

# REPORT DOCUMENTATION PAGE

Form Approved  
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE <p style="text-align: center;">04/00/81</p>	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE ANALYSIS OF DENVER WATER SAMPLES, TECHNICAL PROGRESS REPORT NUMBER M9-81		5. FUNDING NUMBERS	
6. AUTHOR(S) <p style="text-align: center;">SILVEIRA, E.</p>		7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <p style="text-align: center;">SHELL CHEMICAL COMPANY DENVER, CO</p>	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		8. PERFORMING ORGANIZATION REPORT NUMBER <p style="text-align: center;">83041R01</p>	
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT <p style="text-align: center;">APPROVED FOR PUBLIC RELEASE; DISTRIBUTION IS UNLIMITED</p>		10. SPONSORING/MONITORING AGENCY REPORT NUMBER	
13. ABSTRACT (Maximum 200 words) METHODOLOGY AND RESULTS OF THE ANALYSIS OF 102 DENVER GROUND WATER SAMPLES FOR VARIOUS TARGET COMPOUNDS ARE PRESENTED. THE OBJECTIVE OF THE DENVER SOIL AND GROUND WATER PROJECT IS TO PREVENT FURTHER ENVIRONMENTAL CONTAMINATION, CONTROL/CONTAIN EXISTING CONTAMINATION, AND UNDERTAKE MITIGATIVE EFFORT AS DEEMED NECESSARY. AS PART OF THE PROBLEM DEFINITION PHASE OF THIS PROJECT A LARGE NUMBER OF DENVER WATER SAMPLES WERE COLLECTED AND ANALYZED AT BSRC. THE PURPOSE OF THIS SURVEY WAS THE CONFIRMATION OF SEMI-QUANTIFICATION OF SPECIFIC TARGET COMPOUNDS KNOWN OR SUSPECTED TO BE PRESENT IN THE WATER SAMPLES. GB/MS WAS THE METHOD OF CHOICE FOR THIS WORK; THE OVERALL METHODOLOGY BEING SIMILAR TO THAT EMPLOYED FOR PRIORITY POLLUTANT ANALYSIS OF WATER. ALSO DESIRED WAS IDENTIFICATION AND SEMIQUANTIFICATION OF ANY OTHER SIGNIFICANT COMPONENTS. IN ADDITION, PH, CONDUCTANCE, CHLORIDE ION, SULFATE ION, AND IONIC COPPER WERE DETERMINED. <p style="text-align: right; margin-top: 20px;"><b>DATA QUALITY INDICATED 1</b></p>			
12b. DISTRIBUTION CODE		14. SUBJECT TERMS VOA, PH, CONDUCTANCE, CHLORIDE, ION, SULFATE, COPPER, RUN-OFF, WELL WATER, EFFLUENT	
17. SECURITY CLASSIFICATION OF REPORT UNCLASSIFIED		15. NUMBER OF PAGES	
18. SECURITY CLASSIFICATION OF THIS PAGE		16. PRICE CODE	
19. SECURITY CLASSIFICATION OF ABSTRACT		20. LIMITATION OF ABSTRACT	

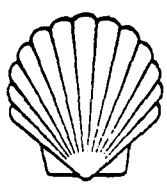
19941214 011

# DISCLAIMER NOTICE



**THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.**

83041R01  
2nd Copy



# SHELL CHEMICAL COMPANY

A DIVISION OF SHELL OIL COMPANY

P. O. BOX 2171

DENVER, COLORADO 80201

April 16, 1981

Colorado Department of Health  
Water Quality Control Division  
ATTN Mr. Robert Shukle, Industrial  
Waste Consultant  
4210 East 11th Avenue  
Denver, CO 80220

Gentlemen:

Shell has conducted a survey of the groundwater on its leasehold on the Rocky Mountain Arsenal to assess groundwater quality. The analytical results from the survey as they became available have been reviewed with members of the Technical Review Committee at the last several meetings. These results have been summarized in a Technical Progress Report (M-9-81) which was recently issued by Shell Development Company. A copy of this report and a map showing well locations are attached for your information.

Yours very truly,

Original [unclear] [unclear]

J. H. Knaus  
Plant Manager

### Attachments

cc: Commander  
Rocky Mountain Arsenal  
Commerce City, CO 80022

Commander  
Rocky Mountain Arsenal  
ATTN SARRM-TOE-C, Greg Ward, Bldg. 741  
Commerce City, CO 80022

Accession For	
NTIS CRA&I	<input checked="" type="checkbox"/>
DTIC TAB	<input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	
Distribution /	
Availability Codes	
Dist	Avail and/or Special
A-1	



ANALYSIS OF DENVER WATER SAMPLES  
TECHNICAL PROGRESS REPORT NO. M-9-81

By E. J. Silveira

ANALYSIS OF DENVER WATER SAMPLES



Project No. 83596.00

Denver Plant Ground Water Program

Technical Progress Report No. M-9-81

Date of Issue:

Written and Reviewed : E. J. Silveira  
Participants : G. W. Campbell, D. R. Farinha,  
K. S. Williams, B. Calog  
Approval : R. A. Newman  
References : MOLR 2383, 2606

SHARED - Under the Research Agreement between SIRM,  
and Shell Oil Company dated January 1, 1960,  
as amended.

ABSTRACT

Methodology and results of the analysis of 102 Denver groundwater, samples for various target compounds are presented.

LHINK Keywords: Water, analysis, Denver, groundwater, Rocky Mountain, arsenal, Colorado, VOA, pH, conductance, chloride, ion, sulfate, copper, method, run-off, well water, effluent

## ANALYSIS OF DENVER WATER SAMPLES

### Introduction

The objective of the Denver Soil and Groundwater Project is to prevent further environmental contamination, control/contain existing contamination, and undertake mitigative effort as deemed necessary. As part of the Problem Definition Phase of this project a large number of Denver water samples were collected and analyzed at BSRC. The purpose of this survey was the confirmation and semi-quantification of specific target compounds known or suspected to be present in the water samples. GC/MS was the method of choice for this work; the overall methodology being similar to that employed for priority pollutant analysis of water. The list of desired target compounds is shown in Table 1. Also desired was identification and semi-quantification of any other significant components.

In addition, pH, conductance, chloride ion, sulfate ion and ionic copper were determined.

### Sampling and Storage

The sampling protocol for the Denver Plant Groundwater Survey Program is as follows.

#### Preparation of the Wells Before Sampling Water

Wells are to be drilled at designated spots on the properties, lined with polyvinyl chloride pipe, and capped. Each well is to be numbered by stencil "Denver Plant Groundwater Well No. \_\_\_\_" (1 through n). Each well is to have an altitude benchmark referenced to the U.S.G.S. benchmark. Prior to each sampling of the well water, the height of the water will be determined, measured from the top of the well, and referenced to the benchmark. By use of a submersible pump (pumps which require priming or vacuum are unsuitable) and a length of Teflon tubing, about 10 volumes of water (as compared to the amount in the well casing) will be pumped out of the well. If recovery times are short and the pumping operation can be accomplished in a reasonable time frame, pumping will be done before each sampling. After each pumping operation, Denver drinking water will be used to rinse the pump. The Teflon tube should require no rinsing but may require drying by use of a piece of gauze or similar clean material.

#### Sampling the Water

In advance of the sampling operation, new quart bottles will be rinsed with methylene chloride and dried at 100°C. Smaller bottles or vials, 40-ml, will be supplied by Westhollow Research Center (WRC)(G. W. Stanko). All bottle caps will contain Teflon liners also to be supplied by WRC. Each bottle will be carefully stored and handled so as to avoid contamination.

The actual water sample will be obtained by bailing as follows: Immediately after pumping, the sample bottle will be placed into a weighted, stainless cage. By use of a stainless steel chain, the bottle will be quickly lowered to the bottom of the well and allowed to fill with water. The full bottle will be brought to the surface, capped, labeled with tape labels, and placed in an

ice bath. The 40-ml size bottle will be sampled in a similar manner, with care being taken to insure liquid full bottles (no air space) upon insertion of the Teflon septum. Four of the 40-ml bottles will be placed in a wide-mouth quart jar and cushioned with wads of paper. After capping, the quart jar will be placed in an ice bath. Two quart and three 40-ml samples of water shall be obtained from each well at each sampling. The full bottles will be returned to the laboratory and placed in a clean refrigerator at a temperature of 0 to 5°C (32 to 41°F); freezing must be avoided. The refrigerator will be used for no other purpose during this groundwater survey program. After the completion of the sampling for the period, or when about 20 wells have been sampled, the samples will be sent to Modesto (BSRC) by refrigerated truck or by air freight in a manner which will keep the bottles between 0 and 5°C. Upon receipt of the samples at BSRC, they will be placed in a refrigerator (0 to 5°C) pending analysis.<sup>a)</sup>

Sampling of the wells at Denver will be coordinated with the work load at BSRC to insure volatile analyses within two weeks of sampling. Extraction should be accomplished within one to two weeks of sampling. Extracts may be sealed in airtight vials and stored in a freezer to await analysis.

#### Records

A log book will be maintained for recording all sampling data. Among the entries will be the names of persons doing the sampling, weather data, height of the water in the well, any variance in the sampling procedure, and unusual events. The log book will be signed by the responsible person after each series of sampling.

A map showing the location of each well is available on request from the Denver Plant.

#### Instrumentation and Methodology for Volatile Organics Analysis (VOA)

The general scheme for VOA analysis is shown in flowchart form in Figure 1. Specific analytical conditions are given in Table 2.

#### VOA Subsampling Procedure

The VOA vial was removed from the refrigerator and allowed to come up to room temperature. The vial was opened and the tip of a 1-ml syringe (no needle attached) was inserted well below the surface and a 1.0-ml sample was drawn very slowly into the syringe. The internal standard was then added by syringe directly into the subsample. A needle was then immediately attached and the sample was injected into the sparging vessel through the septum valve.

#### VOA Standards

VOA reference standard solutions were freshly prepared at least once each week. The reference standard contained 20 µg/ml each of the internal standard and the target compounds in methanol solution. At least one reference standard run was made each day that samples were run. The reference standard run sample was prepared by syringe addition of 5 µl of reference standard solution to 1.0-ml of distilled water previously boiled to remove volatiles. The purpose of this reference standard run was to (1) ensure the reliability of the analysis, and (2) to update response

a) The procedure for analysis is described separately.

factors upon which the quantification was based. A typical VOA reference standard run is shown in Figure 2.

VOA internal standard solutions were freshly prepared at least once each week. This solution contained 20  $\mu\text{g}/\text{ml}$  of only the internal standard, bromochloromethane, in methanol. A 5  $\mu\text{l}$  aliquot of the internal standard solution (100 ng bromochloromethane) was added by syringe to each sample and blank immediately prior to introduction to the sparging vessel. Blank runs, containing only internal standard added to distilled, previously boiled water, were made at least once each day.

VOA reference standard and internal standard solutions were kept refrigerated when not in use.

A typical gas chromatogram/mass spectrum (GC/MS) of the VOA is shown in Figure 2.

#### Extraction Procedure

Filtration - Prior to extraction samples were filtered through a 0.45  $\mu\text{m}$  Millipore membrane filter, catalogue number HAWP-047-00, covered with a Millipore glass fiber prefilter, catalogue number AP25-047-00. A Millipore filter holder with glass frit was used.

#### pH Adjustment

Prior to pH adjustment and extraction approximately 100-ml of each sample was retained and submitted for pH, conductance, chloride ion, sulfate ion and ionic copper determinations.

The volume of the remaining filtrate was noted and the filtrate transferred to a 2-l separatory funnel. Well samples 1A-46A were subjected to extraction without pH adjustment.

The pH of all other samples were adjusted to pH 11 with sodium hydroxide pellets. After extraction the aqueous phase was then adjusted to pH 2 with 6N HCl and reextracted.

#### Extraction

The aqueous solutions were extracted with 120-ml  $\text{CH}_2\text{Cl}_2$  and the  $\text{CH}_2\text{Cl}_2$  phase collected. The aqueous solutions were then extracted twice more with 80-ml portions of fresh  $\text{CH}_2\text{Cl}_2$  and the three extracts combined.

#### Concentration

The combined  $\text{CH}_2\text{Cl}_2$  extracts were concentrated as rapidly as possible in a Kuderna-Danish Evaporator equipped with a 3-ball Snyder column to a volume of approximately 10-ml. The extracts were then further concentrated to approximately 0.8-ml by blowdown with dry nitrogen. An aliquot of a standard solution of  $d_{10}$ -anthracene internal standard (containing 100  $\mu\text{g}$ ) was then added to the extract concentrates and the volume adjusted to 1.0-ml. The extracts derived from the basic solutions are the base-neutral (BN) extracts and those derived from the acidic solutions are the acid extractables (AE). Those extracts derived from solutions without pH adjustment are listed in the result table under the BN heading.

## Instrumentation and Methodology for GC/MS Analysis for Extractable Organics

The general scheme for extractable organics analysis is shown in flowchart form in Figure 3. Specific analytical conditions are given in Table 3.

### BN Standards

BN reference standard solutions were freshly prepared at least every 3-4 weeks. The reference standard contained 100  $\mu\text{g}/\text{ml}$  each of the internal standard and the target compounds in methylene chloride solution. At least one reference standard run was made each day that samples were run. The purpose of this reference standard run was (1) to ensure the reliability of the analysis, and (2) to update response factors upon which the quantification was based. A typical reference standard run is shown in Figure 4.

BN internal standard solutions were freshly prepared at least every 3-4 weeks. This solution contained 1  $\text{mg}/\text{ml}$  of only the internal standard,  $\text{d}_{10}$ -anthracene, in methylene chloride. A 100  $\mu\text{l}$  aliquot of the internal standard solution (100  $\mu\text{g}$   $\text{d}_{10}$ -anthracene) was added by syringe to each sample extract after nitrogen blowdown.

BN reference standard and internal standard solutions were kept refrigerated when not in use.

A typical GC/MS of a BN extract is shown in Figure 4.

Samples 1A-4A, 9A, 13A, 16A, 17A, 23A-25A, 32A-34A, and 39A-41A were run on the OV-101 packed column (conditions A in Table 3). Samples 5A-8A, 10A-12A, 14A, 15A, 18A-22A, 26A-31A, 35A-38A, 42A-46A, 16B, 24B, 40B, were run on the glass capillary column (conditions B in Table 3). All other samples were run on the fused silica capillary column (conditions C in Table 3).

### Data Processing of GC/MS Runs

The general scheme for data processing is shown in flowchart form in Figure 5. Details of the data processing procedures and programs are to be documented in a separate report.

#### pH Measurement

The pH of the water samples was determined by using a Corning 110 Digital pH Meter with a Metrohm EA 121 combination glass electrode.

#### Conductance Measurement

Conductance was determined using a Western Instruments Model 210 Conductivity Meter with a Model 219-200 flow through cell. The calibration solution was 0.01 M KCl.

#### Chloride Ion Determination

Chloride ion was determined by silver nitrate titration using a Metrohm E 436 Potentiograph with a Metrohm EA 246 silver electrode.

#### Sulfate Ion Determination

Sulfate ion was determined turbidimetrically as  $\text{BaSO}_4$  using a Hach Model 2100 Turbidimeter.

#### Ionic Copper Determination

Ionic copper was determined using a colorimetric method - EMS 2C14/59.

#### Results

The analytical results are presented in Table 4. Concentration values (in  $\mu\text{g}/\text{l}$  or ppb) are given for target compounds exceeding the nominal minimum detectable concentration of 10 ppb. Concentration values for other detected peaks, including tri- and tetrachlorethylene, DMK (acetone),  $\text{CH}_2\text{Cl}_2$  and THF, are given if the peak could be tentatively identified and the concentration exceeded 200 ppb.

FIGURE 1

VOA SCHEME

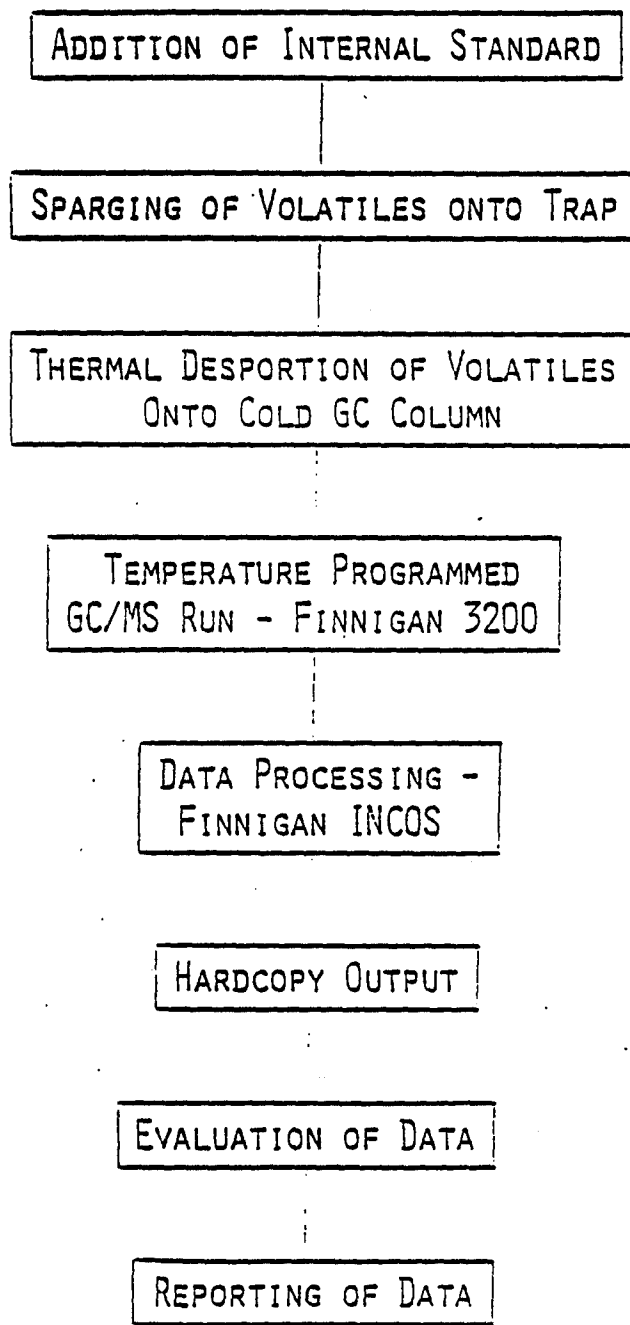
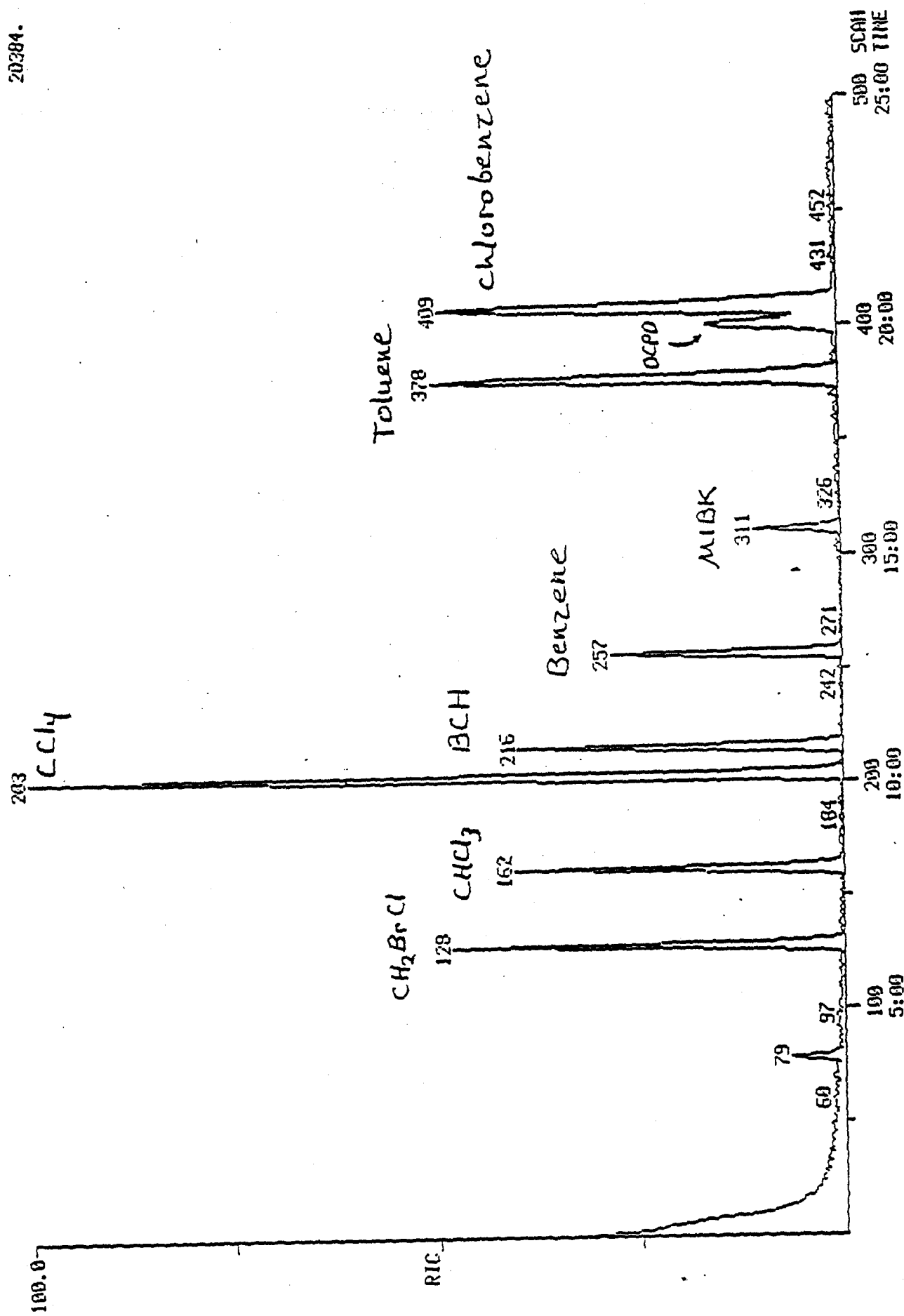


FIGURE 2  
VOA STANDARDS



20384.

FIGURE 3

LLE SCHEME

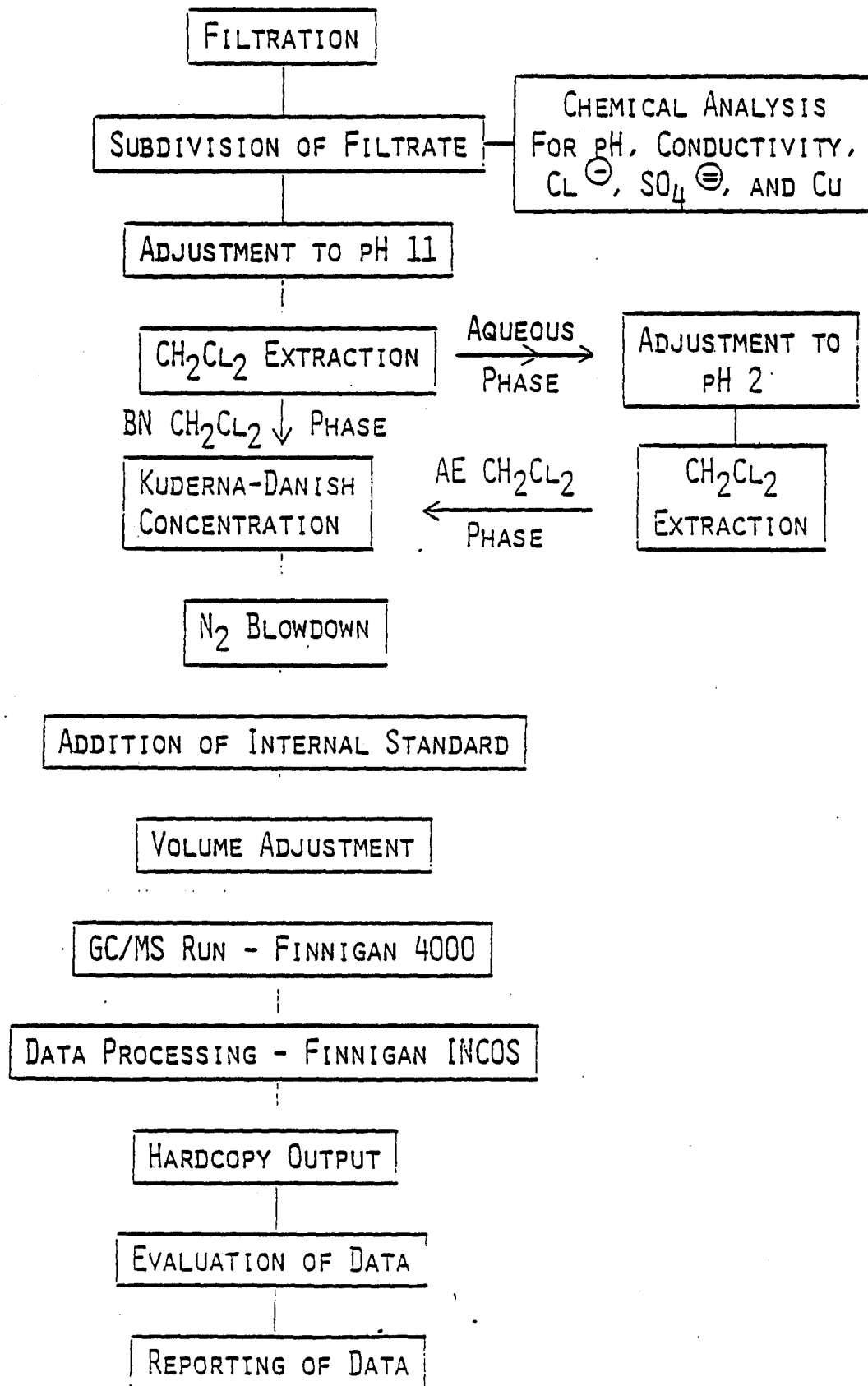
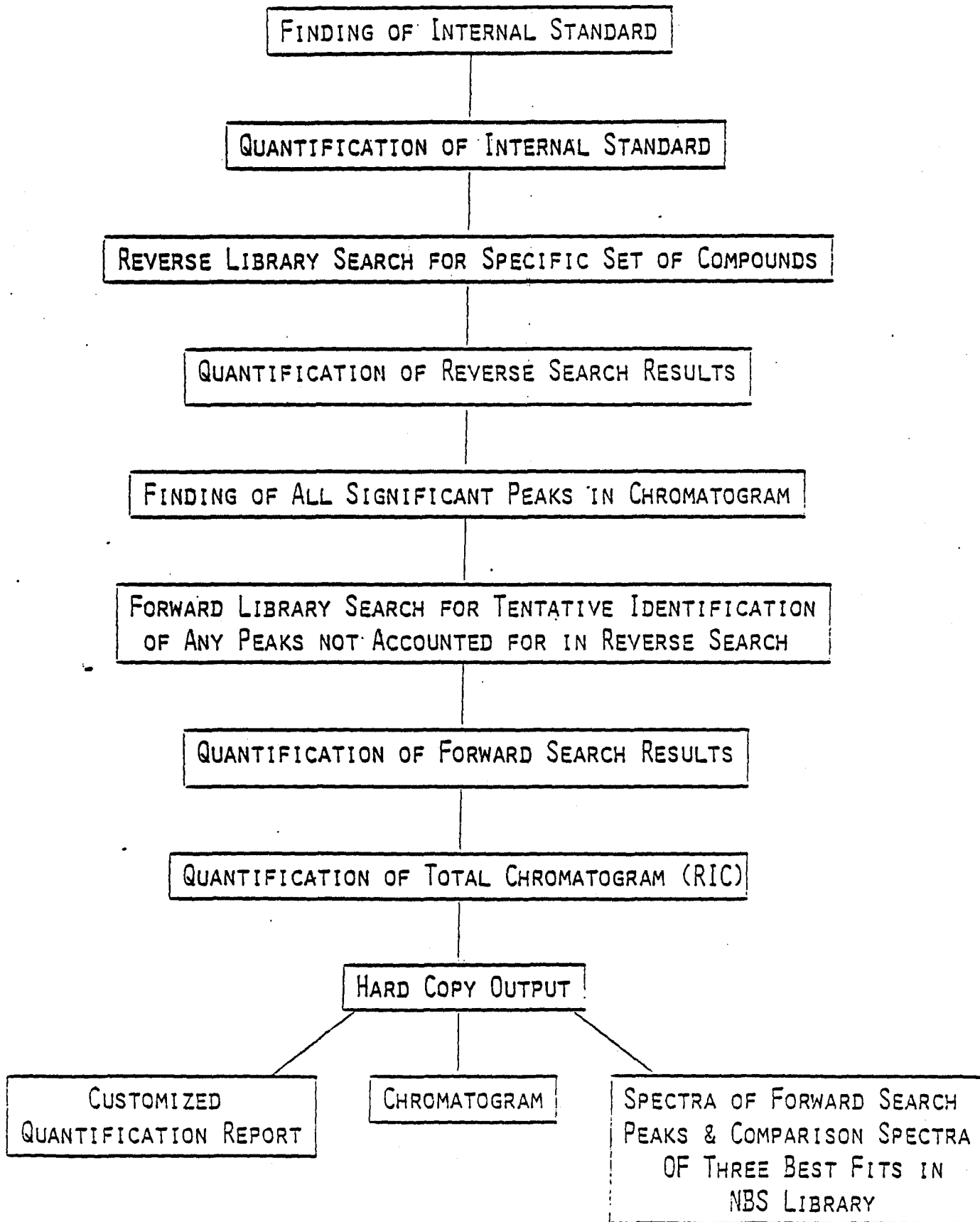






FIGURE 5

DATA PROCESSING SCHEME

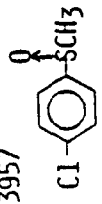
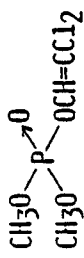
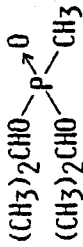


DENVER PLANT GROUNDWATER ANALYSIS

VOLATILE ORGANICS	MW	QUANTIFICATION ION	ASSIGNMENT	RELATIVE ABUNDANCE
1. CHLOROFORM	118	83	M <sup>+</sup> - CL	100
2. CARBON TETRACHLORIDE	152	117	M <sup>+</sup> - CL	100
3. BICYCLOHEPTADIENE (BCH)	92	91	M <sup>+</sup> - H	100
				
4. BENZENE	78	78	M <sup>+</sup>	100
- 5. METHYLISOBUTYLKETONE (MIBK)	100	100	M <sup>+</sup>	
6. TOLUENE	92	91	M <sup>+</sup> - H	100
7. DICYCLOPENTADIENE (DCPD)	132	66		100
8. CHLOROBENZENE	112	112	M <sup>+</sup>	100

DENVER PLANT GROUNDWATER ANALYSIS

EXTRACTABLE ORGANICS	MW	QUANTIFICATION ION	ASSIGNMENT	RELATIVE ABUNDANCE
1. DICHLOROBENZENES	146	146	M <sup>+</sup>	100
2. DIISOPROPYLMETHYLPHOSPHONATE (DIMP)	180	97	$\begin{array}{c} \text{HO} \quad \text{OH} \\ \diagdown \quad / \\ \text{P} \\ / \quad \diagdown \\ \text{HO} \quad \text{CH}_3 \end{array} \text{ } ^{+}$	100
3. DIBROMOCHLOROPROPANE (DBCP)	234	157	M <sup>+</sup> - Br (P+2 ISOTOPE)	100
4. HEXACHLOROBUTADIENE	258	225	M <sup>+</sup> - Cl (P+2 ISOTOPE)	100
5. VAPONA	220	109	(CH <sub>3</sub> O) <sub>2</sub> P=O <sup>+</sup>	100
6. SD 9636	158	158	M <sup>+</sup>	100
7. HEXACHLOROCYCLOPENTADIENE (HEX)	270	237	M <sup>+</sup> - Cl (P+2 ISOTOPE)	100
8. HEXACHLORONORBORBIADIENE (HCNB)	296	263	M <sup>+</sup> - Cl (P+2 ISOTOPE)	100
9. SD 13957	174	159	M <sup>+</sup> - CH <sub>3</sub>	100



RELATIVE ABUNDANCE

ASSIGNMENT

QUANTIFICATION ION

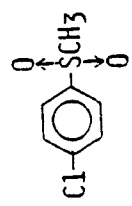
m/z

100



111

10. SD 13000



100



142

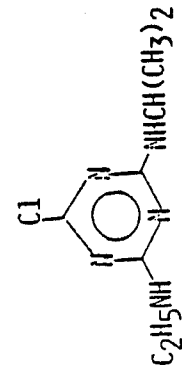
11. HEXACHLOROBENZENE (HCB)

65



200

12. ATRAZINE

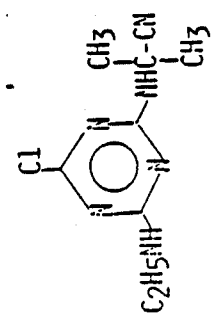


45

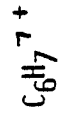


212

13. BLADEX

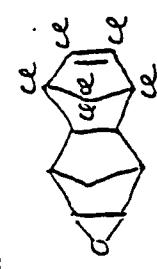


100



79

14. DIELDRIN (HEOD)



OTHER COMPOUNDS WHICH HAVE BEEN DETECTED IN SELECTED SAMPLES BY SPECIFIC RESIDUE METHODS:

1. TRIMETHYL PHOSPHATE
2. SD 15042



TABLE 2 - Conditions for Volatile Organics Analysis

Instrument: Finnigan 3200 GC/MS equipped with a Chemical Data Systems Model 310 Concentrator

Trapping Column: 2' x 1/8" OD stainless steel packed with Tenax 60/80 mesh

Sparge Gas: Helium

Sparge Rate: 30 ml/minute

Sparge Cycle: 12 minutes with sparging vessel at 50°C onto trapping column at room temperature

Desorb Cycle: 4 minutes at 180°C onto GC column at room temperature

Trap Bakeout Cycle: 4 minutes at 280°C

Sample Size: 1 ml or 5 ml

GC Column: 10' x 2mm ID glass column packed with 1% SP-1000 on Carbopack B, 60/80 mesh

Temperature Program: 50°C for 4 minutes, then programmed to 200°C at 10°/minute, then held at 200°C for 13.5 minutes

Injector Temperature: 200°C

Carrier: Helium at 30 ml/minute

Separator: Glass jet

Separator Temperature: 200°C

Transfer Line Temperature: 200°C

MS Mode: Electron Impact (EI)

Electron Energy: 70 eV

Electron Multiplier Voltage: Approximately 1700 V

Emission Current: 1.0 ma

Preamplifier Sensitivity:  $10^{-7}$  a/v

Scan Range: 40-540 amu

Scan Time: 3 seconds

Scans per Run: 650

Internal Standard: 100 ng bromochloromethane

TABLE 3 - Conditions for Extractable Organics Analysis

Instrument: Finnigan 4000 GC/MS

GC Columns: (A) 6' x 2mm ID glass column packed with 3% OV-101 on Gas Chrom Q, 80/100 mesh  
(B) 30m x 0.25mm ID glass WCOT capillary column coated with SE-54  
(C) 30m x 0.25mm ID fused silica WCOT capillary column coated with SE-54

Temperature Program: (A) 50°C for 4 minutes, then programmed to 260°C at 10°/minute  
(B) 70°C for 4 minutes, then programmed to 280°C at 8°/minute  
(C) 70°C for 4 minutes, then programmed to 300°C at 8°/minute

Injector Temperature: 280°C

Carrier Gas: Helium

Flow Rate: 20 ml/minute (A)

Injector: Modified German-Horning (B and C)

Injector Flow: 20 ml/minute (B and C)

Injector Pressure: 14 psi (B and C)

Split Ratio: Approximately 10:1 (B and C)

Separator: Glass jet (A)

Separator Oven Temperature: 280°C

Transfer Line Temperature: 280°C

MS Mode: Electron Impact (EI)

Electron Energy: 70 e/V

Electron Multiplier Voltage: Approximately 1700 V (without conversion dynode) or approximately 1000 V (with conversion dynode at 3000 V)

Emission Current: 0.2 ma

Preamplifier Sensitivity:  $10^{-7}$  a/v

Scan Range: 40-640 amu

Scan Time: (A) 3 seconds; (B) 2 seconds; (C) 1.5 seconds

Scan per Run: (A) 500; (B) 900; (C) 1400

Volume Injected: 2 or 3  $\mu$ l

Internal Standard: 100  $\mu$ g/ml  $d_{10}$ -anthracene in final extract

TABLE 4

Water Sample	CHCl <sub>3</sub>	CCL <sub>4</sub>	BCR	Benzene	Styrene	Toluene	DCPD	Chlorobenzene	Dichloro Benzenes	DDEP	DACP	HCSD	Tapwa	SD 9636	HEX	HCNB	SD 13957	SD 13000	HCB	Atrazine
1A				140																
2A	2900 <sup>(1)</sup>		84	170	1100	44	370	110									17			
3A	2000	230	9500 <sup>(1)</sup>	2300 <sup>(1)</sup>	130	370	3100	5200	660											
4A	470		8000 <sup>(1)</sup>	3000 <sup>(1)</sup>		2600	15000 <sup>(1)</sup>		33											
5A	18000 <sup>(1)</sup>	160		1700 <sup>(1)</sup>	15			850	150 <sup>(65)</sup>		27 <sup>(65)</sup>							68 <sup>(65)</sup>		
6A	4200 <sup>(1)</sup>		88	180	1200	48	400	120	30									27 <sup>(65)</sup>		
7A	740			26																
8A	4700			100				11										17 <sup>(64)</sup>		
9A	2900			55																
10A	1200	1500		370				230	85		47									
11A	12			23		15														10
12A	250	35		42				34												
13A	20000 <sup>(1)</sup>		31	1900 <sup>(1)</sup>	1700	2600	560	70						170				1700		
14A	1100	1200		490				380	23 <sup>(65)</sup>						33 <sup>(65)</sup>			120 <sup>(65)</sup>		
15A	1000 <sup>(1)</sup>	33		140			720 <sup>(1)</sup>	76	15 <sup>(65)</sup>		20 <sup>(64)</sup>							11 <sup>(65)</sup>		
16A	170	19		110																41
17A	3600 <sup>(1)</sup>	1800 <sup>(1)</sup>	1000 <sup>(1)</sup>	1000 <sup>(1)</sup>	37	740 <sup>(1)</sup>		1700 <sup>(1)</sup>	51		7100 <sup>(1)</sup>	18						60		
18A	2900 <sup>(1)</sup>	750		49				29	500 <sup>(65)</sup>		120 <sup>(65)</sup>							25 <sup>(65)</sup>		
19A	2900 <sup>(1)</sup>	1200	450	24		74		190										660		
20A			2600	760				49	48					17				320		59
21A	11			5800 <sup>(1)</sup>		120	26	35												
22A	30			12																150
23A	240	25		36						25										
24A	250	74	74	1200 <sup>(1)</sup>	4400	1200 <sup>(1)</sup>		2100 <sup>(1)</sup>	3400 <sup>(1)</sup>					89			17	22		
25A	1500 <sup>(1)</sup>			280	650	560	120	210						730				7300		
26A	9800 <sup>(1)</sup>	2500	310	930		3700 <sup>(1)</sup>		420	670									96		
27A	6000 <sup>(1)</sup>	1200	5000 <sup>(1)</sup>	3700 <sup>(1)</sup>		3400 <sup>(1)</sup>												73 <sup>(64)</sup>		
28A				21				60												61
29A	19			5800 <sup>(1)</sup>		36		31												20
30A	24			3900 <sup>(1)</sup>																
31A																				
32A	55			8700 <sup>(1)</sup>																
33A	86		260	23000 <sup>(1)</sup>		630	2700 <sup>(1)</sup>													

All concentrations are in µg/l (ppb)

Water Sample	Bladex	HEAD	trichloro ethylene	1,1,1-trichloro ethylene	DMK	CH2Cl2	THF	Methanol	VOA	SS	SE	PH	Conductance Osm-Cu-X 10-3	Chloride mg/ml	Sulfate mg/ml	Copper ppm	(66095)	(66095)
1A			280	660								8.2	0.55	0.033	0.036	<0.5		<1
2A	110		490					2) 3)				7.6	0.96	0.081	0.13	<0.5		<1
3A			210	630	280			4)				11.9	3.0	0.18	0.17	<0.5		<1
4A			990	7600	6800	450	500	5) 6) 7)				12.4	10.0	0.72	0.24	<0.5		<1
5A			220									7.4	3.0	0.22	0.20	<0.5		2
6A			520					8) 9)				7.6	4.5	1.4	0.62	<0.5		100
7A												8.3	0.37	<0.02	0.033	<0.5		<1
8A			480									7.3	3.8	1.1	0.36	<0.5 (trace)		<1
9A												7.5	1.4	0.076	0.12	<0.5		<1
10A							210					8.6	0.82	0.073	0.10	<0.5		<1
11A							680					8.2	1.0	0.065	0.18	<0.5		<1
12A												8.1	2.3	0.37	0.40	<0.5 (trace)		<1
13A			72	260	4200	1400	2700	10) 11)				9.2	3.0	0.80	0.17	<0.5	205.88)	120
14A			430	6400				12)				7.8	1.5	0.19	0.12	<0.5	<10.88)	<1
15A												7.4	2.3	0.61	0.15	<0.5	1400.88)	<1
16A			21000									8.0	1.1	0.15	0.11	<0.5	15.88)	70
17A			2400	1100	2200			13) 14) 15)				7.2	1.8	0.28	0.24	<0.5		<1
18A							200	16)				7.2	1.4	0.27	0.12	<0.5		<1
19A								62)				7.8	1.6	0.18	0.30	<0.5		<1
20A			240									7.2	0.96	0.12	0.10	<0.5		<1
21A							330	41)				8.1	1.3	0.14	0.23	<0.5		<1
22A												8.3	1.3	0.18	0.24	<0.5		<1
23A												8.1	0.65	0.020	0.064	<0.5		<1
24A			790	340	2700			17) 18) 19) 53)				8.0	1.0	0.17	0.10	<0.5		<1
25A			230	980		300		20) 21) 22)				7.3	14.0	1.9	0.72	<0.5		140
26A						3200	690	36) 37) 38) 39) 40)				7.5	2.3	0.60	0.11	<0.5		<1
27A			510	400								7.3	1.4	0.28	0.24	<0.5		80
28A								78)				7.6	2.8	0.033	0.42	<0.5		<1
29A												8.3	0.82	0.054	0.083	<0.5		<1
30A							240					8.4	0.96	0.14	0.072	<0.5		<1
31A							220					7.9	1.0	0.056	0.26	<0.5		<1
32A								23) 24) 25) 26) 27)				8.1	0.96	0.020	0.14	<0.5		<1
33A								79) 80) 81) 82) 83)				7.8	1.1	0.043	0.26	<0.5		<1

All concentrations are in ug/l (ppb)

Water Sample	CHCL3	CCl4	BCR	Benzene	Styrene	Chlorobenzene	DCPD	Dichloro Benzene	DIBP	2,3,4,5-TCDF	TCDF	Hexachlorobenzene	PCNB	SD 9639	HEX	PCNB	SD 15557	SD 15559	PCNB	Atrazine	
34A	32			13000			270	240	440												
35A	220		34	28000				56	1600	15											
36A	100	13	160	16000				220	1000	15											
37A			240	72			20	3700													
38A			16	5300			18	1100													
39A	110		1000	850			1000	1600													
40A				510			360	45													
41A				480			810	150													
42A	77		11	5600			17	28	1100	12											
43A	46			44																	
44A	26							270													
45A	47		16	11																	
46A																					
47A																					
48A			720	3200			150	1500													
49A				12000			390	130													
50A			1100	5900			690	2400													
51A																					
52A			300	6100			1800														
53A																					
54A			140	9600			840	2500													
55A			39	6900			1200	430													
56A			900	12000			3500	2000													
57A			620	11000			3000	400													
58A			92	19000			140	110													
59A				18000																	
60A				74																	
61A				12000			51	120													
62A	88			23000			56	940													25
63A	120		130	8500				340													14
64A	200		33	5600				190	310												
65A			300	37000			370	67													

All concentrations are in µg/l (ppb)

Water Sample	B index	HEAD	1,1,1-trichloro ethylene	1,1,2-trichloro ethylene	DYK	CH2Cl2	THF	0.1 hrs	VOL	LN	ME Total	PH	Conductance Ohm-cm x 10 <sup>-3</sup>	Chloride mg/ml	Sulfate mg/ml	Other ppm	TPD (5)
34A								28) 29) 30) 31) 32)				7.9	1.4	0.19	0.20	<0.5	
35A												8.0	1.4	0.17	0.25	<0.5	
36A												8.3	1.7	0.17	0.42	<0.5	
37A												8.4	0.58	<0.01	0.035	<0.5	
38A												7.6	3.2	0.074	1.2	<0.5	
39A								33)				8.0	2.2	0.60	0.20	<0.5	
40A								34)				7.6	2.6	0.20	0.72	<0.5	
41A								35)				8.1	2.3	0.65	0.17	<0.5	
42A												8.0	2.5	0.30	0.76	<0.5	
43A												8.4	0.69	0.043	0.072	<0.5	
44A												7.6	2.2	0.65	0.11	<0.5	
45A												8.0	0.76	0.066	0.086	<0.5	
46A												7.7	0.42	0.048	0.069	<0.5	
47A										180		7.6	1.7	0.26	0.43	<0.5	
48A								650 42) 43)		22000 3900		7.7	0.85	0.056	0.12	<0.5	
49A					680			580 44) 45) 46) 47)		53000 1400		7.9	0.98	0.074	0.15	<0.5	
50A								360 56) 57) 58)		37000 10000		8.0	0.88	0.068	0.11	<0.5	
51A								230		1100 150		7.4	3.3	0.083	0.68	<0.5	
52A										27000 62000		7.3	1.2	0.14	0.19	<0.5	
53A										48000 1500		7.0	1.8	0.16	0.57	<0.5	
54A								3700		94000 350		7.7	2.4	0.62	0.22	<0.5	
55A								880 53) 54)		66000 7900		7.2	2.8	0.86	0.18	<0.5	
56A								52)		51000 450		7.2	2.6	0.78	0.16	<0.5	
57A										88000 640		7.5	2.6	0.77	0.19	<0.5	
58A								51)		75000 230		7.7	2.6	0.77	0.19	<0.5	
59A								340 50)		1800 130		7.7	1.0	0.12	0.16	<0.5	
60A								1600		46000 220		7.7	1.8	0.38	0.23	<0.5	
61A								3900		85000 310		7.2	2.2	0.25	0.82	<0.5	
62A										44000 580		7.5	1.2	0.13	0.19	<0.5	
63A								12000 49)		15000 1100		7.8	1.4	0.13	0.26	<0.5	
64A										150000 11000		7.4	1.3	0.12	0.27	<0.5	
65A								48)									

All concentrations are in ug/l (ppb)

Water Sample	CHCl3	CCl4	BCH	Benzene	MIBK	Toluene	DCPD	Chlorobenzene	Dichloro Benzenes	DIBP	BPCP	HCBP	Hex	SD 5636	Yapona	HCBP	SD 13957	SD 13090	HCB	Atrazine
72A						110	15											110		
73A			500	94	26	76	68													
74A				870			83	11												
75A	38		1500	1700			270	16												
76A				300																
77A	440			220																
78A	12																			
79A			43	3700			1200	51										12		
80A							18											41		
81A					70															
82A	230	20	3600 <sup>1)</sup>				130	15												
83A	670	20	15000	35			270	15												
84A			3900	470																
85A																				
86A																				
87A																				
88A			680	3600 <sup>1)</sup>	210	17	75										68	12		
89A			2600 <sup>1)</sup>	5400 <sup>1)</sup>	370	3600 <sup>1)</sup>	2500													
90A	67	420	36	1500																
91A	6200 <sup>1)</sup>	4900 <sup>1)</sup>	100	450	530			880	65	560 <sup>1)</sup>				480			180	1400		
92A	1900	6300 <sup>1)</sup>	600	690	18			16						95			32			
93A	120	280		100										310			2900		41	
94A	380	33					320												40	
16B	270	19		48														34		19
24B	440	180	180	2100 <sup>1)</sup>	13000 <sup>1)</sup>	1900 <sup>1)</sup>	7200 <sup>1)</sup>	29										11		
37B			180				2200													
38B			13	1800 <sup>1)</sup>		13	1200													
40B				13000 <sup>1)</sup>		790 <sup>1)</sup>		170	21000 <sup>1)</sup>					76					15	
52B			2100 <sup>1)</sup>	12000 <sup>1)</sup>	11	7500 <sup>1)</sup>	2600											63	26	
55B				2100 <sup>1)</sup>		600	58													90
58B			160	4000 <sup>1)</sup>		3800 <sup>1)</sup>	270													26

All concentrations are in µg/l (ppb)

SD 1540296  
TU9095

Water Sample	Bladex	HEAD	trichloro ethylene	tetrachloro ethylene	DMK	CH <sub>2</sub> Cl <sub>2</sub>	THP	Others	VOA	BN	AE	pH	Conductance Osm-Cm <sup>-1</sup> X 10 <sup>-3</sup>	Chloride mg/ml	Sulfate mg/ml	Copper ppm	
72A						660			760	60	84	7.3	1.5	0.21	0.17	<0.5	
73A									1600	110	170	7.2	1.5	0.18	0.16	<0.5	
74A						640			2000	250	76	7.3	1.7	0.24	0.18	<0.5	
75A						1100			4500	170	230	7.0	4.1	1.5	0.39	<0.5	
76A						200			790	79	73	7.5	0.96	1.4	0.10	<0.5	
77A						420			1300	120	150	7.1	4.5	1.8	0.10	<0.5	
78A									640	77	92	7.4	3.6	1.2	0.23	<0.5	
79A						2600			7200	360	51	7.3	3.1	0.94	0.27	<0.5	
80A									1100	220	60	7.7	1.4	0.15	0.15	<0.5	
81A									790	210	85	7.4	1.3	0.13	0.15	<0.5	
82A									2300	79	63	7.3	1.7	0.21	0.31	<0.5	
83A									29000	670	260	7.1	2.9	0.62	0.75	<0.5	
84A						360			5400	94	91	7.6	1.1	0.16	0.17	<0.5	
85A						230			860	76	75	7.8	0.81	0.08	0.08	<0.5	
86A									86	110	58	7.5	0.83	0.08	0.07	<0.5	
87A									90	33	110	7.8	0.90	0.10	0.10	<0.5	
88A						530	84)		19000	1200	220	7.6	1.0	0.14	0.09	<0.5	
89A							61)		19000	25000	3400	8.0	0.64	0.06	0.07	<0.5	
90A						660			4000	330	100	7.6	2.2	0.44	0.43	<0.5	
91A							89)		18000	8800	3000	7.4	2.1	0.40	0.43	<0.5	
92A									11000	260	100	7.7	1.9	0.29	0.37	<0.5	
93A						690			1500	730	190	7.7	2.1	0.36	0.39	<0.5	
94A									14000	930	38	7.1	7.0	3.3	0.25	<0.5	
16B									970	1100	7.9	1.3	0.24	0.09	<0.5		
24B									470	760	7.7	0.99	0.19	0.09	<0.5		
37B									380000	10000	7.8	0.64	<0.01	0.03	<0.5		
38B									3500	980	2700	7.0	3.6	0.07	1.2	<0.5	
40B									26000	1000	1000	7.7	3.3	0.40	0.74	<0.5	
52B									55000	170000	35000	7.8	1.1	0.13	0.16	<0.5	
55B						200			55000	2500	760	7.4	2.5	0.65	0.19	<0.5	
58B									100000	4600	1700	7.2	2.5	0.78	0.15	<0.5	

All concentrations are in ug/l (ppb)

Water Sample	CHCl3	CCl4	BCH	Benzene	MIBK	Toluene	DCPD	Chlorobenzene	Dichloro Benzenes	STP	DACP	HCB	PCP	Hex	HCNB	SD 13957	SD 13190	HCB	Atrazine	
59B			12	13000		270	89												14	
61B				9400																16
65B			190	3700		180	32													600
77B																				540
78B																				
79B								1200												520
80B																				

Water Sample	Bladex	HEOD	Trichloro ethylene	Trichloro ethylene	1,1,1-trichloro ethylene	1,1,2-trichloro ethylene	1,1,1,2-tetra	1,1,2,2-tetra	1,1,1,2,2-penta	1,1,1,2,2,2-hexa	VOA	EM	HE	PH	Conductance Dhm-Cu-X-10-3	Chloride mg/l	Sulfate mg/ml	Copper ppm	TUPO 95	SD 15402 94
59B											73000	1300	820	7.7	2.5	0.78	0.16	<0.5		
61B											60000	150	230	7.3	1.8	0.55	0.18	<0.5		
65B											210000	30000	14000	93	93	93	93	93		
77B											1200	550	220	7.3	4.2	1.7	0.10	<0.5		
78B											450	450	300	7.6	2.7	0.91	0.15	<0.5		
79B											1800	260	250	7.5	2.8	0.85	0.24	<0.5		
80B											750	610	200	7.7	1.3	0.16	0.13	<0.5		

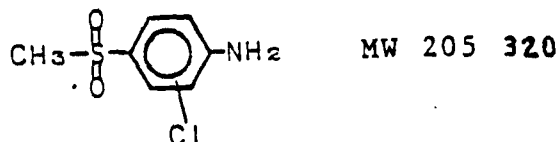
All concentrations are in ug/l (ppb)

Footnotes to Table 4

- 1) At least one ion in spectrum saturated; actual concentration probably greater.
- 2) Dimethyldisulfide 3600<sup>1)</sup>
- 3) 1,2-bis(methylthio)ethane 560
- 4) Dichloroethene 280
- 5) Cyclopentene 1900
- 6) Cyclopentadiene 400
- 7) Methyl cyclohexane 500
- 8) Dimethyldisulfide 4200<sup>1)</sup>
- 9) 1,2-bis(methylthio)ethane 590
- 10) Methyl cyclohexane 250
- 11) Ethyl benzene 4500
- 12) Hexachloroethane 1800
- 13) Dichloropropene 210
- 14) Bromochloropropene 310
- 15) Ethyl benzene 630
- 16) Bromodichloro methane 520
- 17) 2-propanol 360
- 18) Dichloroethene 300
- 19) Methyl cyclohexane 300
- 20) Ethyl benzene 340
- 21) Methoxy benzene 440
- 22) Dimethyl disulfido 1200<sup>1)</sup>
- 23) Cyclopentene 360
- 24) Cyclohexane 260
- 25) Hexane 400
- 26) Methyl cyclohexane 450
- 27) Ethyl benzene 490
- 28) Methyl cyclopentane 430
- 29) Dichloropropane 3800
- 30) Hexane 260
- 31) Methyl cyclohexane 420
- 32) Trichloropropane 370
- 33) Ethyl benzene 1900
- 34) Thiophene 200
- 35) 2-butanone 250
- 36) 2-butanone 440
- 37) Bromodichloromethane 1300
- 38) Bromochloropropene 1200
- 39) Bromochloropropane 320
- 40) Trichloroethanol 670
- 41) Methyl cyclohexane 200
- 42) Cyclopentene 380
- 43) Methyl cyclohexane 220
- 44) Cyclopentene 270
- 45) Methyl cyclohexane 490
- 46) Hexane 240
- 47) Methyl cyclohexane 390
- 48) Thiophene 320
- 49) Dichloropropane 380
- 50) Ethyl benzene 200
- 51) Ethyl benzene 440

All concentrations are in  $\mu\text{g/l}$  (ppb)

- 52) Dipropyl ether 250
- 53) Thiophene 240
- 54) Ethyl benzene 210
- 55) dipropyl ether 360
- 56) Methyl cyclopentane 590
- 57) Methyl cyclohexane 540
- 58) Ethyl benzene 730
- 59) Bromodichloromethane 87001)
- 60) Dibromochloromethane 450
- 61) Ethyl benzene 400
- 62)



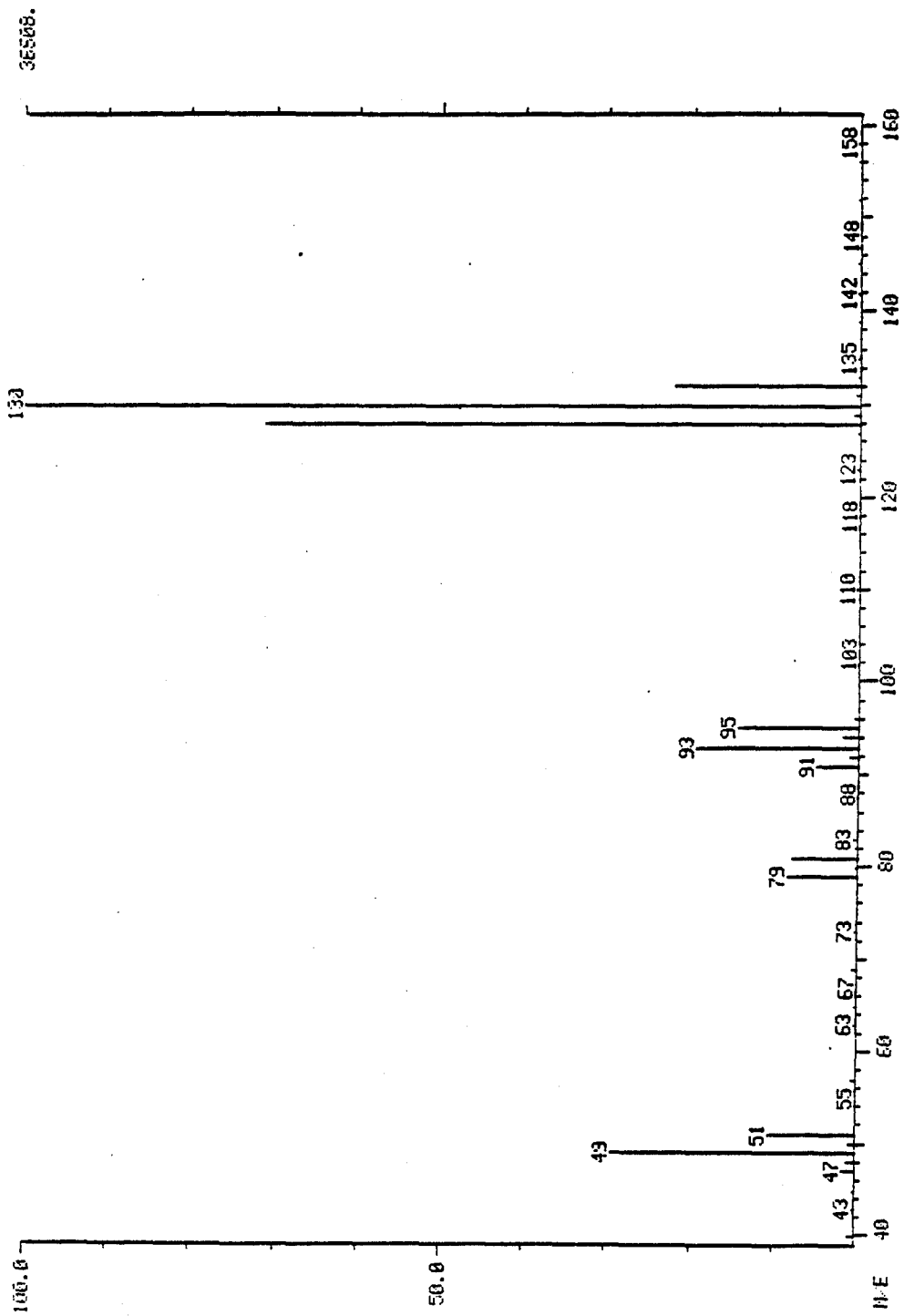
- 63) Dibenzyl ether 350
- 64) From packed column BN run
- 65) From capillary column BA run
- 66) Ethyl benzene 240
- 67) Ethyl benzene 1000
- 68) Dichloroethylene 970
- 69) Methyl cyclohexane 580
- 70) Carbon disulfide 360
- 71) Cyclopentene 230
- 72) Cyclohexane 210
- 73) Thiophene 550
- 74) Methyl cyclohexane 610
- 75) Ethyl benzene 310
- 76) Diphenyl ether 380
- 77) VOA sample taken from quart jar
- 78)

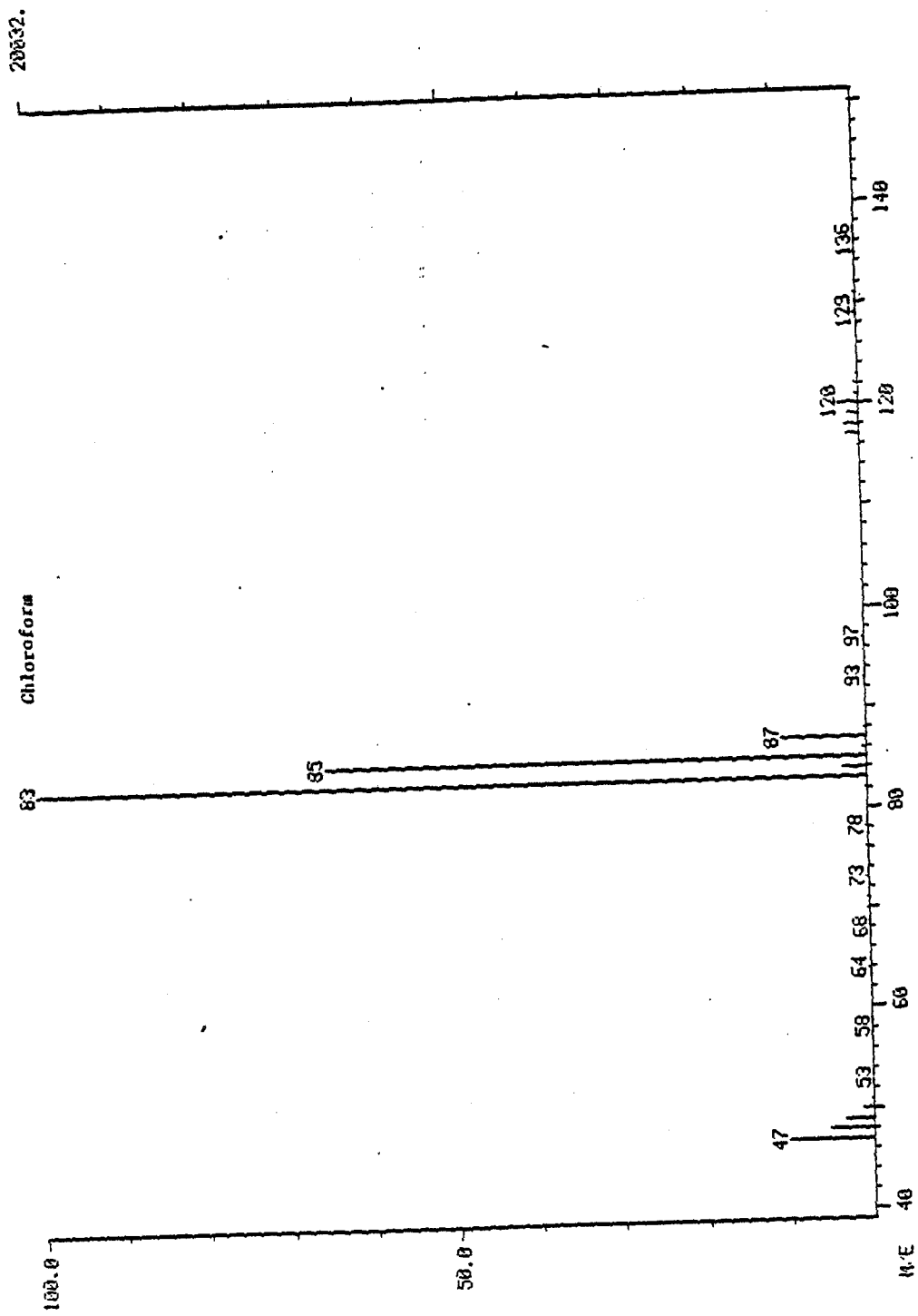


- 79) Cyclopentene 360
- 80) Cyclohexane 260
- 81) Hexane 400
- 82) Methyl cyclohexane 450
- 83) Ethyl benzene 490
- 84) Dipropyl ether 320
- 85) Sample lost
- 86) RIR-24-642-79
- 87) RIR-24-643-79
- 88) Average of two determinations
- 89) Trichlorophenol 910

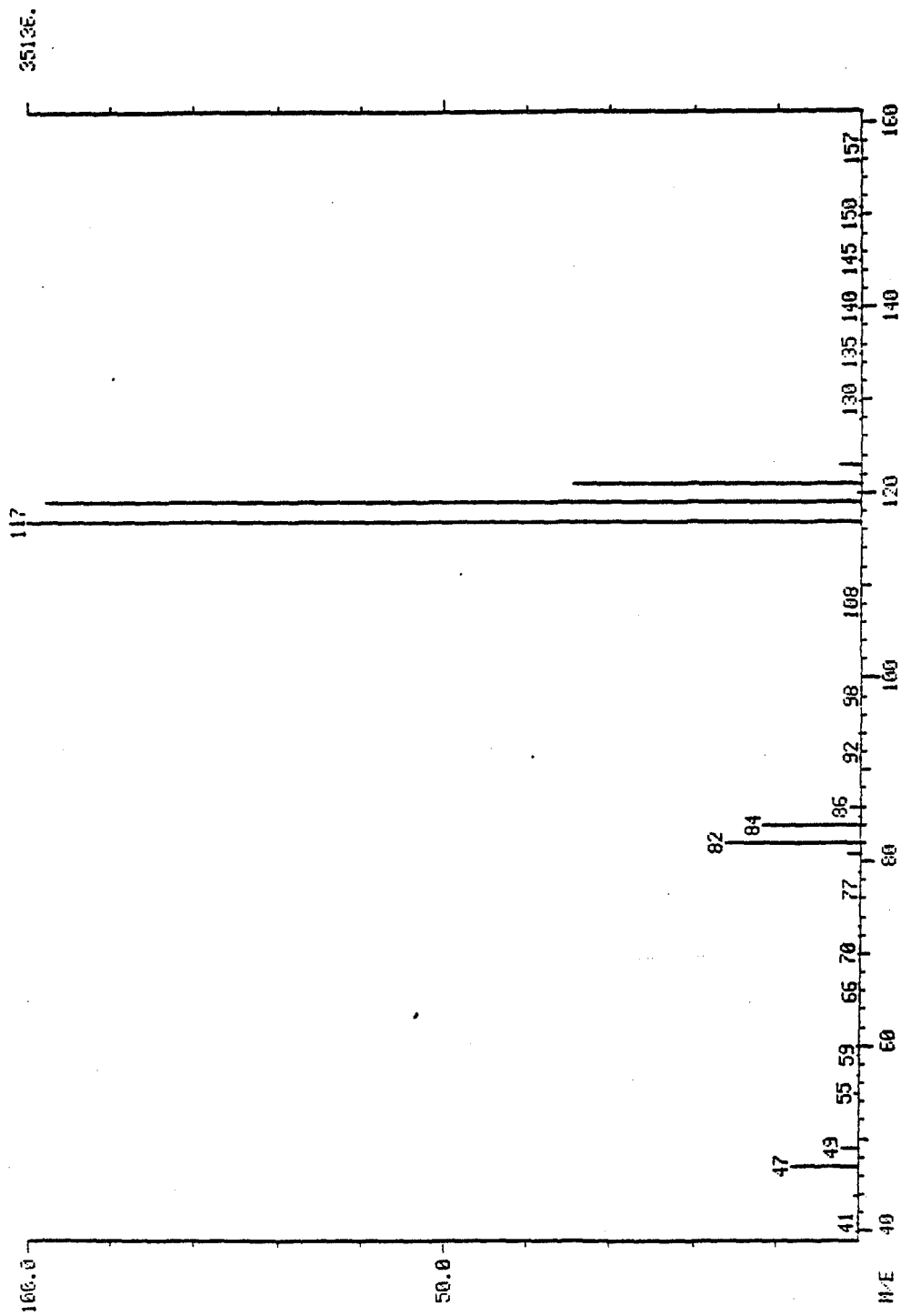
All concentrations are in ug/l (ppb)

Bromochloromethane  
Internal Standard

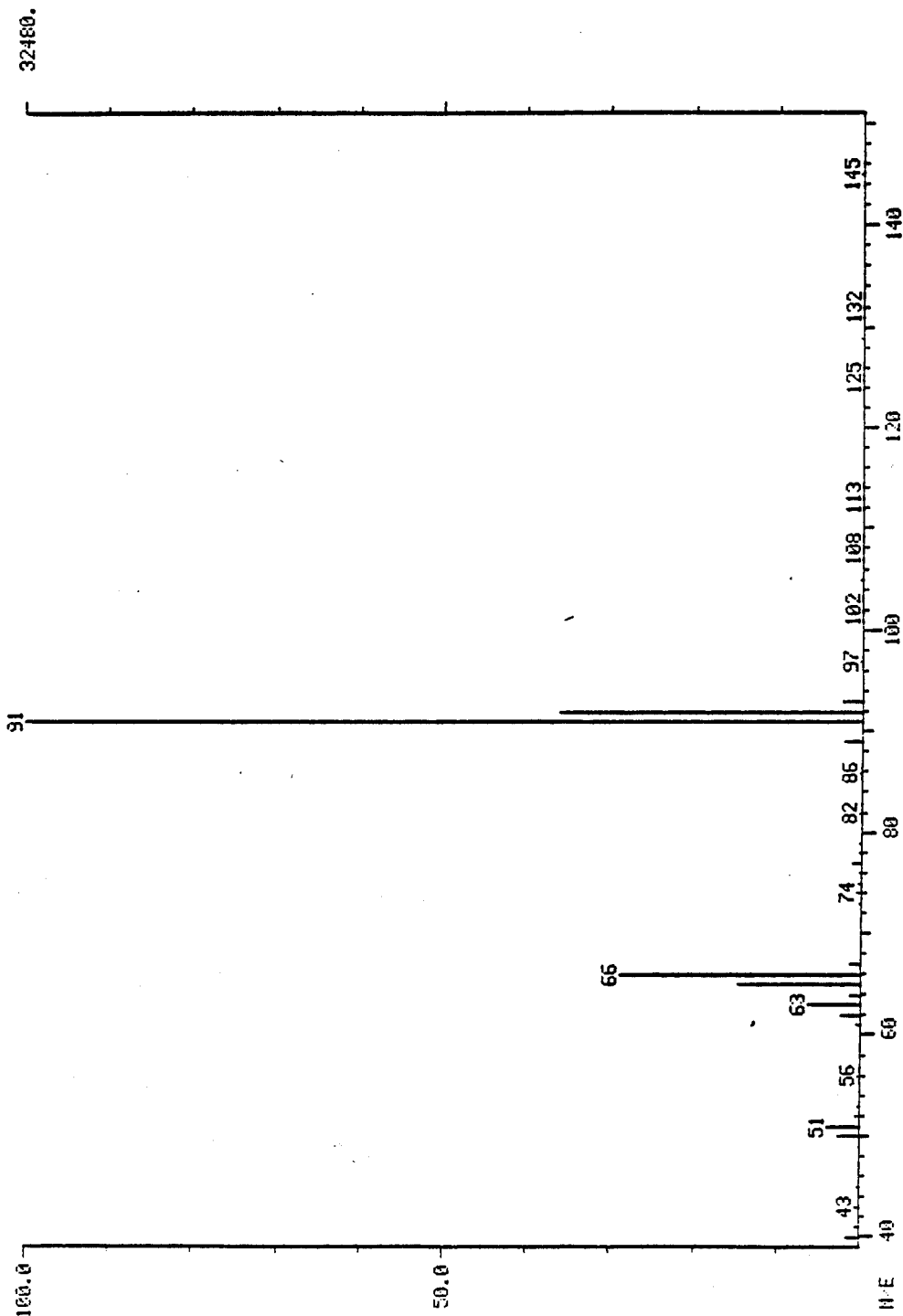




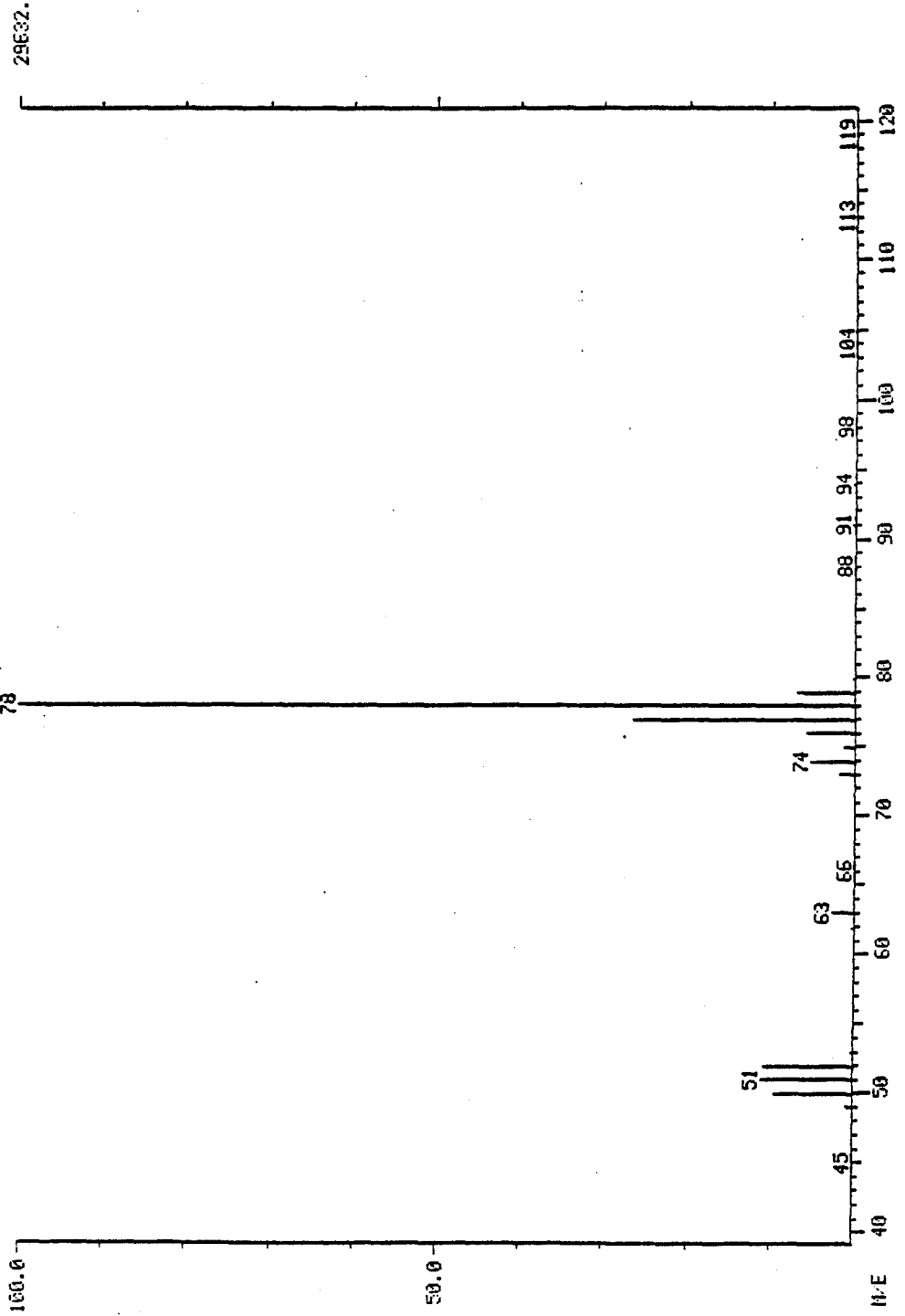
Carbon Tetrachloride



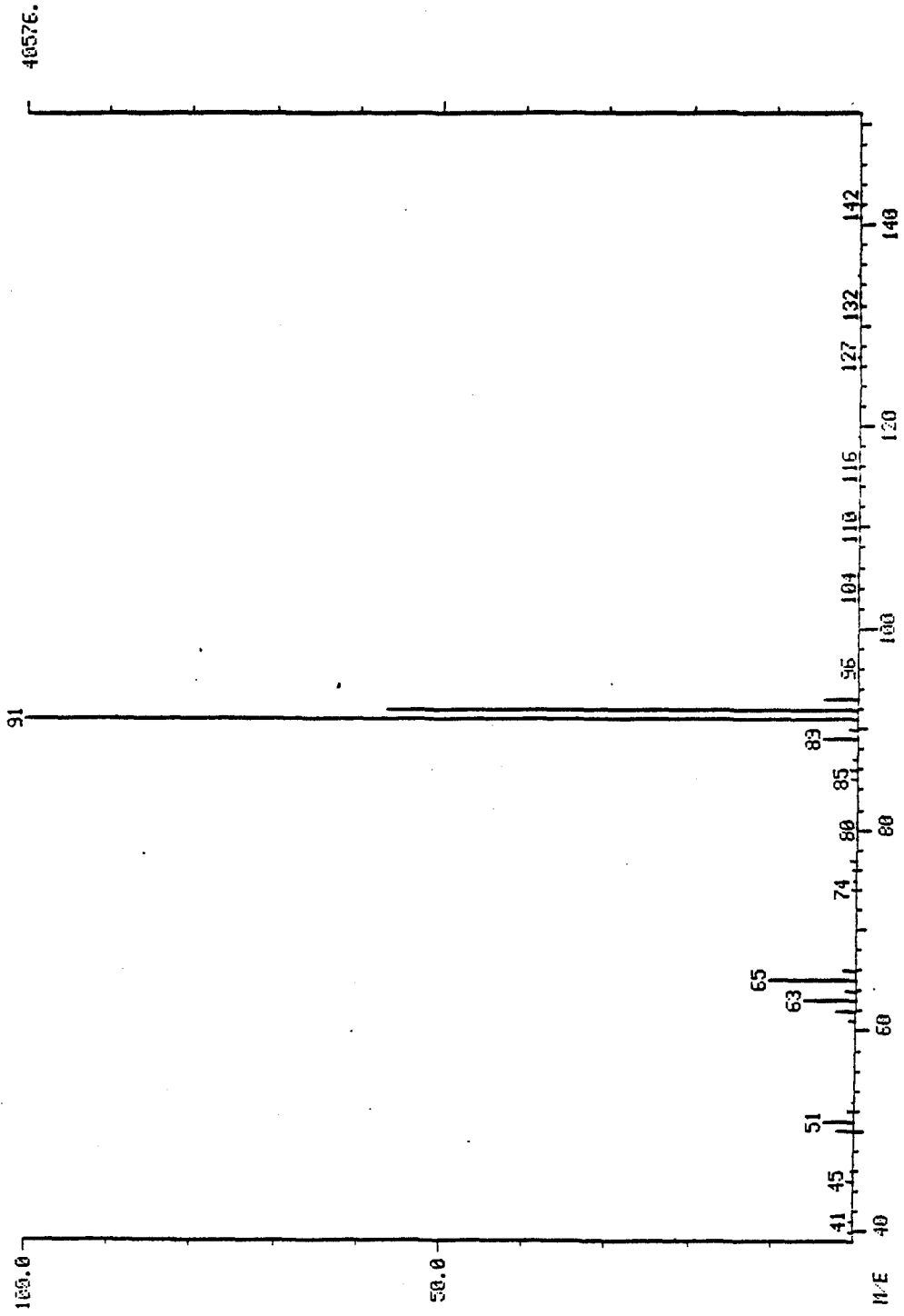
Bicycloheptadiene



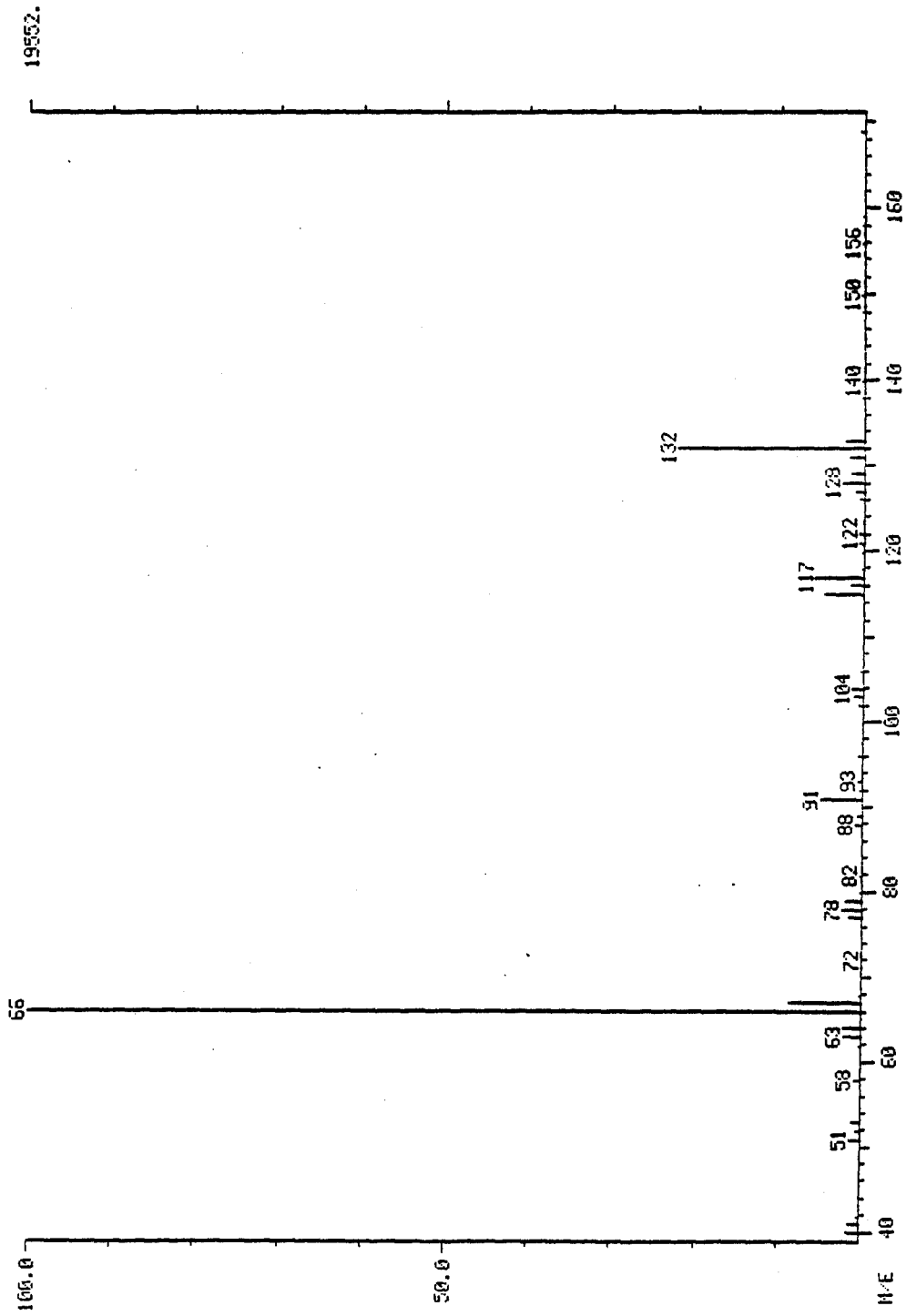
Benzene



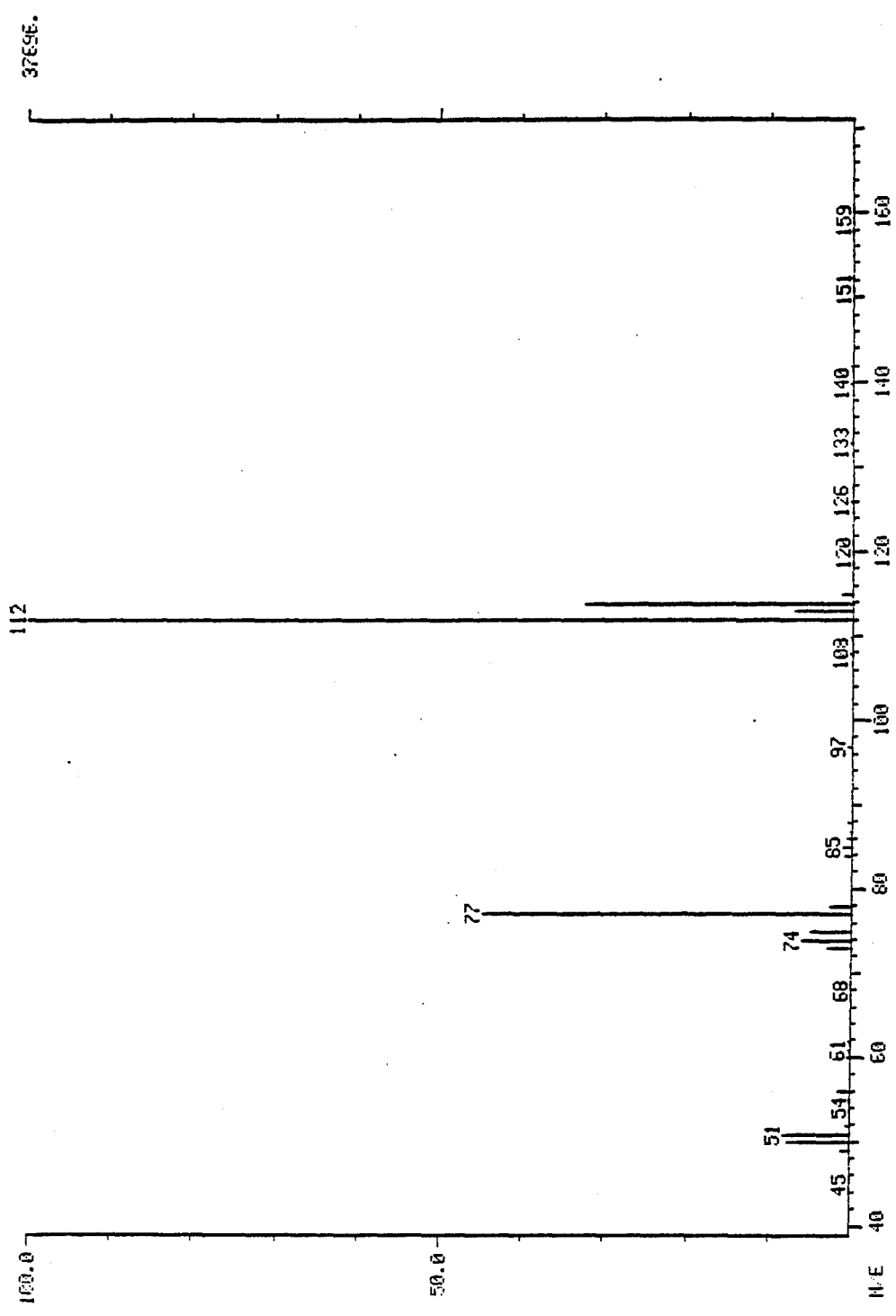
Toluene



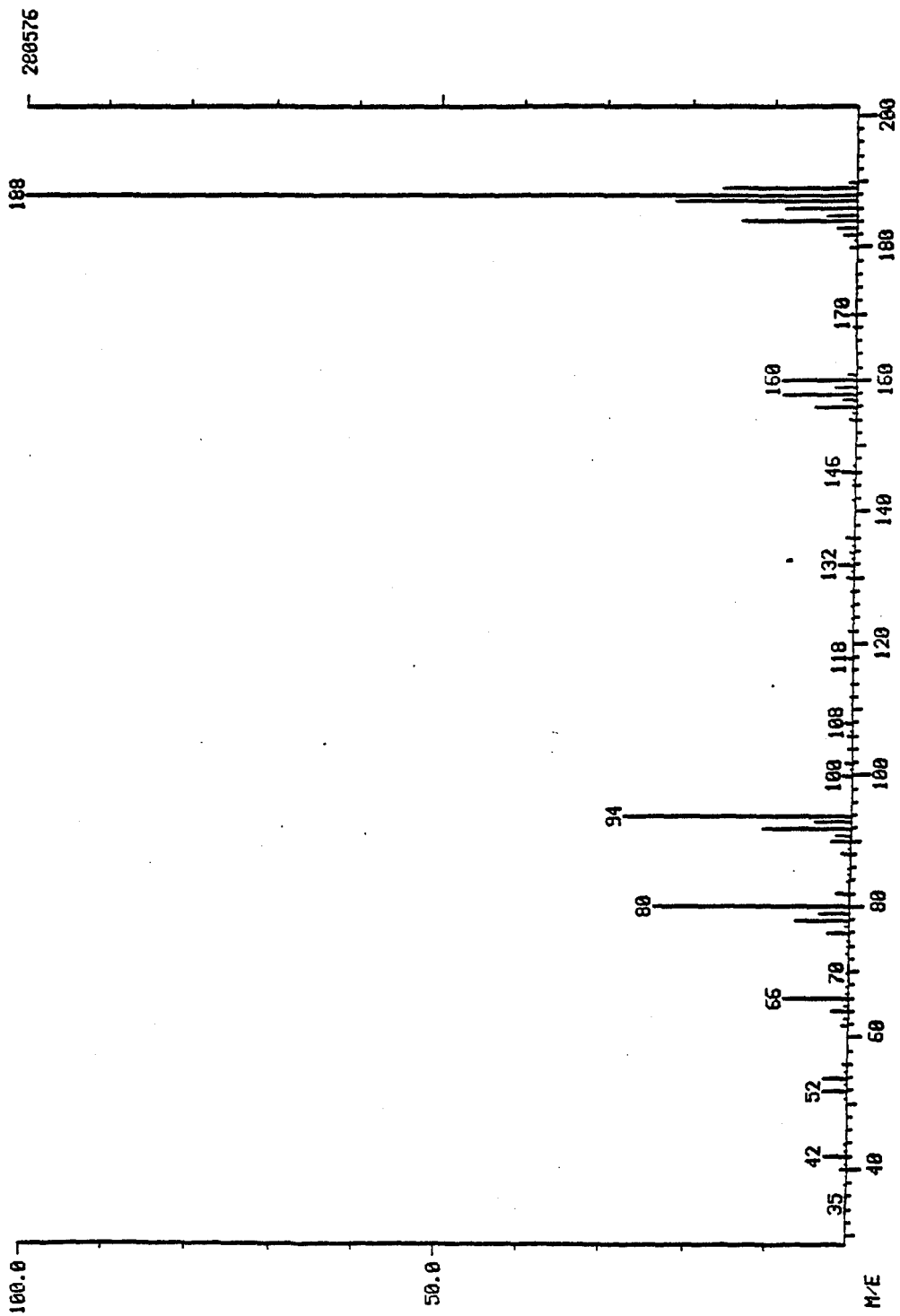
Dicyclopentadiene



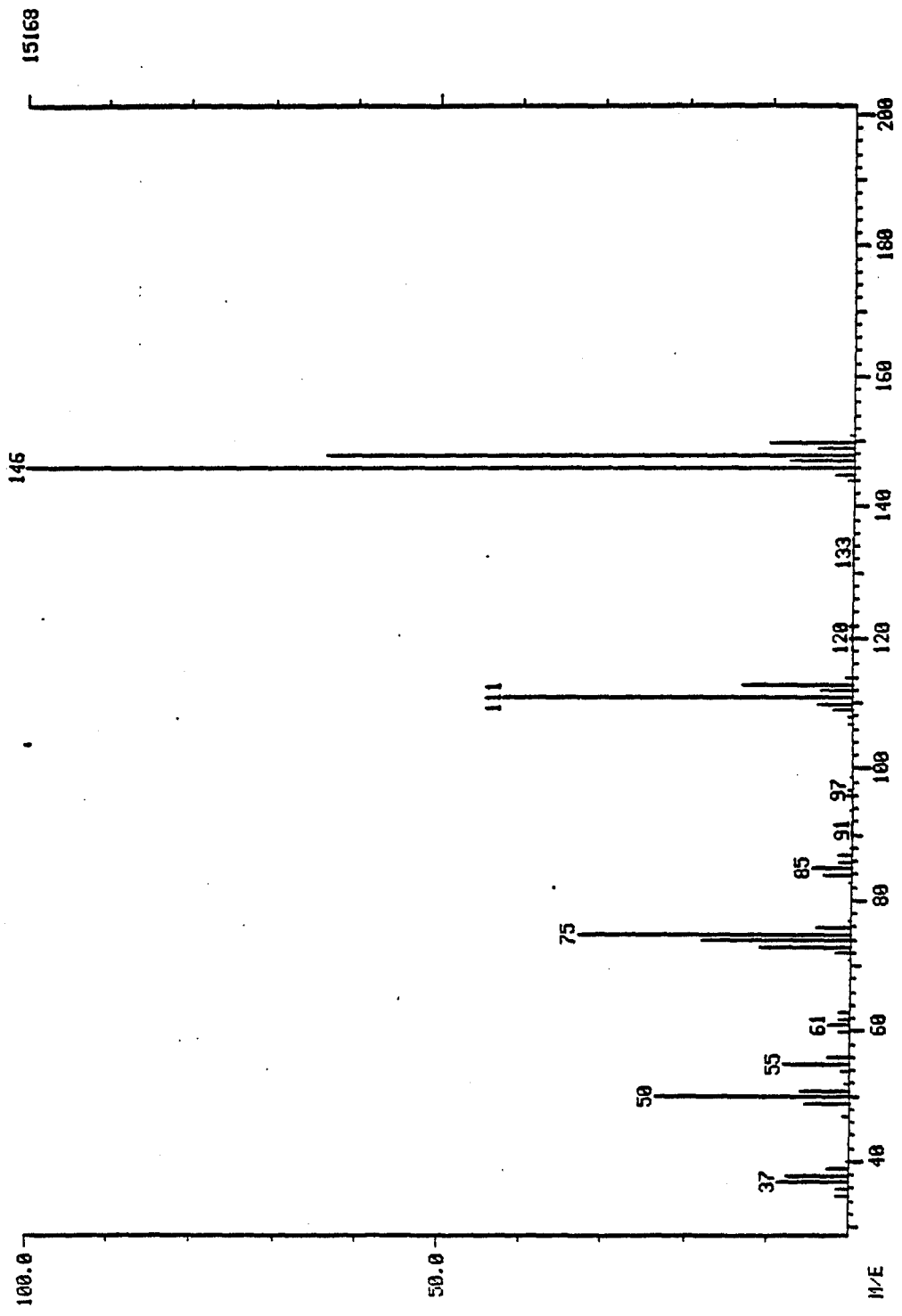
Chlorobenzene



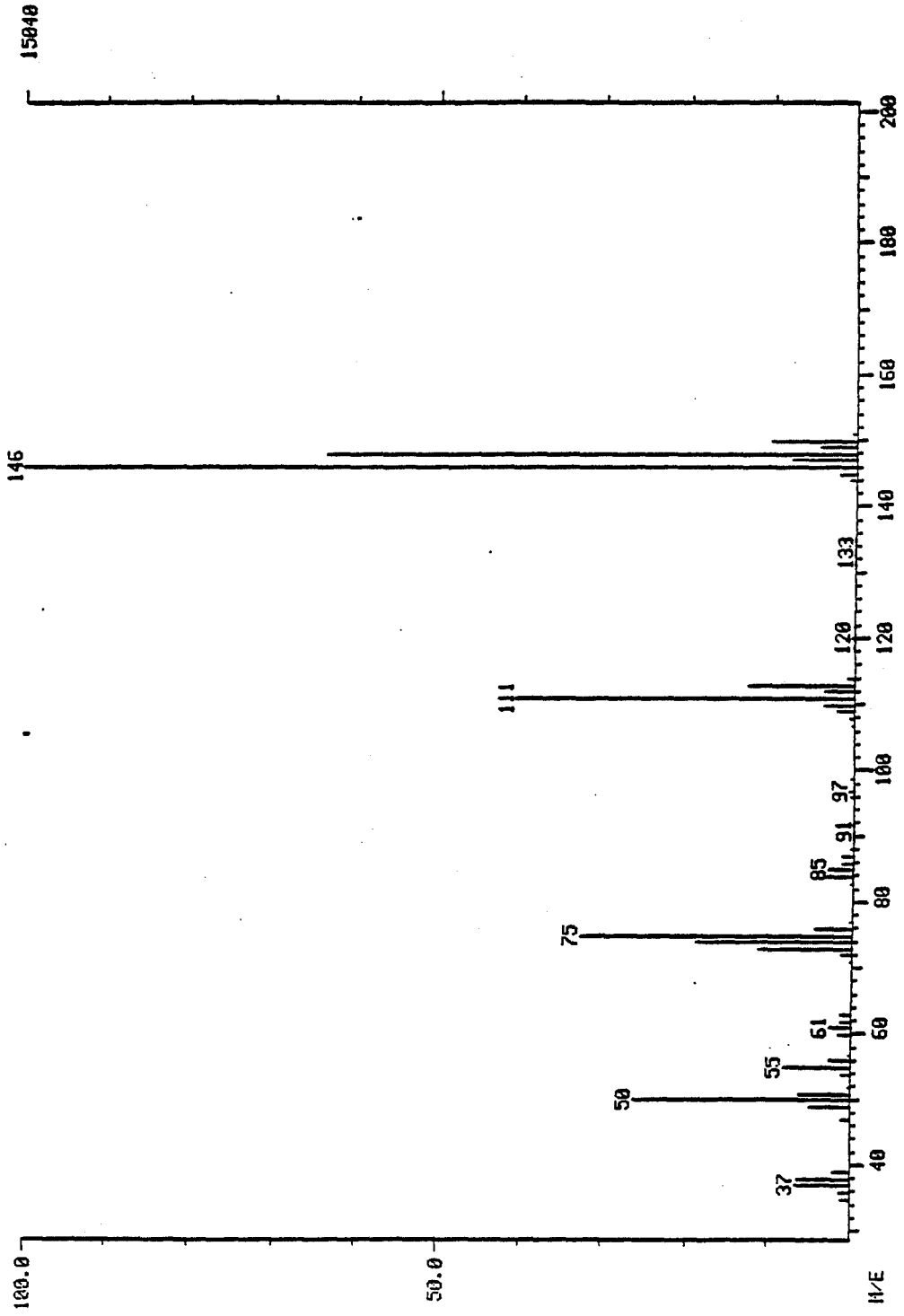
Dio-Anthracene



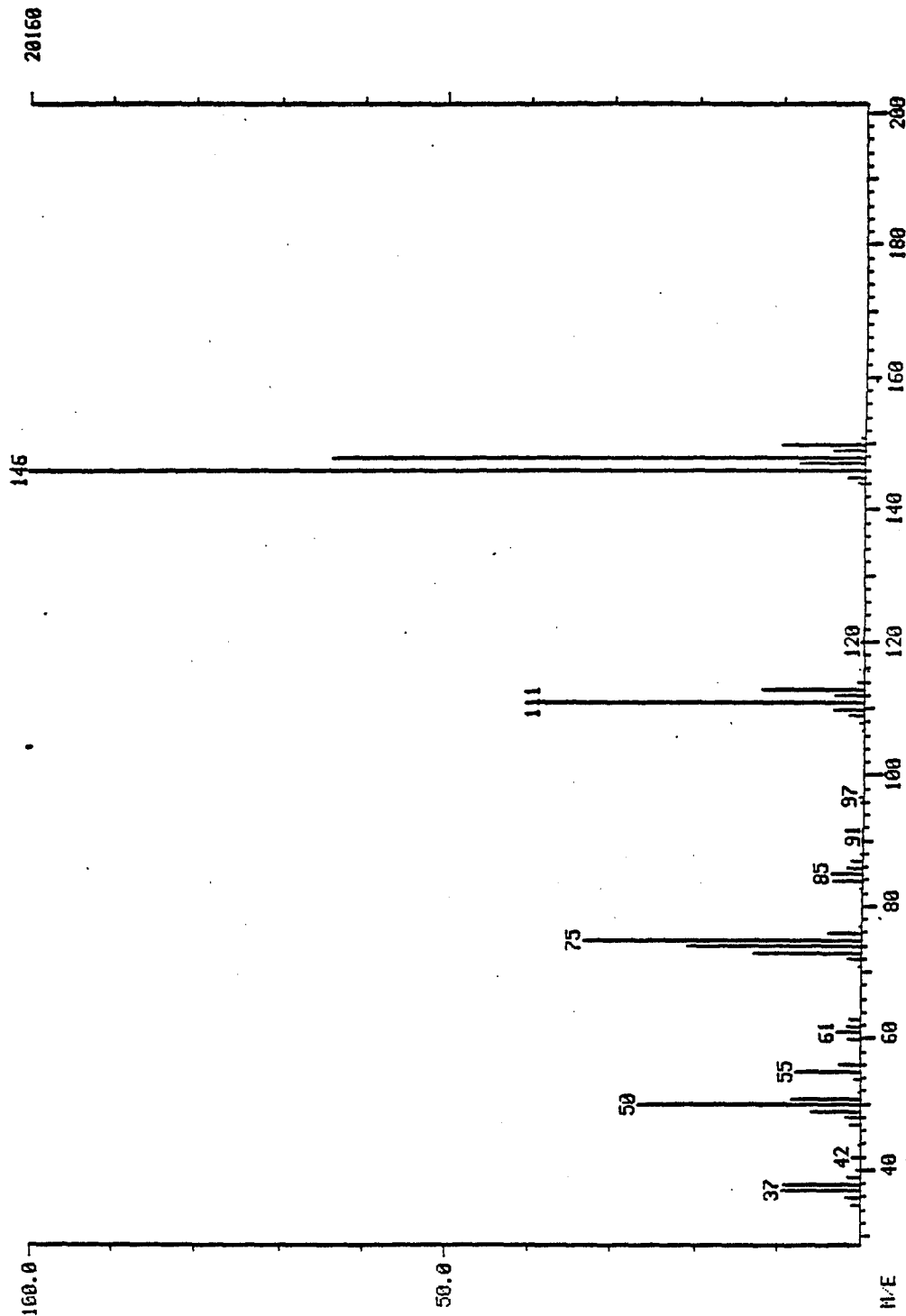
O-DCB



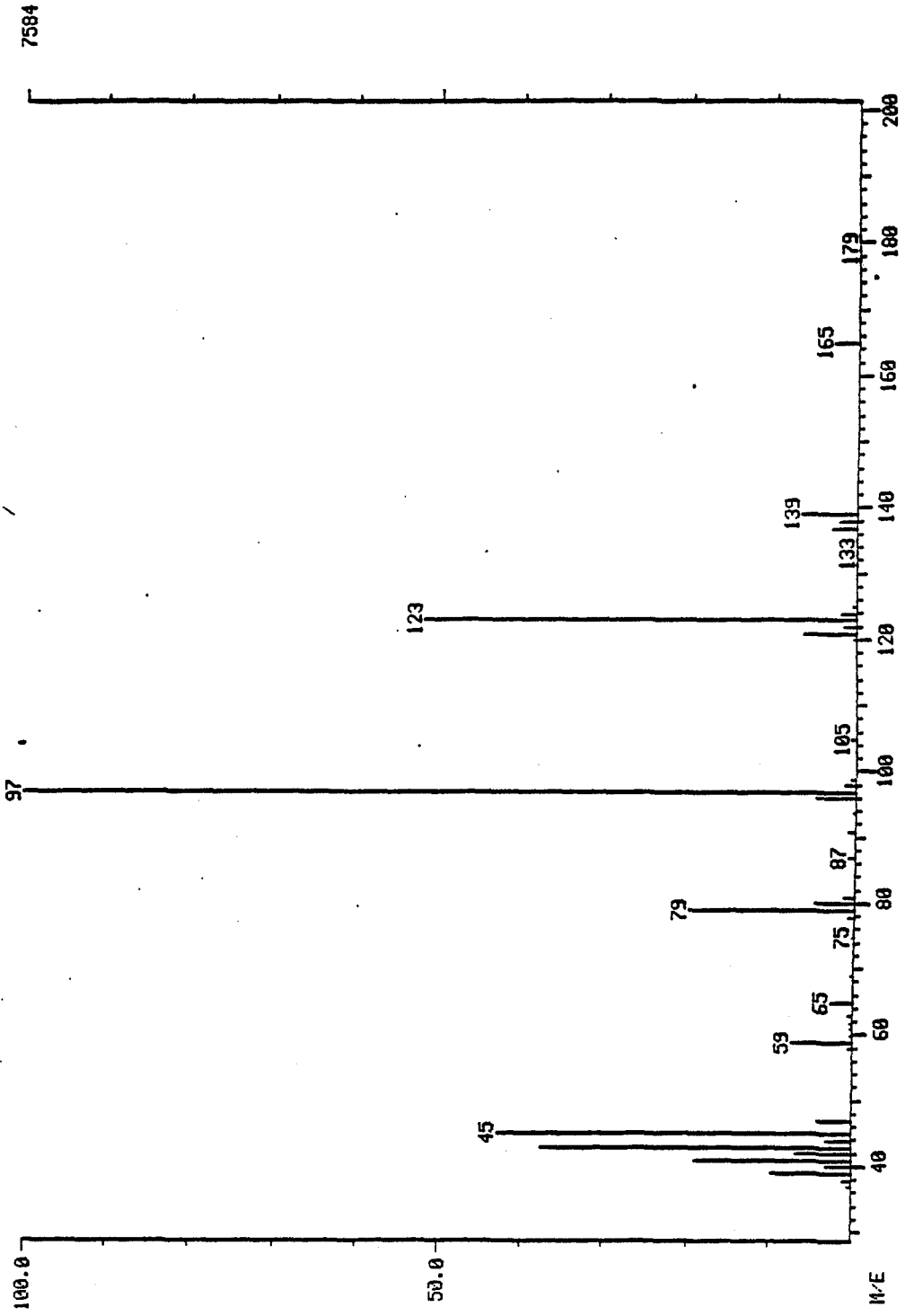
M-DCB



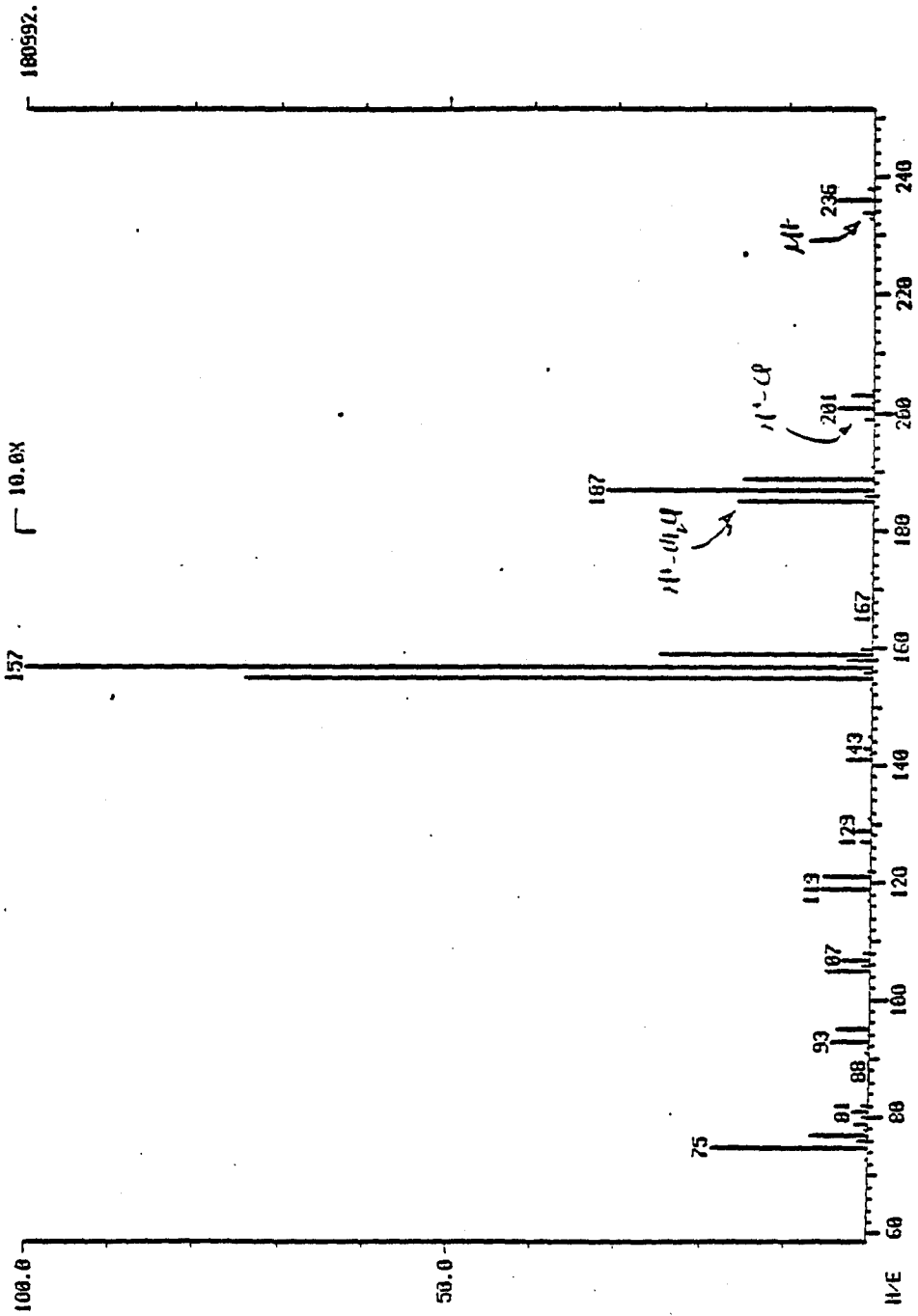
P-DCB



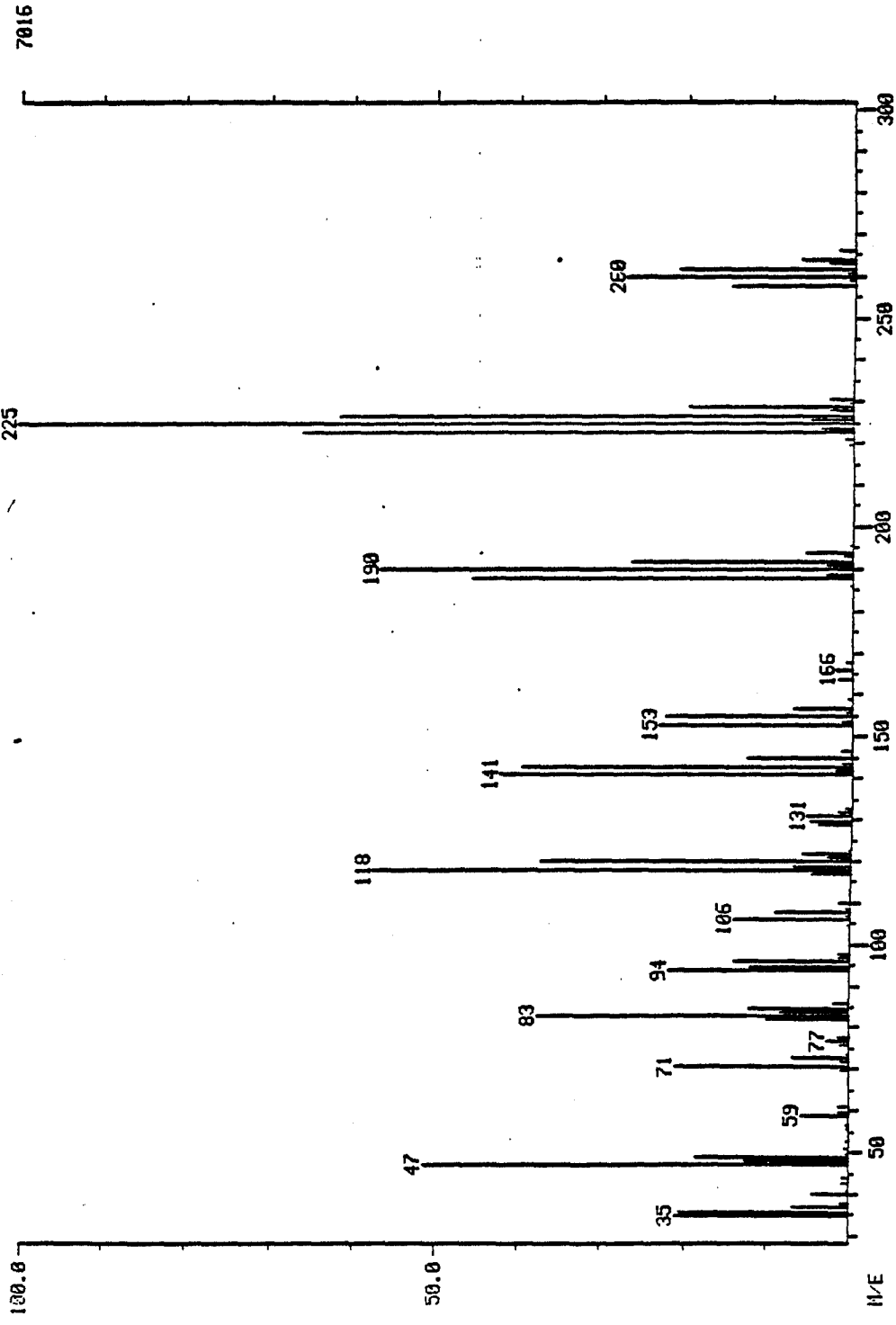
DIMP



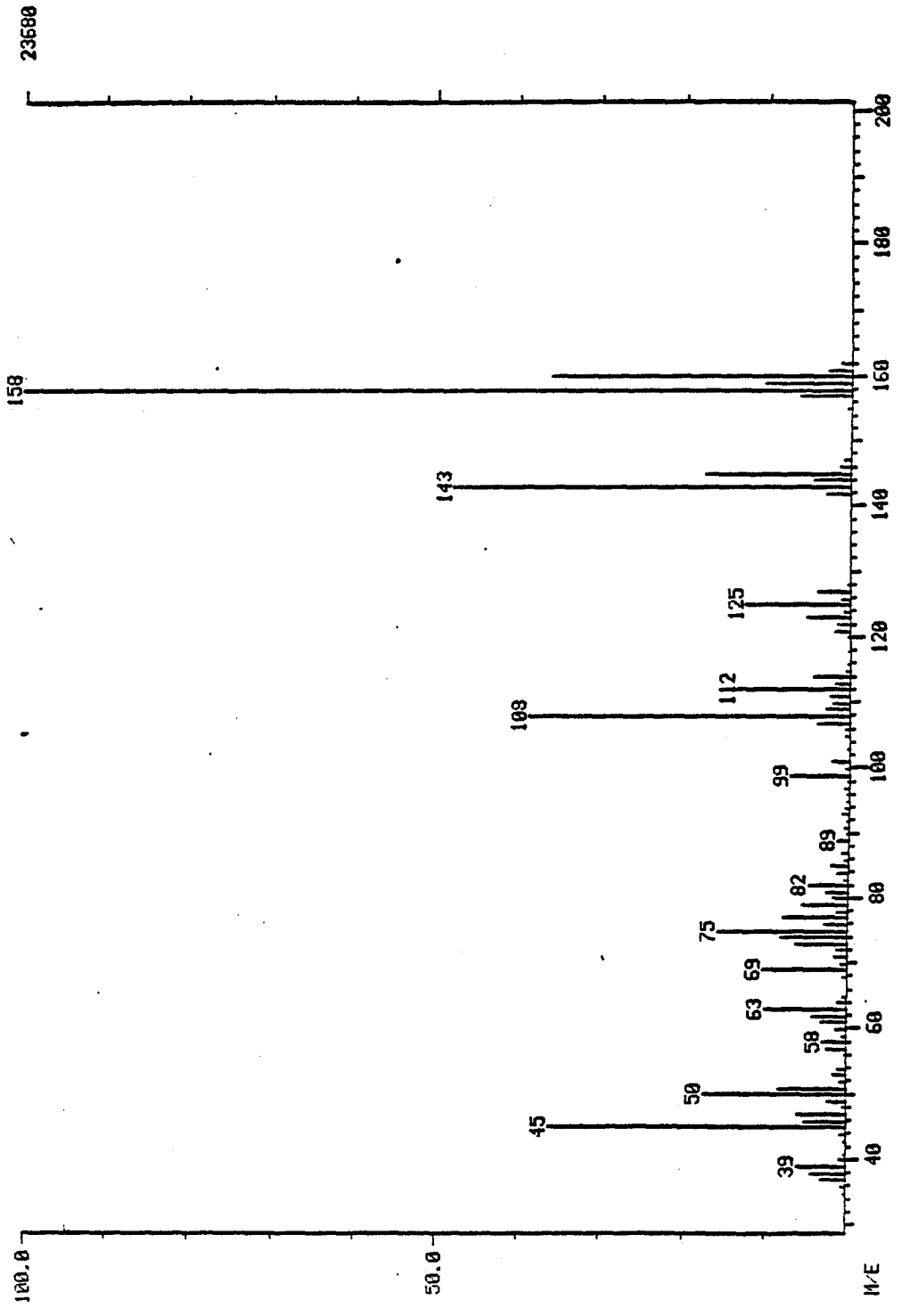
DBCP



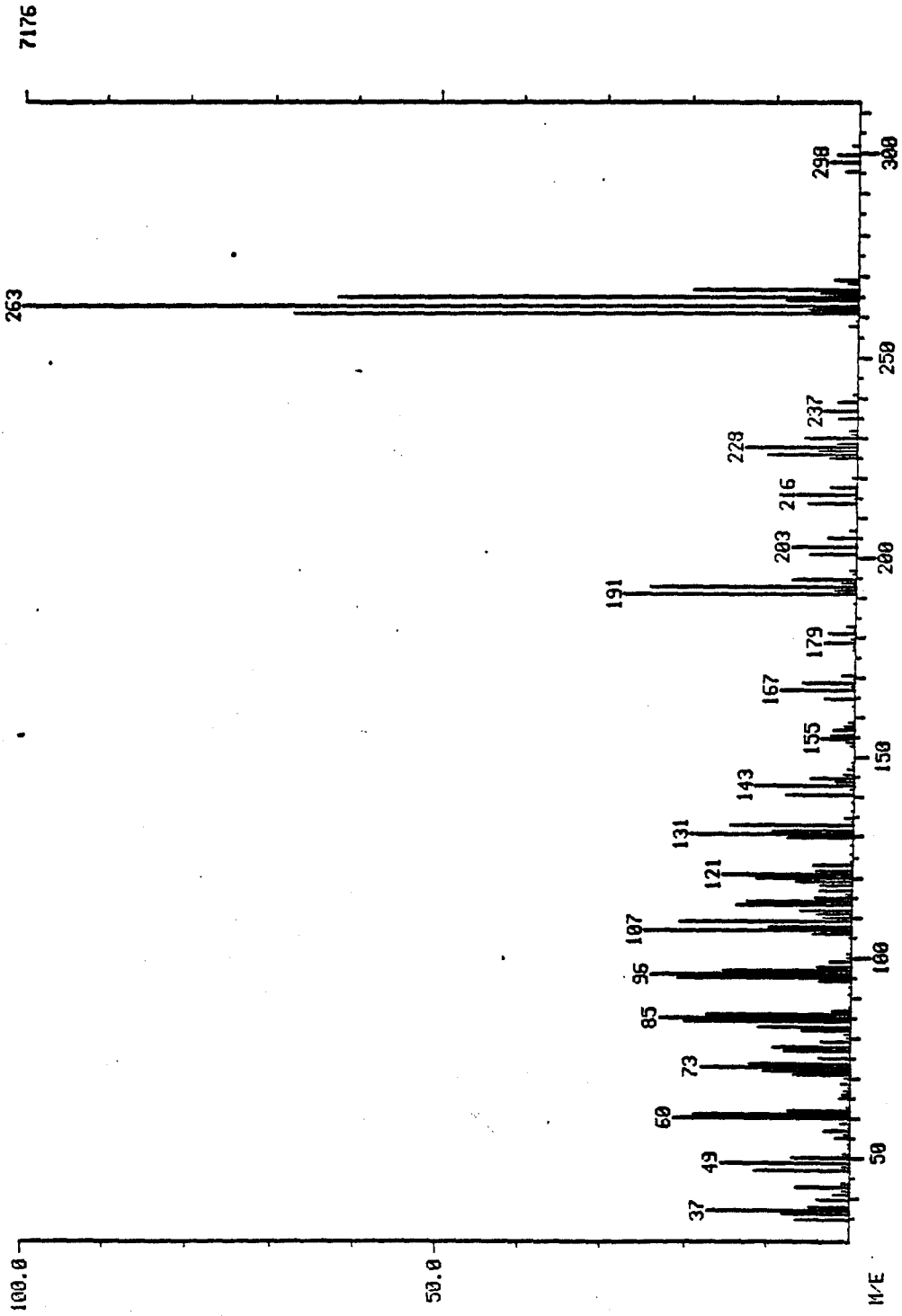
HCBDD



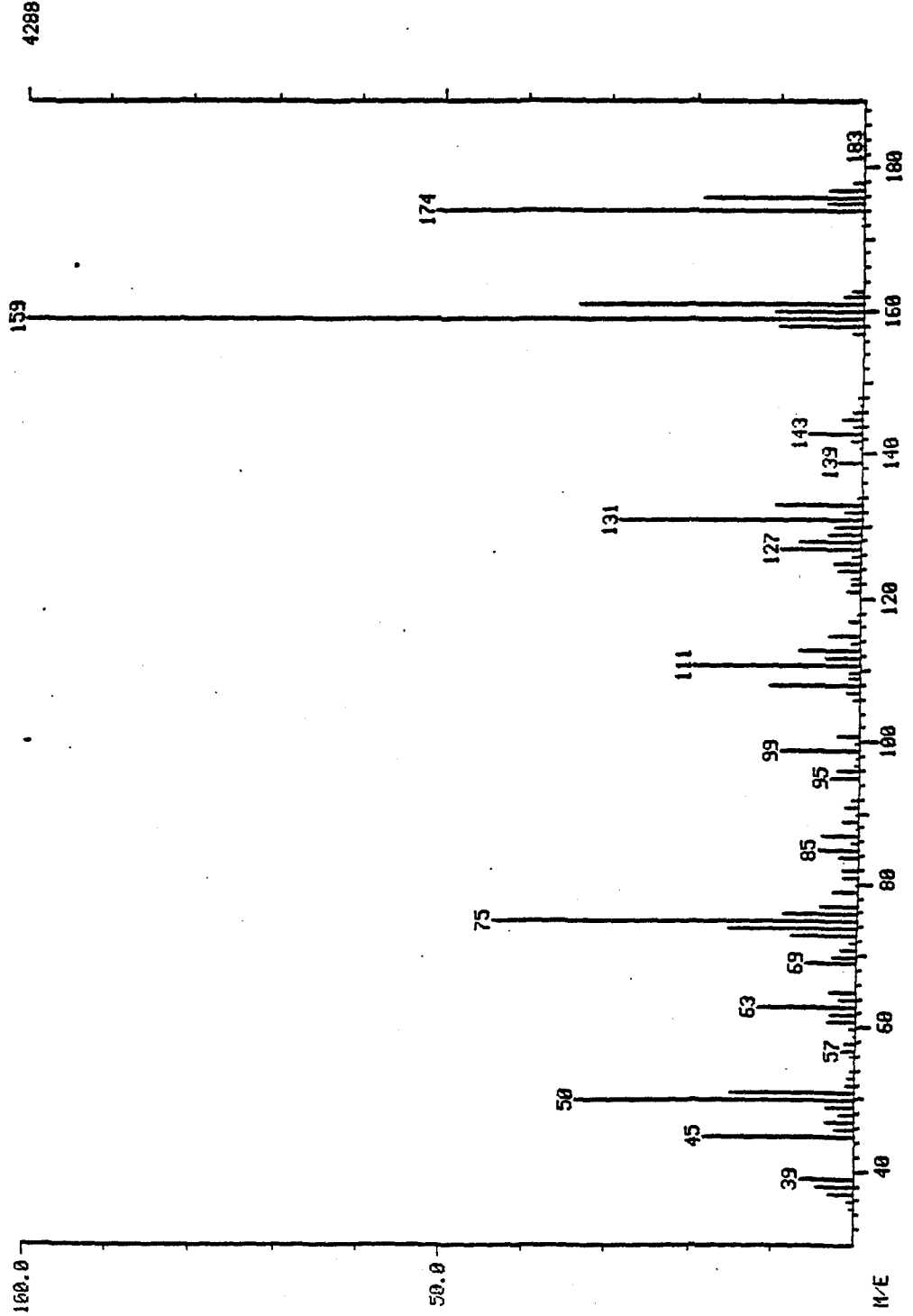
SD 9636



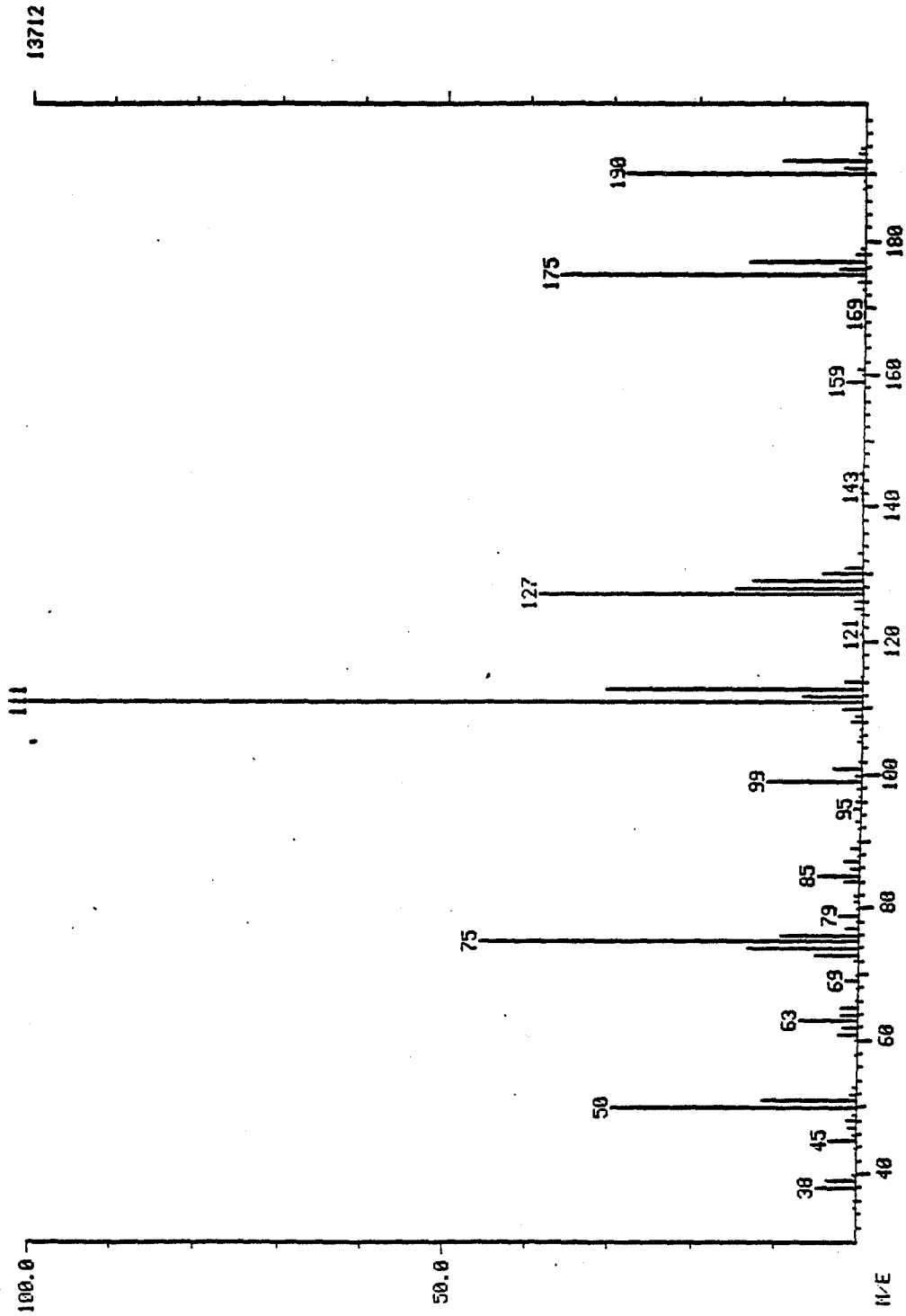
HCNB



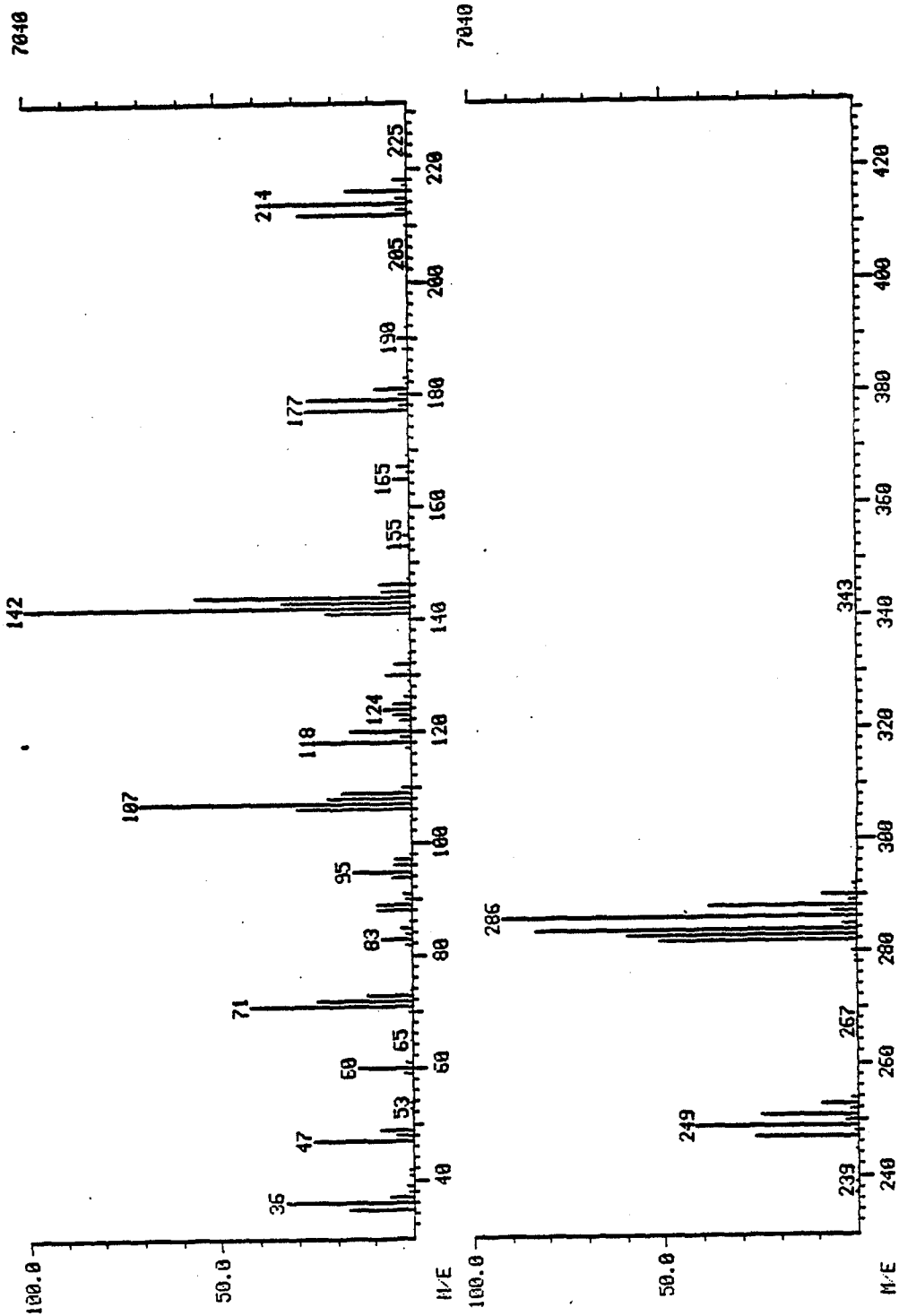
SD 13957



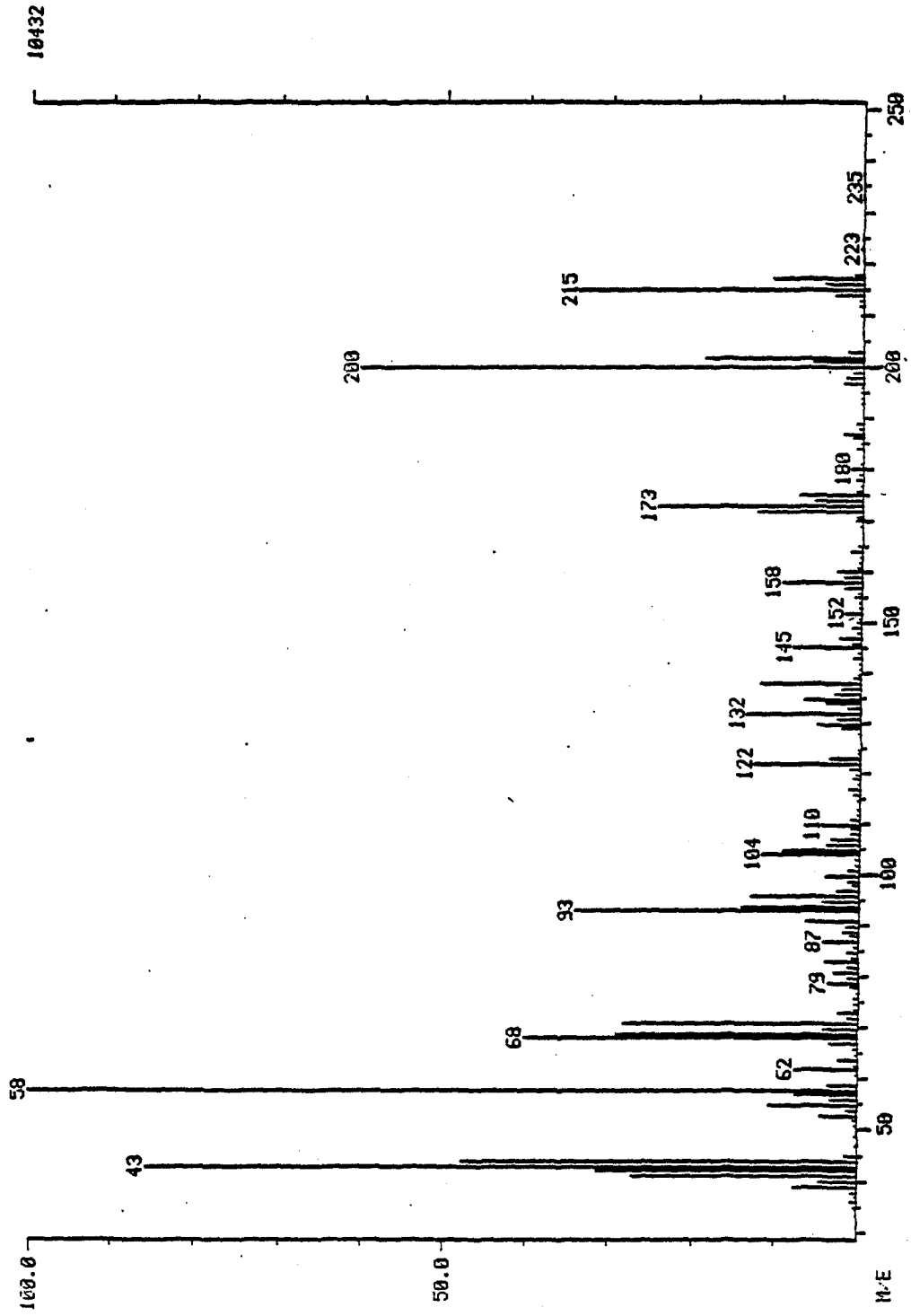
SD 13000



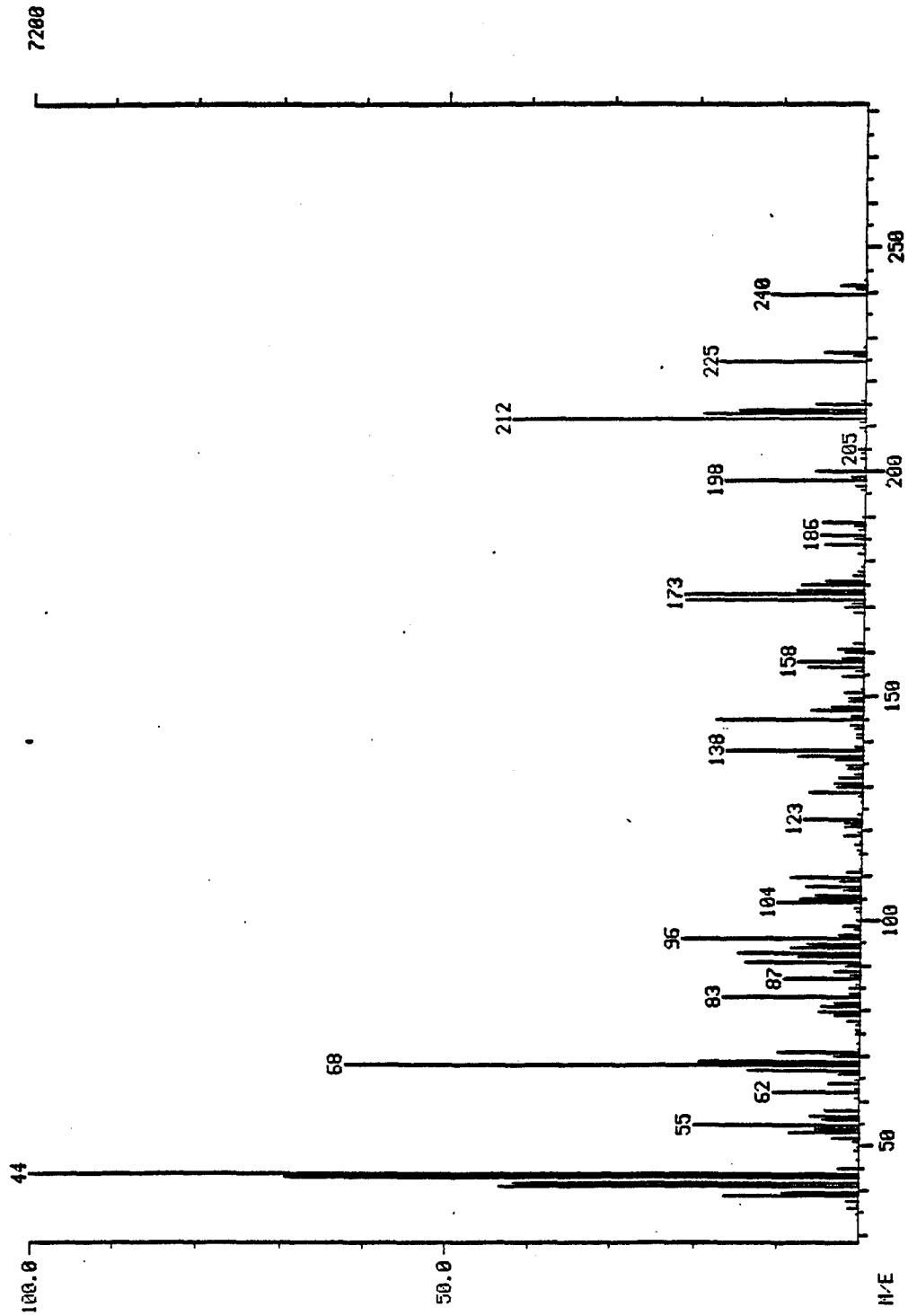
HCB



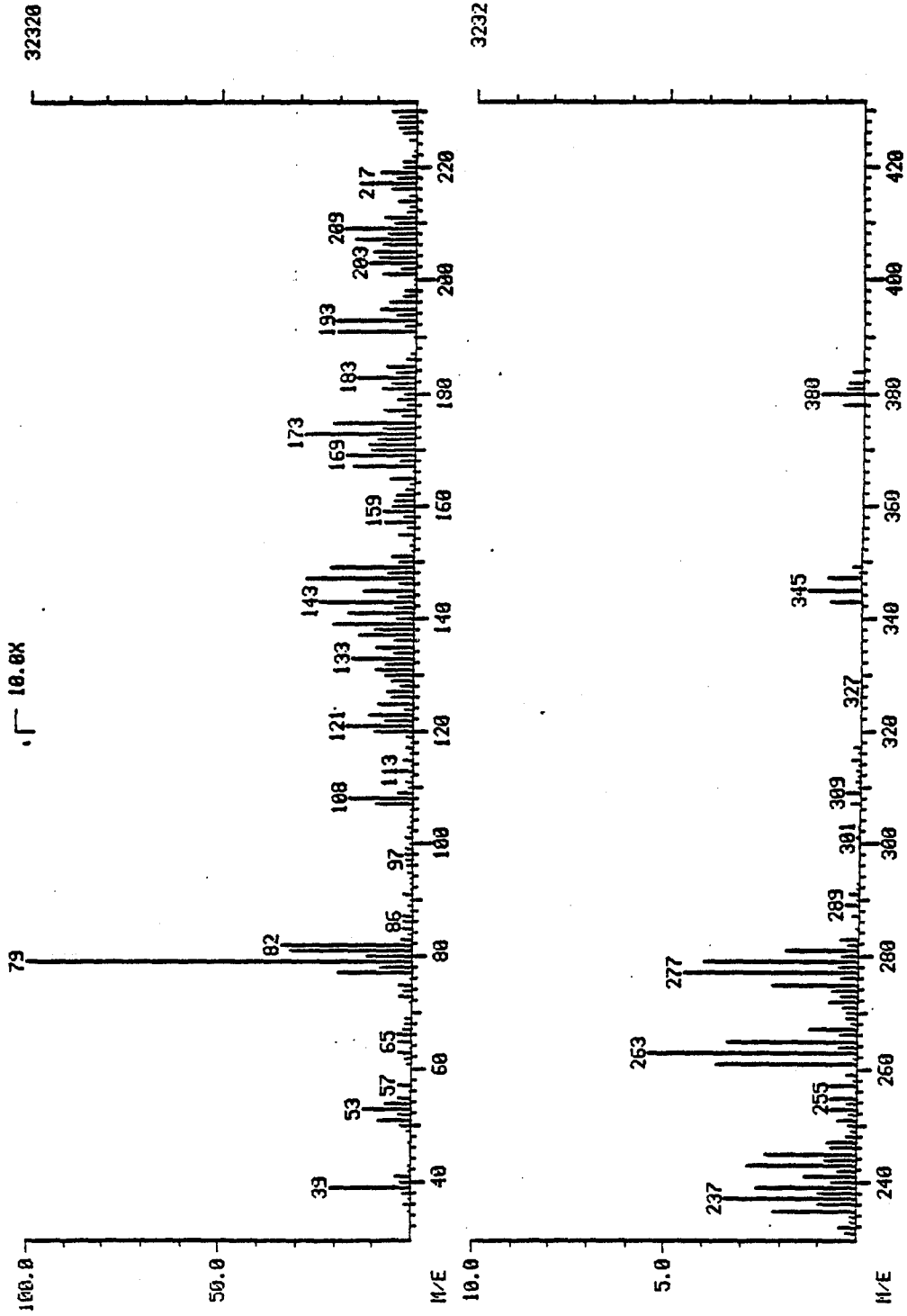
Atrazine



BLADEX



HEAD



2800' 1500' W 2000' W 1800' W 1000' W 500'

SECTION 35

013  
○

PARKING L

SECTION 2

94

75.15

SOIL STORAGE

5000g

006

75.45

330

330

330

330

330

007  
○

00 P.C.

64.58

330

330

330

330

330

57.90

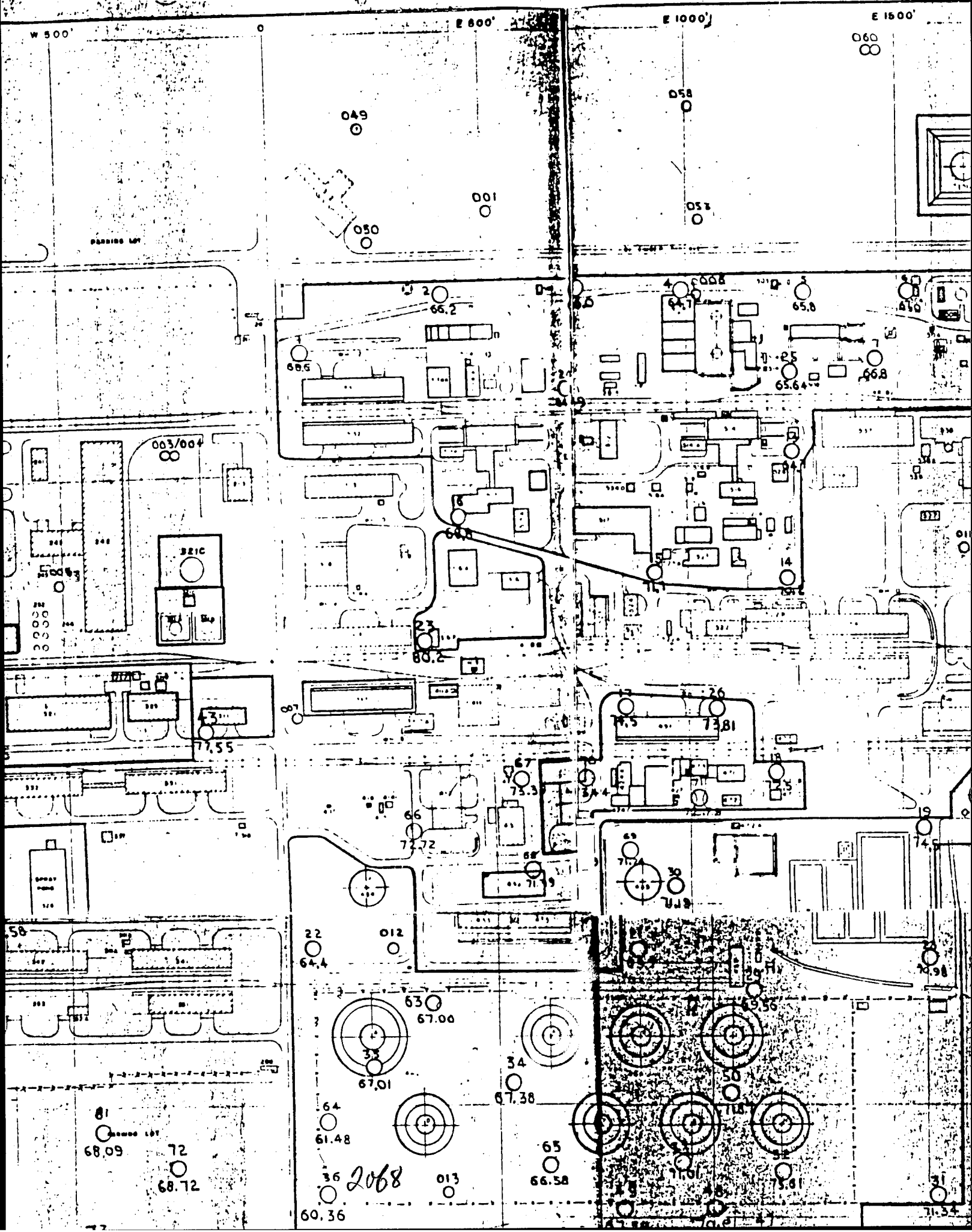
46

81  
○

68.09

1068

73



W 500' E 600' E 1000' E 1500'

049

001

058

057

060

050

066.2

068.8

065.8

066.8

003/004

BRIC

068.2

073.81

077.55

072.72

075.3

022  
064.4

012

063  
067.00

067.01

034  
067.38

071.1

030  
071.9

073.56

065  
066.58

071.01

075.81

081

068.09

072  
068.72

036 2068

013

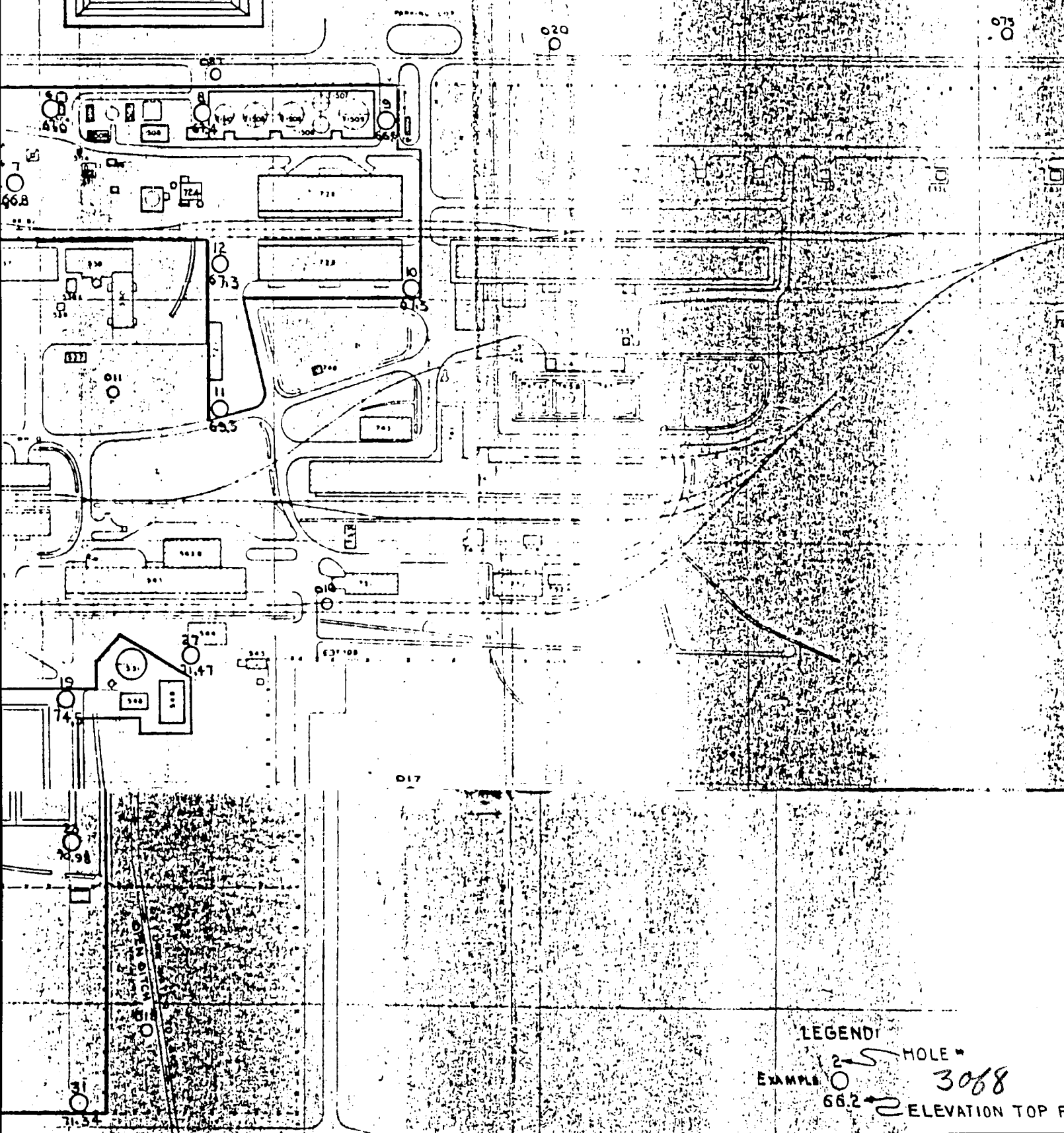
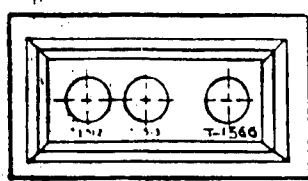
060.36

031  
071.54


E 1500'      E 2000'      E 2500'      E 3000'      E 3500'


DWG. NO	DESCRIP

REF. DWGS



LEGEND

EXAMPLE  HOLE = 3068

 ELEVATION TOP OF

E 2500'

E 3000'

E 3500'

N 800'

DWG. NO	DESCRIPTION

REF. DWGS.

SECTION 36


SECTION 35


SECTION 34

S 1000'

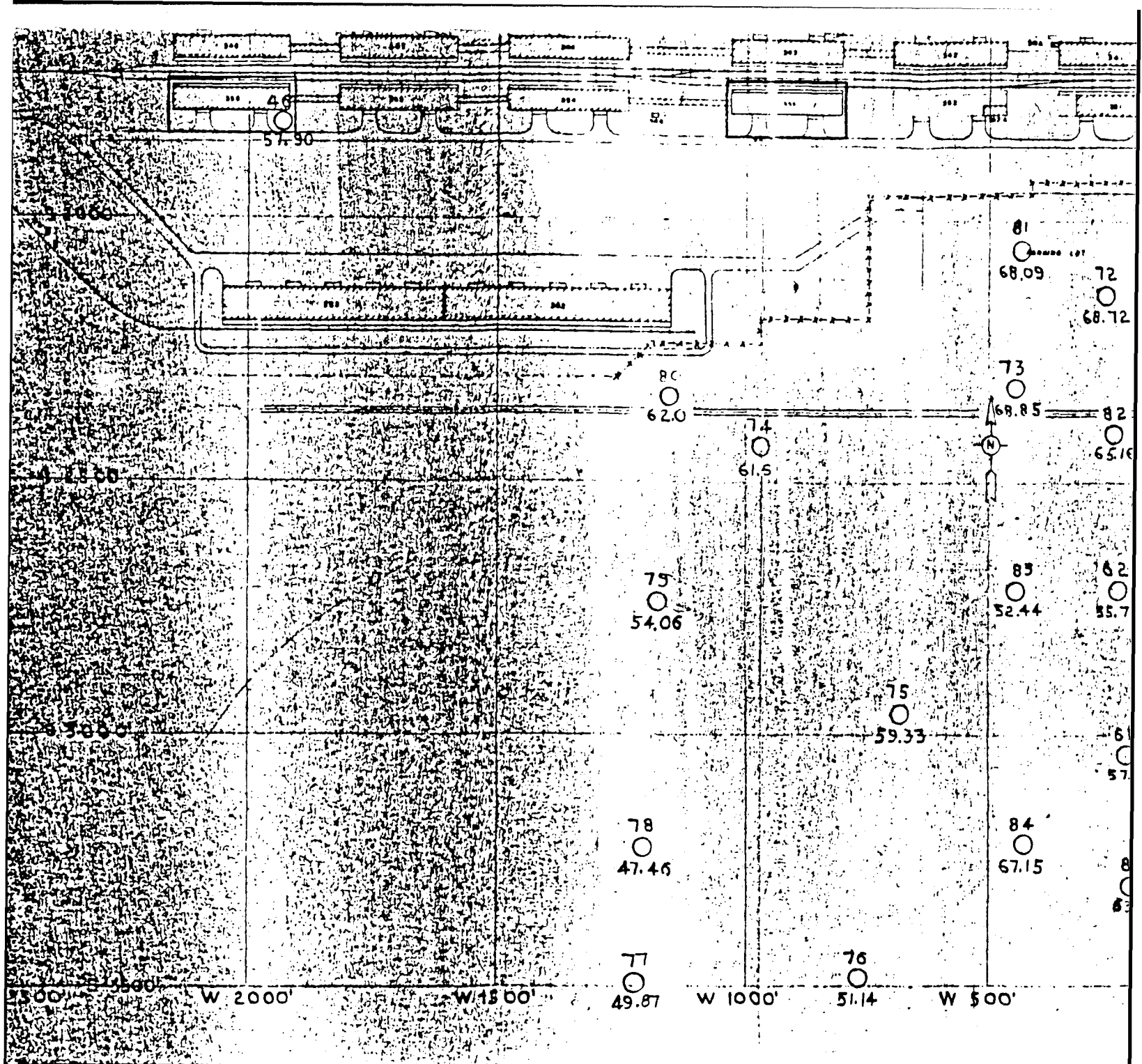
S 2000'

LEGEND

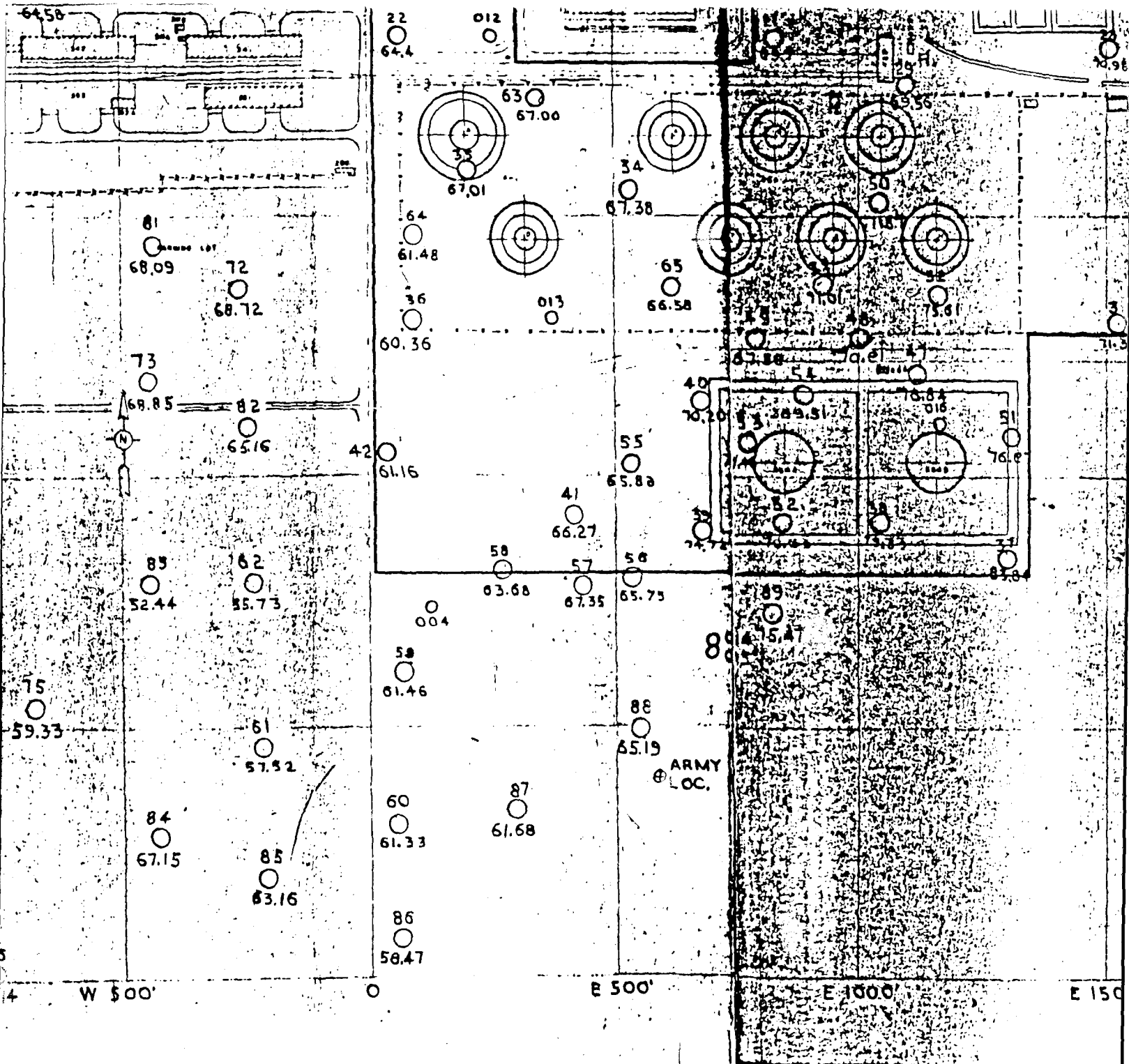
EXAMPLE  HOLE

 66.2 ELEVATION TOP PIPE (+ 5200')

4068

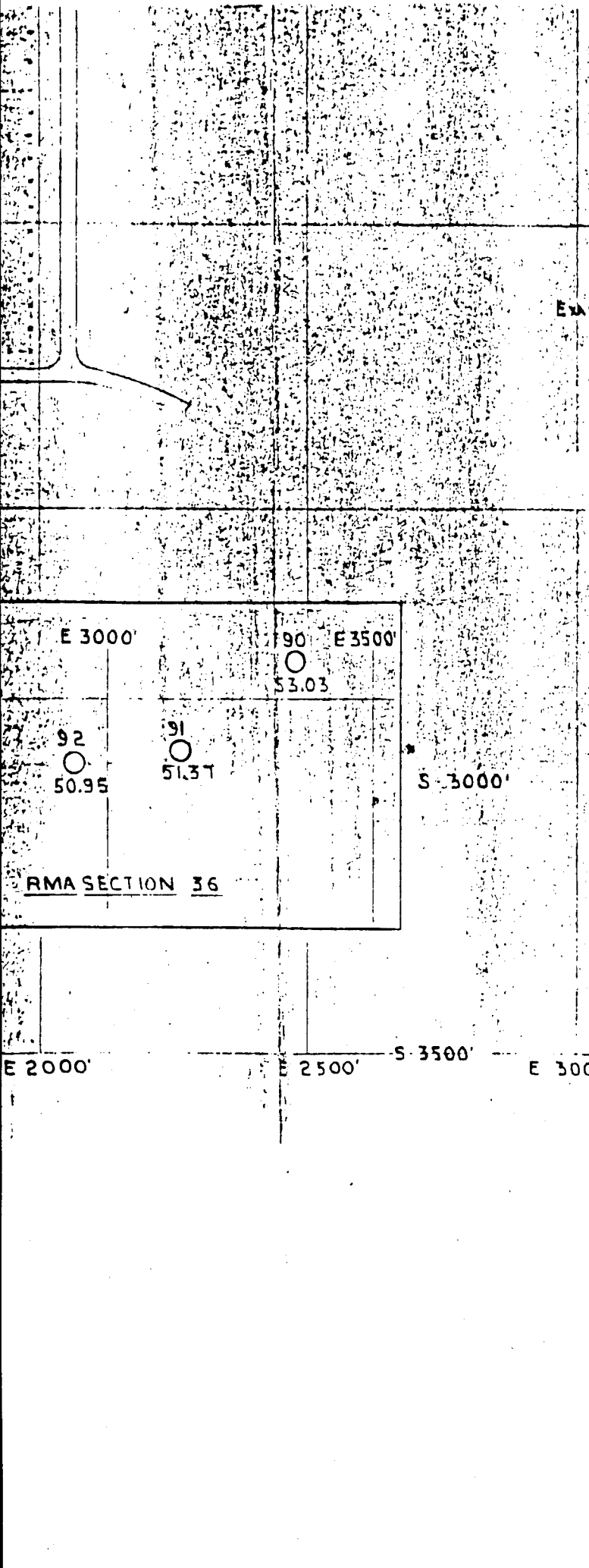


5088



6088





S 2000'

LEGEND:

EXAMPLE: HOLE  
 66.2 ELEVATION TOP PIPE (+ 5200')

NOTES:

1. SHELL OBSERVATION HOLES ARE  $\frac{3}{16}$ "
2. ARMY OBSERVATION HOLES ARE  $\frac{1}{8}$ "

S 2500'

E 3000'

E 3500'

90  
53.03

92  
50.95

91  
51.37

S 3000'

RMA SECTION 36

MARK	DATE	ACCT NO	LIST OF REVISIONS	APP
$\Delta$	11/19	6872	UPDATE	

SHELL CHEMICAL COMPANY  
 A DIVISION OF SHELL OIL COMPANY  
 TECHNICAL DEPARTMENT DENVER PLANT

DENVER CHEMICAL PLANT  
 83041R01  
 2nd Copy

E 2000'    E 2500'    S 3500'    E 3000'

ACCT NO 8042	DATE 9-7-79	APPROVED WDS
SCALE 1" = 200'	DEN DLH	YE-13821-1

80/8