Appl.	Plot No.	Nominal Loading Rate	Appl. No.*	Sludge Applied (kg)	Oil Applied (kg)	Volatility of Sludge (%)	Total Loss in-2 hr. (kg)	Total Loss in-1 d (kg)	Total Loss in 7 d (kg)	Total Loss Since Appl. (kg)	Total No. of Days Since Appl.
07/19/82	1	13	1	230.3	195.755	-	.220	.923	3.073	8.173	29
08/17/82	1	13	2	230.3	195.755	8.0	.070	.320	2.090	6.990	24
09/10/82	1	13	3	230.3	195.755	7.8	.053	.620	2.800	11.250	34
10/14/82	1	13	4	262.2	157.320	13.6	.530	2.550	6.050	9.790	18
11/02/82	1	13	5	262.2	157.320	12.5	.903	3.990	8.700	11.700	15
11/17/82	1	13	6	206.53	163.158	9.1	.130	.630	2.130	4.530	33**
Subtotal				1421.83	1065.063		1.906	9.033	24.843	52.433	153
07/13/82	4	3	1	45.31	38.513	-	.070	.390	1.910	5.849	31
08/13/82	4	3	2	45.31	38.513	8.4	.063	.386	1.452	4.992	41
09/23/82	4	3	3	60.49	36.294	14.0	.340	2.020	6.280	8.340	19
10/12/82	4	3	4	45.31	27.186	13.8	.100	.860	3.230	4.010	20
11/02/82	4	3	5	60.49	36.294	12.5	.260	1.610	3.910	5.220	15
11/17/82	4	3	6	47.67	37.659	9.1	.056	.400	1.400	3.800	33**
Subtotal				304.58	214.459		.889	5.666	18.182	32.211	159
07/13/82	5	10	1	150.58	127.993	-	.150	.720	2.660	7.240	30
08/12/82	5	10	2	150.58	127.993	8.5	.090	.600	2.200	8.390	42
09/23/82	5	10	3	201.67	121.002	14.0	.810	3.100	8.150	13.123	19
10/12/82	5	10	4	201.67	121.002	13.8	.320	1.360	5.260	11.260	20
11/02/82	5	10	5	262.67	157.320	12.5	.330	1.820	5.370	8.290	15
11/17/82	5	10	6	158.86	125.499	9.1	.130	.650	1.850	4.250	33**
Subtotal				1125.56	780.809		1.830	8.250	25.490	52.553	159

(continued)

Source: Habibafshar, (13), page 72.

Table 20 Percent of Total Loss from Different Loading Rates at Different Times from Application

Plot #	% Loading Rate	Total # of days *	Total Loss kg	% of Total Loss in two hours	one day	seven days
4	3	159	32.211	2.75	17.59	56.44
7	6	152	37.660	2.49	15.34	43.22
5	10	159	52.553	3.48	15.69	48.50
1	13	153	52.433	3.63	17.22	47.38
6	13	152	52.343	3.55	17.33	47.63

* Total # of days that total losses were calculated for each plot starting from first application (7/13/1982-7/20/82) to the last sampling date (12/20/82).

Source: Habibafshar, (13), page 75.

Table 19 Total Volatile Loss from Field Plots (continued)

Date of Appl.	Plot No.	Nominal Loading Rate	Appl. No.	Sludge Applied (kg)	Oil Applied (kg)	Volatility of Sludge (%)	Total Loss in-2 hr. (kg)	Total Loss in-1 d (kg)	Total Loss in 7 d (kg)	Total Loss Since Appl. (kg)	Total No. of Days Since Appl.
07/20/82	6	13	1	230.30	195.755	-	.203	1.013	3.163	8.263	28
08/17/82	6	13	2	230.30	195.755	8.0	.070	.310	2.100	6.950	24
09/10/82	6	13	3	230.30	195.755	7.8	.053	.620	2.800	11.250	34
10/14/82	6	13	4	262.20	157.320	13.6	.500	2.510	6.040	9.780	18
11/02/82	6	13	5	262.20	157.320	12.5	.903	3.990	8.700	11.600	15
11/17/82	6	13	6	206.53	163.158	9.1	.130	.630	2.130	4.520	33**
Subtotal				1421.83	1065.063		1.859	9.073	24.933	52.343	152
07/20/82	7	6	1	90.62	77.027	-	.110	.680	2.490	6.800	28
08/17/82	7	6	2	90.62	77.027	8.0	.045	.280	1.700	5.530	37
09/23/82	7	6	3	121.01	72.606	14.0	.560	3.310	6.930	11.110	19
10/12/82	7	6	4	121.01	72.606	13.8	.130	1.000	3.550	10.210	35
11/17/82	7	6	5	95.33	75.310	9.1	.093	.510	1.610	4.010	33**
Subtotal				518.59	374.576		.938	5.780	16.280	37.660	152
TOTAL				4792.39	3499.97		7.422	37.802	109.728	227.200	775
% Total sludge volatilized:							.154	.788	2.289	4.740	
% Total oil volatilized:							.212	1.080	3.135	6.491	

* Application number
** No. of days from 11/17/82 to 12/20/82
d = days

Source: Habibafshar, (13), page 73.

Table 21 Mean and Standard Deviation of Total Amount of Sludge Applied and Total Volatile Loss

Effective Date (1982)	Plot #	Nominal Loading Rate	Weight Sludge Applied, kg (six appl.)	Mean/ APP	Std. Dev.	Weight Oil Applied	Total Volatile Loss/kg	Mean/ APP	Std. Dev.
7/13-12/20	4	3	305	50	8.0	214	32.2	5.37	1.65
7/20-12/20	7	6	519	104	15.9	375	37.7	7.53	3.04
7/13-12/20	5	10	1126	188	43.7	781	52.6	8.76	3.11
7/19-12/20	6	13	1422	237	21.6	1065	52.4	8.74	2.73
7/20-12/20	6	13	1422	237	21.6	1065	52.5	8.75	2.73
Totals			4794	163		3500	227.4	7.84	

APP = Application

Source: Habibafshar, (13), page 79.

Table 22 Total Volatile Loss from Laboratory Experiments

Date of Appl.	Loading Rate (%)	Soil Temp. (°F)	Soil Moist. Content (%)	Relative Humidity (%)	No. of Tilling	Amt.* Sludge Applied (kg)	Amt.** Oil Applied (kg)	Total Loss in 2-hr. (kg)	Total Loss in 1-d (kg)	Total Loss in 7-d (kg)	Max Emission Rate g/hour
3/31/83	3	35	12	52	2	41.746	26.30	0.243	.90	2.35	204.762
5/16/83	3	60	12	52	2	41.746	26.30	0.335	1.10	2.50	307.144
6/1/83	3	85	12	52	2	41.746	26.30	0.350	1.30	4.15	511.906
4/4/83	6	35	12	52	2	82.040	51.68	0.330	1.00	2.75	307.143
5/17/83	6	60	12	52	2	82.040	51.68	0.367	1.40	3.90	375.397
6/1/83	6	85	12	52	2	82.040	51.68	0.388	1.90	5.60	546.033
4/1/83	10	35	12	52	2	133.960	84.39	0.433	1.15	3.15	238.889
5/24/83	10	60	12	52	2	133.960	84.39	0.473	2.65	5.60	375.397
6/3/83	10	85	12	52	2	133.960	84.39	0.622	2.90	7.00	580.160
6/10/83	6	60	23	52	2	82.04	51.68	0.550	2.40	7.60	511.906
7/5/83	6	60	12	75	2	82.04	51.68	0.300	.80	2.30	341.270
7/5/83	10	60	12	75	2	133.96	84.39	0.400	1.50	3.50	341.270

* Volatility of sludge was 8.5% and density of sludge was .90 g/ml
** Amount of oil based on the 63% oil in sludge determined by Extraction Method

Source: Habibafshar, (13), page 81.

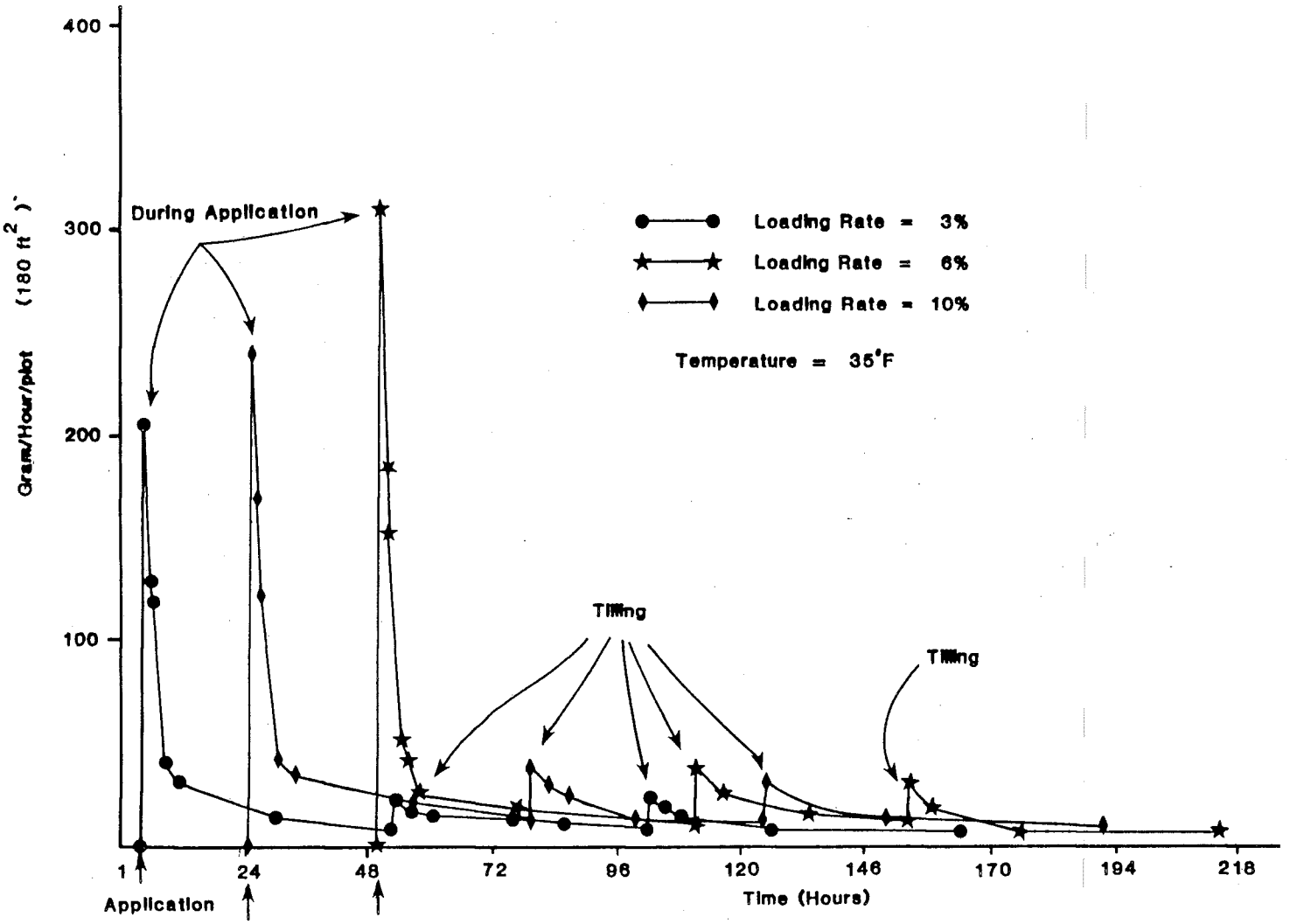

Figure 18 The Effect of Loading Rate and Tilling Frequency on Emission in Laboratory Experiments at 35°F

Source: Habibafshar, (13), page 83.

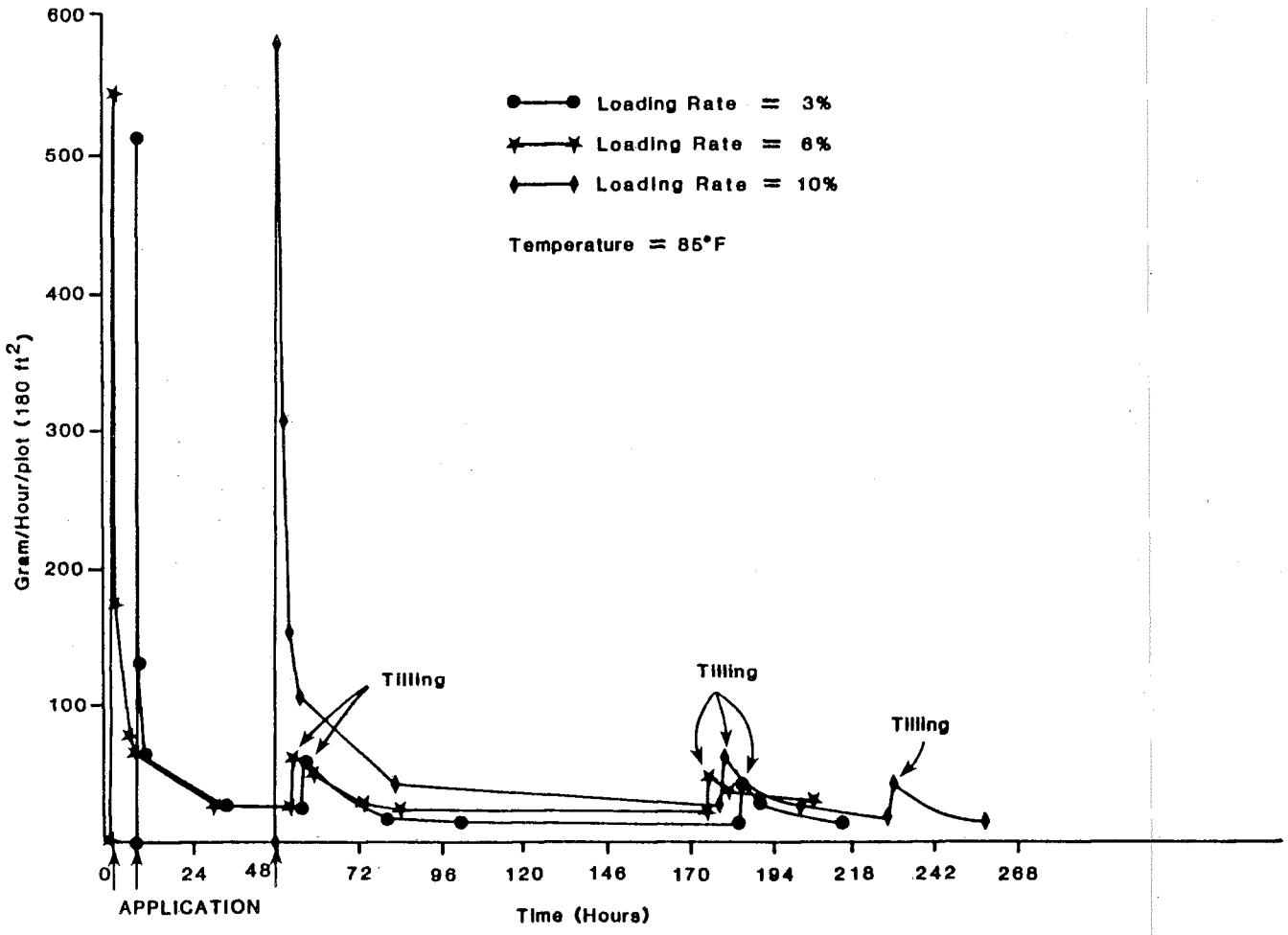

Figure 19 The Effect of Loading Rate and Tilling Frequency on Emission in Laboratory Experiments at 85°F

Source: Habibafshar, (13), page 84.

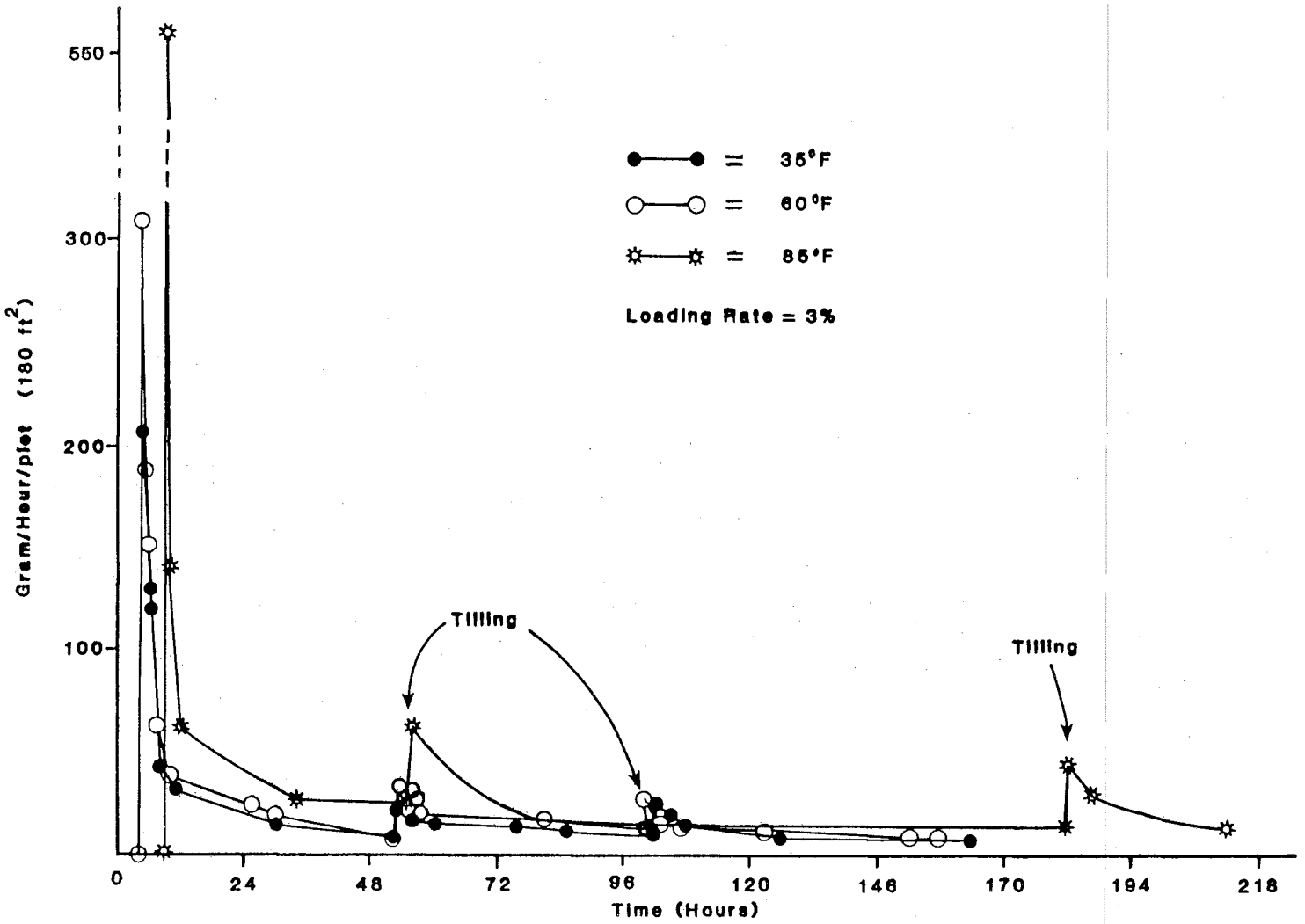

Figure 20 The Effect of Temperature on Emission at 3% Loading Rate

Source: Habibafshar, (13), page 85.

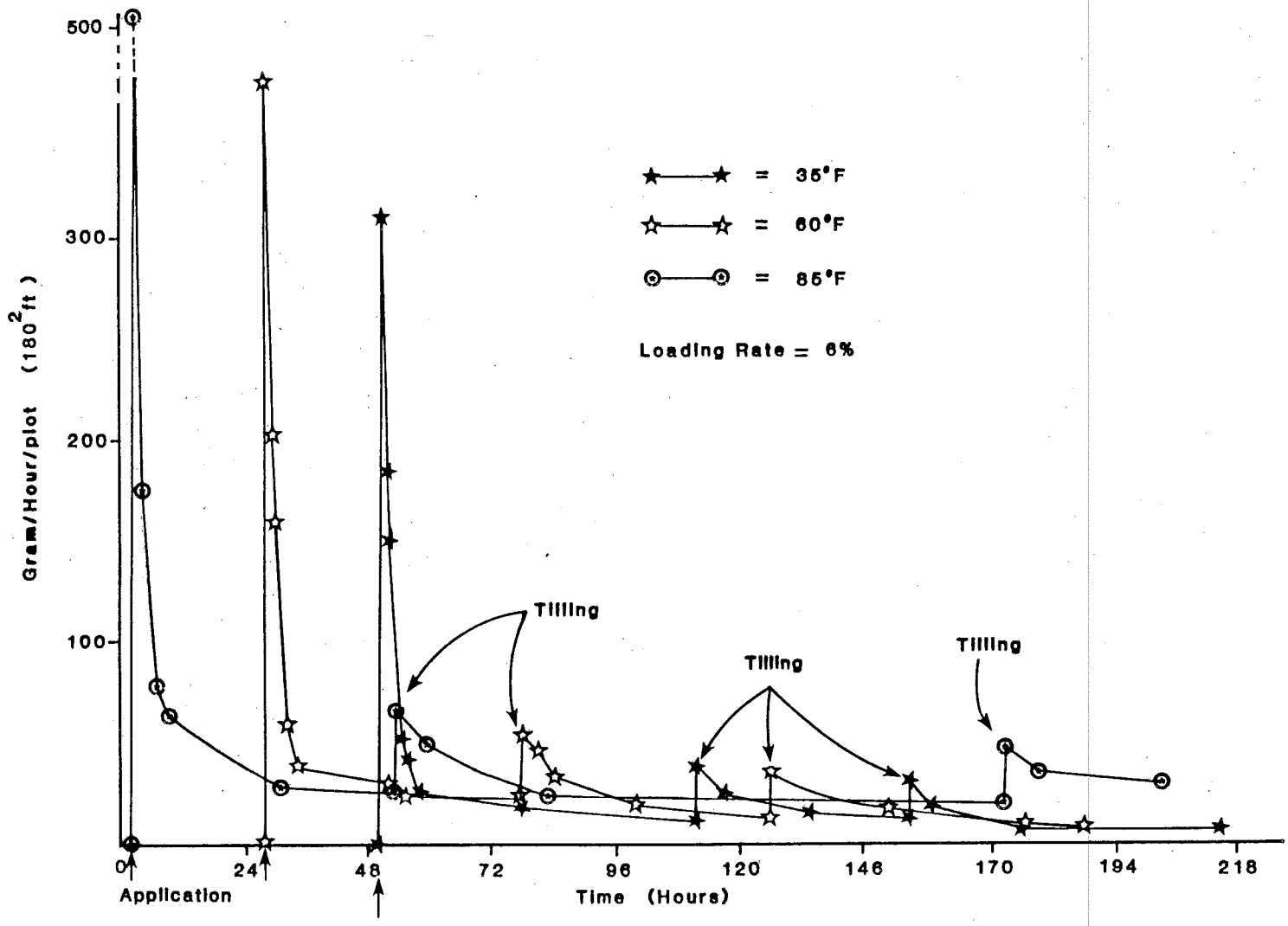

Figure 21 The Effect of Temperature on Emission at 6% Loading Rate

Source: Habibafshar, (13), page 86.

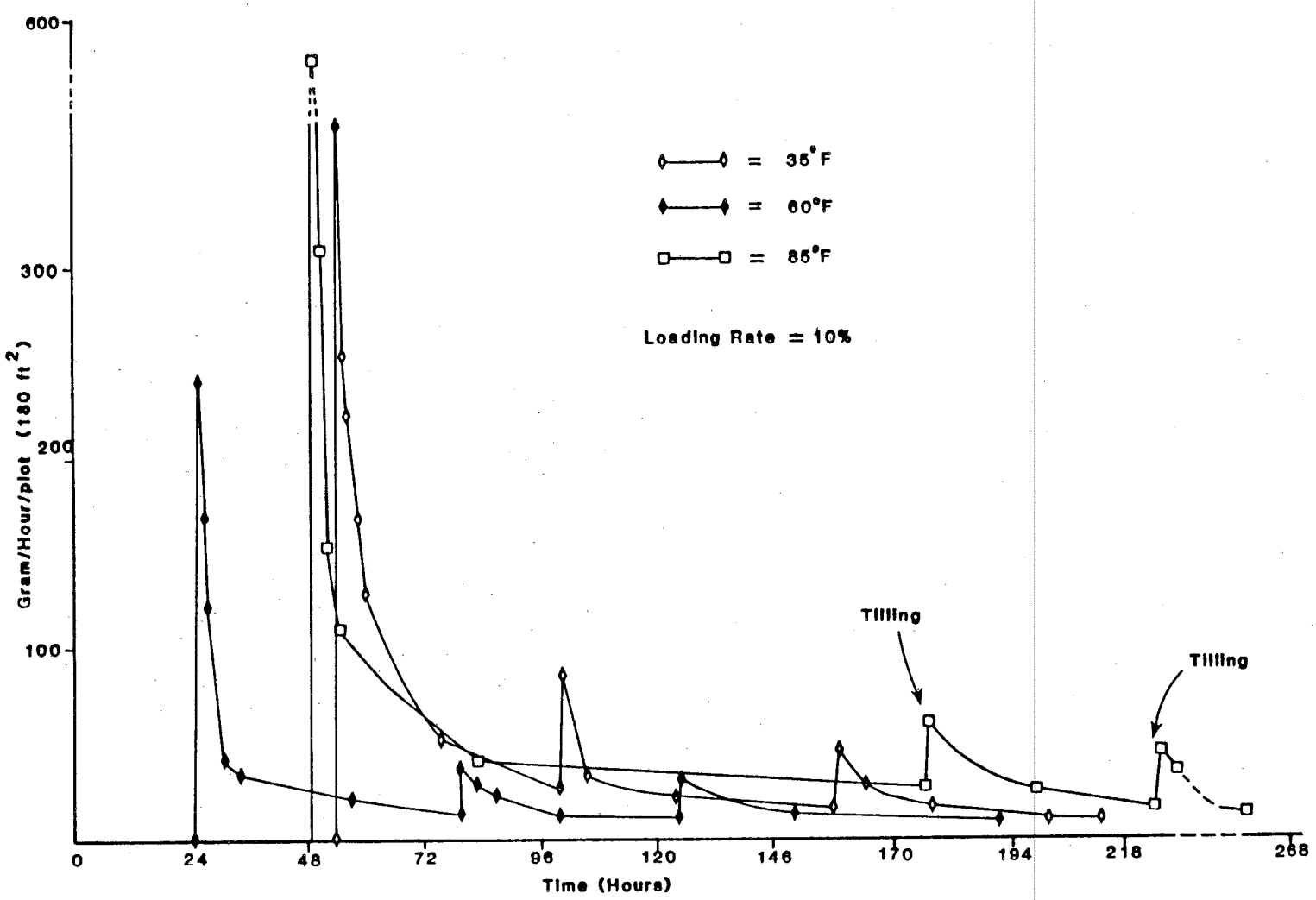

Figure 22 The Effect of Temperature on Emission at 10% Loading Rate

Source: Habibafshar, (13), page 87.

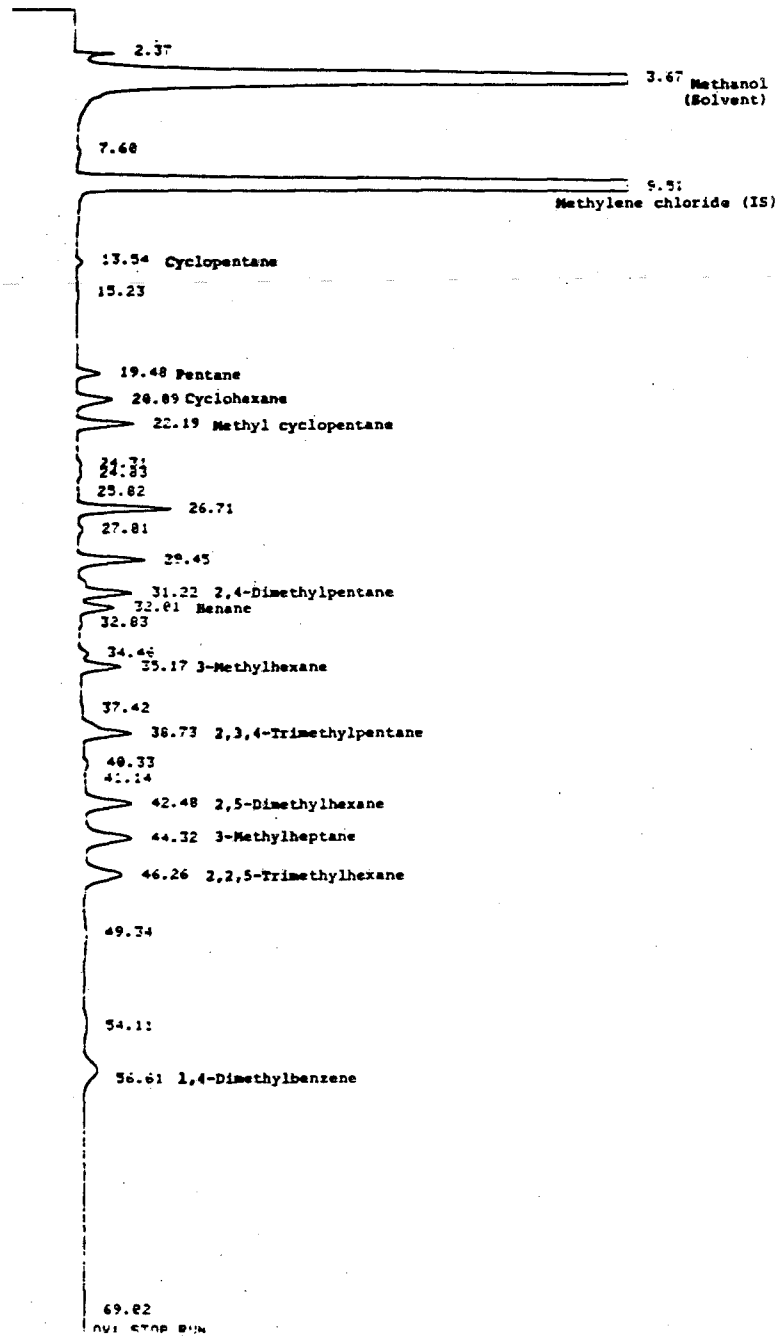

Figure 28 Chromatogram of Air Sample Taken from Plot 4 (before tilling)

Source: Habibafshar, (13), page 110.

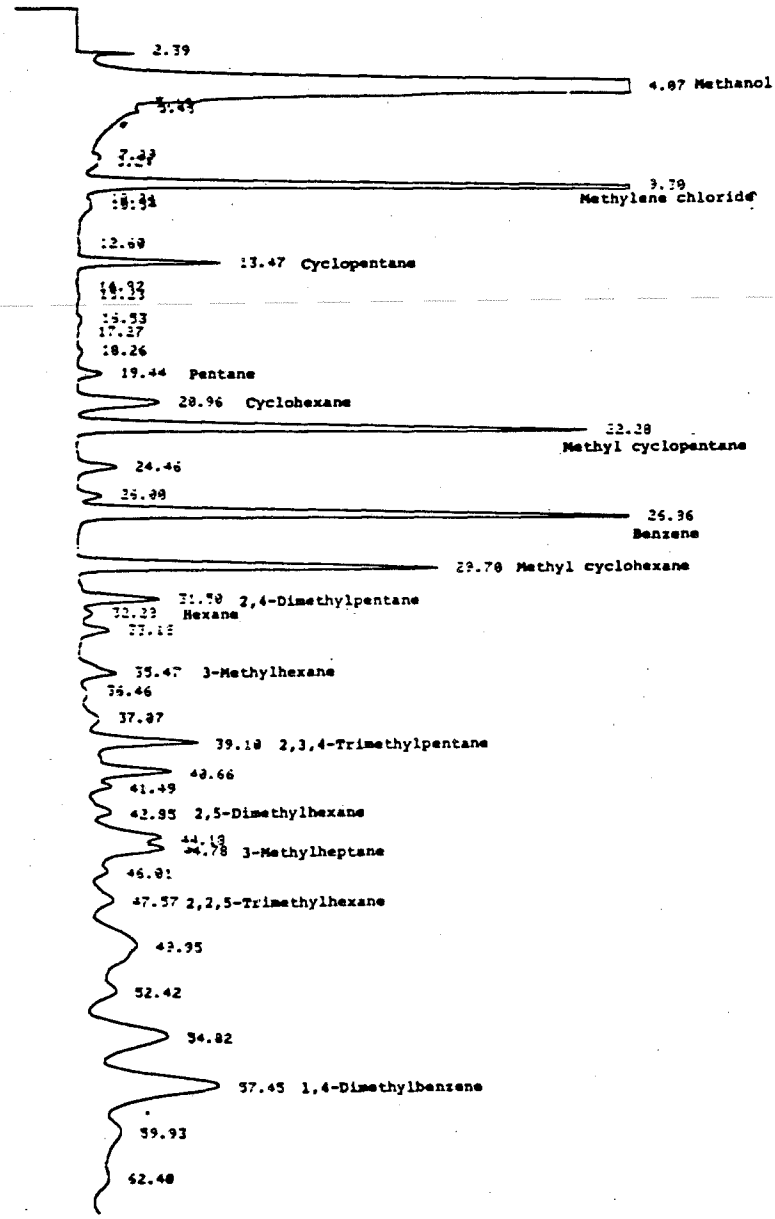

Figure 29 Chromatogram of Air Sample Taken from Plot 4 (after tilling)

Source: Habibafshar, (13), page 111.

14). Wetherold, R. G., J. L. Randall, and R. R. Williams. "Laboratory Assessment of Potential Hydrocarbon Emissions from Land Treatment of Refinery Oily Sludges, Phase II." American Petroleum Institute. June, 1983.

WASTES

The wastes studied were nine oily sludges from eight refineries. The oily sludges consisted of mixes of tank bottoms, separator sludges, biological waste activated sludge, DAF froth, and miscellaneous oily wastes.

SOILS

Eight soils were obtained from eight different sites; however, only three were investigated. These three soils were selected to represent the range of possible soils. One was a predominantly sand soil, the other was a predominantly silt soil, and the last was a predominantly clay soil.

WASTE APPLICATION/DESIGN

This study was conducted entirely in a laboratory. The waste application rates varied from 0.05 to 2 pounds of oil per square foot of soil. These loadings were made to soils four inches deep. Fertilizers and their effect on degradation rates were not investigated in this study. All of the wastes were applied evenly to the soil surface.

A number of variables were studied to find their effect on volatile organic emissions from land treatment areas. The first variable studied was sludge volatility. The following variables were all studied at five different levels that were predetermined by the investigators: (a) soil loading; (b) soil type; (c) soil moisture content; and, (d) relative humidity of the air

RESULTS

- The study found that volatile components present in the raw sludges were also present in emissions from the land treatment areas. The lighter (more volatile) compounds were present in higher concentrations in the air above land treatment

facilities relative to the concentrations of the lighter compounds in the sludge.

- More volatile sludges as based on stripping tests, were found to have greater total volatile organic emissions from land treatment areas.

- A positive correlation was found between oil loading per square foot, and volatile emissions.

- The total emission levels were not significantly effected by the type of soil or its moisture content.

- The effect of relative humidity on volatile emissions was not consistent.

- Sampling the air over the land treatment plots for 240 minutes after applying the oily sludges to the soil typically showed that 6 percent or less of the applied oil had volatilized from the soil.

In some cases abnormally high or low percentages of the applied oil volatilized. The authors conjectured that different mechanisms of volatilization were taking place in these cases, because these experimental runs had either abnormally high or low loadings of the waste to the soil.

- Shortly after most sludges were applied to the soil, a peak concentration of volatile emissions occurred, followed by an exponential decay of the volatile organic concentrations. Less volatile sludges often exhibited an initial high, a slight decline, and then a higher peak concentration in volatile organic emissions followed by an exponential decay in concentrations. No explanation was given for this behavior.

- Tilling of the soil was found to increase the volatile emissions for a short time after tilling.

- A statistically valid empirical relationship was developed to predict volatile organic emissions from surface application of wastes under certain circumstances.

- The major compounds found in the volatile organic emissions were: benzene; toluene; m/p xylene; o-xylene; C_3-benzene; napthalene; anthracene; C_9--Hydrocarbons (alkane); C_{12}--Hydrocarbons (alkane); C_{17}--Hydrocarbons (alkane); C_{17}--Hydrocarbons (pristane); C_{19}--Hydrocarbons; and, C_{20}--Hydrocarbons.

TABLES AND FIGURES

Tables and Figures from the study follow.

TABLE 3-1. EXPERIMENTAL CONDITIONS FOR LANDTREATMENT SIMULATIONS

Run ID No.	Sludge ID No.	Sludge Loading Lb/Ft^2 [b]		Soil ID Number	Soil Moisture Content, Wt. %	Air Relative Humidity %	Temperature °F	
		Total	Oil Only				Soil	Air
2	SL-11	2.0	1.0	D-7	25	50	90	90
5	SL-11	2.0	1.0	D-7	25	50	90	90
6	SL-11	0.6	0.3	D-7	25	40	90	90
7	SL-12	2.1	0.49	D-7	25	50	90	90
8	SL-14	2.1	0.45	D-7	25	50	90	90
9	SL-14	1.5	0.32	D-8	10	50	90	90
10	SL-11	2.1	1.05	D-8	10	50	90	90
11	SL-11	2.0	1.0	D-1	10	50	90	90
12	SL-11	0.6	0.3	D-1	10	50	90	90
13	SL-14	2.3	0.49	D-1	10	50	90	90
15	SL-11	1.0	0.5	D-1	10	50	90	90
16	SL-11	1.0	0.5	D-8	10	50	90	90
17	SL-12	2.13	0.50	D-7	25	50	90	90
18	SL-14	0.467	0.10	D-8	10	50	90	90
19	SL-12	1.06	0.25	D-8	10	50	90	90
20	SL-12	6.4	1.50	D-8	10	50	90	90
21	SL-11	1.0	0.5	D-1	10	30	90	90
22	SL-11	4.0	2.0	D-1	25	30	90	90
24	SL-14	1.5	0.32	D-8	10	50	90	90
25	SL-11	1.5	0.75	D-8	10	30	90	90
26	SL-11	0.1	0.05	D-8	15	70	90	90
27	SL-11	0.1	0.05	D-7	15	70	90	90
29	SL-14	4.65	1.00	D-8	5	70	90	90
29	SL-14	2.13	0.46	D-1	25	30	90	90
32	SL-11	1.17	0.59	D-7	25	50	90	90
33	SL-11	2.34	1.17	D-7	15	70	90	90
34	SL-14	6.0	1.28	D-7	5	80	90	90
35	SL-12	1.06	0.25	D-8	20	50	90	90
36	SL-11	0.1	0.05	D-8	5	30	90	90
37	SL-14	0.456	0.10	D-7	15	50	90	90
38	SL-12	2.13	0.50	D-1	5	50	90	90
39	SL-14	6.0	1.28	D-7	5	30	90	90
40	SL-12	2.0	0.47	D-1	5	30	90	90
41	SL-11	2.0	1.0	D-7	—[c]	50	90	90
42	SL-14	2.33	0.50	D-1	15	30	90	90
43	SL-13	6.17	1.00	D-1	5	70	90	90
44	SL-13	1.54	0.25	D-7	25	70	90	90
45	SL-13	0.62	0.10	D-7	25	30	90	90
46	SL-13	0.62	0.10	D-1	5	30	90	90
47	SL-13	0.62	0.10	D-8	15	30	90	90
48	SL-13	1.54	0.25	D-7	25	70	90	90
49	SL-13	0.62	0.10	D-1	5	30	90	90
50	SL-13	3.05	0.50	D-8	15	70	90	90
51	SL-13	5.95	0.96	D-7	25	50	90	90
56	SL-15	3.0	--[a]	D-7	—[c]	50	90	90

[a] Solid sludge--oil content not defined.
[b] To convert lb/ft^2 loading to barrels/acre, multiply lb/ft^2 by 145. Assumes sludge/oil density = 300 lb/bbl.
[c] Data not obtained.

Source: Wetherold, et al, (14), page 14.

TABLE 4-6. SELECTED HYDROCARBON CONCENTRATION IN SLUDGES
(Concentrations are in μg/gm as measured by GCMS)[a]

Compound	Sludges (Phase II)									Sludges (Phase I)		
	SL-11	SL-12	SL-13	SL-14	SL-15	SL-16	SL-17	SL-18	SL-19	T	S1	S3
Benzene	540	32	18	5	14	20	160	38	250	ND	1,800	1,400
Toluene	1,700	58	98	14	ND	ND	150	36	2,200	0.02	9,300	5,600
M/P-Xylene	700	58	110	30	24	350	40	ND	1,400	1.2	23,000	15,000
O-Xylene	330	28	50	16	11	170	17	ND	510	0.55	42,000	32,000
C_3-Benzene	1,100	150	400	160	1,300	1,000	76	ND	2,800	7.9	222,000	160,000
C_3-Benzene	890	120	400	140	620	900	60	ND	2,100	NR	NR	NR
Naphthalene	230	34	350	64	ND	50	500	ND	400	NR	NR	NR
Anthr./Phen.	150	20	1,100	92	20	210	120	ND	150	NR	NR	NR
C_9-H.C. (alkane)	130	30	14	36	160	8	13	ND	180	NR	NR	NR
C_{12}-H.C. (alkane)	140	57	210	120	410	200	44	ND	230	NR	NR	NR
C_{17}-H.C. (alkane)	84	72	84	68	120	84	60	6	130	NR	NR	NR
C_{17}-H.C. (alkane) (pristane)	66	72	24	68	99	84	34	6	78	NR	NR	NR
C_{19}-H.C.	31	26	40	28	18	54	14	ND	70	NR	NR	NR
C_{20}-H.C.	2	NM	16	14	ND	32	26	ND	38	NR	NR	NR

[a]Light aromatics quantitated based on d_8-toluene. Naphthalene, anthr./phen., and alkanes based on d_{10}-anthracene.

Source: Wetherold, et al, (14), page 37.

TABLE 4-7. VOLATILITY TEST RESULTS (INITIAL TESTING)

Sample ID #	Sample (µl)	Average Hydrocarbon Concentration (Hexane Equivalent) During the Period, ppm[d]						Normalized[b] 4 hr ave. (ppm/ml)
		1st hour	2 hours	3 hours	4 hours	5 hours	6 hours	
Study Phase: Phase II (Current):								
SL-11	50	125	69	49	37	NA	NA	720
	1000	1957	1311	1001	821	699	611	821
SL-12	1000	141	104	85	72	64	57	72
	1000	169	112	85	69	58	50	69
SL-13	250	228	175	145	126	112	102	504
	1000	226	174	145	124	109	97	124
	250	143	106	86	73	64	57	292
SL-14	100	145	86	62	48	40	34	480
	1000	253	162	120	96	80	69	96
	100	104	62	45	35	29	25	350
	1000	272	180	136	110	92	79	110
SL-15	1000	1135	684	504	401	333	288	401[a]
	1000	341	214	163	134	114	99	134[a]
SL-16	1000	197	172	152	136	122	111	136[a]
SL-17	100	70	42	30	24	20	17	240
	1000	196	120	89	71	60	52	71
	100	26	15	11	9.5	8.1	7.1	95
SL-18	100	8.3	5.4	4.3	3.7	3.3	3.0	37
	1000	6.6	5.8	5.4	5.1	4.8	4.6	5.1
SL-19	1000	514	321	239	191	160	138	191[a]
Study Phase: Phase I:								
S1	1	263[c]	-	-	-	-	-	263,000
S2	5	72[c]	-	-	-	-	-	14,300
T	20	4.4[c]	-	-	-	-	-	217

[a]Values are in ppm/mg.
[b]Concentrations are normalized to sample sizes of 1000 µl (1 ml).
[c]Adjusted for nitrogen purge rate of 200 ml/min.
[d]Concentrations are the cumulative average concentrations over the entire periods from the start of the study.

Source: Wetherold, et al, (14), page 39.

TABLE 4-8. WEIGHTED SLUDGE VOLATILITIES

Experimental Run No.	Sludge ID No.	Weighted Sludge Volatility, Average 4 Hour Concn., ppm/ml
2	SL-11	821
5	SL-11	821
6	SL-11	821
7	SL-12	72
8	SL-14	96
9	SL-14	96
10	SL-11	760
11	SL-11	760
12	SL-11	760
13	SL-14	96
15	SL-11	570
16	SL-11	570
17	SL-12	22
18	SL-14	30
19	SL-12	22
20	SL-12	22
21	SL-11	550
22	SL-11	540
23	SL-11	540
24	SL-14	22
25	SL-11	530
26	SL-11	530
27	SL-11	530
28	SL-14	16
29	SL-14	16
32	SL-11	510
33	SL-11	510
34	SL-14	13
35	SL-12	14
36	SL-11	510
37	SL-14	12
38	SL-12	13
39	SL-14	12
40	SL-12	7
41	SL-11	480
42	SL-14	5
43	SL-13	85
44	SL-13	85
45	SL-13	85
46	SL-13	85
47	SL-13	85
48	SL-13	85
49	SL-13	85
50	SL-13	85
51	SL-13	85

Source: Wetherold, et al, (14), page 40.

TABLE 4-9. EXPERIMENTAL RESULTS OF LANDTREATMENT SIMULATIONS (PHASE II STUDY)

			Cumulative VOC Emissions[c]														
			Elapsed Time = 30 minutes			Elapsed Time = 120 minutes			Elapsed Time = 240 minutes			Elapsed Time = 420 minutes			Elapsed Time = 480 minutes		
Run ID No.	Sludge ID No.	Sludge Loading,[b] Lb Oil Per Ft²	VOC, Lb per Ft²	VOC, % of Applied Oil	VOC, % of Applied Sludge	VOC, Lb per Ft²	VOC, % of Applied Oil	VOC, % of Applied Sludge	VOC, Lb Per Ft²	VOC, % of Applied Oil	VOC, % of Applied Sludge	VOC, Lb Per Ft²	VOC, % of Applied Oil	VOC, % of Applied Sludge	VOC, Lb Per Ft²	VOC, % of Applied Oil	VOC, % of Applied Sludge
2	SL-11	1.0	0.0401	4.0	2.0	--	--	--	--	--	--	--	--	--	--	--	--
5	SL-11	1.0	0.0154	1.5	0.77	0.0355	3.6	1.78	0.0431	4.3	2.16	--	--	--	--	--	--
6	SL-11	0.3	0.00424	1.4	0.71	0.00922	3.1	1.54	0.0124	4.1	2.07	0.0157	5.2	2.62	--	--	--
7	SL-12	0.49	0.00356	0.7	0.17	0.00503	1.0	0.24	0.0701	1.4	0.33	0.00905	1.8	0.43	--	--	--
8	SL-14	0.45	0.00496	1.1	0.24	0.0109	2.4	0.52	0.0143	3.2	0.68	--	--	--	--	--	--
9	SL-14	0.32	0.00153	0.5	0.10	0.00363	1.1	0.24	0.00579	1.8	0.39	--	--	--	--	--	--
10	SL-11	1.05	0.00420	0.4	0.20	0.0160	1.5	0.76	0.0218	2.1	1.04	--	--	--	--	--	--
11	SL-11	1.0	0.00256	0.3	0.13	--	--	--	--	--	--	--	--	--	--	--	--
12	SL-11	0.3	0.00515	1.7	0.86	0.0127	4.2	2.12	0.0179	6.0	2.98	0.0251	8.4	4.18	--	--	--
13	SL-14	0.49	0.00284	0.6	0.12	0.0153	3.1	0.67	0.0228	4.6	0.99	0.271	5.5	1.18	--	--	--
15	SL-11	0.5	0.00707	1.4	0.71	0.0138	2.8	1.38	0.0216	4.3	2.16	0.0301	6.0	3.01	--	--	--
16	SL-11	0.5	0.00471	0.9	0.47	0.0123	2.5	1.23	0.0184	3.7	1.84	0.0251	5.0	2.51	--	--	--
17	SL-12	0.5	0.00008	0.02	0.00	0.00008	0.02	0.00	0.00030	0.06	0.01	0.00075	0.15	0.04	--	--	--
18	SL-14	0.10	0.00042	0.4	0.09	0.00157	1.6	0.34	0.00265	2.7	0.57	0.00798	8.0	1.71	0.00907	9.1	1.94
19	SL-12	0.25	0.00023	0.1	0.02	0.00055	0.2	0.05	0.00071	0.3	0.07	--	--	--	--	--	--
20	SL-12	1.50	0.00012	0.01	0.00	--	--	--	--	--	--	--	--	--	--	--	--
21	SL-11	0.5	0.00247	0.5	0.25	0.0102	2.0	1.02	0.0157	3.1	1.57	0.209	4.2	2.09	0.0221	4.4	2.21
22	SL-11	2.0	0.00102	0.1	0.03	0.00554	0.3	0.14	0.0129	0.6	0.32	--	--	--	--	--	--
24	SL-14	0.12	0.00007	0.02	0.00	0.0-007	0.02	0.00	0.00007	0.02	0.00	0.00007	0.02	0.00	0.00007	0.02	0.00
25	SL-11	0.75	0.00356	0.5	0.24	0.00826	1.1	0.55	0.0134	1.8	0.89	0.0176	2.4	1.17	--	--	--
26	SL-11	0.05	0.00102	2.0	1.02	0.00205	4.1	2.05	0.00262	5.2	2.62	0.00292	5.8	2.92	--	--	--
27	SL-11	0.05	0.00015	0.3	0.15	0.00028	0.6	0.28	0.00028	0.6	0.28	0.00028	0.6	0.28	0.00028	0.6	0.28
28	SL-14	1.00	0.00001	0.0	0.00	0.00001	0.0	0.00	0.00001	0.0	0.00	0.00001	0.0	0.00	0.00001	0.1	0.00
29	SL-14	0.46	0.00004	0.01	0.00	0.00015	0.03	0.00	0.00032	0.07	0.02	--	--	--	--	--	--
32	SL-11	0.59	0.00531	0.9	0.45	0.0101	1.7	0.86	0.0133	2.3	1.14	0.0167	2.8	1.43	0.0177	3.0	1.51
33	SL-11	1.17	0.0062	0.5	0.26	0.0158	1.4	0.68	0.0210	1.8	0.90	0.0285	2.4	1.22	0.0304	2.6	1.30
34	SL-14	1.28	0.00011	0.01	0.00	0.00012	0.01	0.00	0.00012	0.01	0.00	0.00012	0.01	0.00	0.00012	0.01	0.00
35	SL-12	0.25	0.00028	0.1	0.03	0.00063	0.3	0.06	0.00133	0.5	0.13	0.00211	0.8	0.20	0.00234	0.9	0.22
36	SL-11	0.05	0.00395	7.9	3.95	0.0136	27.2	13.6	0.0220	44.0	22.0	0.0384	76.7	38.4	0.0393	78.7	39.3
37	SL-14	0.10	0.00061	0.6	0.13	0.00271	2.7	0.58	0.00593	5.9	1.27	0.00921	9.2	1.97	0.00986	9.9	2.11
38	SL-12	0.50	0.00024	0.05	0.01	0.00084	0.17	0.04	0.00185	0.37	0.09	0.00442	0.9	0.21	--	--	--
39	SL-14	1.28	0.00067	0.05	0.01	0.00281	0.2	0.05	0.00592	0.5	0.10	0.00898	0.7	0.15	--	--	--
40	SL-12	0.47	0.00014	0.03	0.00	0.00047	0.1	0.02	0.00108	0.2	0.05	0.00278	0.6	0.14	0.00347	0.7	0.17
41	SL-11	1.0	0.00461	0.46	0.23	0.0115	1.2	0.58	0.0179	1.8	0.90	0.0254	2.5	1.27	0.0278	2.8	1.39
42	SL-14	0.50	0.00024	0.05	0.01	0.00028	0.05	0.01	0.00030	0.05	0.01				--	--	--
43	SL-13	1.00	0.0015	0.2	0.02	0.00393	0.4	0.06	0.00976	1.0	0.16	0.0154	1.5	0.25	--	--	--
44	SL-13	0.25	0.00079	0.3	0.05	0.00261	1.0	0.17	0.00563	2.3	0.37	0.0107	4.3	0.69	0.0123	4.9	0.80
45	SL-13	0.10	0.00326	3.3	0.53	0.0115	11.5	1.85	0.0256	25.6	4.13	0.0445	44.5	7.18	0.0499	49.9	8.05
46	SL-13	0.10	0.00027	0.3	0.04	0.00108	1.1	0.17	0.00318	3.2	0.51	0.00684	6.8	1.10	0.00773	7.7	1.25
47	SL-13	0.10	0.00030	0.3	0.05	0.00104	1.0	0.17	0.00251	2.5	0.40	0.00583	5.8	0.94	0.00687	6.9	1.11
48	SL-13	0.25	0.00050	0.2	0.03	0.00158	0.6	0.10	0.00417	1.7	0.27	0.0101	4.0	0.66	0.0124	5.0	0.81
49	SL-13	0.10	0.00045	0.5	0.07	0.00168	1.7	0.27	0.00408	4.1	0.65	0.00896	8.4	1.45	0.00969	9.7	1.56
[illegible]	SL-13	0.50	0.00016	0.03	0.01	0.00033	0.07	0.01	0.00125	0.3	0.04	0.00427	0.9	0.14	0.00564	1.1	0.18
[illegible]	SL-14	0.96	0.00033	0.03	0.01	0.00081	0.08	0.01	0.00147	0.15	0.02	0.00354	0.37	0.06	0.00452	0.47	0.08
[illegible]	SL-1[illegible]	--[a]	0.00254	--	0.08	0.0115	--	0.35	0.0201	--	0.67	0.024	--	0.80	--	--	--

[a] Solid sludge--oil content not defined.
[b] Applied oil estimated from volume percent oil determined by centrifugation.
[c] Loading and emissions can be converted from lb/ft² to kg/m² by multiplying lb/ft² by 4.89.
[d] Loading can be converted from lb/ft² to bbl/acre by multiplying lb/ft² by 145.

Source: Wetherold, et al, (14), page 42.

TABLE 4-10. RESULTS OF LANDTREATMENT SIMULATION DURING PHASE I STUDY

Run ID No.	Sludge ID No.	Sludge Loading, lb Oil per ft^2	VOC Emissions @ 30 Minutes Elapsed Time		
			VOC, lb per ft^2 [a]	VOC, % of Applied Oil [a]	VOC, % of Applied Sludge
6	S1	2.35	0.0174	0.79	0.70
7	S1	2.35	0.0139	0.63	0.56
9	S1	2.35	0.0119	0.54	0.48
10	S1	0.94	0.0319	3.6	3.2
11	S1	0.94	0.0304	3.5	3.0
12	S1	2.35	0.0513	2.3	2.1
13	S1	2.35	0.0588	2.7	2.4
14	S1	2.35	0.0260	1.2	1.0
15	T	0.25	0.0002	0.90	0.009
16	S1	2.35	0.0159	0.72	0.63
17	S1	3.76	0.0181	0.52	0.45
19	S1	0.47	0.0137	3.1	2.7
19	S1	2.35	0.0165	0.75	0.66
20	S3	0.06	0.0022	1.1	0.22
21	S3	0.15	0.0011	0.22	0.045
22	S3	0.24	0.0035	0.44	0.088
23	S3	0.06	0.0011	0.56	0.11
24	S3	0.24	0.0026	0.33	0.066
27	S3	0.15	0.0018	0.36	0.071

[a] Loading and emissions can be converted from lb/ft^2 to kg/m^2 by multiplying lb/ft^2 by 4.89.
[b] Loading in lb/ft^2 can be converted to bbl/acre by multiplying lb/ft^2 by 145.
[c] Volume fraction of oil in sludge was estimated from centrifugation results.

Source: Wetherold, et al, (14), page 43.

TABLE 4-11. SUMMARY OF AIR SAMPLE ANALYSES

Sample	TNMHC ppmv-C_6	TNMHC ppmv-C	Major Species (ppbv-C)
Run 29/Canister 2	0.43	2.58	C_2 (527) C_3 (331)
Run 29/Canister 6	0.21	1.26	Toluene (199) 2,2,5-Trimethylhexane (170.5)
Run 30/Canister 15	0.14	0.83	Toluene (127) 2,5-Dimethylhexane (89)
Run 30/Canister 11	0.14	0.82	Benzene (299) Toluene (117)
Run 31/Canister 7	0.18	1.03	2.4-Dimethylpentane (376) 2,5-Dimethylhexane (111)
Run 39/Canister 7	0.37	2.22	Methylene Chloride (1318) C_2 (94)
Run 41/Canister 11	5.07	30.42	m & p Xylene (2382) n-Nonane (1731)
Run 42/Canister 2	0.42	2.54	Isobutene (192) C_2 (166)
Run 43/Canister 10	0.23	1.35	C_2 (163) n-Undecane (78)
Run 51/Canister 16	1.48	8.90	n-Undecane (894) n-Decane (456)
Run 51/Canister 68	0.31	1.83	n-Undecane (109) Toluene (64)

Source: Wetherold, et al, (14), page 44.

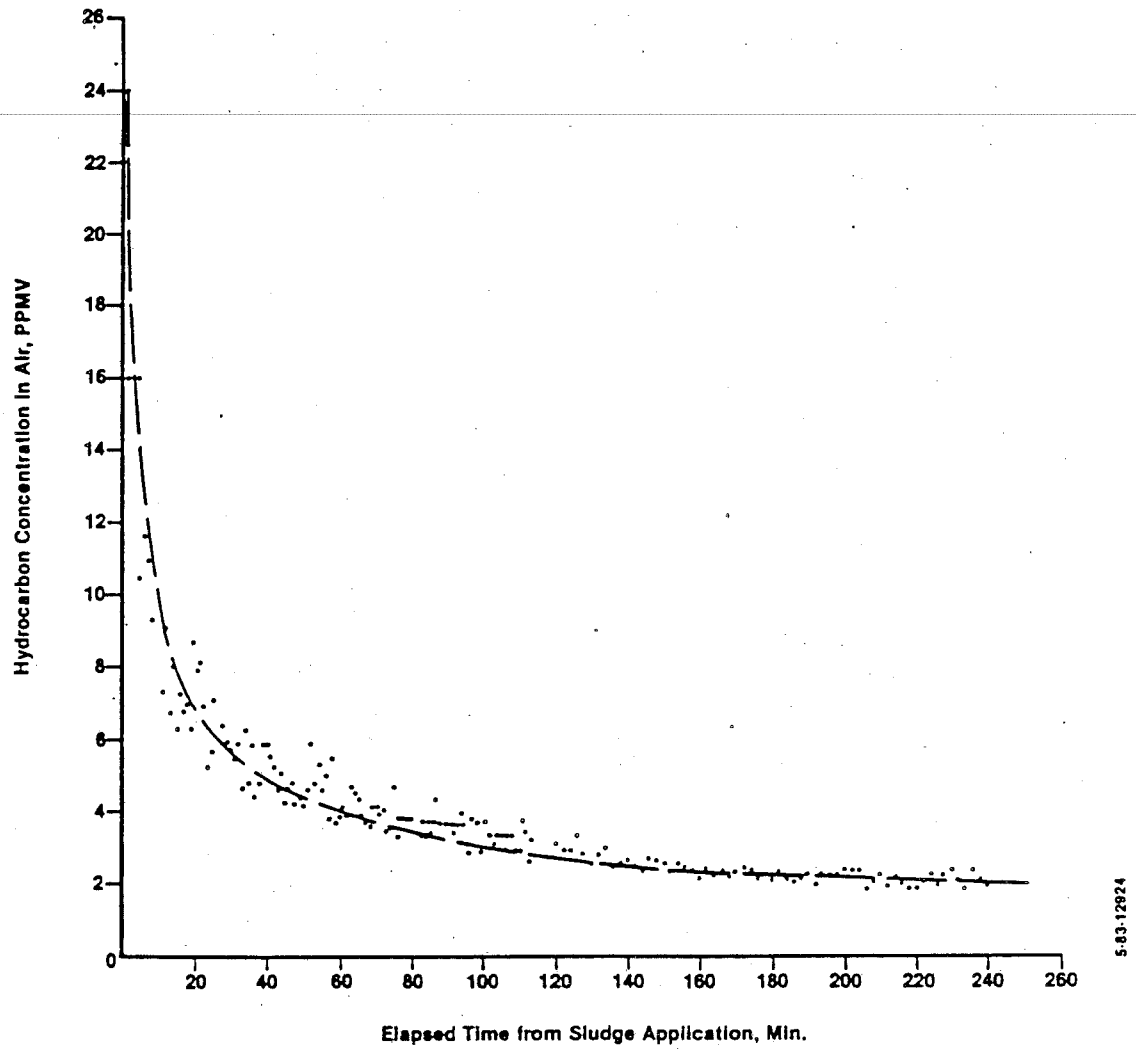

Figure 5-4. Hydrocarbon Concentration in Air During Run 12 (0.6 lb of SL-11 on Soil D-1)

Source: Wetherold, et al, (14), page 56.

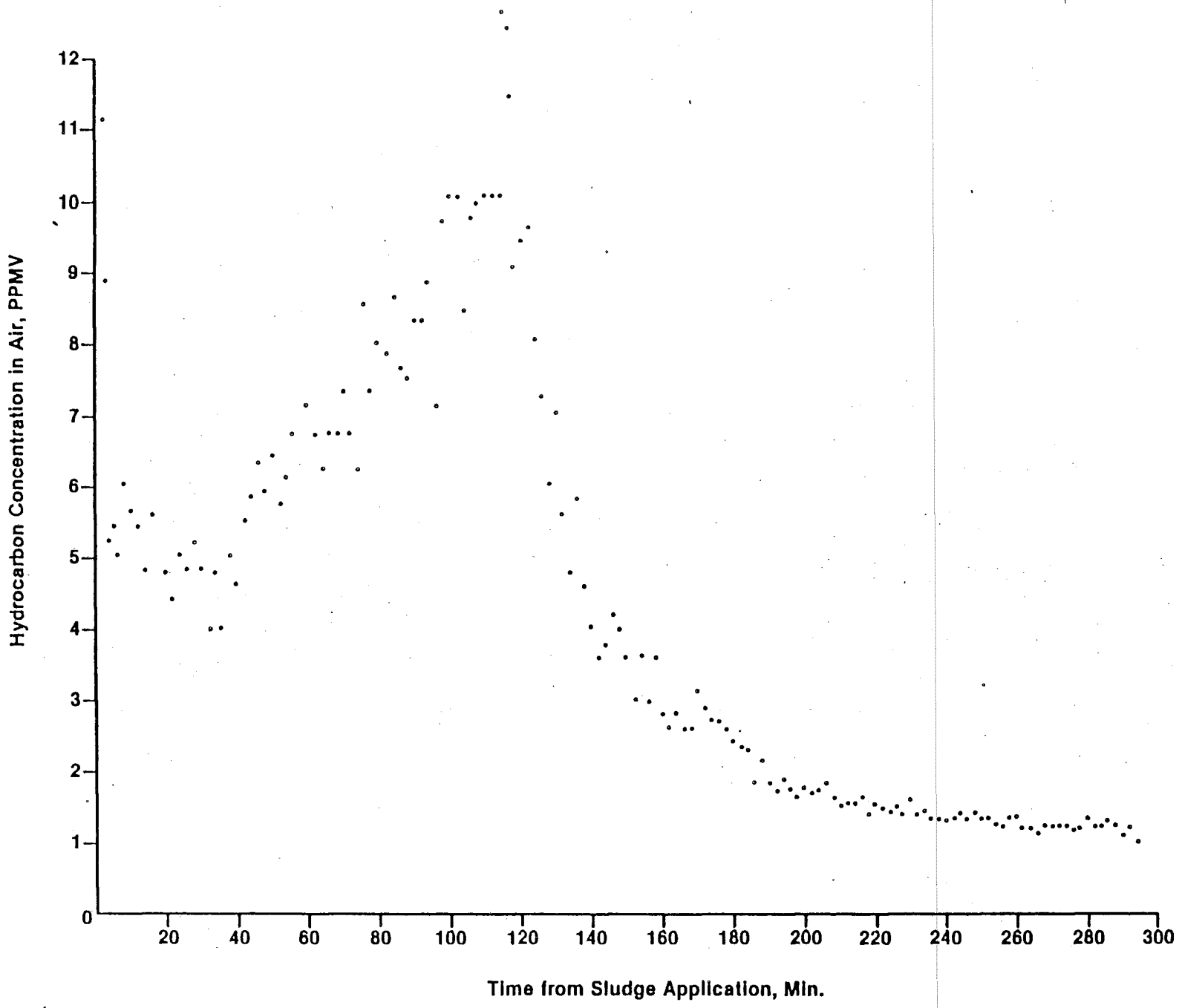

Figure 5-5. Hydrocarbon Concentration in Air During Run 13 (2.3 lbs of SL-11 on Soil D-1)
Source: Wetherold, et al, (14), page 57.

TABLE 5-3. VAPORIZATION OF OILY SLUDGE

Sludge ID	Amount of Oil Sludge Vaporized, % of Applied Oil[a]						Oil Vaporized During 4-Hour Stripping Test, % of Oil in Sludge
	4 Hours After Application			6 Hours After Application			
	Average	Maximum	Minimum	Average	Maximum	Minimum	
SL-11	3.3	6.0	0.6	4.1	8.4	0.6	46.6
SL-12	0.5	1.4	0.06	0.9	1.8	0.15	6.0
SL-13	1.9	4.1	0.15	4.0	8.4	0.4	18.4
SL-14	1.8	5.9	0.0	3.6	9.2	0.0	12.2
Overall	2.0			3.4			

[a]Applied oil amount estimated from results of centrifugation tests

Source: Wetherold, et al, (14), page 60.

TABLE 5-5. COMPOSITION OF AIR FROM SOIL CHAMBER DURING TESTS WITH SLUDGE SL-11

Compound	Sludge Sample			Run 41 Composition of Emissions	
	Sludge Composition, μg/gm	Relative Concentration, wt %	Weight Ratio, Relative to o-Xylene	SL-11 on D-7 Concentration,[a] ppbv-c	Weight Ratio Relative to o-Xylene
Benzene	540	8.9	1.64	0.240	0.17
Toluene	1,700	27.9	5.15	1.481	1.21
m/p-Xylene	700	11.5	2.12	2.382	2.24
o-Xylene	330	5.4	1.00	1.062	1.00
C_3-Benzene	1,100	18.0	6.03	2.366	2.53
C_3- Benzene	890	14.6			
Naphthalene	230	3.8	0.70	--	--
Anthr./Phen.	150	2.5	0.45	--	--
C_9-H.C. (alkane)	130	2.1	0.39	2.036	2.31
C_{12}-H.C. (alkane)	140	2.3	0.42	--	--
C_{17}-H.C. (alkane)	84	1.4	0.25	--	--
C_{17}-H.C. (alkane) (pristine)	66	1.1	0.20	--	--
C_{19}-H.C.	31	0.5	0.09	--	--
C_{20}-H.C.	2	0.0	0.01	--	--
TOTAL	6,093	100			

[a]A dashed line in this column indicates that the compound was not detected in the air sample.

Source: Wetherold, et al, (14), page 66.

TABLE 5-6. COMPOSITION OF AIR FROM SOIL CHAMBER DURING TEST WITH SLUDGE SL-13

Compound	Sludge Samples			Composition of Emissions, Run 43 After Tilling	
	Sludge Composition, μg/gm	Relative Composition, wt %	Weight Ratio, Relative to m/p-Xylene	ppbv-c[a]	Weight Ratio, Relative to m/p-Xylene
Benzene	18	0.6	0.16	12	0.44
Toluene	98	3.4	0.89	32	1.39
m/p-Xylene	110	3.8	1.00	20	1.00
o-Xylene	50	1.7	0.45	--	--
C_3-Benzene	400	13.7	7.27	58	3.3
C_3-Benzene	400	13.7			
Naphthalene	350	12.0	3.18	--	--
Anthr./Phen.	1,100	37.8	10.0	--	--
C_9-H.C. (alkane)	14	0.5	0.13	21	1.27
C_{12}-H.C. (alkane)	210	7.2	1.91	41	3.3
C_{17}-H.C. (alkane)	84	2.9	0.76	--	--
C_{17}-H.C. (alkane) (pristane)	24	0.8	0.22	--	--
C_{19}-H.C.	40	1.4	0.36	--	--
C_{20}-H.C.	16	0.5	0.15	--	--
	2,914				

[a]Dashed line indicates that the compound was not detected in the air sample.

Source: Wetherold, et al, (14), page 67.

TABLE 5-7. COMPOSITION OF AIR FROM SOIL CHAMBER DURING TESTS WITH SLUDGE SL-14

	Concentration in Sludge			Run 29: SL-14 on D-1 Concentration in Air[a]		Run 29: SL-14 on D-1 Concentration in Air[a]		Run 39: SL-14 on D-1 Concentration in Air[a]		Run 42: SL-14 on D-1 Concentration in Air[a]	
	µg/gm	Weight Percent	Weight Ratio, Relative to m/p-Xylene	ppbv-c	Weight Ratio, Relative to m/p-Xylene	ppbv-c	Weight Ratio, Relative to m/p-Xylene	ppbv-c	Weight Ratio, Relative to m/p-Xylene	ppvb-c	Weight Ratio, Relative to m/p-Xylene
Benzene	5	0.6	0.17	204	2.44	72	0.73	21	0.52	53	0.61
Toluene	14	1.8	0.47	166	2.83	200	2.38	72	2.08	94	1.27
m/p-Xylene	30	3.8	1.00	51	1.00	73	1.00	30	1.00	64	1.00
o-Xylene	16	2.0	0.53	-	-	-	-	10	0.33	13	0.20
C_3-Benzene	160	20.4	5.33	363	7.99	39	0.60	34	1.28	94	1.66
C_3-Benzene	140	17.8	4.67								
Naphthalene	64	8.1	2.13	185	4.38	52	0.86	-	-	-	-
Anthr./Phen.	92	11.7	3.07	-	-	-	-	-	-	-	-
C_9-H.C. (alkane)	36	4.6	1.20	19	0.45	-	-	-	-	53	1.00
C_{12}-H.C. (alkane)	120	15.2	4.00	-	-	-	-	-	-	-	-
C_{17}-H.C. (alkane)	68	8.6	2.27	-	-	-	-	-	-	-	-
C_{17}-H.C. (alkane) (pristane)											
C_{19}-H.C.	28	3.6	0.93	-	-	-	-	-	-	-	-
C_{20}-H.C.	14	1.8	0.47	-	-	-	-	-	-	-	-
	787										
Sampling Time Period:				Sample collected for 60 minutes at start of run		Sample collected for 60 minutes at 4 hours after run start		Sample collected for 1 hour at start of run		Sample collected for 30 minutes at start of run	

[a]Dashed line indicates that the compound was not detected in the air sample.

Source: Wetherold, et al, (14), page 68.

TABLE 5-8. AVERAGE MONITORED CONCENTRATIONS AND CONCENTRATIONS OF AIR SAMPLES

Run Number	Average Monitored Hydrocarbon Concentration, ppmv (as hexane)		Canister Concentration	
	First 30 Minutes	First Hour	ppmv-c	ppmv (as hexane)
29	0.101	0.06	2.58	0.43
29	--	--	1.26	0.21
39	1.17	1.22	2.22	0.37
41	8.2	6.7	30.42	5.07
42	0.42	0.23	2.54	0.42
43	3.73	2.43	1.35	0.23
51	0.54	0.42	8.90	1.48
51	0.54	0.42	1.83	0.31

Source: Wetherold, et al, (14); page 69.

15). Environmental Research and Technology, Inc. "Land Treatability of Appendix VIII Constituents Present in Petroleum Industry Wastes." ERT Report No. B-974-220, Prepared for the American Petroleum Institute. February, 1984.

WASTES

This report studied all petroleum wastes disposed of by land treatment operations.

SOILS

Available data on soil types used in petroleum waste land treatment systems included soils that ranged from sands to clays.

WASTE APPLICATION/DESIGN

The waste application rates and designs of the land treatment facilities varied for all of the refineries that participated in this study. The method of study was to assemble literature information as well as existing

petroleum refinery information regarding waste characterization, treatment demonstration, and unsaturated zone monitoring programs.

A major portion of the work regarded identification of Appendix VIII Constituents that may be present in refinery wastes being land treated. A methodology for this identification process included analyses of: petroleum refinery wastes being land treated; petroleum refinery waste waters; soils of petroleum refinery land treatment facilities; crude oil and refined products; and, discussions with individuals knowledgeable of petroleum refinery processes and waste management.

RESULTS AND CONCLUSIONS

- Land treatment of refinery wastes has been successfully practiced in all major climatic regions of the United States, Europe, and Canada.

- Little or no oil degradation was found when the soil temperature was near freezing.

- Most full-scale facilities were found to cultivate their landfarms once per week.

- Nutrient applications to landfarm soil, particularly nitrogen, enhanced oil degradation rates. However, use of soil amendments varied considerably from one refinery to another.

- Annual oil reduction in full scale land treatment facilities typically ranged from 70 to 90% of the applied oil. The entire range varied from 58 to 94% reduction of applied oil per year.

- Two feet below the soil surface was found to be the maximum depth of oil migration at the facilities studied. The oil concentration in the zone of incorporation (typically the upper six inches of the treatment zone) varied widely from refinery to refinery.

- The concentration of heavy aromatics and asphaltenes increased in the soil with oil degradation. The heavy aromatics and asphaltenes were found to degrade, but at a slower rate than the overall oil reduction weight.

- Full scale land treatment facilities have found an accumulation of metals in the zone of incorporation, particularly chromium and lead. The concentration of these metals attenuated to background levels within three to five feet of the soil surface. No migration of the metals out of the treatment zone has been found at a full-scale land treatment facility.

- Accumulation and migration of certain salts, such as sodium, was observed at some facilities, particularly in arid regions. The salt concentration levels were not high enough to impair microbial degradation at any of the sites investigated.

- In the major petroleum waste streams analyzed for Appendix VIII metals and anions, beryllium, cadmium, cyanide, and mercury were the contaminants present in the lowest concentrations (with median concentrations typically less then one milligram per kilogram of waste). Chromium was present in the highest concentrations, and normally exceeded a median concentration of 100 milligrams per kilogram of waste. The other Appendix VIII metals and anions were present in median concentrations of 1-10 milligrams per kilogram of waste.

- Approximately two percent of Appendix VIII organic constituents found in a solid waste were found to be leachable as based on analyses of leachates from the USEPA Extraction Procedure test.

- Toluene, benzene, napthalene, chrysene were found to be the Appendix VIII organics present in the greatest concentrations in DAF waste and API separator sludge. Biological wastewater treatment

sludge were found to be significantly lower in the above compounds, but much higher in concentrations of P-cresol, phenol, and methyl ethyl ketone. Concentrations of phenol and benzo(a)pyrene were very low in all wastes analyzed. Phenol concentrations were commonly less then 10 milligrams per kilogram of waste, and benzo(a)pyrene concentrations are commonly less then 1 milligram per kilogram of waste.

- A list of Appendix VIII organic constituents suspected to be present in petroleum refinery wastes was developed based on knowledge of the refinery process, and knowledge or refinery wastewater discharges.

- An equation was presented, taken from literature, relating organic movement in soil to: soil migration length; velocity of wastewater; bulk density of the soil; porosity of the soil; and, the sediment/water partition coefficient as determined from the slope of the linear portion of

the adsorption isotherm for the constituent. It was stated that waste constituents with sediment/water partition coefficients of greater then 100 milliliters per gram are very immobile in soils.

- The authors concluded that all Appendix VIII organic constituents possibly in land treated petroleum wastes were degradable in soil under the proper conditions.

- It was stated that the organic constituents found to be the most soluble in water have the shortest half-lives. Also, the organic constituents least soluble in water have the longest half-lives.

- Lead and chromium present in full scale land treatment site soil were of very low leaching potential, based on results using the USEPA Extraction Procedure.

TABLES AND FIGURES

Tables and Figures from the study follow.

TABLE 2-4

SUMMARY OF SITE CHARACTERISTICS AT REFINERY LAND TREATMENT FACILITIES

Site Parameter Location	Site A Mont.	Site B Calif.	Site C N.J.	Site D Ill.	Site E Miss.	Site F La.	Site G Wash.	Site H Wash.	Site I Texas	Site J Texas	Site K Texas	Site L Texas	Site M Okla.	Site N Okla.
Land Area (Acres)	11	6	8	30	12	7	14.5	6	50	N.D.	N.D.	1.5	17	19
Degradation * Months/year	6	12	7	7	12	12	7	6	12	12	12	12	9	8
Net Water Budget ** (inches/year)	-29.2	-52.1	19.7	11.0	15.1	16.6	-0.5	20.4	4.3	-41.5	-26	-29.5	2.4	4.4
Surface Soil Texture	silty clay	fine sand	N.D.	silty clay	fine sand	sandy silt	fine sandy clay	silty clay loam	clay	fine sandy loam	clay	clay	silty loam	clayey silt
Cation Exchange	11.3	5.5	N.D.	10-25	8	24	15	5.5	35	8.7	11.4	57	10-20	11
pH	6.6-8.1	6.6-7.0	7.0-7.8	7.7-8.2	6-8	7	6.9	5.7	7.4-8.3	7.5-8.0	6.4-7.3	8.0	6.5-7.2	7
Depth to Seasonally High Water Table (ft)	5	42	2	2'	5	3-5	3	N.D.	12	N.D.	N.D.	N.D.	N.D.	19.5
Depth to Usable Aquifer (ft)	N.D.	130	N.D.	22'	350	219	45	N.D.	50	N.D.	N.D.	200+	12	N.D.
Previous Land Use	Agri-culture	Former Lagoon	Former Sani-tary Landfill	Agri-culture	N.D.	N.D.	N.D.	N.D.	Agri-culture	N.D.	Former Tank Farm	N.D.	N.D.	N.D.

*Degradation month is a month when the average ambient temperature is greater than 10°C.
**Net water budget = precipitation - evapotranspiration.
ND - No Data

Source: ERT, 1983

Source: Environmental Research and Technology, (15), page 2-9.

TABLE 2-6

OIL APPLICATION RATES AND FREQUENCY OF APPLICATION

AT FULL SCALE REFINERY FACILITIES

Site	Location	A Depth of Incorporation (inches)	B Annual Oil Loading Barrels/Acre	B Annual Oil Loading lbs/ft^3 [c]	C Number of Applications Per Year	D[a] Oil Loading Per Application Barrels/acre	D[a] Oil Loading Per Application lbs/ft^3 [c]	E Number of Degradation Months Per Year	F[b] Oil Application/ Degradation Month Barrels/Acre	F[b] Oil Application/ Degradation Month lbs/ft^3 [c]
A	Montana	6	70	0.98	2-3	23-35	0.33-0.49	6	12	0.16
B	California	12	1900	13.35	52	36	0.26	12	158	1.11
C	New Jersey	6-8	650	7.82	2-4	160-325	1.95-3.9	7	93	1.12
D	Illinois	6	100	1.40	N.D.	N.D.	ND	7	14	0.20
E	Mississippi	8	840	8.85	24	35	0.37	12	70	0.74
F	Louisiana	8	380	4.00	5-6	65-75	0.67-0.80	12	32	0.33
G	Washington	6-8	650	7.82	52	12	0.15	7	93	1.11
H	Washington	12	280	1.97	N.D.	N.D.	N.D.	6	47	0.33
I	Texas	6-8	220	2.65	10-12	18-22	0.22-0.26	12	18	0.22
J	Texas	8	680	7.16	10-12	56-68	0.60-0.72	12	57	0.60
K	Texas	6	400	5.62	ND	ND	ND	12	33	0.47
M	Oklahoma	6-8	500	6.00	10-12	42-50	0.5-0.6	9	56	0.67
N	Oklahoma	6	110	1.54	6	18	0.26	8	14	0.19

[a] D = B - C

[b] F = B - E

[c] pounds of oil per cubic foot of incorporation zone

ND - No data available

Source: Environmental Research and Technology, (15), Page 2-15

TABLE 2-7

OIL REDUCTION RATES AT FULL SCALE REFINERY FACILITIES

Site	Location	Years in Operation	Annual Oil Loading		Applications/ Year	Degradation Months/Year	Estimated Annual Oil Reduction		Estimated Oil Reduction/ Degradation Month		% Reduction
			Barrels/ Acre	lbs/ft^3*			Barrels/ Acre	lbs/ft^3*	Barrels/ Acre	lbs/ft^3*	
A	Montana	9	70	0.98	2-3	6	41	0.57	5	0.09	58
B	California	2	1,900	13.35	52	12	1,460	10.28	122	0.86	77
C	New Jersey	8	650	7.82	2-4	7	455	5.47	65	0.78	70
D	Illinois	9	100	1.40		7	70	0.98	10	0.14	70
F	Louisiana	5	380	4.00	5-6	12	332	3.52	28	.29	88
H	Washington	8	280	1.97		6	182	1.26	26	0.21	64
I	Texas	2	220	2.65	10-12	12	163	1.96	14	0.16	74
J	Texas	6	680	7.16	10-12	12	640	6.73	53	0.56	94
K	Texas	3	400	5.62		12	350	4.94	29	0.41	88
M	Oklahoma	12	500	6.00	10-12	9	400	4.80	36	0.53	80
N	Oklahoma	5	110	1.54	6	8	70	0.98	9	0.12	64

*pounds of oil per cubic foot of incorporation zone

Source: Environmental Research and Technology, (15), page 2-17

TABLE 2-8

OIL REDUCTION RATES AT PILOT SCALE REFINERY FACILITIES

Site	Location	Years in Operation	Types of Waste Added	Average Annual Oil Loading		Applications/ Year	Degradation Mos./yr.	Estimated Annual Oil Reduction		Estimated Oil Reduction/ Degradation Month		% Reduction
				Barrels/Acre	lbs/ft^3*			Barrels/ Year	lbs/ft^3*	Barrels/ Acre	lbs/ft^3*	
1.	Ohio	3	Composite Centrifuged Oily Sludge	735	7.72	4-5	6	595	6.25	99	1.04	81
			API Separator Sludge	690	7.25	4-5	6	607	6.38	101	1.06	88
2.	Oklahoma	3	Composite Oily Sludge	1140	11.97	5-7	9	832	8.74	93	0.97	73
			Composite Oily Sludge	730	7.68	5-7	9	569	5.99	63	0.66	78
			Composite Oily and Biological Sludge	540	5.67	3-7	9	340	3.57	38	0.40	63
3.	Texas	3	DAF Sludge	162	1.70	4-7	12	152	1.60	12	0.13	94
			Separator Sludge	177	1.86	4-7	12	129	1.36	11	0.11	73
			Tank Bottoms Sludge	345	3.62	2-3	12	314	3.29	26	0.27	91
4.	Oklahoma	2	Composite Oily Sludge	380	3.99	1	8	163	1.71	20	0.21	43

*pounds of oil per cubic foot of incorporation zone

Source: Environmental Research and Technology, (15), page 2-18.

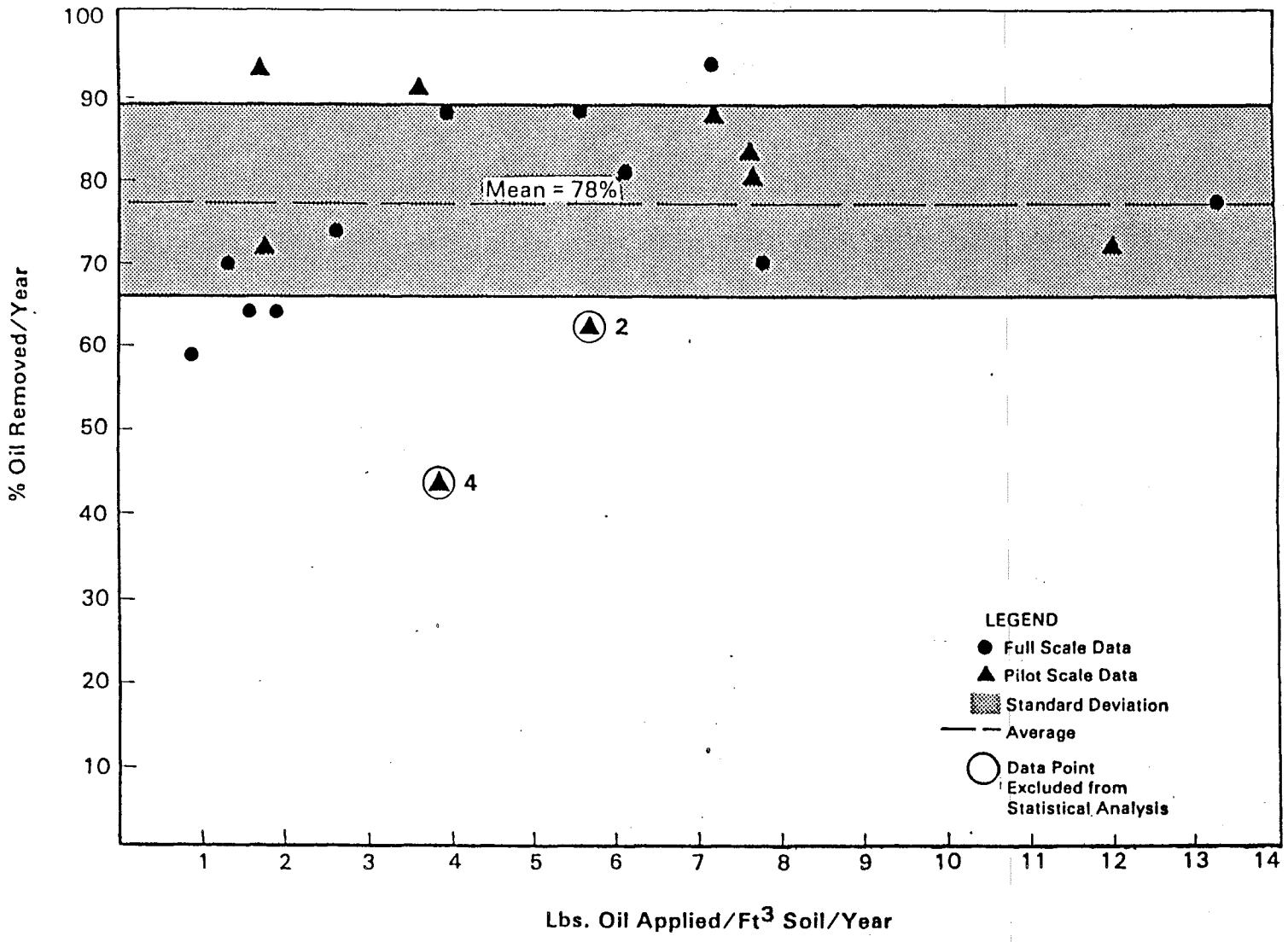

Figure 2-4 % Oil Removed Vs. Oil Application Rate

Source: Environmental Research and Technology, (15), page 2-19.

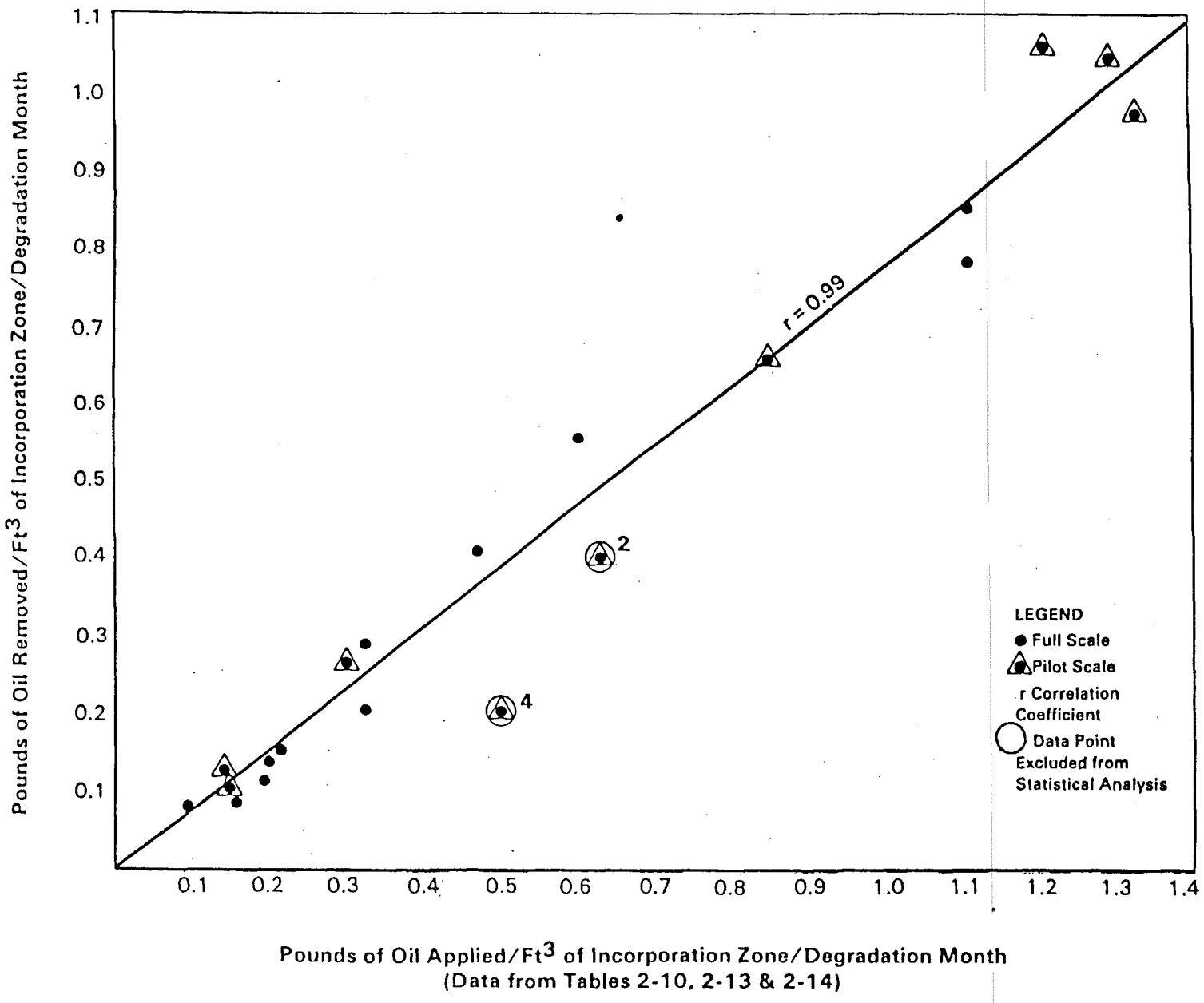

Figure 2-5 Oil Removal Rates as a Function of Oil Application Rates
Source: Environmental Research and Technology, (15), page 2-21.

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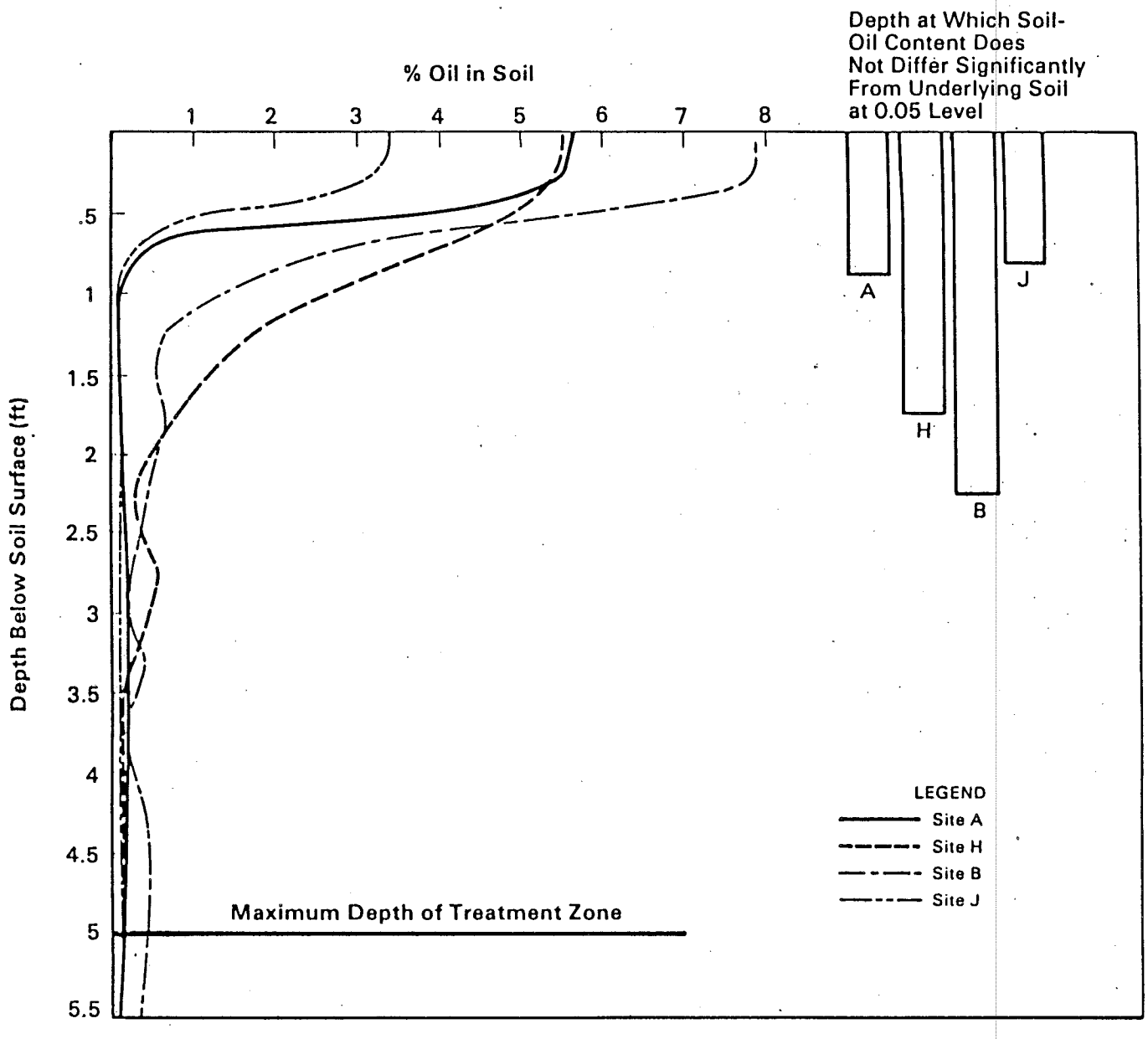

Figure 2-7 Oil Content in Soil with Depth

Source: Environmental Research and Technology, (15), page 2-24.

TABLE 2-9

METAL CONTENT OF ACTIVE REFINERY FACILITIES*

Depth Below Ground Surface (ft.)	As	Cd	Cr	Cu	Hg	Ni	Pb	V	Zn
	mg/kg Dry Soil Weight								
0-1									
	2.76	5.11	277	89	2.11	17.5	718	45.5	306
	0.41-16.3	0.11-10	1.5-1468	2.3-260	0.04-11	2.5-50	2.5-5560	2.5-121	7.3-1041
	15	23	30	15	23	24	30	15	22
	21	29	48	27	29	29	48	20	34
1-3									
	2.14	5.00	71.8	32.1	0.55	18.6	119	46	180
	0.06-11.3	0.03-10	1.4-315	2.4-75	0.01-1.8	2.9-50	1.47-1250	2.5-130	3.7-1175
	16	19	23	7	21	21	23	18	16
	36	39	49	13	41	41	49	38	22
3-5									
	1.89	2.15	76.3	33.7	0.42	17.0	19.5	57.3	72.6
	0.063-6.6	0.01-4	1.5-248	4.0-84	0.01-1.2	4.0-30.9	0.84-40	2.5-94.4	15.3-138
	9	14	17	8	14	13	17	13	8
	15	22	25	10	22	20	25	20	10

*Data reported as:

Average
Range
No. of Individual Plots Sampled
No. of Total Samples Collected

Source: American Petroleum Institute, 1983.

Source: Environmental Research and Technology, (15), page 2-26.

TABLE 2-10

METAL CONTENT OF BACKGROUND SOILS NEAR REFINERY FACILITIES*

Depth Below Ground Surface (ft.)	As	Cd	Cr	Cu	Hg	Ni	Pb	V	Zn
	mg/kg Dry Soil Weight								
0-1									
	2.74	3.51	65.8	24.3	0.675	17.1	40.5	52.1	92.1
	0.08-6.2	0.07-10	1.7-244	6.3-42	0.07-1.6	1.8-50	4.91-150	2.5-109.3	16.3-156
	7	9	12	5	9	10	12	9	6
	16	20	23	7	20	18	23	17	9
1-3									
	1.79	2.42	30.1	8.1	0.81	15.9	24.5	58.6	74.2
	0.1-4.8	0.03-8	2-146	7.4-8.7	0.01-1.5	4.0-36	1.1-88.5	2.5-111	9.8-176
	7	7	9	2	8	9	9	9	4
	27	27	33	6	28	28	33	28	9
3-5									
	2.07	1.75	37.9	12	0.74	18.7	18.7	84.3	85
	0.11-3.9	0.02-4.0	2.07-152	-	0.01-1.4	7.9-29.0	1.26-40	44.1-152	-
	2.07	7	7	1	7	6	7	6	1
	13	16	16	3	16	13	16	13	3

*Data reported as:

Average
Range
No. of Individual Plots Sampled
No. of Total Samples Collected

Source: American Petroleum Institute, 1983.

Source: Environmental Research and Technology, (15), page 2-27.

TABLE 3-1

ESTIMATED AMOUNTS OF REFINERY WASTES WHICH ARE LAND TREATED

	% Refineries Which Landfarm Waste[b,c]	Estimated Annual Generation Rate by All U.S. Refineries[c] (10^3 Tons/Yr)		Estimated Annual Amount of[d] Waste Applied to Landfarm (10^3 Tons/Yr)	
		Oil Basis	Oil & Solids Basis	Oil Basis	Oil & solids Basis
DAF Float	50	27	62	14	31
API Separator Sludge	62	47	144	29.	89.28
Slop Oil Emulsion Solids[a]	39	27	58	11.	23
Heat Exchanger Bundle[a] Cleaning Sludge	28	0.02	0.7	0.01	0.20
Leaded Tank Bottoms[a]	23	0.3	2	0.07	0.46
Non Leaded Tank Bottoms[a]	51	26	85	13	43
Bio Sludge	75	1	34	0.75	26
Primary Sludge[a]	62	6	23	3.72	14
Secondary Sludge[a]	36	2	6	0.72	2.2
Filter Clays[a]	20	1.3	10	0.26	2.0
Cooling Tower Sludge[a]	50	0.07	6	0.03	3.0
Stretford Solution[a]	9	0	0.7	0	0.06
Neutralized HF Alkylation[a] Sludge	37	0.6	12	0.22	4.4
FCC Catalyst	5	0.9	101	0.04	5.1
Spent Catalysts	10	0.07	15	0.01	1.5
		139	559	72	245

(a) These wastes are often routed to the API separator. The % shown is that portion which is directly landtreated and not routed to the API separator.

(b) Source: ERM, 1982

(c) % of responding refineries possessing the particular sludge which land treat it (survey included approximately 100 refineries).

(d) Estimated from the product of the previous columns.

Source: Environmental Research and Technology, (15), page 3-3.

TABLE 3-3

MEDIAN CONCENTRATIONS OF APPENDIX VIII METALS AND ANIONS DETECTED IN REFINERY SOLID WASTES

(mg/kg)[a]

Waste Stream	Arsenic		Beryllium	Cadmium		Chromium			Cyanide		Fluoride[b]	Lead		
	Eng/Sc	Jacobs	Jacobs	Eng/Sc	Jacobs	Eng/Sc	Jacobs	ERM	Eng/Sc	Jacobs	Eng/Sc	Eng/Sc	Jacobs	ERM
Crude Oil[c]	0.023	NA	NA	0.06	NA	0.04	NA	NA	NA	NA	NA	0.25	NA	NA
Dissolved Air Flotation	0.04	2.0	0.0025	0.6	0.005	190.0	140.0	42.5	0.44	0.28	8.3	8.3	7.5	17.5
API Separator Sludge	2.0	6.2	0.0025	1.04	0.42	161.5	253.0	146	0.29	0.001	4.5	45.0	26.0	54
Wastewater Treatment Plant Sludge	2.85	3.8	0.0013	0.74	0.3	270.0	300.0	129.5	0.35	0.001	5.4	30.4	5.0	14.0
Storm Water Runoff ~~Site~~ Silt	3.0	5.5	0.0019	1.1	0.22	150.0	354	NA	NA	1.72	NA	182.0	53.3	NA
Tank Bottoms (Crude)	1.6	21.1	0.0026	0.8	0.31	2.5	19.4	NA	0.22	0.0012	1.06	7.9	18.9	NA
Tank Bottoms (Leaded)	NA	294	0.0025	NA	6.3	NA	11.4	95.5	NA	0.009	NA	NA	790.0	535.0
Tank Bottoms (non leaded)	NA	0.007	0.26	NA	0.33	NA	12.9	90.0	NA	7.4	NA	NA	24.7	46.0
Once Through(c) Cooling Sludge	1.3	5.4	0.24	0.86	0.003	42	63.0	NA	NA	0.11	NA	36.5	57.0	0
Cooling Tower (c) Sludge	8.3	8.2	0.0013	0.9	0.3	865.0	554.0	2430	NA	0.1	NA	48.0	38.0	83.5
FCC Catalyst(c)	1.0	1.0	0.5	2.0	0.003	47.0	71.0	48.0	NA	0.12	NA	11.1	50.0	72.5
Kerosene Filter Clay	NA	2.2	0.2	NA	0.25	NA	2.88	NA	NA	0.005	NA	NA	8.3	NA
Lube Oil Filter Clay	NA	0.7	0.26	NA	0.76	NA	23.2	NA	NA	0.12	NA	NA	1.28	NA
Heat Exchange Bundle Cleaning Sludge	NA	10.6	0.20	NA	1.3	NA	311.0	217.0	NA	1.7	NA	NA	78.0	328.0
Slop Oil Emulsion Solids	NA	7.4	0.0025	NA	0.19	NA	525.0	NA	NA	0.001	NA	NA	28.1	49.0
Coke Fines	NA	2.0	0.005A	NA	1.0	NA	0.02	NA	NA	0.001	NA	NA	13.0	
Neutralized HF Alkylation Sludge	NA	2.3	0.07	NA	0.07	NA	2.8	28.5	NA	23.1	22,200	NA	7.1	33.0
Spent Lime from Boiler Feedwater	NA	0.1	0.0012	NA	0.003	NA	2.2	NA	NA	0.001	NA	NA	3.8	NA

Source: Environmental Research and Technology, (15), page 3-8.

NA = Not Analyzed

TABLE 3-3 (continued)
(mg/kg)[a]

Waste Stream	Mercury		Nickel		Selenium		Vanadium		Copper[b]		Zinc[b]	
	Eng/SC	Jacobs	Eng/SC	Jacobs	Eng/SC	Jacobs	Eng/SC	Jacobs	Eng/SC	Jacobs	Eng/SC	Jacobs
Crude Oil[c]	0.13	NA	2.65	NA	0.008	NA	2.0	NA	0.028	NA	0.63	NA
Dissolved Air Flotation	0.1	0.27	4.15	0.025	0.1	2.0	4.8	0.05	15.7	7.0	72.3	85.0
API Separator Sludge	0.3	0.4	11.7	19.3	0.2	0.001	13.7	9.8	55.2	18.6	191.6	298.0
Wastewater Treatment Plant Sludge	0.08	0.18	5.85	0.025	0.25	0.01	4.74	0.05	8.6	9.5	200.0	122.0
Storm Water Runoff Site	0.63	0.30	24.0	85.0	0.8	1.7	21.0	69.0	73.0	28.3	207.0	230.0
Tank Bottoms (Crude)	0.051	0.48	9.7	16.2	0.39	0.03	11.8	17.4	7.2	65.4	9.9	145.0
Tank Bottoms (Leaded)	NA	0.57	NA	314.0	NA	6.95	NA	5.4	NA	141.0	NA	9092.0
Tank Bottoms (non leaded)	NA	0.43	NA	26.7	NA	12.0	NA	21.9	NA	85.1	NA	285.0
Once Through[c] Cooling Sludge	0.19	0.51	14.0	35.0	2.7	1.6	11.0	39.0	47.5	153.0	49.5	125.0
Cooling Tower[c] Sludge	0.12	0.09	15.0	6.8	1.6	0.015	29.0	7.8	170.0	50.0	490.0	675.0
FCC Catalyst[c]	0.22	0.004	190.0	241	0.9	0.01	230.0	240.0	23.0	17.5	37.0	39.0
Kerosene Filter Clay	NA	0.004	NA	0.04	NA	9.6	NA	35.0	NA	11.4	NA	25.0
Lube Oil Filter Clay	NA	0.19	NA	11.1	NA	1.1	NA	33.0	NA	4.3	NA	57.6
Heat Exchange Bundle Cleaning Sludge	NA	1.9	NA	116.0	NA	27.2	NA	25.0	NA	71.0	NA	194.0
Slop Oil Emulsion Solids	NA	0.59	NA	50.0	NA	1.0	NA	25.0	NA	48.0	NA	250.0
Coke Fines	NA	0.04	NA	580	NA	0.01	NA	455.0	NA	4.0	NA	14.0
Neutralized HF Alkylation Sludge	NA	0.07	NA	55.2	NA	7.10	NA	2.6	NA	14.3	NA	9.1
Spent Lime from Boiler Feedwater	NA	0.4	NA	2.5	NA	0.01	NA	0.05	NA	3.8	NA	15.0

(a) Jacobs data reported on a dry weight basis, Eng/Sc and ERM data is on a whole weight basis
(b) Noted constituents are not listed Appendix VIII Constituents, however, compounds containing these constituents are listed in Appendix VIII.
(c) Engineering Science (Eng/Sc) data is for solid phase only.
NA = Not Analyzed

Source: Environmental Research and Technology, (15), page 3-9.

TABLE 3-4

MEDIAN CONCENTRATION RANGES FOR APPENDIX VIII METALS AND ANIONS IN WASTES COMMONLY LAND TREATED

	Arsenic	Beryllium	Cadmium	Chromium	Copper	Cyanide	Lead	Mercury	Nickel	Selenium	Vanadium	Zinc
DAF Float	*	*	*	X	o	*	+	*	+	+	+	o
API Separator Sludge	+	*	+	X	o	*	o	*	o	*	+ o	X
Slop Oil Emulsion Solids	+	*	*	N.A.	o	*	o	*	o	+	o	X
Wastewater Treatment Sludge	+	*	*	X	o	*	o	*	+	*	+	X
Tank Bottoms (non-leaded)	*	*	*	o	o	+	o	*	o	o	o	X

* = <1ppm

\+ = 1-10 ppm

o = 10-100 ppm

X = 100 ppm

Source: Engineering Science, 1976

Source: Environmental Research and Technology, (15), page 3-10.

TABLE 3-5

CONCENTRATIONS OF BENZO-A-PYRENE AND PHENOL IN PETROLEUM WASTES

	Benzo-a-Pyrene (mg/kg)			Phenol(mg/kg)			
	Jacobs(a)	Eng/SC(b)	Stewart(c)	Jacobs(a)	Eng/SC(b)	Weldon(d)	Stewart(c)
Crude Oil	NA	1.5	NA	NA	5.6	NA	NA
Dissolved Air Flotation	0.002	1.9	0-1.75	6.5	3.1	NA	3.0-210
API Separator Sludge	0.004	0.7	0-3.7	13.6	2.75	NA	3.8-157
Wastewater Treatment Plant Sludge	0.003	0.5	Trace	4.5	1.0	NA	1.7-10.2
Storm Water Silt	1.27	NA	NA	7.5	1.2	NA	NA
Tank Bottoms Crude	0.11	1.7	0-0.6	15.8	3.3	NA	6.1-37.8
Tank Bottoms (Leaded)	0.21	NA	NA	126	(3.75 & 2.5)	NA	NA
Tank Bottoms (Non-leaded)	0.6	NA	0.3-0.9	1.8	NA	4.6	1.7-1.8
Once Through Cooling Sludge	0.004	NA	0-1.8	2.0	2.5	NA	0-2.1
Cooling Tower Sludge	0.004	NA	NA	3.5	0.79	NA	NA
FCC Catalyst	0.005	NA	NA	2.1	0.39	NA	NA
Kerosene Filter Clays	1.8	NA	NA	2.6	NA	NA	NA
	NA	0.01[e]	NA	NA	2.75[e]	NA	NA
Lube Oil Filter Clays	0.1	NA	NA	3.2	NA	NA	NA
Heat Exchange Bundle Cleaning Sludge	2.2	NA	NA	13.3	NA	NA	NA
Slop Oil Emulsion Solids	0.003	NA	0-0.01	15	NA	NA	5.7-68
Coke Fines	0.002	NA	NA	2.0	NA	NA	NA
Neutralized HF Alkylation Sludge	NA	NA	NA	8.9	NA	NA	NA
Spent Lime From Boiler Feedwater	0.002	NA	NA	2.1	NA	NA	NA

a) Source - Jacobs, 1976 Industry-Wide Survey

b) Source - Engineering Science 1978 Industry-Wide Survey

c) Source - Stewart, 1978 Select Wastes

d) Source - Weldon 1982 Select Wastes

e) Includes Kerosene and Lube Oil Filter Clays

NA - not analyzed

Source: Environmental Research and Technology, (15), page 3-11.

TABLE 3-6

APPENDIX VIII ORGANIC CONSTITUENTS ANALYZED FOR IN SELECT PETROLEUM REFINERY WASTES

Constituent	DAF Sludge[a] (mg/kg) as is basis	API Separator[b] Bottoms (mg/kg) as is basis	Digested[a] Bio Sludge mg/kg D.M.
Benzene	102	230	1
Toluene	1700	1200	0.6
Phenol	1.3	0.19	13.4
4,6-dinitro-o-cresol	N.D.	N.D.	N.D.
Benzo(a)anthracene	N.D.	160	N.D.
Benzo(k)fluoranthene	N.D.	N.D.	N.D.
benzo(a)pyrene	N.D.	N.D.	N.D.
chrysene	51	140	20.1
Fluoranthene	N.D.	N.D.	N.D.
Naphthalene	1430	N.D.	Trace
Di-n-octylphthalate + bis-(2-ethylhexyl) phthalate	22	N.D.	49.0
Nitrobenzene			

a - mean value

b - only one sample

D.M. - dry matter

N.D. - not detected

Source: PACE, 1983

Source: Environmental Research and Technology, (15), page 3-13

TABLE 3-7

CONCENTRATION RANGES FOR SPECIFIC APPENDIX VIII CONSTITUENTS IN EP TOXIC EXTRACTS OF REFINERY WASTES (mg/l in the extract)*

Constituent	Separators	Slop Oil	DAF	Biopond
Toluene	0.31-5.7	4.8-13	5.7	2.2
Naphthalene	0.01-0.24	0.14-1.6	0.32	NA
Fluoranthene	0.035-9.4	1.7	10	NA
Chrysene/Benzanthracene	0.14-15	0.40-1.5	15	NA
Benzopyrene/benzo fluoranthene	22.7	2.9	11	NA

*The concentration in ug/g of orginal solid is approximately .02 times the value given for ug/l in the extract.

NA = Not analyzed

Source: Environmental Research and Technology, (15), page 3-14.

TABLE 3-8

APPENDIX VIII CONSTITUENTS FOUND IN WASTEWATER FROM API SEPARATORS AND DAF UNITS

Antimony
*Arsenic
*Benzo(a)pyrene
*Beryllium
*Bis(2-ethylhexyl) Phthalate
*Cadmium
Chloroform
2-Chlorophenol
*Chromium
*Chrysene
*Cyanides
DDE
1,2-dichloroethane
Dichloroethylene
Diethyl Phthalate
2,4-dimethyl phenol
4,6-dinitro-o-cresol
2,4-dinitrophenol
Di-n-octylphthalate
*Fluoranthene
Hexachlorobenzene
*Lead
*Mercury
*Naphthalene
*Nickel
4-nitrophenol
Pentachlorobenzene
*Phenol
*Selenium
Silver
Tetrachloroethylene
*Toluene

*Previously listed as known to be present

Source: EPA (1982)

Source: Environmental Research and Technology, (15), page 3-16.

TABLE 3-11

FINAL CATEGORIES FOR APPENDIX VIII CONSTITUTENTS IN REFINERY WASTES WHICH ARE LAND TREATED

Known to be Present	Suspected to be Present	Expected not to be Present
Arsenic	Antimony	All other
Benzene	Benz(c)acridine	EPA Appendix VIII
Bis(2-ethylhexyl)phthalate	Dibenz(a,h)acridine	Constituents
butyl benzyl phthalate	Dibenz(a,j)acridine	
Benzanthracene	Dibenz(a,h)anthracene	
Benzo(a)pyrene	Dibenz(c,g)carbazole	
Benzo fluoranthene	Dibenz(a,e)pyrene	
Beryllium	Dibenz(a,h)pyrene	
Cadmium	Dibenz(a,i)pyrene	
Chromium	Diethyl phthalate	
Chrysene	Ethylene dibromide	
Copper'	Ethylene dichloride	
Cyanide	7,12-dimethylbenz(a)anthracene	
Fluoranthene	2,4-dimethyl phenol	
Lead	4,6-dinitro-o-cresol	
Mercury	2,4-dinitrotoluene	
Naphthalene	2.6-dinitrotoluene	
Nickel	2,4-dinitrophenol	
Phenol	di-n-octylphthalate	
Selenium	di-n-propylnitrosamine	
Silver	Hydrogen sulfide	
Toluene	Indeno(1,2,3-cd)pyrene	
Vanadium'	Nitrobenzene	
Zinc	4-nitrophenol	
	Phthalic acid esters, N.O.S.	
	Pyridine	
	Tetraethyl Lead	

Source: Environmental Research and Technology, (15), page 3-21.

TABLE 4-3

SUMMARY OF A SOIL ADSORPTION DATA FOR ORGANIC CONSTITUENTS

Compound	Aqueous Solubility (mg/l)	log octanol/ water parti- Coefficient Kow	Organic Carbon Partition Coefficient Koc
Monoaromatics			
Benzene	1780-1800 (25°C)	1.95-2.13	83[a]
Toluene	535 (25°C)	2.69	No Data
Nitrobenzene	1000 (20°C)	1.85	No Data
2,4-Dinitrotoluene	270 (22°C)	2.01	No Data
2,6-Dinitrotoluene	No Data	2.05	No Data
Phenolics			
Phenol	93,000 (25°C)	1.46	No.Data
2,4-Dimethylphenol	4,200 (20°C)	2.50	No Data
4,6-Dinitro-o-cresol		2.85	No Data
4-Nitrophenol	16,000 (25°C)	1.91	No Data
2,4-Dinitrophenol	5,600 (18°C)	1.53	No Data
Phthalate Esters			
Bis (2-ethylhexyl)	0.4 (25°C)	5.3-8.7	31,700[b]
Butyl Benzyl	2.9	4.8-5.8	21,900[b]
Diethyl	896 (25°C)	3.22	1,870[b]
Di-n-octyl	3.0 (25°C)	9.2	No Data
Dimethyl	4320 (25°C)	2.12	No Data
PAH			
Benz(c)acridine	No Data	No Data	No Data
Benz(a)Anthracene	0.014	5.61	1,871,400[c]
Benzo(b)-Fluoroanthene	0.0012	6.57	No Data
Benzo(j)-Fluoroanthene	No Data	No Data	No Data
Benzo(a)Pyrene	0.005	6.04	4,510,650[d]
Chrysene	0.0018	5.61	No Data
Dibenz(a,h)Acridine	No Data	No Data	No Data
Dibenz(a,j)Acridine	No Data	No Data	No Data
Dibenz(a,h)-Anthracene	0.0005	5.97	2,029,000[e]
7H Dibenzo(c-g)Carbazole	No Data	No Data	No Data
Dibenzo(a,e)Pyrene	No Data	No Data	No Data
Dibenzo(a,h)Pyrene	No Data	No Data	No Data
Dibenzo(a,i)Pyrene	No Data	No Data	No Data
7,12-Dimethylbenz(a)-Anthracene	0.0244	5.97	225,308[e]
Fluoranthene	0.26	5.33	No Data
Indeno(1,2,3-cd)-Pyrene	0.0002	7.66	No Data
Naphthalene	31.7	3.37	1,300[d]

[a]Karickhoff et al., 1979
[b]McDuffie and Russell, 1982
[c]Hasset et al., 1980
[d]Reinbold et al., 1978
[e]Means et al., 1980

Source: Environmental Research and Technology, (15), page 4-13.

TABLE 4-4

KINETIC PARAMETERS DESCRIBING RATES OF DEGRADATION OF ORGANIC COMPOUNDS IN SOIL SYSTEMS

Substance	Initial Concentration (ug/g soil)	K (day^{-1})	1/2 Life (days)	Reference
Toluene	5,000-20,000	0.40-1.0	0.7-1.7	Donnelly (1979)
Toluene	-	0.10	7	Berkowitz et al (1979)
Pyridine	-	0.10	7	Berkowitz et al (1979)
Phenol	500	0.693	1.0	Medvedev & Davidov (1972)
Phenol	500	0.315*	2.2*	Medvedev & Davidov (1972)
2,4-dimethylphenol	500	0.35-0.69	1-2	Medvedev & Davidov (1972)
4,6-dinitro-o-cresol	-	0.023	30	Versar, Inc. (1977)
2,4-dinitrophenol	5-50	0.025	28	Overcash et al. (1982)
2,4-dinitrophenol	20-25	0.099-0.23	3-7	Sudhakar-Barik & Sethunathan (1978)
4-nitrophenol	-	0.043	16	Verschueren (1977)
Bis(2-ethylhexyl phthalate)	-	0.050	14	Johnson and Lulves (1975)
Diethyl Phthalate	10	0.173	4	McDuffie & Russell (1982)
Napthalene	7	5.78	0.12	Herbes & Schwall (1978)
Napthalene	7	0.005*	125*	Herbes & Schwall (1978)
Napthalene	7	0.173	4**	Herbes & Schwall (1978)
Benz(a)anthracene	0.12	0.046*	15.2*	Herbes & Schwall (1978)
Benz(a)anthracene	0.12	0.0001	6,250	Herbes & Schwall (1978)
Benz(a)anthracene	3.5	0.007	102	Groenewegen & Stolp (1976)
Benz(a)anthracene	20.8	0.003	231	Gardner et al. (1979)
Benz(a)anthracene	25.8	0.005	133	Gardner et al. (1979)
Benz(a)anthracene	17.2	0.008	199	Gardner et al. (1979)
Benz(a)anthracene	22.1	0.006	118	Gardner et al. (1979)
Benz(a)anthracene	42.6	0.003	252	Gardner et al. (1979)
Benz(a)anthracene	72.8	0.004	196	Gardner et al. (1979)
Benz(a)anthracene	0.07	0.005	134	Sims (1982)
Benz(a)anthracene	0.10	0.005	142	Sims (1982)
Benz(a)anthracene	0.15	0.005	154	Sims (1982)
Benz(a)anthracene	7	0.016	43	Sims (1982)

*Low temperature (<15°C)

**High temperature (>25°C)

Source: Environmental Research and Technology, (15), page 4-14.

TABLE 4-4 (Continued)

Substance	Initial Concentration (ug/g soil)	K (day^{-1})	1/2 Life (days)	Reference
Benz(a)anthracene	8.2	0.017	41	Sims (1982)
Benz(a)anthracene	9.7	0.017	41	Sims (1982)
Chrysene	4.4	0	-	Groenewegen & Stolp (1976)
Chrysene	500	0.067	10.5	Medvedev & Davidov (1972)
Chrysene	5	0.126	5.5	Medvedev & Davidov (1972)
Dibenz(a,j)-acridine	0.57	0.015	44	Sims (1982)
Dibenz(a,j)-acridine	0.71	0.017	40	Sims (1982)
Dibenz(a,j)-acridine	0.69	0.012	55	Sims (1982)
Dibenz(a,j)-acridine	57	0.016	43	Sims (1982)
Dibenz(a,j)-acridine	64	0.017	41	Sims (1982)
Dibenz(a,j)-acridine	73	0.015	46	Sims (1982)
Indeno(1,2,3-cd)-pyrene	0.57	0.001	600	Sims (1982)
Indeno(1,2,3-cd)-pyrene	1.14	0.002	360	Sims (1982)
Indeno(1,2,3-cd)-pyrene	1.30	0.003	200	Sims (1982)
Indeno(1,2,3-cd)-pyrene	57	0.001	600	Sims (1982)
Indeno(1,2,3-cd)-pyrene	114	0.001	600	Sims (1982)
Indeno(1,2,3-cd)-pyrene	168	0.001	600	Sims (1982)
Dibenz(a,h)-anthracene	9700	0.033**	21**	Lijinsky & Quastel (1956)
Dibenz(a,h)-anthracene	5.7	0.004	183	Sims (1982)
Dibenz(a,h)-anthracene	4.5	0.005	141	Sims (1982)
Dibenz(a,h)-anthracene	3.5	0.004	190	Sims (1982)
Dibenz(a,h)-anthracene	57	0.005	130	Sims (1982)
Dibenz(a,h)-anthracene	93	0.007	99	Sims (1982)
Dibenz(a,h)-anthracene	147	0.007	119	Sims (1982)

*Low temperature (<15°C)

**High temperature (>25°C)

Source: Environmental Research and Technology, (15), page 4-15.

TABLE 4-4 (Continued)

Substance	Initial Concentration (ug/g soil)	K (day^{-1})	1/2 Life (days)	Reference
Fluoranthene	3.9	0.016	44	Groenewegen & Stolp (1976)
Fluoranthene	18.0	0.004	182	Gardner et al. (1979)
Fluoranthene	23.0	0.007	105	Groenewegen & Stolp (1976)
Fluoranthene	16.5	0.005	143	Gardner et al. (1979)
Fluoranthene	20.9	0.006	109	Groenewegen & Stolp (1976)
Fluoranthene	44.5	0.004	175	Gardner et al. (1979)
Fluoranthene	72.8	0.005	133	Gardner et al. (1979)
Benzo(b)fluoranthene	0.33	0.007	98	Sims (1982)
Benzo(b)fluoranthene	0.57	0.006	123	Sims (1982)
Benzo(b)fluoranthene	0.30	0.006	130	Sims (1982)
Benzo(b)fluoranthene	33	0.010	67	Sims (1982)
Benzo(b)fluoranthene	46	0.008	85	Sims (1982)
Benzo(b)fluoranthene	53	0.010	73	Sims (1982)
Benz(a)pyrene	0.048	0.014*	50*	Herbes & Schwall (1978)
Benz(a)pyrene	0.01	0.001*	694*	Herbes & Schwall (1978)
Benz(a)pyrene	3.4	0.012	57	Groenewegen & Stolp (1976)
Benz(a)pyrene	9.5	0.002	294	Gardner et al. (1979)
Benz(a)pyrene	12.3	0.005	147	Gardner et al. (1979)
Benz(a)pyrene	7.6	0.003	264	Gardner et al. (1979)
Benz(a)pyrene	18.5	0.023	30	Gardner et al. (1979)
Benz(a)pyrene	17.0	0.002	420	Gardner et al. (1979)
Benz(a)pyrene	32.6	0.004	175	Gardner et al. (1979)
Benz(a)pyrene	1.0	0.347**	2**	Shabad et al. (1971)
Benz(a)pyrene	0.513	0.347**	2**	Shabad et al. (1971)
Benz(a)pyrene	0.00135	0.139**	5**	Shabad et al. (1971)
Benz(a)pyrene	0.0094	0.002*	406*	Shabad et al. (1971)
Benz(a)pyrene	0.545	0.011	66	Shabad et al. (1971)
Benz(a)pyrene	28.5	0.019*	37*	Shabad et al. (1971)
Benz(a)pyrene	29.2	0	-	Shabad et al. (1971)

*Low temperature (<15°C)

**High temperature (>25°C)

Source: Environmental Research and Technology, (15), page 4-16.

TABLE 4-4 (Continued)

Substance	Initial Concentration (µg/g soil)	K (day^{-1})	1/2 Life (days)	Reference
Benz(a)pyrene	9,100	0.018**	39**	Liginsky & Quastel (1956)
Benz(a)pyrene	19.5	0.099	7	Poglazova et al. (1967b)
Benz(a)pyrene	19.5	0.139	5	Poglazova et al. (1967b)
Benz(a)pyrene	19.5	0.231	3	Poglazova et al. (1967b)
Benz(a)pyrene	130.6	0.173	4	Poglazova et al. (1967b)
Benz(a)pyrene	130.6	0.116	6	Poglazova et al. (1967b)
Benz(a)pyrene	0.36	0.009	79	Sims (1982)
Benz(a)pyrene	0.41	0.008	83	Sims (1982)
Benz(a)pyrene	0.75	0.006	120	Sims (1982)
Benz(a)pyrene	36	0.008	92	Sims (1982)
Benz(a)pyrene	55	0.007	100	Sims (1982)
Benz(a)pyrene	69	0.008	92	Sims (1982)

*Low temperature (<15°C)

**High temperature (>25°C)

Source: Environmental Research and Technology, (15), page 4-17.

TABLE 4-5

ESTIMATES OF DEGRADATION AND IMMOBILIZATION CONSTANTS

	First Order[a] Kinetic Constant, K ($days^{-1}$)	Carbon Partion[b] Coefficient, K_{oc} (ml/g)
MONOAROMATICS		
Benzene	0.1-1.0[e]	83
Toluene	0.40-1.0	100-1000[e]
Nitrobenzene	0.01-0.1[e]	10-100[e]
2,4 Dinitrotoluene	0.01-0.1[e]	10-100[e]
2,6 Dinitrotoluene	0.01-0.1[e]	10-100[e]
PHENOLICS		
Phenol	0.69	10-100[e]
2,4-dimethylphenol	0.35-0.69	100-1000[e]
4,6-dinitro-o-cresol	>0.023	100-1000[e]
4-nitrophenol	>0.043	10-100[e]
2,4-dinitrophenol	>0.025	10-100[e]
PHTHALATE ESTERS		
Bis(2-ethylhexyl)	>0.05	31,700
Butyl Benzyl	0.1-1.0[e]	21,900-7[e]
Diethyl	>0.17	1,870
Di-n-octyl	0.01-0.10[e]	>1,000,000[e]
Dimethyl	0.1-1.0[e]	100-1000[e]
PAH		
Benz(c)acridine	0.001-0.10[e]	100,000-1,000,000[e]
Benz(a)anthracene	0.003[d]-0.017	1,871,400
Benzo(b)fluoranthene	0.006-0.010	>1,000,000[e]
Benzo(j)fluoranthene	0.001-0.10[e]	>1,000,000[e]
Benzo(a)pyrene	0.002-0.023	4,510,650
Chrysene	0.067-0.126	100,000-1,000,000[e]
Dibenz(a,h)acridine	0.001-0.10[e]	100,000-1,000,000[e]
Dibenz(a,j)acridine	0.12-0.017	100,000-1,000,000[e]
Dibenz(a,h)anthracene	0.004-0.007	1,668,800

Source: Environmental Research and Technology, (15), page 4-19.

TABLE 4-5 (Continued)

ESTIMATES OF DEGRADATION AND IMMOBILIZATION CONSTANTS

	First Order[a] Kinetic Constant, K ($days^{-1}$)	Carbon Partion[b] Coefficient, K_{oc} (ml/g)
PAH (Continued)		
7,H Dibenzo(c,g)carbazole	0.001-0.10[e]	100,000-1,000,000[e]
Dibenzo(a,e)Pyrene	0.001-0.10[e]	100,000-1,000,000[e]
Dibenzo(a,h)Pyrene	0.001-0.10[e]	100,000-1,000,000[e]
Dibenzo(a,i)Pyrene	0.001-0.10[e]	100,000-1,000,000[e]
7,12-Dimethylbenz(a)-anthracene	0.001-0.10[e]	225,308
Fluoranthene	0.004-0.016	100,000-1,000,000[e]
Indeno(1,2,3,cd)pyrene	0.001-0.003	1,000,000[e]
Napthalene	0.005-0.173[f]	1300

[a,b] experimental values from Table 4-19
[d] dropped low experimental value
[e] estimated value (see text)
[f] dropped high experimental value

Source: Environmental Research and Technology, (15), page 4-20.

TABLE B2-1

RING ARRANGEMENT AND RELATIVE STABILITY

	Ring Arrangement		
	Linear	Cluster	Angular
Description	all rings in line	at least one ring surrounded on three sides	rings in steps
Stability+	least	intermediate	most
Examples	anthracene tetracene	pyrene benzopyrene	phenanthrene chrysene

SOURCE: BLUMER 1976

+Chemical stability in the environment from least to most stable.

Source: Environmental Research and Technology, (15), Appendix B.

TABLE B2-2 (Continued)

PHYSICAL CHEMICAL PROPERTIES OF SELECTED PAH COMPOUNDS

Name	# Rings	Formula	Molecular Weight	Physical Properties
Naphthalene	2	$C_{10}H_8$	128	Sol mg/l H_2O = 31.7 M.P. = 80.2°C B.P. = 217.9°C V.P. = 4.92×10^{-2} log K_{ow} = 3.37

M.P. = Melting Point
B.P. = Boiling Point
V.P. = Vapor Pressure at 2-°C in torr
log K_{ow} = logarithm of the octanol; water coefficient

Source: Environmental Research and Technology, (15), Appendix B.

TABLE B2-2 (Continued)

PHYSICAL CHEMICAL PROPERTIES OF SELECTED PAH COMPOUNDS

Name	# Rings	Formula	Molecular Weight	Physical Properties
Benz(c)acridine	4	$C_{17}H_{11}N$	229	Sol Mg/l H_2O = No Data
Dibenz (a,h) Anthracene 1,2:5,6-Dibenzanthracene	5	$C_{22}H_{14}$	278	Sol Mg/l H_2O = .0005 M.P. = 266°C B.P. = 524°C V.P. = 1.0×10^{-10} log K_{ow} = 5.97
7H-Dibenzo (c,g) - Carbazole 7-Aza-7H-dibenzo- (c,g) fluorene 3,4,5,6-Dibenzo- carbazole	5	$C_{20}H_{13}N$	267	Sol Mg/l H_2O M.P. = B.P. =
Dibenzo (a,e) pyrene Naphtho (1,2,3,4-ef) Chrysene 1,2:4,5-Dibenzopyrene	6	$C_{24}H_{14}$	302	Sol Mg/l H_2O = M.P. = 225°C B.P. =
Dibenzo (a,h) pyrene 1,2:6,7-Dibenzopyrene 3,4:8,9-Dibenzopyrene Dibenzo (b,def)chrysene	6	$C_{24}H_{14}$	302	Sol Mg/l H_2O M.P. = 315°C B.P. =
Dibenzo (a,i) pyrene Benzo (rst) pentaphene 1,2:7,8-Dibenzopyrene 3,4:9,10-Dibenzopyrene	6	$C_{24}H_{14}$	302	Sol Mg/l H_2O = M.P. = 282°C B.P. =
7,12-Dimethylbenz(a)- anthracene	4	$C_{20}H_{16}$	256	Sol Mg/l H_2O= M.P. = 122.5°C B.P. =
Fluoranthene	4	$C_{16}H_{10}$	202	Sol Mg/l H_2O = 0.26 M.P. = 110°C B.P. = 393°C V.P. = 6.0×10^{-6} log K_{ow} = 5.33
Indeno (1,2,3-CD) pyrene O-phenylenepyrene	6	$C_{22}H_{12}$	276	Sol Mg/l H_2O = .0002 M.P. = 162.5°C B.P. = V.P. = 1.0×10^{-10} log K_{ow} = 7.66

Source: Environmental Research and Technology, (15), Appendix B.

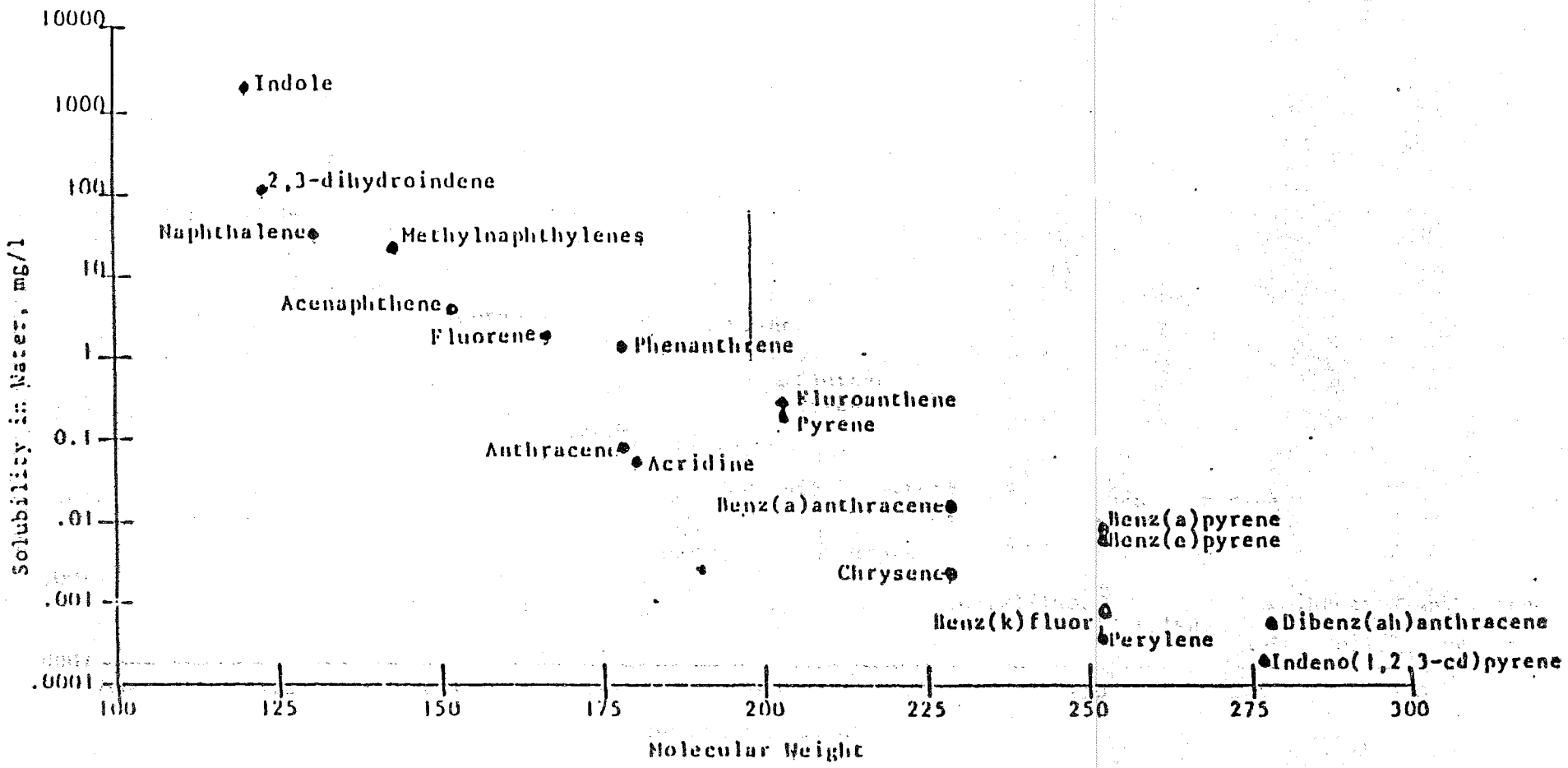

Figure B2-1 Solubility as a Function of Molecular Weight for PAH Compounds

Source: Environmental Research and Technology, (15), Appendix B.

TABLE B2-5

ADSORPTION OF PNA'S BY ACTIVATED CARBON AND BY SOILS AND SEDIMENTS

(SIMS AND OVERCASH 1983)

PNA	Log K_{ow}[a]	Soils and Sediments	
		K	K_{oc}
Naphthalene	3.37	-	1,300[d]
2-Methylnaphthalene	-	-	8,500[d]
Benzo(b)thiophene	-	50	-
Anthracene	4.45	0.01-0.05[c]	26,000[d]
Benzo(f)quinoline	-	1,313	-
Acenphthalene	4.07	-	-
Phenanthrene	4.46	-	23,000[d]
Fluorene	4.18	-	-
9H-carbazole	-	175[d]	-
Fluoranthene	5.33	-	-
Tetracene	-	-	650,000[d]
Pyrene	5.32	-	84,000[d]
Benz(a)anthracene	5.61	26,200[d]	-
Dibenzothiopene	-	137[g]	10,240(mean)[g]
3-Methylcholanthrene	6.97	18,196(mean)[f]	1,789,000(mean)[f]
Benzo(b)fluoranthene	6.57	-	-
Benzo(k)fluoranthene	6.84	-	-
Benz(a)pyrene	6.04	76,000[d]	4,510,651(mean)[d]
Dibenz(a,h)anthracene	5.97	22,774(mean)[f]	2,029,000(mean)[f]
Benzo(ghi)perylene	7.23	-	-
7H-dibenzocarbazole	-	26,233(mean)[d]	-
Acenaphthene	4.33	-	-

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[a] Versar (1979)
[b] Dobbs & Cohen (1980)
[c] Herbes (1979)
[d] Reinbold *et al*. (1978)
[e] McBride *et al*. (1975)
[f] Means *et al*. (1980)
[g] Hassett *et al*. (1980)

K_{ow} - Octanol water partition coefficient
K - Freundlich isotherm constant
K_{oc} - Organic Carbon partition coefficient

Source: Environmental Research and Technology, (15), Appendix B.

TABLE B2-5

ADSORPTION OF PNA'S BY ACTIVATED CARBON AND BY SOILS AND SEDIMENTS

(SIMS AND OVERCASH 1983)

PNA	Log K_{ow}[a]	Soils and Sediments K	Soils and Sediments K_{oc}
Naphthalene	3.37	-	1,300[d]
2-Methylnaphthalene	-	-	8,500[d]
Benzo(b)thiophene	-	50	-
Anthracene	4.45	0.01-0.05[c]	26,000[d]
Benzo(f)quinoline	-	1,313	-
Acenphthalene	4.07	-	-
Phenanthrene	4.46	-	23,000[d]
Fluorene	4.18	-	-
9H-carbazole	-	175[d]	-
Fluoranthene	5.33	-	-
Tetracene	-	-	650,000[d]
Pyrene	5.32	-	84,000[d]
Benz(a)anthracene	5.61	26,200[d]	-
Dibenzothiopene	-	137[g]	10,240(mean)[g]
3-Methylcholanthrene	6.97	18,196(mean)[f]	1,789,000(mean)[f]
Benzo(b)fluoranthene	6.57	-	-
Benzo(k)fluoranthene	6.84	-	-
Benz(a)pyrene	6.04	76,000[d]	4,510,651(mean)[d]
Dibenz(a,h)anthracene	5.97	22,774(mean)[f]	2,029,000(mean)[f]
Benzo(ghi)perylene	7.23	-	-
7H-dibenzocarbazole	-	26,233(mean)[d]	-
Acenaphthene	4.33	-	-

[a] Versar (1979)
[b] Dobbs & Cohen (1980)
[c] Herbes (1979)
[d] Reinbold *et al*. (1978)
[e] McBride *et al*. (1975)
[f] Means *et al*. (1980)
[g] Hassett *et al*. (1980)

K_{ow} - Octanol water partition coefficient
K - Freundlich isotherm constant
K_{oc} - Organic Carbon partition coefficient

Source: Environmental Research and Technology, (15), Appendix B.