Reference 1

10828448

U.S. EPA REGION IV

SDMS

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V. 2-040506

WESTON

Roy F. Weston, Inc.
17 March 1986
W.O. No. 2640-01-01

CARRIER CORPORATION

Collierville, Tennessee Plant

PROGRESS REPORT

I. Background

Following heavy rains in late January 1985, a trichloroethylene (TCE) leak was detected near the southeast corner of the main production building at the Carrier facility in Collierville, Tennessee. TCE was found emanating from under an above ground, diked TCE storage tank pad and flowing into a nearby storm sewer. With immediate corrective action, Carrier recovered 542 gallons of TCE. The source of the leakage was later identified by Carrier Corporation as corroded distribution pipes which connected two of the tanks on the pad, installed in 1977 or 1978, to the main production building. Borings were drilled immediately after the spill into fill material (emplaced natural soil) that covered the upper four to six feet of the site. Lab results of soil samples indicated that the fill contained elevated TCE levels, thought to result from perching of water and contaminants on a permeability contrast between the fill and native silt/clay soils. The storage tank pad and distribution lines were removed in February 1985 along with a quantity of fill material.

Up to 15 feet of material was subsequently excavated by Carrier in the northeast corner of the affected area based on the results of a second series of borings. In May of 1985, soil samples from uncased borings in this excavated "pit" showed elevated levels of TCE down to the maximum boring penetration depth of 30 feet below original grade.

ROY F. WESTON, INC. (WESTON) was contracted by Carrier Corporation in June of 1985 to investigate and determine the extent of contamination and provide viable remedial options

based on the results. A multi-phase program was initiated by WESTON.

Phase I

The WESTON Phase I study of TCE contamination at Carrier's Collierville, Tennessee site was completed in late July 1985. Phase I field activities included drilling of and sampling from 6 boreholes around the perimeter of the TCE release area and subsequent installation of lysimeters. Results and conclusions of the Phase I study included:

1. The site is underlain by 20 to 25 feet of unsaturated silts and clays overlying 20 to 25 feet of unsaturated sands in turn underlain by a minimum of 2 to 3 feet of low permeability (5×10^{-8} cm/sec), highly plastic clay (USCS classification CH).

2. Lab analyses of continuous soil samples from all 6 borings showed no trichloroethylene (TCE) above the detection limit of 1 ppm. These included samples from the top and bottom of Shelby tubes taken of the top of the confining clay.

Vapor wells (lysimeters) were installed in each borehole to monitor soil gas at the interface between the clay and overlying units in the event that the clay layer inhibited vertical movement of any contaminants. (Samples from the top of Shelby tubes showed the highest Organic Vapor Analyzer (OVA) head space readings.)

The clay layer was not penetrated during Phase I, since background data had indicated that groundwater in the Collierville area was frequently found under confined conditions beneath clay units at the same approximate depth of the clay unit near the pit. Logs of the two municipal supply wells, located approximately 2,000 feet northeast and at approximately the same elevation as the study area, showed in descending order 30 feet of clay, 20-25 of sand and gravel and 60 to 85 feet of clay and clayey sand above 180 to 190 feet of water bearing (Memphis Formation) sand.

Phase I results have been reported in detail in Reference A.

WESTON

Phase II (through 23 October 1985)

The purpose of the Phase II study was to:

- Determine the potential for vertical migration of TCE into the first groundwater system located within or beneath the clay unit identified in Phase I.

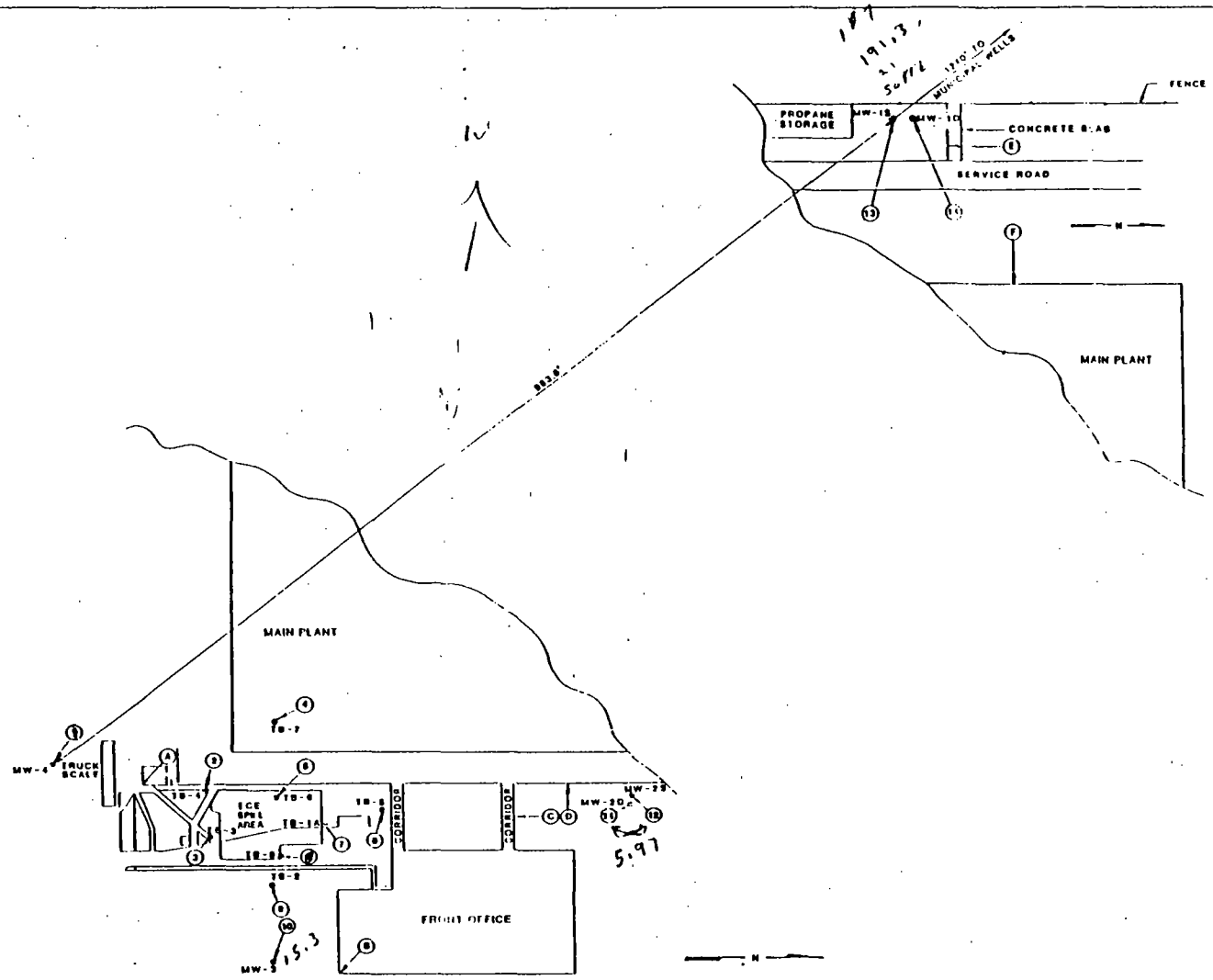
- Obtain additional soil and water samples for laboratory analysis, to substantiate Phase I conclusions. In particular, place two additional borings, one inside the pit excavation to verify original contaminant levels; one within the main production building to "close the loop" of borings around the pit.

- Characterize groundwater (depth, quality, flow direction), by installation of four monitoring wells.

Three additional test borings/vapor wells were installed during the first stage of Phase II (see Figure 1 for all boring and well locations). The first, test boring 7 (TB #7), was drilled during the week of 14 October 1985 on the west side of the pit (through the foundation of the main manufacturing building) and completed the system of borings meant to encircle the pit. Borehole stratigraphy and lab results of soil samples from the borehole were similar to those of the previous 6 holes.

An attempt to place an all-terrain vehicle into the pit to obtain the second boring was unsuccessful, heavy rains having made the pit bottom unstable. As a result, it was decided to relocate this boring location to the pit perimeter. Two test borings (TB-8 and TB-1A) were subsequently accomplished on 19-20 November 1985 (refer to Section II of this report).

During the period 14 to 23 October 1985, an attempt was made to install groundwater monitoring wells at the site. The effort was curtailed prematurely due to cumulative problems with the drilling subcontractor; however, the boring for proposed monitoring well, MW-1, was advanced to 36 feet before termination of activities. Subsurface conditions in this hole were found to differ in several ways from the consistent pattern of silt-to-sand-to-clay in the vicinity of the pit. Alternating layers of unsaturated silt, clayey-silt, and sand characterize the upper 26 feet of MW-1. Even more significant, however, was that saturated



NOTE
NUMBERS 1 THROUGH 14 ARE KEYED TO ELEVATION SURVEY (REFER TO APPENDIX B)

CARRIER CORPORATION
COLLIERVILLE TENNESSEE
WESTON

WELL LOCATIONS

FIG 1

conditions were encountered at a depth of approximately 29 feet within a sand and gravel zone.It was not known whether the encountered groundwater represented a perched system above the clay, flow within a channelized sand and gravel deposit incised into the clay or, in the absence of the clay unit, a local subcrop/recharge area of the groundwater system anticipated to be below the clay unit in the pit area.

Additionally, during the 14-23 October period, water samples of the untreated sprinkler water main, and a drinking fountain within the Carrier plant were obtained. Both measured less than detectable (<2.5 ppb) concentrations of TCE.

The Phase II data, through 23 October, were summarized in the Reference B report.

Following a subsequent review of these Phase II data, WESTON and Carrier decided that the Phase II effort should proceed as follows:

- The two test borings along the pit perimeter would be installed and sampled.
- Two wells would be installed at the MW-1 location to investigate both the shallow water bearing zone and the deep aquifer.
- Mud rotary drilling techniques (as opposed to hollow stem auger) would be used for well drilling.

II. <u>Phase II Data and Results (after 23 October 1985)</u>

The two additional perimeter test borings (TB-8 and TB-1A) were installed on 19-20 November 1985. TB-8 was located on the pit edge as close as possible to the area where initial Carrier sampling (May 1985) had identified elevated TCE levels below the pit (1850 ppm max). TB-1A was drilled less than 5 feet away from the location of TB-1 (which had to be backfilled during the initial WESTON drilling program due to overheating of augers). Stratigraphy in both TB-8 and TB-1A was again similar to that of earlier borings. However, laboratory results of soil samples showed TCE levels of 0.3 ppm (300 ppb) at two intervals within each boring. In both borings, the first interval (14.0 to 15.5 feet) corresponds

to both the excavated bottom of the pit (then covered by 2 to 3 feet of silts and clays) and the change between predominantly brown and gray soils. The second interval differs in depth for the two borings, occurring at the sand-clay interface in TB-1A but 5 to 6 feet above the interface in TB-8. While 300 ppb TCE levels in TB-8 and 1A soils are high compared to the less than detectable levels in the other soil borings, the proximity of these soils to the area where TCE levels in May 1985 were measured at upwards of 1850 ppm suggests that either:

1. TCE levels are diminishing with time, following the removal of the contamination source by Carrier or,

2. The initial elevated TCE measurements were not indicative of concentrations below the pit, possibly being influenced by vertical migration of TCE during placement of the initial uncased boreholes.

All Phase II soil sample results are included in the Appendix to this report.

Following receipt of the November 1985 soil results, Carrier requested permission from the Tennessee Department of Health and Environment (DHE) to backfill the pit and restore elevations to grade level. The basis for this request was 1) absence of actionable levels of TCE in soil samples, 2) safety, and 3) to preclude further erosion and undermining of underground pipes in the area. Permission was granted by DHE on 20 November. The pit was backfilled shortly thereafter.

The additional Phase II effort was the installation of five monitoring wells to ascertain groundwater quality in the first drinking water aquifer beneath the Carrier facility. Well installation and development were completed during the period 2-11 December and 18-20 December 1985. Well data are shown in Tables 1 and 2, well locations in Figure 1. Water samples and water levels were obtained on 6-7 January and 20 February 1986. Water samples were analyzed for TCE by American Interplex Corporation in the former instance and by both American Interplex and WESTON in the latter instance.

Water samples were split with the Tennessee DHE on 7 January. All sample results are in Table 2 and 3. TCE levels above detection limits were measured in wells MW-4 and MW-1S; based on available data the source of the TCE cannot be determined.

Monitoring well water level measurements, taken on 6-7 January are also listed in Table 2. Based on these two sets of water level measurements, localized groundwater flow within the Memphis Sand aquifer is to the northwest in the direction of the municipal wells. It is not known, based on available data, if this is the natural flow direction or one induced by pumping of the municipal wells (a cone of influence from the municipal wells is possible but is yet undefined).

The presence of saturated conditions above the traditional elevation of the clay in boring MW-1, drilled at a location between the plant and a nearby municipal water supply well, dictated that two wells be set into this area, one into a shallow perched water system and the second into the underlying Memphis sand. An outer casing set and grout sealed 3 to 5 feet into the top of the clay circumvented any possibility of cross-contamination between water-bearing systems. This type of an outer casing was subsequently used in the construction of all deep wells to protect the lower aquifer even though no perched conditions were reported in the other three borings.

The presence of the perched water system in MW-1S was only one of several indications of the confining ability of the clay unit. As shown in Table 1, in monitoring well 1 deep (MW-1D) the top of the clay was penetrated at 36 feet while the first water bearing sand was reported at 90 feet. Static water level in the finished well following development was approximately 57 feet below grade, a level within the unsaturated confines of the clay unit. The confining/retarding ability of the clay at MW-1S/1D is further supported by the absence of TCE in the single MW-1D groundwater sample (whereas groundwater from shallow monitoring well MW-1S contained 21 to 50 ppb TCE).

The clay unit thins to the southeast (the top dips while the bottom rises slightly in the southeast direction). Perhaps

more important is the finding that the clay unit also becomes progressively sandier to the south and southeast, possible limiting both its confining ability and its potential effect as a barrier to contaminant migration.

Predicting the movement (if any) of residual TCE away from the pit area is difficult. TCE tied up in soils beneath the pit area may possibly be released by infiltration and migrate down to and along the natural permeability contrast between the clay and overlying sand (which slopes to the south and southwest) and then vertically into the deeper Memphis aquifer through the sandy clay/clayey sand areas. However, data are insufficient to confirm this.

III. Summary of Results and Observations

1. Measured TCE levels in soil immediately adjacent to the pit excavation do not exceed 300 ppb.

2. Based on a limited number of monitoring well level measurements, localized groundwater flow in the area of the Carrier Corporation is to the northwest in the direction of the municipal drinking water supply well. It is not known if this is a natural flow direction or one induced by the pumping of the municipal well field.

3. A TCE contaminated, perched water system of unknown size and character exists northwest of the main production building near monitoring wells MW-1S and MW-1D. Measured TCE levels ranged from 21 to 50 ppb. The analyte does not presently appear in the drinking water aquifer immediately below at or above the detection limit of 2.5 ppb.

4. The trace levels of TCE measured in the drinking water aquifer at MW-4 could result from low-level TCE release from soils under the pit area (migrating vertically to the top of clay and travelling along the clay interface

TABLE 1

WELL DATA AND WATER LEVELS (6-7 January 1986)

Well No.	Top of Clay (ft) BGS	Top of Memphis Sand (ft) BGS	Static Water Level (ft) BGS
MW-1D	~36'	90'	57.23
MW-2D	50'	85'	57.66
MW-3	54.5	75'	56.59
MW-4	~ 53	75-80'	56.59

BGS - below ground surface

TABLE 2

MONITORING WELL WATER LEVEL AND TCE DATA (6-7 January 1986)

Well	Elevation (MSL) TSU[2]	Stick-Up Length (ft)	Total Depth (ft) TSU	Water Level (ft) TSU	Water Level Elevation (MSL[3]) TSU	TCE[4] in ppb
MW-1D	343.20	2.25	110.55	59.19	284.01	< 2.5
MW-1S	343.03	2.40	33.66	30.2	312.87	21.0
MW-2D	344.84	2.15	105.15	59.78	285.06	< 2.5
MW-3	344.03	2.10	90.27	58.26	285.77	< 2.5
MW-4	343.91	----	107	58.1	285.81	9.4

1. Elevation data for monitoring wells was obtained and provided by Carrier Corporation. Data are included in Appendix B.

2. TSU is Top of stick-up

3. MSL is mean sea level

4. Analysis performed by American Interplex Corporation (Memphis, TN). TCE analyses of split samples by Tennessee DHE show 20 ppb for MW-15 and 12 ppb for MW-4; other results less than detectable.

TABLE 3

MONITORING WELL TCE DATA (20 February 1986)[1]

Well	TCE in ppb (analysis by American Interplex)	TCE in ppb (analysis by WESTON)
MW-1D	<2	<1
MW-1S	<2	50
MW-4	<2	<1[2]

---

1 Samples obtained by ENSAFE (Memphis, TN).

2 Duplicate sample measured 1.1 ppb.

toward MW-4). However, data are not sufficient to confirm this hypothesis.

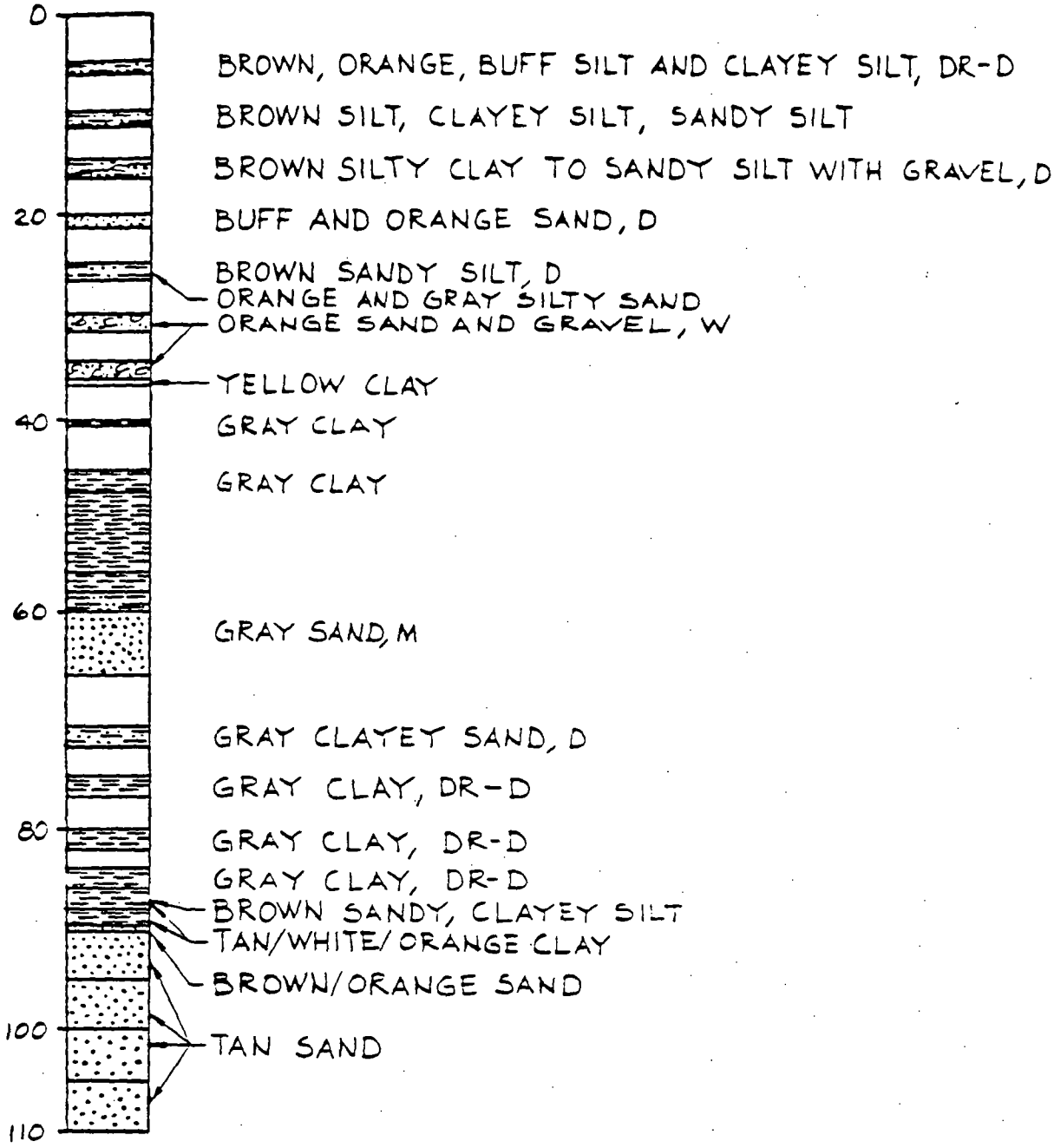
5. The public water system is not presently being affected by TCE.

IV. References

A. Progress Report by Roy F. Weston, Inc., 19 September 1985.

B. Progress Report by Roy F. Weston, Inc., 11 November 1985.

MW-1



DR - DRY
D - DAMP
M - MOIST
W - WET

1/4" = 4'

MONITORING WELL-1

BORING LOG

ROY F. WESTON, INC.

WESTON

ENVIRONMENTAL CONSULTANTS-DESIGNERS

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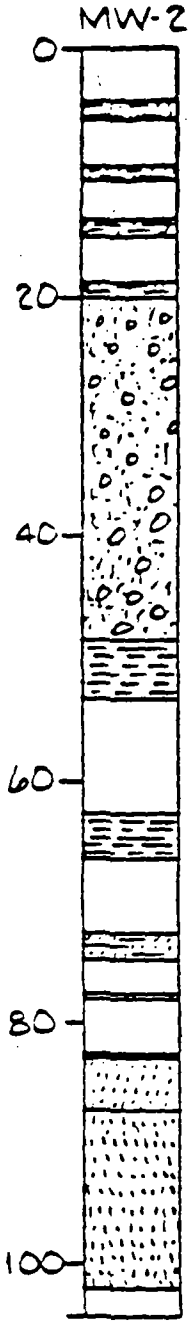
CHECKED		APPROVED		DWG. NO.



BROWN/GRAY CLAYEY SILT, D

GRAY/TAN CLAYEY SILT, D

BROWN/GRAY SILTY CLAY MOTTLED, DR-D

BROWN SILTY SAND, D

BROWN SAND & GRAVEL, W

MAROON/YELLOW/WHITE CLAY, D

TAN/ORANGE SANDY, SILTY CLAY, D

ORANGE SILTY SAND & GRAY/ORANGE CLAY

ORANGE CLAYEY SAND

BROWN SAND

1/4" = 4'

DR-DRY
D-DAMP
M-MOIST
W-WET

MONITORING WELL-2

BORING LOG

ROY F. WESTON, INC.

WESTON

ENVIRONMENTAL CONSULTANTS-DESIGNERS

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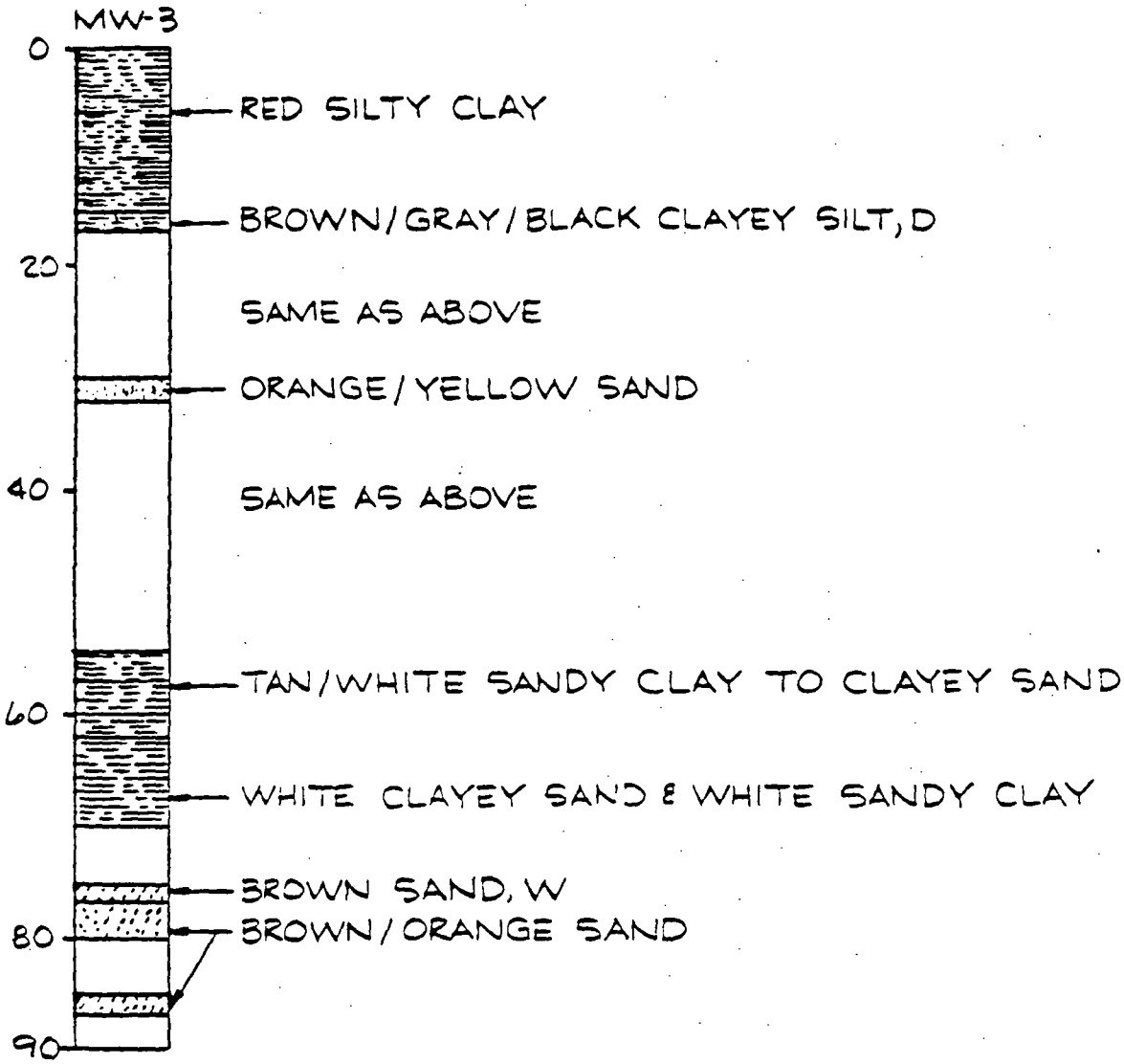

1/4" = 4'

D - DAMP
W - WET

MONITORING WELL-3
BORING LOG

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN BBB	DATE 2-12-86	DES. ENG.	DATE	W. O. NO.
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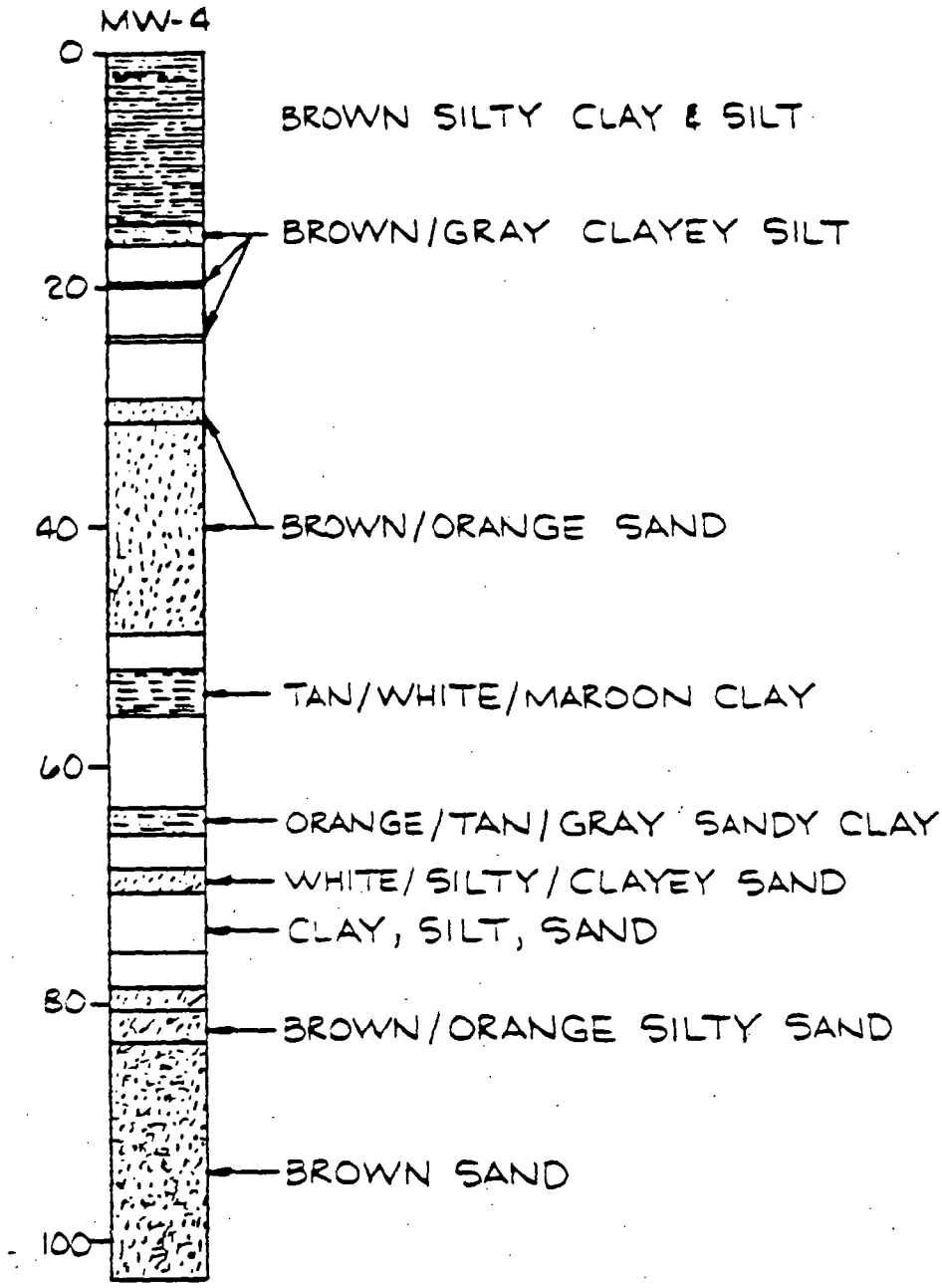

1/4" = 4'

MONITORING WELL-4

BORING LOG

ROY F. WESTON, INC.

WESTON

ENVIRONMENTAL CONSULTANTS-DESIGNERS

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BBB	2-13-86			
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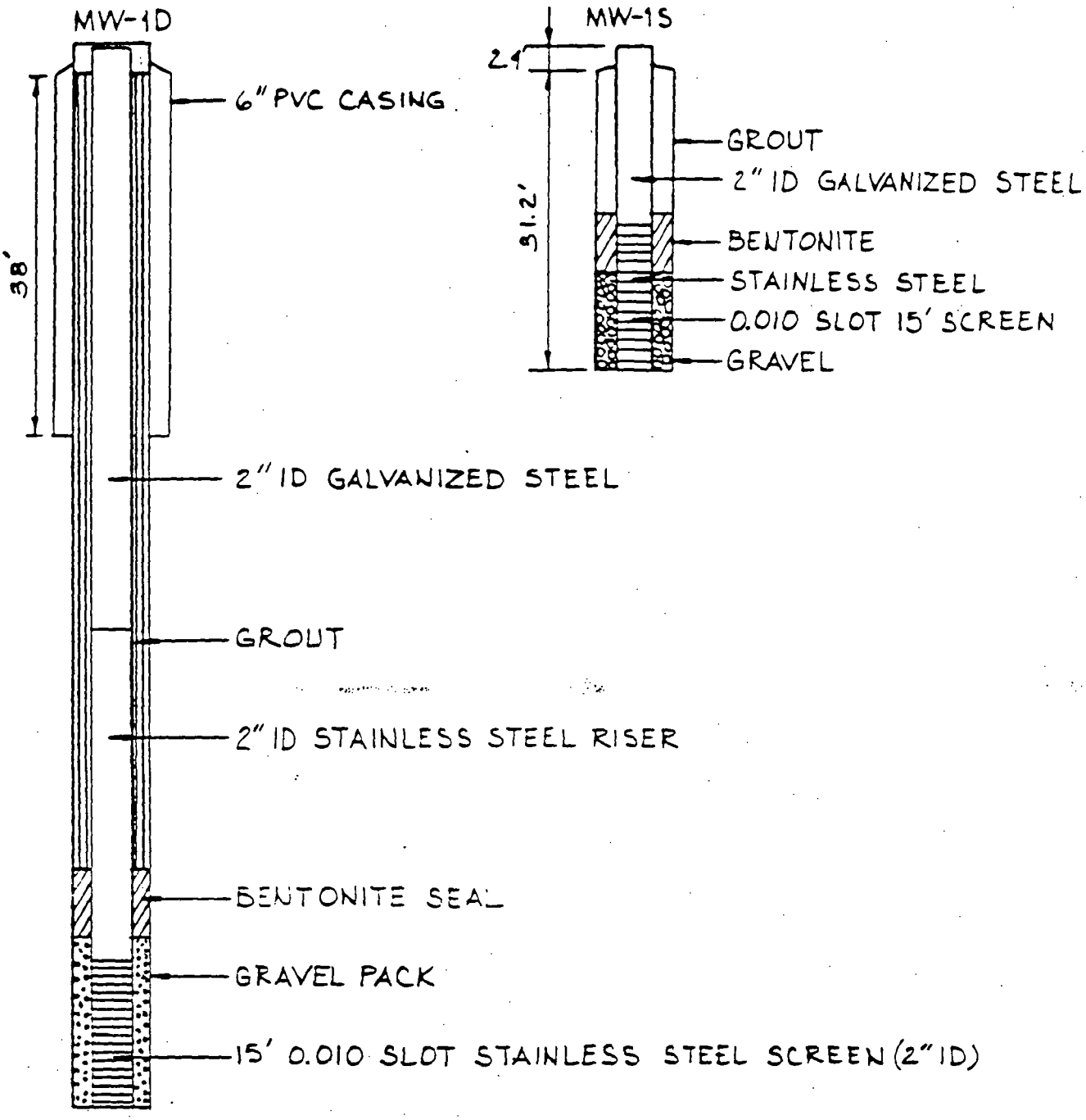
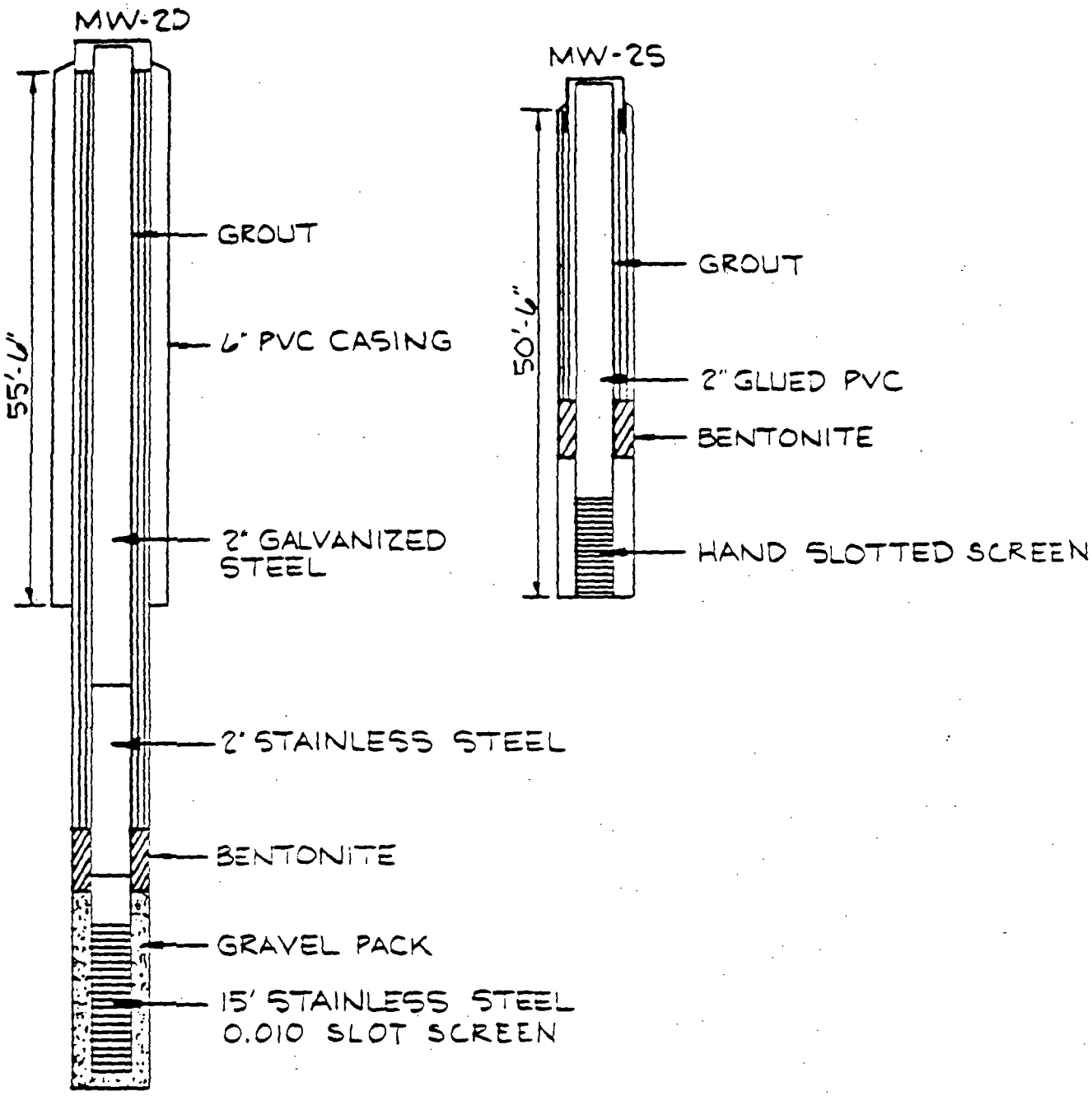


DR- DRY
D - DAMP
M - MOIST
W - WET

MONITORING WELL
1D & 1S
CONSTRUCTION
DETAILS

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN LRM	DATE 2-14-86	DES. ENG.	DATE	W. O. NO.
CHECKED		APPROVED		DWG. NO.



1/4" = 4'

MONITORING WELL 2D & 2S CONSTRUCTION DETAILS

ROY F. WESTON, INC.

WESTON ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
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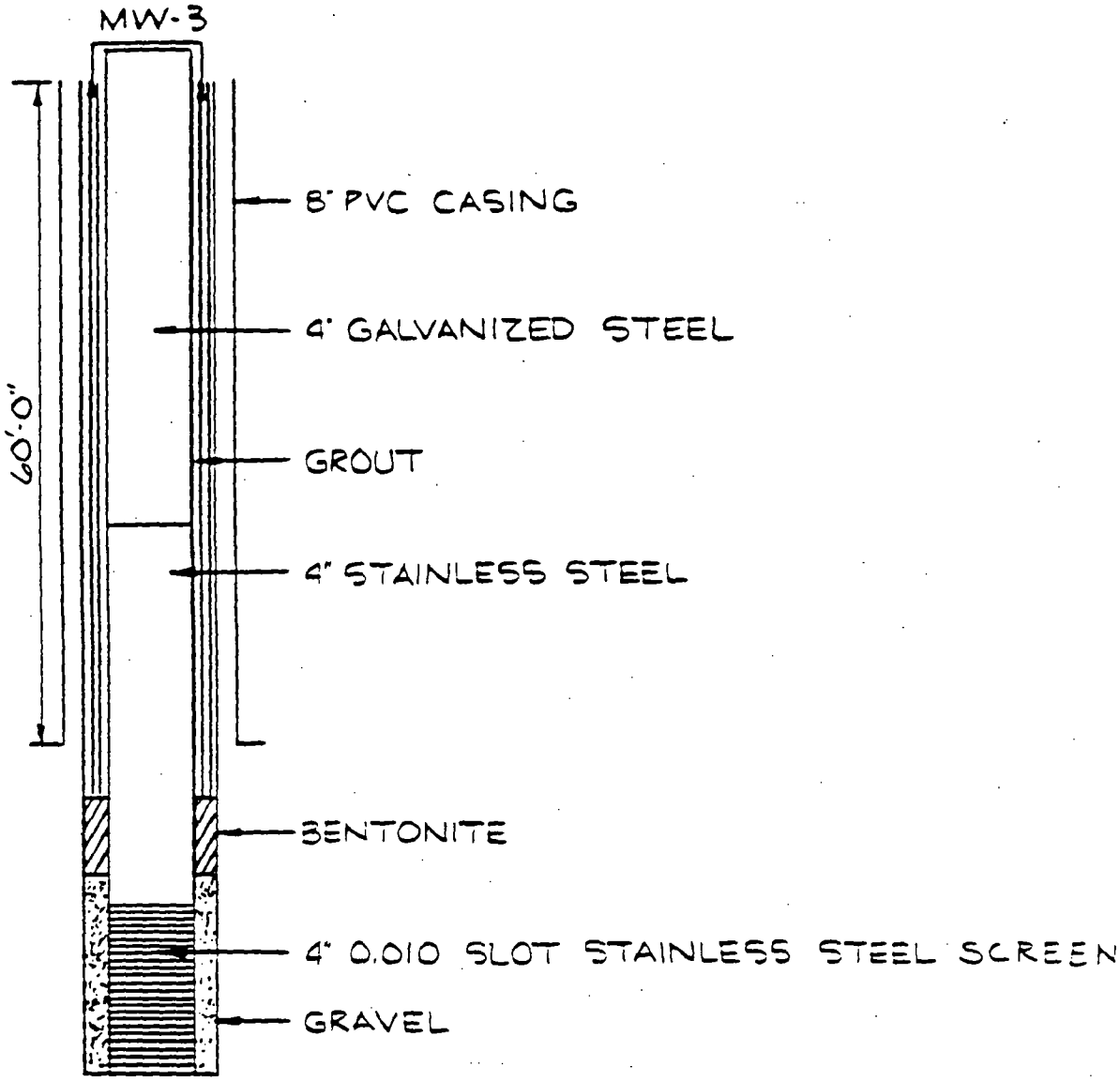

1/4" = 4'

MONITORING WELL-3

CONSTRUCTION DETAILS

ROY F. WESTON, INC.

WESTON

ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
BSB	2-12-86			
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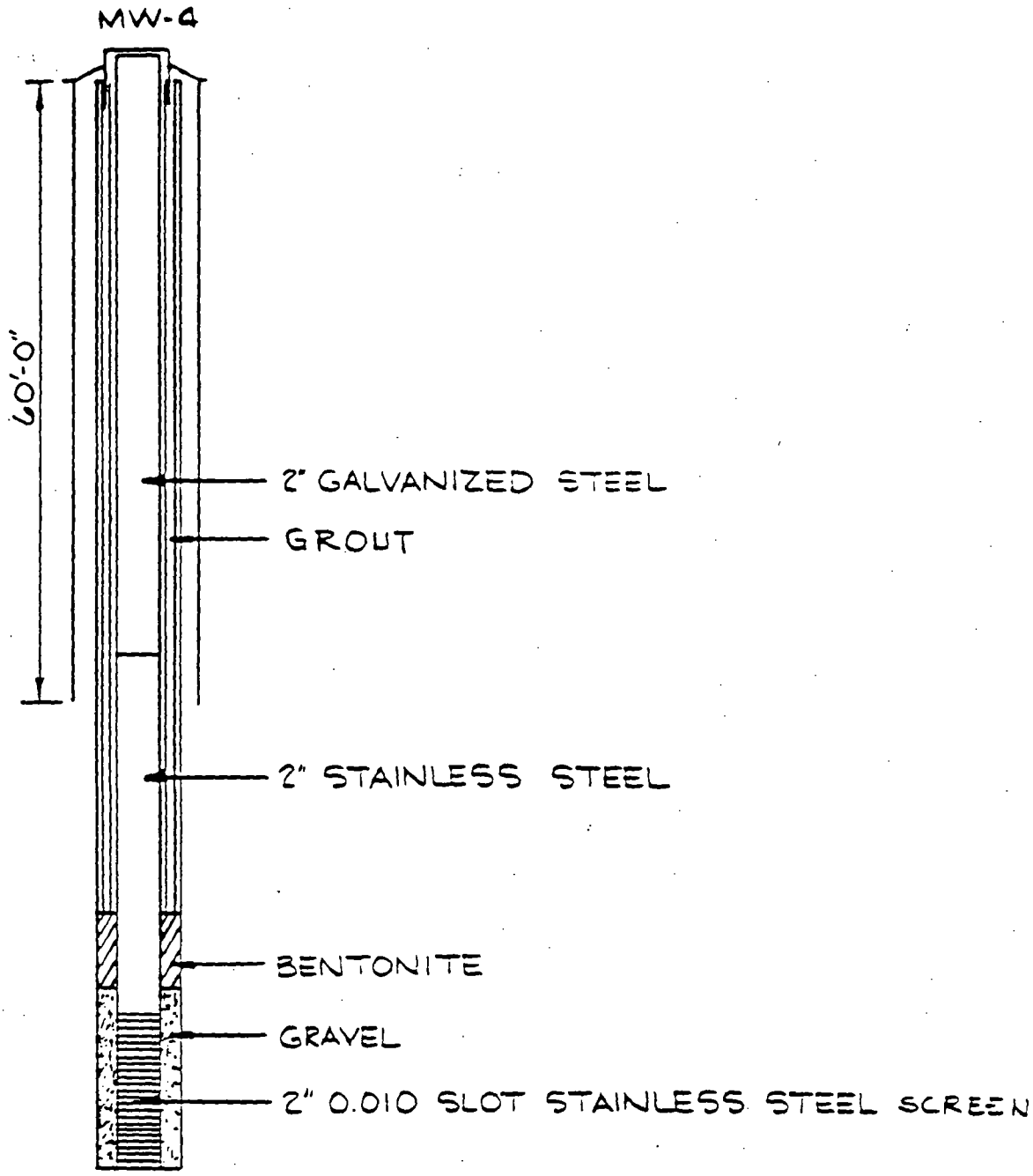


1/4" = 4'

MONITORING WELL-4

CONSTRUCTION DETAILS

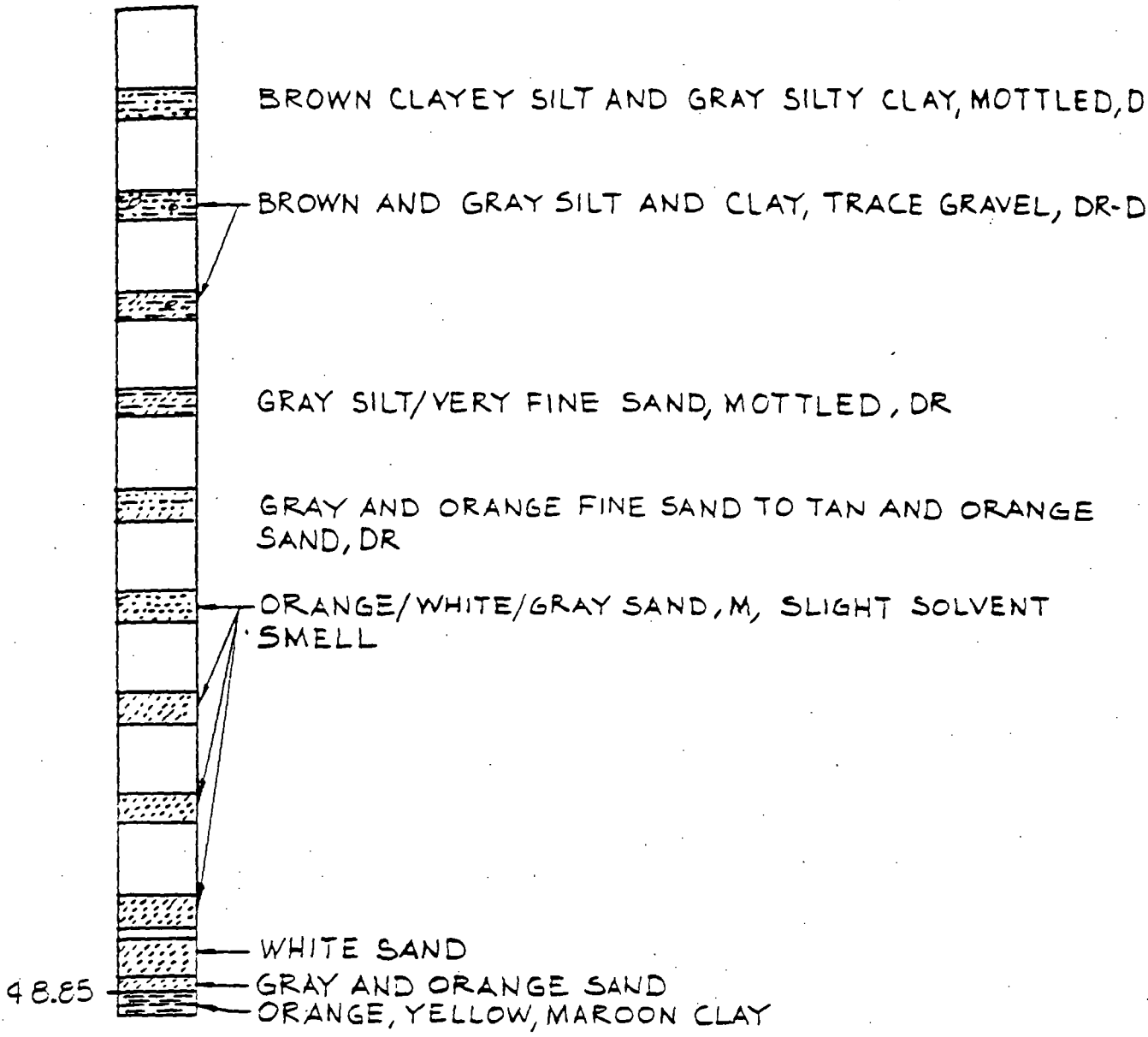
ROY F. WESTON, INC.

WESTON

ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN	DATE	DES. ENG.	DATE	W. O. NO.
BBB	2-13-86			
CHECKED		APPROVED		DWG. NO.

TB-1A



DR - DRY
D - DAMP
M - MOIST

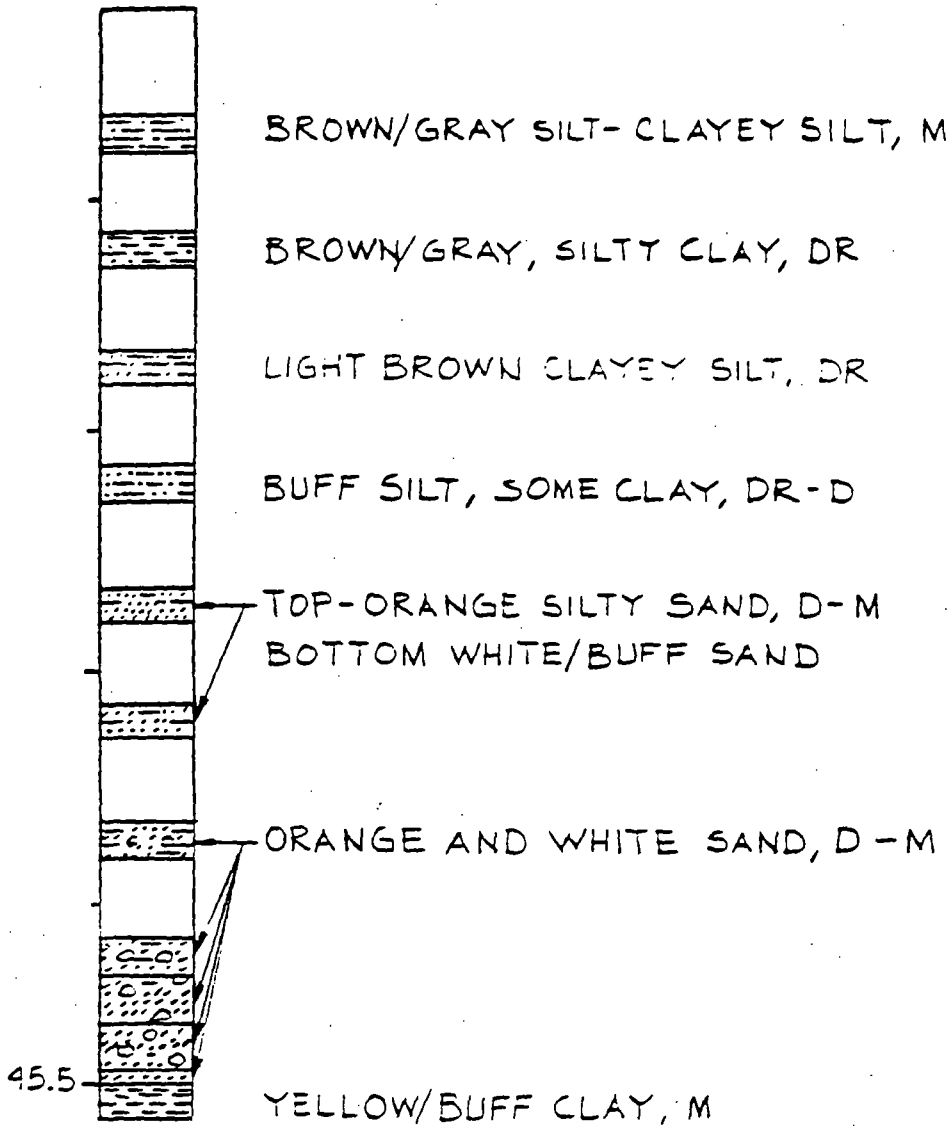
1/8" = 1'

TEST BORING
- 1A -

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN LRM	DATE 2-14-86	DES. ENG.	DATE	W. O. NO.
CHECKED		APPROVED		DWG. NO.

TB-7



DR - DRY
D - DAMP
M - MOIST

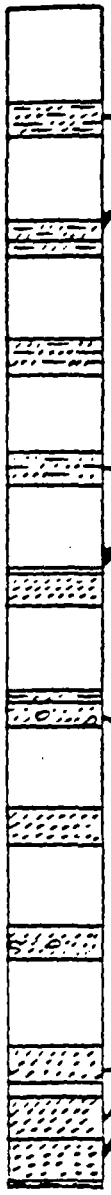
1/8" = 1'

TEST BORING
-7-

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN LRM	DATE 2-14-86	DES. ENG.	DATE	W. O. NO.
CHECKED		APPROVED		DWG. NO.

TB-8



GRAY CLAYEY SILT, D

BROWN CLAYEY SILT TO SILT AND CLAY, DR-D

SAME AS 5.0-5.5

GRAY SILT, LITTLE CLAY, MOTTLED, DR

BUFF TO BROWN SILTY SAND, LITTLE GRAVEL, DR

GRAY SILTY CLAY, DR

ORANGE/WHITE SAND, TRACE GRAVEL, DR-D

ORANGE/WHITE MEDIUM GR. SAND, LITTLE GRAVEL D

ORANGE SAND, TRACE GRAVEL, D-M

ORANGE AND WHITE SAND

ORANGE AND WHITE CLAY

DR - DRY
D - DAMP
M - MOIST

1/8" = 1'

TEST BORING
- 8 -

ROY F. WESTON, INC.
WESTON
ENVIRONMENTAL CONSULTANTS-DESIGNERS

DRAWN LRM	DATE 2-16-86	DES. ENG.	DATE	W. O. NO.
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WESTON

APPENDIX B

Monitor Well Survey and Elevation Data

UNITED TECHNOLOGIES CARRIER

Carrier Corporation

97 South Byhalia Road
Collierville Tennessee 38017
(901) 853-9761

January 15, 1986

"PROJECT MGMT"

JAN 27 1986

Mr. Don Messenger
Roy F. Weston Inc.
Weston Way
West Chester, Pennsylvania 19380

Re: Monitoring Well Location and Elevation Report,
Site Plan; attached.

Gentlemen:

Enclosed please find the monitoring well information you requested. The following notes should help clarify this report:

- wells for this report have been numbered from 1 through 14, South to North respectively from their reference points,
- wells which reach into ground water are designated by GW,
- wells which do not reach ground water are designated by MW,
- Reference Point A is the Southeast corner of the main plant,
- Reference Point B is the Southeast corner of the front office building,
- Reference Point C is the North edge of the North corridor concrete slab,
- Reference Point D is the East edge of the main plant floor,
- Reference Point E is the South edge of concrete slab North of the propane storage tank,
- Reference Point F is the West edge of main plant floor,
- location measurements were taken perpendicular from the plane of the Reference Points to the center-line of the well,
- elevations are measured to the top of the well covers, and
- the benchmark for elevations is our main plant floor elevation established at 343.00 feet above sea level.

Please advise if additional information is required.

Copy to:
Gerald Bailey
John Brewer
Bradford Cushing
Jim Kelly

Respectively,

Edgar Smith

CLV-7

Potential Hazardous Waste Site

Site Inspection Report

CARRIER AIR CONDITIONING COMPANY

TND 044062222

COLLIERVILLE, SHELBY COUNTY, TENNESSEE

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

OFFICE CORRESPONDENCE

FROM	TO	DATE
MJH	files	9-12-86

DATE: September 10, 1986

TO: The Carrier Air Conditioning Co. File

FROM: Michael J. Higgs MJH

SUBJECT: Sample Collected On July 15, 1986

The field number associated with the samples collected on July 15, 1986, correspond to those location numbers depicted in figure 1 of the Roy Weston, Inc. report on March 17, 1986. The exception to this is the result marked "MW-2" which is actually from the west well of the City of Collierville's water plant number 2.

FROM	DATE

TO

PH-0001
SR 3/77

ENVIRONMENTAL TESTING & CONSULTING INC.
2924 WALNUT GROVE RD. • MEMPHIS, TENN. 38111 • PHONE (901) 327-2750

July 30, 1986

Philip M. Baker, Director
Knoxville Branch Laboratory
State of Tennessee
Dept. of Health & Environment
P.O. Box 15156
Knoxville, Tenn. 37901-5156

REF: ANALYTICAL TESTING
SAMPLE(S) DATED: 7/15 & 7/16/86
VOLATILE ORGANIC COMPOUNDS
P.O.# 47631 & # 47637

Dear Dr. Baker:

The above referenced samples have been analyzed per your instructions. The tests were performed in our laboratory (#00210) in accordance with GC Methods 601, 602 & 603.

The Quality Control was performed on a water sample on P.O. #47637. A copy of the Quality Control has been included with P.O. #47631.

If you have any questions please call me.

Very truly yours,

Michael J. Cimbalo
President

MJC/mg

Attachments

INTERIM REPORT
Date 8/4/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

P.O. #47631

Sample Source	Date	Well No.	Time (CST)
Carrier	7/15/86	MW 12	11:45
Carrier	7/15/86	MW 13A	14:45
Carrier	7/15/86	MW 1	12:40
Carrier	7/15/86	MW 10	13:00
Carrier	7/15/86	MW 13	14:45
Carrier	7/15/86	MW 14	13:20
Carrier	7/15/86	MW #2	14:53

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - MW#1

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601,602,603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	<0.5
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	<0.5
methyl chloride	<0.5
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	21.5
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP

Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - ~~MW#2~~ City well #2

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601.602. 603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	7.10
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	98.9
methyl chloride	<0.5
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	5.97
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP

Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - MW#10

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601,602, 603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	<0.5
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	<0.5
methyl chloride	94.8
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	15.3
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP
Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - MW #12

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601,602, 603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	8.16
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	39.0
methyl chloride	<0.5
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	<0.05
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP

Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - MW#13

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601,602,603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	11.6
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	101.2
methyl chloride	<0.5
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	191.3
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP

Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - MW13A

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601,602,603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	2.7
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	126.6
methyl chloride	<0.5
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	189.2
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP

Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

CARRIER - 7/15/86 - MW#14

VOLATILE ORGANIC COMPOUNDS - GC METHODS 601,602,603

	ug/l
acrolein	<0.5
acrylonitrile	<0.5
benzene	<0.5
toluene	<0.5
ethylbenzene	<0.5
carbontetrachloride	<0.5
chlorobenzene	<0.5
1,2-dichloroethane	<0.5
1,1,1-trichloroethane	<0.05
1,1-dichloroethane	<0.5
1,1-dichloroethylene	<0.5
1,1,2-trichloroethane	<0.5
1,1,2,2-tetrachloroethane	<0.5
chloroethane	<0.5
2-chloroethyl vinyl ether	<0.5
chloroform	<0.5
1,2-dichloropropane	<0.5
1,3-dichloropropene	<0.5
methylene chloride	<0.5
methyl chloride	<0.5
methyl bromide	<0.5
bromoform	<0.5
dichlorobromomethane	<0.5
trichlorofluoromethane	<0.5
dichlorodifluoromethane	<0.5
chlorodibromomethane	<0.5
1,1,2,2-tetrachloroethylene	<0.5
trichloroethylene	<0.05
vinyl chloride	<5.0
1,2-trans-dichloroethylene	<0.5
bis(chloromethyl) ether	<0.5

Analyst: NAP

Date: 7/29/86

TENNESSEE DEPARTMENT OF HEALTH & ENVIRONMENT

QUALITY CONTROL

P.O. #47631 & #47637

	Initial	Spike	Expected	Found	Percent Recovery
Methylene Chloride	0.044	0.10	0.144	0.10	69
1,1-Dichloroethylene	-	0.10	0.10	0.10	100
1,1-Dichloroethane	-	0.10	0.10	0.10	100
Chloroform	-	0.10	0.10	0.09	90
Carbontetrachloride	-	0.10	0.10	0.11	110
1,2-Dichloropropane	-	0.10	0.10	0.10	100
Trichloroethylene	-	0.10	0.10	0.11	110
*Chlorodibromomethane	-	0.10	0.20	0.28	140
*1,1,2-Trichloroethane					
Tetrachloroethylene	-	0.10	0.10	0.11	110
Chlorobenzene	-	0.10	0.10	0.10	100

* These compounds co-elute. Percent recovery is calculated based on total concentration expected of both compounds.

Pg 2

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-1550 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1-14-86

Sample Source & Identification: Carrier Corp NW Deep Well (ID)
Field #1 Shelby Co.

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5.0 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRA USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.(AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene	↓	N-Butyl Benzene	↓
Ethyl Benzene	↓	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
0-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND - none detected

FH-2398

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø - 1549 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1-14-86

Sample Source & Identification: Carrier Corp. N.W. Deep Well (1D) Field #1 Shelby Co.

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRA USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORIN MODE.

2/5/86

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	ND	Dibromochloromethane	ND
Bromomethane	↓	1,1,2-Trichloroethane	↓
Vinyl Chloride	↓	Bromoform	↓
Chloroethane	↓	1,1,2,2-Tetrachloroethylene	*
Methylene Chloride	*	1,1,2,2-Tetrachloroethane	ND
1,1-Dichloroethylene	ND	Chlorobenzene	↓
Bromochloromethane	↓		
1,1-Dichloroethane	↓		
Trans-1,2-Dichloroethylene	↓		
Chloroform	*		
1,2-Dichloroethane	ND		
1,1,1-Trichloroethane	*		
Carbon Tetrachloride	ND		
Bromodichloromethane	↓		
Trichloroethylene	**		

Remarks: ND - none detected

* - Possible peaks at component's retention time.

** - Possible peak at component's retention time but in amounts less than 0.5ppb the minimum quantifiable amount of information

SWM

ORGANIC LABORATORY ANALYSIS REPORT

Laboratory Log No. 1551 Laboratory Analysis by: MAC Date completed 2-19-86
Date Received 1-7-86 Date Extracted/Opened 2-19-86

Field Log No. #1 Sample collected by: KLK
Date collected 1-7-86 Kind of sample VOA water
Sample collected at: Carrier Corp. N.W. Deep well (ID) Field #1 Shelby County
N.W. well (deep) near propane tank in rear of plant

Sample Treatment: 9.0 mls purged on LSC-2 ; analysis on OWA GCMS

GC-MS Analysis:

GC: Perkin-Elmer Sigma 3 with 1% SP-1000 carbopak-B column. Carrier gas is UHP He at a flow rate of 25 ml per minute.

GC Program: Initial hold is 7 minutes at 35 °C. Ramp rate is 8 °C per minute Final hold is 40 minutes at 210 °C. Separator temperature is 245 °C an manifold temperature is 80 °C.

MS: Finnigan OWA-1030

MS Program: Solvent divert valve open for 60 seconds after injection. 1000 scans at 3.0 seconds per scan, mass range is 35 to 260 amu. Minimum peak area count is: 20. Sample file name is V1551. Splitless injection time is ——— seconds. Filament and electron multiplie come on ——— seconds after injection.

COMPOUNDS DETECTED AND IDENTIFIED

1. Acetone (trace)	16.	31.
2. Chloroform (slight trace)	17.	32.
3.	18.	33.
4.	19.	34.
5.	20.	35.
6.	21.	36.
7.	22.	37.
8.	23.	38.
9.	24.	39.
10.	25.	40.
11.	26.	41.
12.	27.	42.
13.	28.	43.
14.	29.	44.
15.	30.	45.

FEB 27 1986

Remarks:

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-1554 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1-15-86

Sample Source & Identification: Carrier Corp. Shelby Co.
N.E. Deepwell (2D) Field #2

AROMATIC VOLATILE ORGANIC ANALYSIS

A 50 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene	↓	N-Butyl Benzene	↓
Ethyl Benzene	↓	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
O-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND-none detected

FEB 2[illegible]

FR-2398
[illegible] 11/83

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-1552 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1-15-86

Sample Source & Identification: Carrier Corp. Shelby Co.
N.E. Deepwell (2D) Field #2

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50ºC
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8º PER MIN.
FINAL TEMP:	200ºC
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	ND	Dibromochloromethane	ND
Bromomethane	↓	1,1,2-Trichloroethane	↓
Vinyl Chloride	↓	Bromoform	↓
Chloroethane	↓	1,1,2,2-Tetrachloroethylene	*
Methylene Chloride	*	1,1,2,2-Tetrachloroethane	ND
1,1-Dichloroethylene	ND	Chlorobenzene	↓
Bromochloromethane	↓		
1,1-Dichloroethane	↓		
Trans-1,2-Dichloroethylene	↓		
Chloroform	*		
1,2-Dichloroethane	ND		
1,1,1-Trichloroethane	*		
Carbon Tetrachloride	ND		
Bromodichloromethane	↓		
Trichloroethylene	* *		

Remarks: ND- none detected

*- Possible peaks at component's retention time.

** - Possible peaks at component's retention time but in amounts less than 0.5ppb, the minimum quantifiable

SWM

ORGANIC LABORATORY ANALYSIS REPORT

Laboratory Log No. 1555 Laboratory Analysis by: MAC Date comp
Date Received 1-7-86 Date Extracted/Opened 2-19-86

Field Log No. #2 Sample collected by: KLK
Date collected 1-7-86 Kind of sample VOA water
Sample collected at: Carrier Corp (2D) N.E. Deep well Field
Courtyard area

Sample Treatment: 9.0 mls purged on LSC-2 ; analysis on OWA-GC

GC-MS Analysis:

GC: Perkin-Elmer Sigma 3 with 1% SP-1000 carbopak-B column. Carrier gas is UHP He at a flow rate of 25 ml per minute.

GC Program: Initial hold is 7 minutes at 35 °C. Ramp rate is 8 °C per minute. Final hold is 40 minutes at 210 °C. Separator temperature is 245 °C and manifold temperature is 80 °C.

MS: Finnigan OWA-1030

MS Program: Solvent divert valve open for 60 seconds after injection. 1000 scans at 3.0 seconds per scan, mass range is 35 to 260 amu. Minimum peak area count is: 20. Sample file name is V1555. Splitless Injection time is ——— seconds. Filament and electron multiplier come on ——— seconds after injection.

COMPOUNDS DETECTED AND IDENTIFIED

1. Tetrahydrofuran (tr)	16.	31.
2. Trimethoxymethane (trace)	17.	32.
3. 1-Butanol (trace)	18.	33.
4.	19.	34.
5.	20.	35.
6.	21.	36.
7.	22.	37.
8.	23.	38.
9.	24.	39.
10.	25.	40.
11.	26.	41.
12.	27.	42.
13.	28.	43.
14.	29.	44.
15.	30.	45.

Remarks:

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø - 1557 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1-14-86

Sample Source & Identification: Carrier Corp. S.E. (W-11 (4)
Field # 3 Shelby Co.

AROMATIC VOLATILE ORGANIC ANALYSIS

A 50ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	*	p-Dichlorobenzene	ND
Toluene	*	N-Butyl Benzene	↓
Ethyl Benzene	ND	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
O-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND - none detected

* - Possible peak at component's retention time.

FM-2388

[illegible]

[illegible]

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-1556 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1-14-86

Sample Source & Identification: Carrier Corp. SE Well (4)

Field # 3 Shelby Co.

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	ND	Dibromochloromethane	ND
Bromomethane	↓	1,1,2-Trichloroethane	↓
Vinyl Chloride	↓	Bromoform	↓
Chloroethane	↓	1,1,2,2-Tetrachloroethylene	*
Methylene Chloride	*	1,1,2,2-Tetrachloroethane	ND
1,1-Dichloroethylene	ND	Chlorobenzene	↓
Bromochloromethane	↓		
1,1-Dichloroethane	↓		
Trans-1,2-Dichloroethylene	*		
Chloroform	ND		
1,2-Dichloroethane	*		
1,1,1-Trichloroethane	ND		
Carbon Tetrachloride	↓		
Bromodichloromethane	↓		
Trichloroethylene	12.3		

Remarks: ND-none detected

sible peaks at component's retention time.

thylene value amended

SWM

ORGANIC LABORATORY ANALYSIS REPORT

Laboratory Log No. 1558 Laboratory Analysis by: MAC Date completed 2-19-86
Date Received 1-7-86 Date Extracted/Opened 2-19-86

Field Log No. #3 Sample collected by: KLK
Date collected 1-7-86 Kind of sample VOA water
Sample collected at: Carrier Corp S.E. well (4) Field #3 Shelby County

Sample Treatment: 9.0 mls purged on LSC-2 ; analysis on OWA GCMS

GC-MS Analysis:

GC: Perkin-Elmer Sigma 3 with 1% SP-1000 carbopak-B column. Carrier gas is UHP He at a flow rate of 25 ml per minute.

GC Program: Initial hold is 7 minutes at 35 °C. Ramp rate is 8 °C per minute. Final hold is 40 minutes at 210 °C. Separator temperature is 245 °C and manifold temperature is 80 °C.

MS: Finnigan OWA-1030

MS Program: Solvent divert valve open for 60 seconds after injection. 1000 scans at 3.0 seconds per scan, mass range is 35 to 260 amu. Minimum peak area count is: 20. Sample file name is V1553. Splitless Injection time is ——— seconds. Filament and electron multiplier come on ——— seconds after injection.

COMPOUNDS DETECTED AND IDENTIFIED

1. Tetrahydrofuran	16.	31.
2. Methyl ethyl ketone (low)	17.	32.
3. Trichloroethylene	18.	33.
4. Toluene (low)	19.	34.
5. Ethyl benzene (trace)	20.	35.
6. Xylenes (trace)	21.	36.
7.	22.	37.
8.	23.	38.
9.	24.	39.
10.	25.	40.
11.	26.	41.
12.	27.	42.
13.	28.	43.
14.	29.	44.
15.	30.	45.

Remarks:

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-1560 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1/16/86

Sample Source & Identification: Carrier Corp Shelby Co.
(MW3) E well in front of plant
Field #4

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene	↓	N-Butyl Benzene	↓
Ethyl Benzene	↓	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
0-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND- none detected

PH-2390

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency S(L)M

Laboratory Sample No. Ø-1559 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: KLK Date Completed 1/16/86

Sample Source & Identification: Carrier Corp. Shelby Co.

(MW 3) E Well in front of plant

Field # 4

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	ND	Dibromochloromethane	ND
Bromomethane	↓	1,1,2-Trichloroethane	↓
Vinyl Chloride	↓	Bromoform	↓
Chloroethane	↓	1,1,2,2-Tetrachloroethylene	* *
Methylene Chloride	* *	1,1,2,2-Tetrachloroethane	ND
1,1-Dichloroethylene	ND	Chlorobenzene	↓
Bromochloromethane	↓		
1,1-Dichloroethane	↓		
Trans-1,2-Dichloroethylene	↓		
Chloroform	* *		
1,2-Dichloroethane	ND		
1,1,1-Trichloroethane	* *		
Carbon Tetrachloride	ND		
Bromodichloromethane	↓		
Trichloroethylene	(*)		

Remarks: ND-none detected

(*)-Possible peak at component's retention time but in amounts less than 0.5ppb the minimum quantifiable amount of instrumentation.

* * - Possible peak at component's retention time.

SWM

ORGANIC LABORATORY ANALYSIS REPORT

Laboratory Log No. 1561 Laboratory Analysis by: MAC Date completed 2-17-86
Date Received 1-7-86 Date Extracted/Opened 2-17-86

Field Log No. #4 Sample collected by: KLK
Date collected 1-7-86 Kind of sample VOA water
Sample collected at: Carrier Corp (MW3) E. well in front of Plant Field #4
Shelby County

Sample Treatment: 9.0 mls purged on LSC-2 ; analysis on OWA GCMS

GC-MS Analysis:

GC: Perkin-Elmer Sigma 3 with 1% SP-1000 carbopak-B column. Carrier gas is UHP He at a flow rate of 25 ml per minute.

GC Program: Initial hold is 7 minutes at 35 °C. Ramp rate is 8 °C per minute. Final hold is 10 minutes at 210 °C. Separator temperature is 245 °C and manifold temperature is 80 °C.

MS: Finnigan OWA-1030

MS Program: Solvent divert valve open for 60 seconds after injection. 1000 scans at 3.0 seconds per scan, mass range is 35 to 260 amu. Minimum peak area count is: 20. Sample file name is V1561. Splitless Injection time is ——— seconds. Filament and electron multiplier come on ——— seconds after injection.

COMPOUNDS DETECTED AND IDENTIFIED

1. Tetrahydrofuran (low)	16.	31.
2. Chloroform (slight trace)	17.	32.
3.	18.	33.
4.	19.	34.
5.	20.	35.
6.	21.	36.
7.	22.	37.
8.	23.	38.
9.	24.	39.
10.	25.	40.
11.	26.	41.
12.	27.	42.
13.	28.	43.
14.	29.	44.
15.	30.	45.

Remarks:

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. 86-1563 Date Collected 1-7-86 Date Received: 1-9-86

Sampled Collected By: KLK Date Completed 1-17-86

Sample Source & Identification: Carrier Corp. Shelby Co.
N.W. Shallow Well (MW 1S)
Field # 5

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5.0 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	*	p-Dichlorobenzene	ND
Toluene	ND	N-Butyl Benzene	↓
Ethyl Benzene	↓	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
O-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND - none detected
* - Possible peak at component's retention time.

FH-2398

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. 86-1562 Date Collected 1-7-86 Date Received: 1-7-86

Sampled Collected By: ~~Car~~ KLK Date Completed 1-15-86

Sample Source & Identification: Carrier Corp. Shelby Co.

(MW 1S) N.W. Shallow Well Field #5

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 50ML SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 GC AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	30 PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	ND	Dibromochloromethane	ND
Bromomethane	↓	1,1,2-Trichloroethane	↓
Vinyl Chloride	↓	Bromoform	↓
Chloroethane	↓	1,1,2,2-Tetrachloroethylene	*
Methylene Chloride	*	1,1,2,2-Tetrachloroethane	ND
1,1-Dichloroethylene	ND	Chlorobenzene	↓
Bromochloromethane	↓		
1,1-Dichloroethane	↓		
Trans-1,2-Dichloroethylene	*		
Chloroform	*		
1,2-Dichloroethane	ND		
1,1,1-Trichloroethane	*		
Carbon Tetrachloride	ND		
Bromodichloromethane	↓		
Trichloroethylene	20.4		

Remarks: ND - none detected

* Possible peak at component's retention time.

SWM

ORGANIC LABORATORY ANALYSIS REPORT

Laboratory Log No. 1565 Laboratory Analysis by: MAC Date completed 2-20-86
Date Received 1-7-86 Date Extracted/Opened 2-20-86

Field Log No. #5 Sample collected by: M.L.R.
Date collected 1-7-86 Kind of sample [illegible] water
Sample collected at: Carrier Corp. [illegible] Plant MAC Field:
(MW 19) [illegible] shallow well Shelby County

Sample Treatment: 9.0 mls purged on LSC-2 ; analysis on OWA GCMS

GC-MS Analysis:

GC: Perkin-Elmer Sigma 3 with 1% SP-1000 carbopak-B column. Carrier gas is UHP He at a flow rate of 25 ml per minute.

GC Program: Initial hold is 7 minutes at 35 °C. Ramp rate is 8 °C per minute. Final hold is 40 minutes at 210 °C. Separator temperature is 245 °C and manifold temperature is 80 °C.

MS: Finnigan OWA-1030

MS Program: Solvent divert valve open for 60 seconds after injection. 1000 scans at 3.0 seconds per scan, mass range is 35 to 260 amu. Minimum peak area count is: 20. Sample file name is V1565. Splitless injection time is ——— seconds. Filament and electron multiplier come on ——— seconds after injection.

COMPOUNDS DETECTED AND IDENTIFIED

1. Tetrahydrofuran	16.	31.
2. $C_3H_4O_2N$ Isomer (trace)	17.	32.
3. Trichloroethylene *	18.	33.
4.	19.	34.
5.	20.	35.
6.	21.	36.
7.	22.	37.
8.	23.	38.
9.	24.	39.
10.	25.	40.
11.	26.	41.
12.	27.	42.
13.	28.	43.
14.	29.	44.
15.	30.	45.

Remarks: * denotes largest peak

Ref 3

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

OFFICE CORRESPONDENCE

FROM	TO	DATE

DATE: February 27, 1987

TO: Bill Forrester

FROM: Kristen Allen KA

SUBJECT: Volatile Detection Limits, Collierville Samples

After reviewing the City of Collierville laboratory samples, collected August 27, 1986, with the Organic Laboratory personnel, the following detection limits were in effect.

The halogenated Volatile Organics were quantifiable to 0.4 to 0.5 ppb, except for bromoform which was higher. Due to the lack of matrix interference, the components could be detected at very low limits.

The aromatic Volatile Organics were quantifiable to 1 ppb using either an FID or PID.

FROM	DATE

TO

Both of these limits take into consideration GC/MS confirmation. While some of the components could be detected at 0.2 ppb levels with the HALL detector, they were not necessarily able to confirm at that level. Therefore, the quantification limits include confirmation.

PH-000
SR 3/77

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

OFFICE CORRESPONDENCE

FROM	TO	DATE

DATE:

TO:

FROM:

SUBJECT:

The laboratory followed EPA SW-846 methods 5030 (purge-and-trap), 8010 (Halogenated Volatile Organics), 8020 (Aromatic Volatile Organics), and 8240 (GC/MS Confirmation).

Methodology is followed to the letter including daily system blanks, daily standard analyses, and a 10% spike/duplicate QA program.

The QA program is matrix specific in that 10% of the waters and 10% of the sediments are analyzed as spiked duplicates to evaluate accuracy and precision. In addition, EPA unknowns are analyzed at least quarterly and by all new lab employees prior to starting the Volatile's Section.

All sample calculations are double checked with completed files kept in a locked cabinet. QA results are kept in a seperate logbook.

FROM	DATE

TO	

PH-0001
SR 3/77

LEGAL

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 1 Sampling Agency SWM - State Superfund

Laboratory Sample No. Ø - 225 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 9-2-86

Sample Source & Identification: City of Collierville, Water Plant #1, East Well, Shelby County, State Superfund

HALOGENATED VOLATILE ORGANIC ANALYSIS

A ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	NA	Dibromochloromethane	ND
Bromomethane	↓	1,1,2-Trichloroethane	↓
Vinyl Chloride	↓	Bromoform	↓
Chloroethane	↓	1,1,2,2-Tetrachloroethylene	↓
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	↓
1,1-Dichloroethylene	↓	Chlorobenzene	↓
Bromochloromethane	↓	1,2-Dichloropropane	↓
1,1-Dichloroethane	↓		
Trans-1,2-Dichloroethylene	↓		
Chloroform	↓		
1,2-Dichloroethane	↓		
1,1,1-Trichloroethane	↓		
Carbon Tetrachloride	↓		
Bromodichloromethane	↓		
Trichloroethylene	↓		

Remarks: NA= not analyzed

ND= None Detected

LEGAL

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 1 Sampling Agency SWM - State Superfund

Laboratory Sample No. Ø - 225 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 9-2-86

Sample Source & Identification: City of Collierville, Water Plant #1, East Well, Shelby County, State Superfund

AROMATIC VOLATILE ORGANIC ANALYSIS

A ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene		N-Butyl Benzene	
Ethyl Benzene		O-Dichlorobenzene	
p-Xylene		1,2,4 Trichlorobenzene	
m-Xylene			
o-Xylene			
Styrene			
n-Propyl Benzene			
0-Chlorotoluene			
1,3,5,-Trimethylbenzene			

Remarks: ND = none detected

Analysis performed 8-30-86 KVA

LEGAL

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 2 Sampling Agency SWM- State Superfund

Laboratory Sample No. Ø- 226 Date Collected 8-27-86 Date Received: 828-86

Sampled Collected By: MJH Date Completed 9-2-86

Sample Source & Identification: City of Collierville, Water Plant #1, West Well, Shelby County, State Superfund

HALOGENATED VOLATILE ORGANIC ANALYSIS

A ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	NA	Dibromochloromethane	ND
Bromomethane		1,1,2-Trichloroethane	
Vinyl Chloride		Bromoform	
Chloroethane		1,1,2,2-Tetrachloroethylene	
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	
1,1-Dichloroethylene		Chlorobenzene	
Bromochloromethane		1,2-dichloropropane	
1,1-Dichloroethane			
Trans-1,2-Dichloroethylene			
Chloroform			
1,2-Dichloroethane	0.4		
1,1,1-Trichloroethane	ND		
Carbon Tetrachloride			
Bromodichloromethane			
Trichloroethylene			

Remarks: NA = not analyzed

ND = none detected

LEGAL

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 2 Sampling Agency SWM- State Superfund

Laboratory Sample No. Ø - 226 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 9-2-86

Sample Source & Identification: City of Collierville, Water Plant #1, West Well, Shelby County, State Superfund

AROMATIC VOLATILE ORGANIC ANALYSIS

A ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	1.1	p-Dichlorobenzene	ND
Toluene	ND	N-Butyl Benzene	
Ethyl Benzene		O-Dichlorobenzene	
p-Xylene		1,2,4 Trichlorobenzene	
m-Xylene			
o-Xylene			
Styrene			
n-Propyl Benzene			
O-Chlorotoluene			
1,3,5,-Trimethylbenzene			

Remarks: ND= none detected

Analysis performed ~~8-30~~ 8-30-86 KVA

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-227H Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 9-2-86

Sample Source & Identification: City of Collierville - Water Plant #1 finished Water Shelby Co. Field #3

State Superfund

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	NA	Dibromochloromethane	2.3
Bromomethane	NA	1,1,2-Trichloroethane	ND
Vinyl Chloride	NA	Bromoform	1.1
Chloroethane	NA	1,1,2,2-Tetrachloroethylene	ND
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	ND
1,1-Dichloroethylene		Chlorobenzene	ND
Bromochloromethane			
1,1-Dichloroethane			
Trans-1,2-Dichloroethylene	ND		
Chloroform	0.7		
1,2-Dichloroethane	*		
1,1,1-Trichloroethane	ND		
Carbon Tetrachloride	ND		
Bromodichloromethane	1.1		
Trichloroethylene	ND		

Remarks: ND= none detected; NA= not analyzed, instrument unable to detect
* Presence indicated, less than 0.5 ppb

State Superfund

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 3 Sampling Agency SWM

Laboratory Sample No. Ø-227 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MIKE HIGGS Date Completed 8-29-86

Sample Source & Identification: Collierville City H_2O wells

Plant #1 Finished H_2O Shelby Co.

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene		N-Butyl Benzene	
EUtyl Benzene		O-Dichlorobenzene	
p-Xylene		1,2,4 Trichlorobenzene	
m-Xylene			
o-Xylene			
Styrene			
n-Propyl Benzene			
O-Chlorotoluene			
1,3,5,-Trimethylbenzene			

Remarks: ND - none detected

PH-2398

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-228 H Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 8-29-86

Sample Source & Identification: City of Collierville - Water Plant # 2 - East Well Shelby Co. Field # 4 State Superfund

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	NA	Dibromochloromethane	ND
Bromomethane	NA	1,1,2-Trichloroethane	
Vinyl Chloride	NA	Bromoform	
Chloroethane	NA	1,1,2,2-Tetrachloroethylene	
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	
1,1-Dichloroethylene		Chlorobenzene	ND
Bromochloromethane			
1,1-Dichloroethane			
Trans-1,2-Dichloroethylene			
Chloroform			
1,2-Dichloroethane			
1,1,1-Trichloroethane			
Carbon Tetrachloride			
Bromodichloromethane	ND		
Trichloroethylene	0.9 *		

Remarks: ND = none detected; NA = not analyzed, instrument unable to detect

* Presence confirmed by GC/MS

State Superfund

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 4 Sampling Agency SWM

Laboratory Sample No. Ø-228 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 8-29-86

Sample Source & Identification: City of Collierville Water Plant #2 Eastwell Shelby Co.

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene		N-Butyl Benzene	
Ethyl Benzene		O-Dichlorobenzene	
p-Xylene		1,2,4 Trichlorobenzene	
m-Xylene			
o-Xylene			
Styrene			
n-Propyl Benzene			
O-Chlorotoluene			
1,3,5,-Trimethylbenzene			

Remarks: ND - none detected

State Superfund

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 5 Sampling Agency SWM

Laboratory Sample No. Ø - 229 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: Mike Higgs Date Completed 9-2-86

Sample Source & Identification: City of Collierville Wells Shelby Co. Plant #2 finished water

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene		N-Butyl Benzene	
Ethyl Benzene		O-Dichlorobenzene	
p-Xylene		1,2,4 Trichlorobenzene	
m-Xylene			
o-Xylene			
Styrene			
n-Propyl Benzene			
O-Chlorotoluene			
1,3,5,-Trimethylbenzene			

Remarks: ND - none detected

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-230 H Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 8-29-86

Sample Source & Identification: City of Collierville - Water Plant #2 West Well Shelby Co. Field #6 State Superfund

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	NA	Dibromochloromethane	ND
Bromomethane	NA	1,1,2-Trichloroethane	
Vinyl Chloride	NA	Bromoform	
Chloroethane	NA	1,1,2,2-Tetrachloroethylene	
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	
1,1-Dichloroethylene		Chlorobenzene	ND
Bromochloromethane			
1,1-Dichloroethane			
Trans-1,2-Dichloroethylene			
Chloroform			
1,2-Dichloroethane			
1,1,1-Trichloroethane			
Carbon Tetrachloride			
Bromodichloromethane	ND		
Trichloroethylene	3.0*		

Remarks: ND = none detected; NA = not analyzed, instrument unable to detect

* Presence confirmed by GC/MS

State Superfund

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 6 Sampling Agency SWM

Laboratory Sample No. Ø-230 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 8-29-86

Sample Source & Identification: City of Collierville Water Plant #2 West Well Shelby Co.

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene	↓	N-Butyl Benzene	↓
Ethyl Benzene	↓	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
O-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND - none detected

PH-2308

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. _____ Sampling Agency SWM

Laboratory Sample No. Ø-231 H Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: MJH Date Completed 8-29-86

Sample Source & Identification: City of Collierville - Water Plant #2 West Well Shelby Co. Field # 6 dup - Field duplicate to Ø-230

State Superfund

HALOGENATED VOLATILE ORGANIC ANALYSIS

A 5.0ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A HALL 700A ELECTROCONDUCTIVITY DETECTOR IN THE CHLORINE MODE.

COLUMN:	1% SP-1000/CARBOPACK B
STARTING TEMP:	50°C
INITIAL HOLD:	4 MIN.
PROGRAM RATE:	8° PER MIN.
FINAL TEMP:	200°C
FINAL HOLD:	10 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Chloromethane	NA	Dibromochloromethane	ND
Bromomethane	NA	1,1,2-Trichloroethane	
Vinyl Chloride	NA	Bromoform	
Chloroethane	NA	1,1,2,2-Tetrachloroethylene	
Methylene Chloride	ND	1,1,2,2-Tetrachloroethane	
1,1-Dichloroethylene		Chlorobenzene	ND
Bromochloromethane			
1,1-Dichloroethane			
Trans-1,2-Dichloroethylene			
Chloroform			
1,2-Dichloroethane			
1,1,1-Trichloroethane			
Carbon Tetrachloride			
Bromodichloromethane	ND		
Trichloroethylene	3.1 *		

Remarks: ND= none detected; NA= not analyzed, instrument unable to detect.

* Presence confirmed by GC/MS

State fund

ORGANIC LABORATORY ANALYSIS REPORT

Field Log No. 6 duplicate Sampling Agency SWM

Laboratory Sample No. Ø-231 Date Collected 8-27-86 Date Received: 8-28-86

Sampled Collected By: Mike Higgs Date Completed 9-2-86

Sample Source & Identification: Collierville City water well Plant #2 west well water pump

AROMATIC VOLATILE ORGANIC ANALYSIS

A 5 ML. SAMPLE FROM A SPECIALLY PREPARED VOA BOTTLE IS PURGED ONTO A TENAX TRAP USING ULTRA HIGH PURITY HELIUM. THE TRAP IS THEN DESORBED TO A TRACOR 560 G.C. AND ANALYZED USING A FLAME IONIZATION DETECTOR.

COLUMN:	5% SP-1200/1.75% Bentone
STARTING TEMP:	50°C
INITIAL HOLD:	2 MIN.
PROGRAM RATE:	6° PER MIN.
FINAL TEMP:	110°C
FINAL HOLD:	15 MIN.

COMPOUND	RESULTS (ppb)	COMPOUND	RESULTS (ppb)
Benzene	ND	p-Dichlorobenzene	ND
Toluene	↓	N-Butyl Benzene	↓
Ethyl Benzene	↓	O-Dichlorobenzene	↓
p-Xylene	↓	1,2,4 Trichlorobenzene	↓
m-Xylene	↓		
o-Xylene	↓		
Styrene	↓		
n-Propyl Benzene	↓		
O-Chlorotoluene	↓		
1,3,5,-Trimethylbenzene	↓		

Remarks: ND - none detected

UNITED TECHNOLOGIES CARRIER

Carrier Corporation

97 South Byhalia Road
Collierville Tennessee 38017
(901) 853-9761

May 6, 1986

MAY 0 8 1986

Mr. Michael J. Higgs
Assistant Project Director
Division of Superfund
Tennessee Department of Health
and Environment
Custom House, 701 Broadway
Nashville, TN 37219-5403

Dear Mr. Higgs:

This letter responds to your inquiry, dated April 18, 1986 and made pursuant to Section 104(e) of the Comprehensive Environmental Response, Compensation and Liability Act, with respect to possible environmental contamination at Carrier's Collierville, Tennessee facility. For your convenience, I have repeated each of your requests before providing the response.

Request 1: Copies of documents concerning the closure of the waste water lagoon located near the present softball field.

Response: Such documentation on this pre-RCRA closure as Carrier has been able to discover by reasonable search are attached to this letter. Set forth at the end of this letter is a listing of those documents.

Request 2: The time period when the lagoon was active (contained waste).

Response: The commencement date for first use of the lagoon cannot be determined, but upon information and belief, it was in use during 1972 and at various times thereafter until closure commenced on or before November 12, 1980.

Request 3: The source or sources of material going into the lagoon.

Response: According to our best information, the material placed in the lagoon came from the clarifier pit. This material should have consisted of the sludge from the paint washers.

CLV

Request 4: Whether the lagoon was authorized under an NPDES or other permit.

Response: We never had an NPDES or other permit for the lagoon and are not aware of having applied for any such permit. As is explained in response number 5, such permits were not required.

Request 5: Whether the lagoon discharged liquids to a surface drainage feature.

Response: Based on reasonable investigation, we have been unable to discover any Carrier employee who is aware of there ever being any drainage from the lagoon. My personal recollection is that the level of the materials in the lagoon never came closer than two feet to the top of the lagoon.

Request 6: The types of waste and amount of each type placed into the lagoon over its lifetime.

Response: We are unable to determine with any certainty the types of wastes (other than as disclosed in response number 3) or the amounts thereof placed in the lagoon. However, we have enclosed, as Attachment 2, a letter from Environmental Testing & Consulting, Inc. setting forth results of the sampling of dried sludge in the lagoon. As you will note from that attachment, ETC's conclusion, based on its sampling, is that the "sludge would not be considered toxic and could be accepted at a State approved landfill." Also enclosed, as Attachment 3, are internal sampling results which are consonant with those of ETC.

Request 7: The method used to close the lagoon (closure plan).

Response: In order to close the lagoon, contaminated soil was removed and placed on plastic with a plastic cover. At the earliest practical time, the contaminated soil was shipped to an approved Subtitle C facility. Attachment 4 is a bill, dated November 12, 1980, from C & M Builders for its work in removing the contaminated dirt from the lagoon. Since closure commenced before November 19, 1980, no closure plan was required and none was prepared.

Request 8: The ultimate disposition of any material, both solid and liquid, removed during the closure of the lagoon.

Response: The material removed at the closing of the lagoon was sent to Chemical Waste Management, Inc., P. O. Box 55, Emelle, Alabama 35457 as indicated in manifest in Attachment 5.

Request 9: The amount of material, including the soil, removed as a result of the TCE spill resulting from the failure of the filter cover.

Response: Although this spill required some material to be removed, we have no knowledge or documents concerning the amount of material that was removed.

Request 10: The ultimate disposition of the material thus removed.

Response: Although we have no knowledge of or documents concerning the disposition of this material, we do know that it was removed from the Collierville facility.

Request 11: Whether any groundwater monitoring wells have been established at the site.

Response: No groundwater monitoring wells were established because of this spill.

Request 12: Analytical data from any such well should they exist.

Response: None, from wells established as the result of subject spill.

I hope the foregoing and the attached documents constitute a satisfactory response to your inquiry. They are based on Carrier's best efforts to locate relevant documents and a reasonable inquiry as to facts not found in existing documents. Should these answers not be satisfactory or should you have any further questions, please do not hesitate to contact me.

Sincerely,
CARRIER CORPORATION

John Brewer

John Brewer
Safety & Security Coordinator

JB/ab

ATTACHMENTS

1. Letter to Chemical Waste Management from Clifton Ritter with sample results, a three page form code no. 25997.

2. Letter from Environmental Testing & Consulting, Inc. to Roger Beaupre with sample results from sludge.

3. Internal memo dated October 9, 1980 regarding lagoon sludge.

4. Statement from C & M Builders on lagoon cleaning.

5. Hazardous waste manifests concerning the disposal of contaminated soil.

6. Page of notes dated 12/9/80.

Carrier
Air Conditioning

ROGER BEAUPRÉ (L)

November 7, 1980

Chemical Waste Management, Inc.
P.O. Box 55
Highway 17 @ Mile Marker 163
Emelle, Alabama 35459

ATTENTION: CHIEF CHEMIST

Dear Sir:

Enclosed is a sample of our waste, along with a copy of the respective completed and signed Waste Material Profile Sheet.

If any other information is needed concerning our waste, you can contact me at (901) 853-9761 ext. 324.

Sincerely,

CARRIER AIR CONDITIONING

Clifton Ritter
Environmental Engineer

?db
enc.

#1

Air Conditioning

Set 3

Nov

Chemical Waste Management, Inc.
2131 Kingston Court, S.E.
Suite 112
Marieeta, Georgia 30067

To whom it may concern:

Attached is the "original" completed and signed Waste Material Profile Sheet for our waste.

If there are any questions, I can be contacted at 901-853-9761 extension 324.

Sincerely,

CARRIER AIR CONDITIONING CO.

Clifton Ritter
Environmental Engineer

/db
attachment

SALES CODE

№ 25997

Chemical Waste Management

GENERATOR'S WASTE MATERIAL PROFILE SHEET

GENERAL DIRECTIONS: In order for us to determine whether we can lawfully, safely and environmentally transport, store, treat or dispose of your waste stream, we must ask certain information about your waste. All of the information we seek is necessary, for our purposes and yours. Be complete in your answers: if your response is "none," so indicate. Answers must be in ink or typewritten. Information you provide will be maintained in strictest confidence. Please make a copy of this form for your records, returning the original to the location indicated below.

THIS FORM AND ANY SUPPLEMENTAL INFORMATION SHOULD BE RETURNED TO:
CHEMICAL WASTE MANAGEMENT, INC.
2131 KINGSTON COURT, S.E.
SUITE 112
MARIETTA, GEORGIA 30067

AUDIT SAMPLES DIRECT TO:

1. GENERATOR NAME: CARRIER A/C CO.
2. GENERATING FACILITY NAME/ADDRESS: Carrier Air Conditioning Co.
   97 S. Byhalia Road
   Collierville, TN 38017
3. COMPANY CONTACTS:

GENERAL	Clifton Ritter	TITLE	Envir. Engr.	PHONE	(901)853-9761
	William Brown	TITLE	Facilities Mgr.	PHONE	(901)853-9761
TECHNICAL		TITLE		PHONE	
		TITLE		PHONE	

4. WASTE NAME: 75% Trichloroethylene contaminated soil and 25% paint sludge
5. PROCESS GENERATING WASTE: Industrial painting and stripping

WASTE PROPERTIES:

A. ORGANIC ☐ INORGANIC ☐ HAS BOTH ORGANIC AND INORGANIC COMPONENTS ☒

B. PHASES/LAYERS: BILAYERED ☐ MULTILAYERED ☐ NONE ☒

C. PHYSICAL STATE AT 70°F: SOLID ☒ SEMI-SOLID ☐ LIQUID ☐ POWDER ☐ OTHER: _____

D. SOLIDS: TOTAL (%) appr. 90 TOTAL DISSOLVED (ppm or %): _____

E. SPECIFIC WEIGHT (AS # PER UNIT): approximately 100 pounds per cubic foot

F. pH: 8.0 (Show the following as range of %)

AS:	H_2SO_4	- %	H_3PO_4	- %
	HCl	- %	NaOH	- %
	HF	- %	NH_4OH	- %
	HNO_3	- %	$Ca(OH)_2$	- %
OTHER:		- %		- %
		- %		- %

G. FLASH POINT: >150 °F CLOSED CUP ☒ OPEN CUP ☐

H. VAPOR PRESSURE (in mm of Hg at 25°C): N/A

I. BTU PER #: N/A ASH CONTENT N/A %

J. HALOGENATED? Yes, Trace ___ % SULFONATED? N/A %

K. ALPHA RADIATION AS pCi/l: _____

6. WASTE COMPOSITION:

A. ORGANIC COMPONENTS (WITH RANGES — INDICATE WHETHER % OR ppm) all ppm

Trichloroethylene	5 - 370	Cyanide	0 - 2.5
Xylene	0 - 12		-
Toluene	0 - 2		-
MEK	0 - 8		-

(ATTACH ADDITIONAL PAGES IF NECESSARY)

B. HEAVY METALS (WITH ppm RANGES): . from leachate test

	DISSOLVED	SUSPENDED		DISSOLVED	SUSPENDED
Ag	<.002		Hg	<.001	
As	<.001		Ni	none	
Ba	.23		Pb	<.01	
Cd	<.01		Se	<.001	
Cr	<.003		Zn	none	
Cu	none		Other (specify)		

C. INORGANIC COMPONENTS (WITH % RANGES): OTHER

TOTAL CYANIDE Trace	- %		- %
FREE CYANIDE	- %		- %
SULFIDE AS:	- %		- %
BISULFITE AS:	- %		- %
SULFITE AS:	- %		- %

(ATTACH ADDITIONAL PAGES IF NECESSARY)

D. DOES THIS WASTE STREAM CONTAIN BIOLOGIC MATERIALS, PATHOGENS, OR ETIOLOGICAL AGENTS? No

E. IF WASTE IS A PESTICIDE OR PRODUCED BY A PESTICIDE MANUFACTURING PROCESS, CHECK THE FOLLOWING:

THE WASTE CONTAINS:

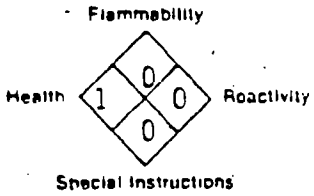
- ☐ ORGANOPHOSPHATES — CONTAINING SULFUR ☐ YES ☐ NO
- ☐ CARBAMATES
- ☐ CHLORINATED HYDROCARBONS

7. HAZARDOUS COMPONENTS AND CHARACTERISTICS

A. HAZARDOUS PROPERTIES (INSERT NUMBER CODES PER INSTRUCTIONS ON LAST PAGE)

(1) TOXICITY RATING: INHALATION 0 DERMAL 0 ORAL 1

(2) HAZARD IDENTIFICATION SYSTEM:



B. IS THIS WASTE A "HAZARDOUS MATERIAL" AS DEFINED BY REGULATIONS OF THE U.S. DEPARTMENT OF TRANSPORTATION PURSUANT TO THE HAZARDOUS MATERIALS TRANSPORTATION ACT? No
(SEE 49 CFR 172.101 AND 173 FOR "HAZARDOUS MATERIALS" LIST AND CHARACTERISTICS.) IF SO, PLEASE ADVISE OF THE FOLLOWING:

(1) CORRECT SHIPPING DESCRIPTION: Hazardous Waste, Solid N.O.S.

(2) HAZARD CLASS(ES): O.R.M.-E

(3) IDENTIFICATION NUMBER (FROM HAZARDOUS MATERIALS LIST): NA 9198

C. DOES THIS WASTE CONTAIN ANY "HAZARDOUS SUBSTANCE" AS DEFINED BY REGULATIONS OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY PURSUANT TO SECTION 311 OF THE CLEAN WATER ACT? Yes
(SEE 40 CFR 116 FOR "HAZARDOUS SUBSTANCES" AND CATEGORIES.) IF SO, PLEASE ADVISE OF THE FOLLOWING:

(1) THE NAMES OF EACH HAZARDOUS SUBSTANCE PRESENT IN THE WASTE (INDICATING HAZARD CATEGORY — A, B, C, D, X):

Trichloroethylene - C Tolvene - C

Xylene - C

(ATTACH ADDITIONAL PAGES IF NECESSARY)

(2) THE NAMES OF EACH SUCH SUBSTANCE WHICH MAY BE PRESENT IN CONCENTRATIONS GREATER THAN 10% BY WEIGHT (SHOWING PROBABLE % RANGE):

(ATTACH ADDITIONAL PAGES IF NECESSARY)

D. IS THIS WASTE A "HAZARDOUS WASTE" AS DEFINED BY REGULATIONS OF THE U.S. ENVIRONMENTAL PROTECTION AGENCY PURSUANT TO SECTION 3001 OF THE RESOURCE CONSERVATION AND RECOVERY ACT? Yes
(THIS PART NEED NOT BE COMPLETED UNTIL PROMULGATION OF FINAL 3001 REGULATIONS.) IF SO, PLEASE ADVISE OF THE FOLLOWING:

(1) IF THE WASTE IS A LISTED HAZARDOUS WASTE, STATE:

(a) THE LISTED DESCRIPTION OF THE WASTE: F018 - Wastewater treatment sludges from industrial painting, plus contaminated soil there from.

(b) THE HAZARD CRITERIA FOR WHICH THE WASTE IS LISTED:
Toxic Waste

(2) IF THE WASTE IS NOT LISTED, WHAT HAZARDOUS CHARACTERISTIC(S) DOES IT POSSESS?

8. IS THE INFORMATION PROVIDED IN SECTIONS 5-7 BASED UPON LABORATORY ANALYSIS OF THE WASTE MATERIAL? yes . IF SO, PLEASE ADVISE OF THE DATE OF THE MOST RECENT ANALYSIS: Nov. 6, 1980

9. HAVE YOU OBTAINED TOXICITY STUDIES OF THIS WASTE STREAM? yes IF SO, PLEASE ATTACH A COPY OF THE RESULTS.

10. QUANTITY/SHIPPING REQUIREMENTS:

ANTICIPATED VOLUME IS: 175

GALLONS ☐ TONS ☐ CUBIC YARDS ☒ DRUMS ☐ OTHER ☐

PER: DAY ☐ WEEK ☐ MONTH ☐ YEAR ☐ ONE TIME ☒

TRANSPORTATION EQUIPMENT REQUIRED: 23 cubic yard trucks

SERVICE/SCHEDULING REQUIREMENTS: Need 10 days notice

GENERATOR'S AUTHORIZED SIGNATORY: [illegible] TITLE Envir. Engr. DATE 11/7/80

CONFIDENTIALITY AGREEMENT: [illegible], as consideration for the Generator's release of the above information, and any other supplemental data provided, agrees to treat such information as confidential property and will not disclose such information to others except as is required by law, and in such circumstances only after first giving notice to the Generator.

By: [illegible]
Name

[illegible]
Title

TOXICITY RATINGS

0 = No Toxicity

This designation is given to materials which fall into one of the following categories

(a) Materials which cause no harm under any conditions of normal use

(b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage

1 = Slight Toxicity

(a) *Acute local.* Materials which on single exposures lasting seconds, minutes, or hours cause only slight effects on the skin or mucous membranes regardless of the extent of the exposure

(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slight effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose, regardless of the quantity absorbed or the extent of exposure

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause only slight and usually reversible harm to the skin or mucous membranes. The extent of exposure may be great or small

(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce only slightly usually reversible effects following continuous or repeated exposures extending over days, months, or years. The extent of the exposure may be great or small.

In general, those substances classified as having "slight toxicity" produce changes in the human body which are readily reversible and which will disappear following termination of exposure, either with or without medical treatment.

2 = Moderate Toxicity

(a) *Acute local.* Materials which on single exposure lasting seconds, minutes, or hours cause moderate effects on the skin or mucous membranes. These effects may be the result of intense exposure for a matter of seconds or moderate exposure for a matter of hours

(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following single exposures lasting seconds, minutes, or hours, or following ingestion of a single dose

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years cause moderate harm to the skin or mucous membranes.

(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following continuous or repeated exposures extending over periods of days, months, or years

Those substances classified as having "moderate toxicity" may produce irreversible as well as reversible changes in the human body. These changes are not of such severity as to threaten life or produce serious physical impairment.

3 = Severe Toxicity

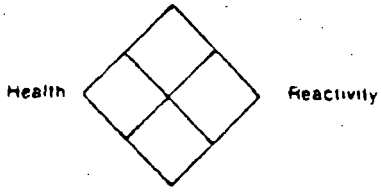
(a) *Acute local.* Materials which on single exposure lasting seconds or minutes cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent physical impairment or disfigurement

(b) *Acute systemic.* Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which can cause injury of sufficient severity to threaten life following a single exposure lasting seconds, minutes, or hours, or following ingestion of a single dose

(c) *Chronic local.* Materials which on continuous or repeated exposures extending over periods of days, months, or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or cause permanent impairment, disfigurement, or irreversible change

(d) *Chronic systemic.* Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairment following continuous or repeated exposures to small amounts extending over periods of days, months, or years.

Hazard Identification System



The above diagram identifies the "health," "flammability" and "reactivity" (instability and water reactivity) of a chemical and indicates the order of severity of each hazard by use of one of five numeral gradings, from four (4), indicating the severe hazard or extreme danger, to zero (0), indicating no *special* hazard. In the diamond-shaped diagram "health" hazard is identified at the left, "flammability" at the top, and "reactivity" at the right. The bottom space is primarily used to identify unusual reactivity with water. A W with a line through its center W alerts fire fighting personnel to the possible hazard in use of water. This bottom space may be also used to identify a radiation hazard by the symbol ☢. Oxidizing chemicals are identified in the bottom space by OXY

To supplement the spatial arrangement NFPA No. 704M recommends the use of colored backgrounds or colored numbers to identify the hazard categories—blue for "health," red for "flammability," yellow for "reactivity."

For a detailed description of the hazard identification system used here, see "Recommended System for the Identification of the Fire Hazards of Materials, NFPA No. 704M, 1969 Edition."

The following paragraphs summarize the meanings of the numbers in each hazard category and explain what a number should tell fire fighting personnel about protecting themselves and how to fight fires where the hazard exists.

Health

4 A few whiffs of the gas or vapor could cause death, or the gas, vapor, or liquid could be fatal on penetrating the fire fighters' normal full protective clothing which is designed for resistance to heat. For most chemicals having a health 4 rating the normal full protective clothing available to the average fire department will not provide adequate protection against skin contact with these materials. Only special protective clothing designed to protect against the specific hazard should be worn

3 Materials extremely hazardous to health, but areas may be entered with extreme care. Full protective clothing, including self-contained breathing apparatus, rubber gloves, boots and bands around legs, arms and waist should be provided. No skin surface should be exposed

2 Materials hazardous to health, but areas may be entered freely with self-contained breathing apparatus

1 Materials only slightly hazardous to health. It may be desirable to wear self contained breathing apparatus

0 Materials which on exposure under fire conditions would offer no health hazard beyond that of ordinary combustible material.

Flammability

4 Very flammable gases, very volatile flammable liquids, and materials that in the form of dusts or mists readily form explosive mixtures when dispersed in air. Shut off flow of gas or liquid and keep cooling water streams on exposed tanks or containers. Use water spray carefully in the vicinity of dusts so as not to create dust clouds

3 Liquids which can be ignited under almost all normal temperature conditions. Water may be ineffective on these liquids because of their low flash points. Solids which form coarse dusts, solids in shredded or fibrous form that create flash fires, solids that burn rapidly usually because they contain their own oxygen, and any material that ignites spontaneously at normal temperatures in air

2 Liquids which must be moderately heated before ignition will occur and solids that readily give off flammable vapors. Water spray may be used to extinguish the fire because the material can be cooled to below its flash point

1 Materials that must be preheated before ignition can occur. Water may cause frothing of liquids with this flammability rating number if it gets below the surface of the liquid and turns to steam. However, water spray gently applied to the surface will cause a frothing which will extinguish the fire. Most combustible solids have a flammability rating of 1.

0 Materials that will not burn.

Reactivity

4 Materials which in themselves are readily capable of detonation or of explosive decomposition or explosive reaction at normal temperatures and pressures. Includes materials which are sensitive to mechanical or localized thermal shock. If a chemical with this hazard rating is in an advanced or massive fire, the area should be evacuated

3 Materials which in themselves are capable of detonation or of explosive decomposition or of explosive reaction but which require a strong initiating source or which must be heated under confinement before initiation. Includes materials which are sensitive to thermal or mechanical shock at elevated temperatures and pressures or which react explosively with water without requiring heat or confinement. Fire fighting should be done from an explosion-resistant location

2 Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Includes materials which can undergo chemical change with rapid release of energy at normal temperatures and pressures or which can undergo violent chemical change at elevated temperatures and pressures. Also includes those materials which may react violently with water or which may form potentially explosive mixtures with water or generates toxic gases, vapors or fumes when mixed with water. In advanced or massive fires, fire fighting should be done from a protected location

1 Materials which in themselves are normally stable but which may become unstable at elevated temperatures and pressures or which may react with water with some release of energy but not violently. Caution must be used in approaching the fire and applying water

0 Materials which are normally stable even under fire exposure conditions and which are not reactive with water. Normal fire fighting procedures may be used.

ENVIRONMENTAL TESTING & CONSULTING INC.
751 E. BROOKHAVEN CIRCLE • MEMPHIS, TENNESSEE 38117 • PHONE (901) 767-0840

August 21, 1980

Mr. Roger Beaupre, Plant Engineer
Carrier Air Conditioning Company
97 S. Byhalia Road
Collierville, Tennessee 38017

REF: EP TOXICITY

Dear Mr. Beaupre:

We have treated the dried sludge from the drained lagoon for EP Toxicity. The results are tabulated below following the standard leachate test.

TESTS	RESULTS (mg/l)
Arsenic	<0.001
Barium	0.23
Cadmium	<0.01
Chromium	<0.003
Lead	<0.01
Mercury	<0.001
Selenium	<0.001
Silver	<0.002
Endrin	<50 ppt
Lindane	<50 ppt
Methoxychlon	<50 ppt
Toxaphene	<50 ppt
2,4-D	<50 ppt
2,4,5-TP	<50 ppt

The results indicated that the sludge would not be considered toxic and could be accepted at a state spproved landfill.

Very truly yours,

Nathan A. Pera
President

NAP/cp
Attachments

#7

Attachment 3

Carrier Corporation

OCT 10 1980

Interoffice Letter

Date: OCTOBER 9, 1980

To: MR. JOHN BREWER - CY
MR. MICHAEL RIDGE - TOWER 13
MR. DONALD RICH - RDC

From: HENRY B. BALDUZZI/HARRY F. KLODOWSKI

Office: RDC - SYRACUSE

Subject: E & IH - EP TOXICITY - LAGOON SLUDGE (2198, 9-3005-07)

The sample of dried lagoon sludge, numbered 0089, was analyzed for heavy metals in accordance with EP toxicity requirements. Testing for herbicides and pesticides was considered unnecessary due to the nature and origin of the sludge. The results of our findings are listed as follows:

Contaminant	Concentration found (mg/L)	Maximum Concentration (mg/L)
Arsenic	.001	5.0
Barium	.94	100.0
Cadmium	.014	1.0
Chromium	.005	5.0
Lead	.21	5.0
Mercury	<.0001	0.2
Selenium	<.001	1.0
Silver	.013	5.0

HBB/HFK/pav

#3

LESTER ~~M. COX~~
Res. 682-0014

C & M BUILDERS, INC.

JOHN MATLOCK
Res. 754-1238

General Contractors
P. O. BOX 171333
4990 POPLAR AVENUE, ROOM 422
MEMPHIS, TENNESSEE 38117

Telephone (901) 683-5208

11-12-80

Carrier Air Cond.
97 S. Byhalia Rd.
Collierville, Tn. 38017

Nº 1658

RE: Cleaning Sludge Pond

Labor	$ 46.13
Material, Equipment	$ 865.00
	$ 911.13
+10% Overhead & Profit	$ 91.11
Total.....	$1,002.24

Attachments

Thank You

C.K. to pay [illegible]

11/14/80

P.O. _____

#4

Attachment 5

ALABAMA HAZARDOUS WASTE MANIFEST

CWMA NO. 017281

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND044062222
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Ala 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2	Grover F. Boyd	Emelle Al 35459	205-652-7548	ALT000647797
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste Hazardous Waste, N.O.S./ORME, [illegible] (Soil and wastewater treatment sludge from industrial painting.)	40000	LB.	F019		40,000

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation, according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator — Title: Env. Engineer — Date: 2-17-91

This is to certify acceptance of the hazardous waste shipment described above:

Transporter #1 — Title: DRIVER — Date: 2/17/91

[signature] — Transporter #2 — Title: [illegible] — Date: 2/17/91

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer — Title: [illegible] — Date: [illegible]

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	1	Dump	[illegible]	13	19	1	[illegible]

#5

DISPOSER

ALABAMA

HAZARDOUS WASTE MANIFEST

CWMA
NO 017282

IDENTIFICATION INFORMATION

NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901- 853-9761	TN004406222
TRANSPORTER NO. 1 Chemical Waste Management	P. O. Box 55 Emelle, Ala 35459	205- 652-9531	ALT000622464
TRANSPORTER NO. 2			
DISPOSER Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste Hazardous waste, N.O.S./ORMZ, NA9189 (Soil and wastewater treatment sludge from industrial painting.)	40000	LB.	F019		40,000

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator | Title: Env. Engineer | Date: 2-17-81

This is to certify acceptance of the hazardous waste shipment described above:

[signature] — Transporter #1 | Title: [signature] | Date: 2-17-81

Transporter #2 | Title | Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer | Title: [signature] | Date: 2-17-81

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	1	[illegible]	[illegible]	12	19	1	42 183 195

DISPOSER

#2

ALABAMA

HAZARDOUS WASTE MANIFEST

CWMA
NO 017283

IDENTIFICATION INFORMATION

NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901- 853-9761	T N D 0 4 4 0 6 2 2 2
TRANSPORTER NO. 1 Chemical Waste Management	P. O. Box 55 Emelle, Ala 35459	205- 652-9531	A L T 0 0 0 6 2 2 4 6 4
TRANSPORTER NO. 2			
DISPOSER Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	A L T 0 0 0 6 2 2 4 6 4

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste Hazardous waste, N.O.S./ORME, NA9189 (Soil and wastewater treatment sludge from industrial painting.)	40000	LB.	T018		40,000

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator — Title: ~~Eng.~~ Engineer ENV. — Date: 2-17-81

This is to certify acceptance of the hazardous waste shipment described above:

[signature] — Transporter #1 — Title: Driver — Date: 2-17-81

Transporter #2 — Title — Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer — Title: Driver — Date: 2-17-81

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	[illegible]	Dump	D-81	12	19	1	37 96[illegible]

DISPOSER #2

ALABAMA

HAZARDOUS WASTE MANIFEST

CWMA
NO 017284

IDENTIFICATION INFORMATION

NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901- 853-9761	T N D 0 4 4 0 5 2 2 2
TRANSPORTER NO. 1 Chemical Waste Management	P. O. Box 55 Emelle, Alabama 35459	205- 652-9531	A L T 0 0 0 6 2 2 4 6 4
TRANSPORTER NO. 2			
DISPOSER Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	A L T 0 0 0 6 2 2 4 6 4

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste Hazardous Waste, N.O.S./ORME, NA9139 (Soil and Waste Water Treatment Sludge from Industrial Painting)	40,000	LB.	7013		40,00

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation, according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

Generator	Title	Date
[signature]	Env. Engineer	2-15-81

This is to certify acceptance of the hazardous waste shipment described above:

Transporter #1	Title	Date
[signature]	[signature]	2/19/81
Transporter #2	Title	Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

Disposer	Title	Date
[signature]	[signature]	[illegible]

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
		Dump	[illegible]	12	19	1	[illegible]

DISPOSER

CWMA

HAZARDOUS WASTE MANIFEST

No. 017285

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND004402122
TRANSPORTER NO. 1	Chemical Waste Management	P. O. BOX 55 Emelle, Alabama 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2	Grover F. Boyd	P.O. Box 67 Emelle, Al.	205-652-7549	ALT000622499
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste Hazardous Waste, ~~NR~~ N.O.S./ORME	40,000	LB.	F019B		40,000
		(SOIL and Waste Water Treatment Sludge ~~From Industrial Painting~~)					

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR —(901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

Generator	Title	Date
[signature]	ENV. ENGINEER	2-19-81

This is to certify acceptance of the hazardous waste shipment described above:

	Title	Date
Transporter #1		
[signature] Transporter #2	[signature]	2-19-81

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

Disposer	Title	Date
[signature]	Env. Sci Tech	2-20-81

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LEVEL	QUAD	COMMENTS
	1	Dump	D81	12	19	1	4/Tons/Ld.

DISPOSER #2

CWMA

HAZARDOUS WASTE MANIFEST

NO. 01728

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND044062223
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2	CLAYER F. BOYD LEASE TRUCK	P. O. Box 67 EMELLE, ALA.	205-652-7549	ALT000647912
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGH
1	Dump Trailer	Waste hazardous waste, N.O.S./ORME	40,000	LB.	F019		40.0
		NA9189 (Soil and Waste water Treatment Sludge From Industrial Painting)					

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 852-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper conditio for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

	Generator	Title	Date
	[signature]	Env. Engineer	2-13-81

This is to certify acceptance of the hazardous waste shipment described above:

	Transporter #1	Title	Date
	[signature]	[signature]	2-18-81
	Transporter #2	Title	Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

	Disposer	Title	Date
	[signature]	[signature]	[illegible]

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LEVEL	QUAD	COMMENTS
	1	Dump	D-81	12	19	1	[illegible]

DISPOSER

F 2

ALABAMA

- CWMA

HAZARDOUS WASTE MANIFEST

NO. 017287

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	T N D 0 4 4 0 5 2 2 2 2
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	A L T 0 0 0 6 2 2 4 6 4
TRANSPORTER NO. 2				
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	A L T 0 0 0 6 2 2 4 6 4

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste hazardous waste, N.O.S./ORME, NA 9189 (Soil and waste water treatment sludge from industrial painting)	40,000	LB	D019		40,000

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR —(901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[illegible] — Generator | Env. Engineer — Title | 2-19-91 — Date

This is to certify acceptance of the hazardous waste shipment described above:

[illegible] — Transporter #1 | [illegible] — Title | 2-19-91 — Date

Transporter #2 | Title | Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[illegible] — Disposer | Title | Date

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
		LB	[illegible]	12	19	1	[illegible]

DISPOSER

ALABAMA
HAZARDOUS WASTE MANIFEST

CWMA
NO. 017283

NTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND044005220
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2				
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste hazardous waste, N.O.S./ORM	40,000	LB.	NOR?		40,000
		NA9189 (Soil and waste water treatment sludge ~~from industrial painting~~)					

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR —(901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator | Env. Engineer — Title | 2/20/81 — Date

This is to certify acceptance of the hazardous waste shipment described above:

[signature] — Transporter #1 | [signature] — Title | [signature] — Date

Transporter #2 | Title | Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer | [signature] — Title | [signature] — Date

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	1	2	D-81	12	19	1	[illegible]

DISPOSER

4 2

ALABAMA

HAZARDOUS WASTE MANIFEST

CWMA
NO 017289

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia, RD. Collierville, TN 38017	901-853-9761	TND004622222
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2	GRAVER F. BOYD	P.O. Box 67 EMELLE ALA	205 152-7549	ALT000647990
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste hazardous waste, N.O.S./ORM-E	40,000	LB.	F019		40.000
		NA9189 (Soil and waste water treatment sludge from industrial painting)					

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR —(901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator; ENV. ENGINEER — Title; 2/20/91 — Date

This is to certify acceptance of the hazardous waste shipment described above:

[signature] — Transporter #1; [signature] — Title; 2-20-91 — Date

Transporter #2 — Title — Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer; [signature] — Title; 2-20-91 — Date

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	1	Dry	D-5	12	19	1	44,120 LBS

DISPOSER

#02

ALABAMA

CWMA

HAZARDOUS WASTE MANIFEST

NO. 017290

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND044022222
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2				
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste hazardous waste, N.O.S./ORM	40,000	LB.	F019		40,000
		NA9189 (SOIL and Waste Water Treatment Sludge From Industrial Painting)					

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature]	Env. Engineer	2/23/91
Generator	Title	Date

This is to certify acceptance of the hazardous waste shipment described above:

[signature]	[signature]	2-23-91
Transporter #1	Title	Date
Transporter #2	Title	Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature]	[signature]	[illegible]
Disposer	Title	Date

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
		[illegible]	D-81	12	19	1	32 [illegible]

DISPOSER #2

ALABAMA

HAZARDOUS WASTE MANIFEST

CWMA

NO 017291

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND044062222
TRANSPORTER NO. 1	Chemical Waste Management	P. O. BOx 55 Emelle, Alabama 35459	205-652-9531	ALT000622464
TRANSPORTER NO. 2				
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste hazardous waste, N.O.S./ORME	40,000	LB.	F013		40,000
		NA9189 (Soil and waste water treatment sludge from industrial painting)					

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator | Env. Engineer — Title | 7/23/81 — Date

This is to certify acceptance of the hazardous waste shipment described above:

[signature] — Transporter #1 | Driver — Title | 7/23/81 — Date

[signature] — Transporter #2 | Title | Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer | [signature] — Title | [illegible] — Date

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	1	Dump	D-81	12	19	1	[illegible]

DISPOSER

#2

ALABAMA

CWMA

HAZARDOUS WASTE MANIFEST

[illegible] 017292

IDENTIFICATION INFORMATION

	NAME	ADDRESS	PHONE	EPA ID CODE
GENERATOR	Carrier Corporation	97 S. Byhalia Rd. Collierville, TN 38017	901-853-9761	TND044062222
TRANSPORTER NO. 1	Chemical Waste Management	P. O. Box 55 Emelle, Alabama	205-652-9531	ALT000622464
TRANSPORTER NO. 2				
DISPOSER	Chemical Waste Management, Inc. Emelle Facility	P. O. Box 55 Emelle, Alabama 35459	205-652-9531	ALT000622464

WASTE INFORMATION

CONTAINER NO.	CONTAINER TYPE	DESCRIPTION/CLASS	TOTAL QUAN.	UNIT	EPA Hazardous Waste ID No.	CWMA WASTE CODE	WEIGHT
1	Dump Trailer	Waste-hazardous waste, N.O.S./ORMR [illegible] (Soil and waste water treatment sludge from industrial painting)	40,000	LB	T018		25,000 ~~[illegible]~~

EMERGENCY INFORMATION

EMERGENCY NOS.: DISPOSER — (205) 652-9531 ; GENERATOR — (901) 853-9761 US COAST GUARD 1-800-424-8802

SPECIAL INSTRUCTIONS:

CERTIFICATION

This is to certify that the above named materials are properly classified, described, packaged, marked and labeled and are in proper condition for transportation according to the applicable regulations of the Department of Transportation, the U.S. Environmental Protection Agency:

[signature] — Generator | Env. ENgineer — Title | 2/23/81 — Date

This is to certify acceptance of the hazardous waste shipment described above:

[signature] — Transporter #1 | [signature] — Title | 2-23-81 — Date

Transporter #2 | Title | Date

This is to certify acceptance of the hazardous waste shipment described above for treatment, storage or disposal:

[signature] — Disposer | [signature] — Title | [illegible] — Date

DISPOSAL INFORMATION

CWMA WASTE CODE	QUANTITY	UNIT	PROCESS CODE	LOCATION TRENCH	LOCATION LEVEL	LOCATION QUAD	COMMENTS
	1	Dump	D-81	12	19	1	[illegible]

DISPOSER

#2

Attachment 6

12/09/80

The lagoon has been closed and the hazardous waste is piled beside the road and covered with plastic awaiting shipment to a hazardous waste land fill. Plans should be completed and the waste shipped in January 1981.

Soil borings will be taken between the closed lagoon and water well for the city of Collierville. Mr. Ritter said the borings and the testing are necessary to insure the hazardous waste is not migrating toward the well. He also stated that his study of the U.S. geodetic survey maps indicated that the waste that did seep into the soil would migrate in the opposite direction from the well. He pointed out that a siphoning effect could occur.

An analysis of Collierville water samples will be completed in December, 1980.

There was a discussion about a 2,000 to 5,000 gallon spill of trichloroethylene. Mr. Ritter believes that the trichlor would migrate towards the creek. Because there could be a siphoning effect, soil borings and the samplings would be necessary to determine which direction the trichlor is traveling.

6

Reference 5

UNITED TECHNOLOGIES CARRIER

Carrier Corporation
P.O. Box 4808
Carrier Parkway
Syracuse, New York 13221
315/432-6000

JUL 09 1986

JCA 7/10
DA 7/10
WJF 7/12

July 3, 1986

Mr. William J. Forrester
Project Director
Tennessee Department of Health & Environment
Divison of Solid Waste Management
Customs House, 4th Floor
701 Broadway
Nashville, TN 37219-5403

Dear Mr. Forrester:

We very much appreciated the opportunity to discuss the status of your department's HRS investigation of our Collierville facility and to provide you with our opinions. As you requested, the following summarizes our thoughts regarding the appropriate scoring of the HRS (Mitre) model for the site.

OBSERVED RELEASE

We agree that groundwater is the only factor of concern and that there has been an "Observed Release" (9 ppb) identified in one of four monitoring wells thereby generating a score of '45'. Please note that, as we discussed, there is some reason to believe that this may have resulted from the drilling process.

ROUTE CHARACTERISTICS AND CONTAINMENT

These items are not applicable due to the "Observed Release" score.

WASTE CHARACTERISTICS

On this issue, we had disagreement on both "Toxicity/Persistence" and "Hazardous Waste Quantity".

With regards to "Toxicity/Persistence", we believe that the rating should be a '12' based on a '2' for "Toxicity" and a '2' for "Persistence". We base this on analogy to trichloroethane (Table 4) which has a toxicity rating of '2' and on Table 5 which lists the persistence of trichloroethylene as '2'.

Regarding "Hazardous Waste Quantity", we had major differences in interpretation of what the model is seeking to quantify. From a logic standpoint, we believe there is every reason to conclude that less than one barrel of trichloroethylene was "received" by the site from the combined contributions of the lagoon, the 1979 spill, and the 1985 spill of trichloroethylene. We base this conclusion on the following:

1. The purpose of the lagoon was the receipt of paint washer sludge which contained primarily zinc (this is supported by EP toxic analyses). Documents do show the presence of minor amounts of trichloroethylene (5-370 ppm) in the sludge but this certainly does not merit assuming that any significant volume of trichloroethylene was deposited in the lagoon. This interpretation is supported by the model instructions which state: "Do not include amounts of contaminated soil or water; in such cases, THE AMOUNT OF CONTAMINATING HAZARDOUS SUBSTANCE MAY BE ESTIMATED". We therefore maintain that, based on the ppm levels found in the sludge, the appropriate estimate of the amount of trichloroethylene "received" by the lagoon is much less than one drum. If greater quantities of trichloroethylene had been deposited in the lagoon, concentrations in the sludge would most certainly have been much higher.

2. Regarding the 1979 spill of 5,000 gallons of trichloroethylene, we again maintain that much less than one drum of hazardous waste was "received" by the environment. We base this opinion on the facts that:

   (1) The trichloroethylene was discharged from a vapor degreaser at, or near, its boiling point. While it is not possible to quantify the percentage which would have evaporated, certainly a significant amount would have been dissipated to the air and was therefore not "received" by the facility.

   (2) Of the remainder, we maintain that virtually all of the discharge was contained by the asphalt parking lot and was therefore not "received" by the environment. The effectiveness of the parking lot as containment is demonstrated by several facts:

   - Shortly after the spill, the parking lot was excavated and disposed of offsite due to the softening of the asphalt by the trichloroethylene, thereby demonstrating the ability of the asphalt to contain the spill.

   - Following excavation and disposal of the asphalt, Carrier collected soil samples to confirm that no soil contamination resulted from the spill. Five soil borings were taken with six samples collected at one foot intervals in each boring (30 samples total). All samples showed less than detectable (10 ppb) amounts of trichloroethylene in the soil.

   - Eight soil samples, plus one duplicate, were recently collected by your department in the area of the spill. Of the eight samples, six showed no detectable (less than 10 ppb) amounts of trichloroethylene. Your sample number 3 showed 95 ppb. Your sample number 4, which was submitted in duplicate, showed the presence of trichloroethylene in about the same ppb range as number 3 but major analytical discrepancies between the duplicate sample number 4's prevents accurate quantification.

To summarize our belief regarding the fate of the 1979 spill, the facts conclusively demonstrate that much less than one barrel of trichloroethylene was received by the soil at the facility. To believe otherwise would require evidence of much higher and widespread levels of soil contamination than the low ppb levels found in only two of your eight soil samples or in the thirty nondetectable samples collected at the time of the spill.

3. With respect to the 500 gallon trichloroethylene spill of 1985, inventory records resulted in the reported loss of approximately 500 gallons. Immediate recovery actions accounted for a cleanup of 542 gallons thereby deposition ("receipt") of this volume at the facility did not occur. The effectiveness of this recovery is confirmed by soil samples which indicate residual trichloroethylene in the soil at levels of approximately 300 ppb.

Again, this data amply demonstrates that less than one drum of trichloroethylene was "received" by the soil at the facility.

To summarize our position on the issue of "Hazardous Waste Quantity", we believe that the proper interpretation of "hazardous waste quantity...as received" is one which accounts for the actual amount of hazardous waste that is/was deposited in the soil. This interpretation is supported on its own merit by its environmental relevance, i.e., a release, no matter how large, which does not reach or remain in the soil (due to containment, evaporation, immediate recovery, or otherwise) cannot create a risk to the environment. In our case, with numerous studies, documents and reports indicating the presence of trichloroethylene in the soil only at scattered low ppb levels, no supportable rationale can be developed to conclude that there is, or ever was, more than "less than one drum" quantities in the soil from the combined contribution of the three potential sources in question. Further, we believe that the guidance instructions for the HRS model support this technical rationale by allowing the quantity of hazardous waste to be estimated by considering the amount of contamination g substance in soil or water, i.e., "in such cases, the amount of contaminating substance may be estimated".

In contrast to the preceeding, it is my understanding that Mr. Higgs based his estimate of the appropriate quantities on the following:

- The total volume of the lagoon was counted as pure trichloroethylene
- The total volume of the 1979 spill of 5,000 gallons was counted
- The total volume of the 1985 spill of 500 gallons was counted.

As described previously, we believe that this approach is neither technically justified nor required by the model. We therefore conclude that the appropriate score for "Hazardous Waste Quantity" is '0' due to substantial quantitative evidence that trichloroethylene is present only at low ppb levels, i.e., less than one drum.

Based on the preceeding, the total "Waste Characteristics" score is '12' + '0' = '12'.

TARGETS

Regarding "Ground Water Use", since there are alternate unthreatened drinking water sources available, the appropriate score is '2'. With a model multiplier of '3', this gives a score of '6' for "Ground Water Use".

The "Distance to Nearest Well" is, according to model instructions, the distance between the hazardous substance and the nearest well except where there may be a barrier between the substance and the aquifer. In our case, the best data available for the specific local geology and hydrology is the Weston Consultants report of which you have a copy. This report indicates an impermeable clay layer, approximately fifty feet in thickness, at MW-1 and ranging from 20-35 feet thick at other wells. The impermeability of this clay layer is confirmed by the deep well at MW-1D which penetrates the clay layer and which shows no detectable amounts of trichloroethylene in the aquifer at that point even though there appears to be a minor amount (21 ppb) of trichloroethylene present in perched water (MW-1S) immediately above the confined aquifer monitored by MW-1D. Based on this very specific local data, it is reasonable to conclude that the clay barrier extends to the lagoon and city well (please note that we would be glad to confirm this further by sinking more wells if the results would be utilized in your assessment). Only near the site of the 1985 spill (at MW-4) is there any indication that the clay barrier may lose its integrity. This distance being approximately 2,500 feet from the well, the appropriate "Distance" value is given as '3'. Assuming that the "Population served by ground water" is greater than 10,000, "Distance/ Population" matrix score is therefore '35'.

Based on the preceeding, the total "Targets" score is '6' + '35' = '41'.

CALCULATIONS OF Sgw AND Sm

Sgw = 45 X 12 X 41 = 22140/57,330 X 100 = 38.62

Since there is no applicable Ssw, or Sa, Sm = Sgw/1.73
Sm = 38.62/1.73 = 22.32

Based on this calculation, we conclude that the appropriate HRS score is 22.32.

We would like to thank you for this opportunity to express the basis of our position and look forward to receiving a call from you so that we can meet again when you have finalized your assessment. Your willingness to communicate and consider our viewpoint is greatly appreciated.

Very truly yours,

G. E. Bailey

Gerald E. Bailey, Director
IH/Environmental Assurance

GEB/jr

CC: Mr. John Brewer
Mr. Arthur Kanerviko

EPA Notification of Hazardous Waste Site

United States
Environmental Protection
Agency
Washington DC 20460

This initial notification information is required by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and must be mailed by June 9, 1981.

Please type or print in ink. If you need additional space, use separate sheets of paper. Indicate the letter of the item which applies.

A Person Required to Notify:

Enter the name and address of the person or organization required to notify.

Name: CARRIER CORPORATION
Street: 97 SOUTH BYHALIA ROAD
City: COLLIERVILLE State: TN Zip Code: 38017

B Site Location:

Enter the common name (if known) and actual location of the site.

Name of Site: CARRIER AIR CONDITIONING
Street: 97 SOUTH BYHALIA ROAD
City: COLLIERVILLE County: SHELBY State: TN Zip Code: 38017

C Person to Contact:

Enter the name, title (if applicable), and business telephone number of the person to contact regarding information submitted on this form.

Name (Last, First and Title): RITTER, CLIFTON ENVIR. ENGR.
Phone: (901) 853-9761

D Dates of Waste Handling:

Enter the years that you estimate waste treatment, storage, or disposal began and ended at the site.

From (Year): 1978 To (Year): 1978

E Waste Type: Choose the option you prefer to complete

Option 1: Select general waste types and source categories. If you do not know the general waste types or sources, you are encouraged to describe the site in Item I—Description of Site.

General Type of Waste:
Place an X in the appropriate boxes. The categories listed overlap. Check each applicable category.

1. ☐ Organics
2. ☐ Inorganics
3. ☒ Solvents
4. ☐ Pesticides
5. ☐ Heavy metals
6. ☐ Acids
7. ☐ Bases
8. ☐ PCBs
9. ☐ Mixed Municipal Waste
10. ☐ Unknown
11. ☐ Other (Specify)

Source of Waste:
Place an X in the appropriate boxes.

1. ☐ Mining
2. ☐ Construction
3. ☐ Textiles
4. ☐ Fertilizer
5. ☐ Paper/Printing
6. ☐ Leather Tanning
7. ☐ Iron/Steel Foundry
8. ☐ Chemical, General
9. ☐ Plating/Polishing
10. ☐ Military/Ammunition
11. ☐ Electrical Conductors
12. ☐ Transformers
13. ☐ Utility Companies
14. ☐ Sanitary/Refuse
15. ☐ Photofinish
16. ☐ Lab/Hospital
17. ☐ Unknown
18. ☒ Other (Specify) Fabricated metal products

Option 2: This option is available to persons familiar with the Resource Conservation and Recovery Act (RCRA) Section 3001 regulations (40 CFR Part 261).

Specific Type of Waste:
EPA has assigned a four-digit number to each hazardous waste listed in the regulations under Section 3001 of RCRA. Enter the appropriate four-digit number in the boxes provided. A copy of the list of hazardous wastes and codes can be obtained by contacting the EPA Region serving the State in which the site is located.

Form Approved
OMB No. 2000-0138

F Waste Quantity:

Place an X in the appropriate boxes to indicate the facility types found at the site.

In the "total facility waste amount" space give the estimated combined quantity (volume) of hazardous wastes at the site using cubic feet or gallons.

In the "total facility area" space, give the estimated area size which the facilities occupy using square feet or acres.

Facility Type

1. ☐ Piles
2. ☐ Land Treatment
3. ☐ Landfill
4. ☐ Tanks
5. ☐ Impoundment
6. ☐ Underground Injection
7. ☐ Drums, Above Ground
8. ☐ Drums, Below Ground
9. ☒ Other (Specify) Spill

Total Facility Waste Amount

cubic feet

gallons 2000 to 5000

Total Facility Area

square feet

acres

G Known, Suspected or Likely Releases to the Environment:

Place an X in the appropriate boxes to indicate any known, suspected, or likely releases of wastes to the environment.

☒ Known ☐ Suspected ☐ Likely ☐ None

Note: Items H and I are optional. Completing these items will assist EPA and State and local governments in locating and assessing hazardous waste sites. Although completing the items is not required, you are encouraged to do so.

H Sketch Map of Site Location: (Optional)

Sketch a map showing streets, highways, routes or other prominent landmarks near the site. Place an X on the map to indicate the site location. Draw an arrow showing the direction north. You may substitute a publishing map showing the site location.

SEE ATTACHED

I Description of Site: (Optional)

Describe the history and present conditions of the site. Give directions to the site and describe any nearby wells, springs, lakes, or housing. Include such information as how waste was disposed and where the waste came from. Provide any other information or comments which may help describe the site conditions.

J Signature and Title:

The person or authorized representative (such as plant managers, superintendents, trustees or attorneys) of persons required to notify must sign the form and provide a mailing address (if different than address in item A). For other persons providing notification, the signature is optional. Check the boxes which best describe the relationship to the site of the person required to notify. If you are not required

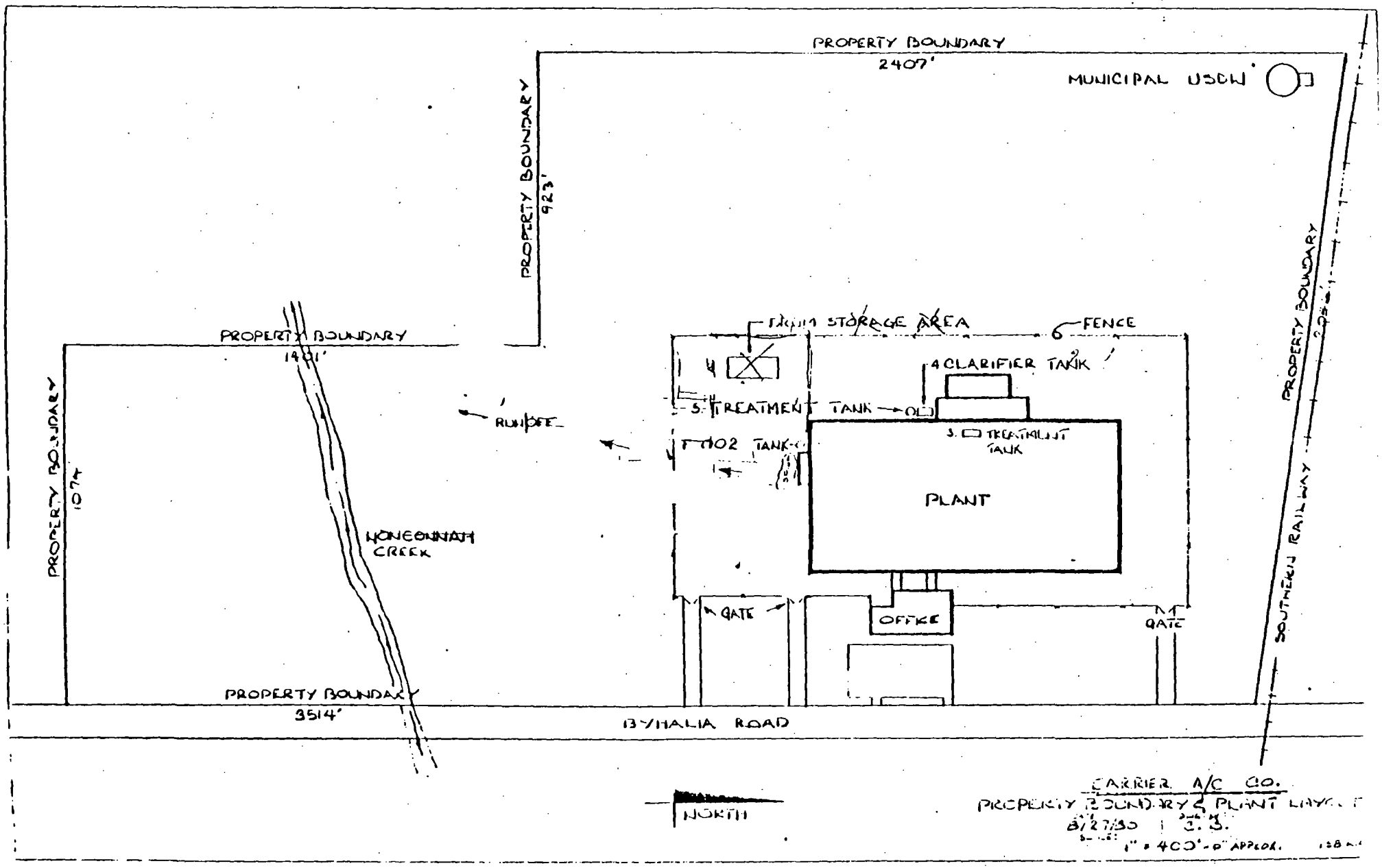
Name CHARLES A. WAGNER PLANT MANAGER

Street 97 SOUTH BYHALIA RD.

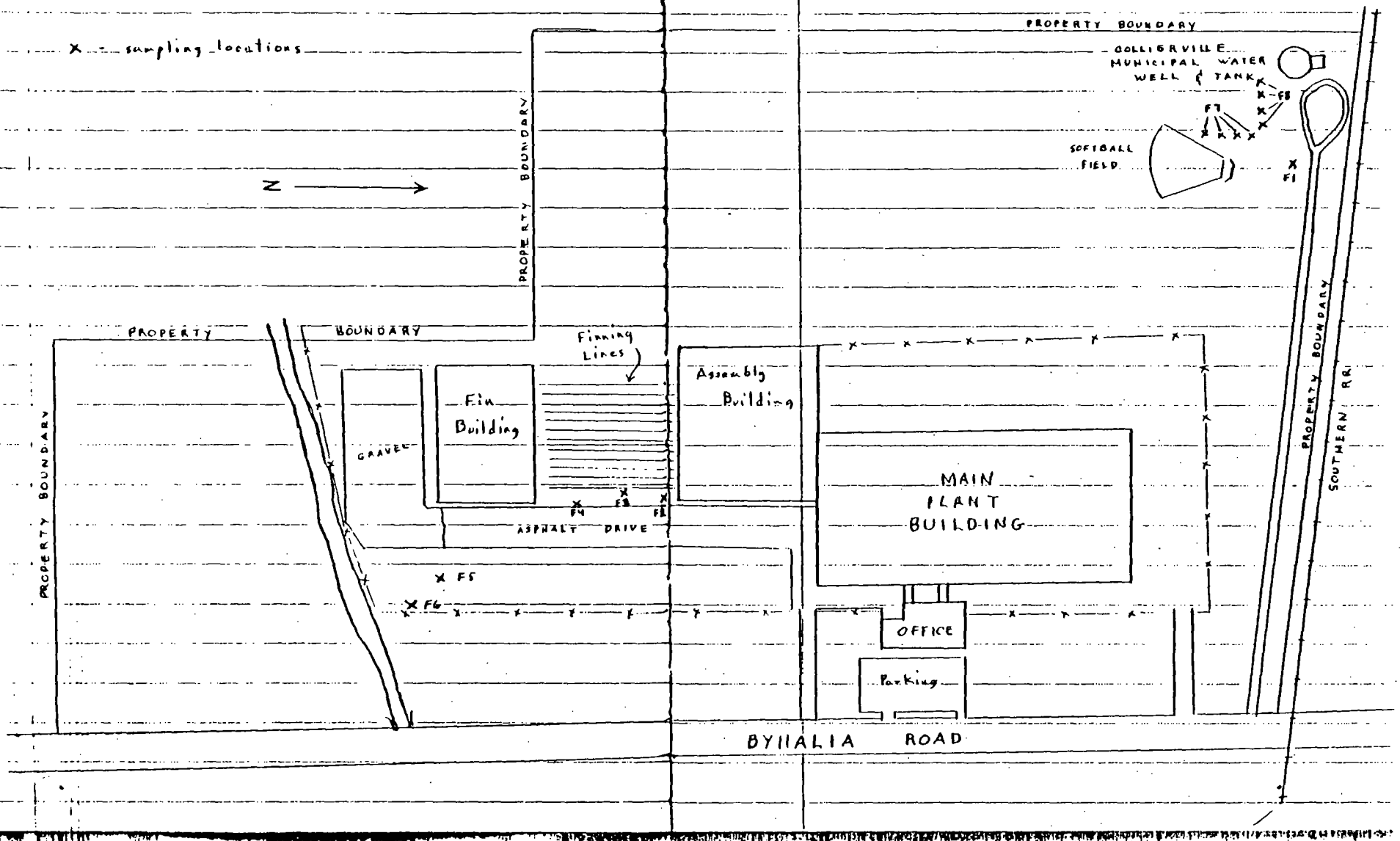
City COLLIERVILLE State TN Zip Code 38017

Signature Charles A. Wagner Date 5/25/81

- ☒ Owner, Present
- ☐ Owner, Past
- ☐ Transporter
- ☐ Operator, Prese
- ☐ Operator, Past
- ☐ Other


PROPERTY BOUNDARY
2407'
MUNICIPAL USDW
PROPERTY BOUNDARY
923'
PROPERTY BOUNDARY
1401'
PROPERTY BOUNDARY
1074'
DRUM STORAGE AREA
FENCE
4 CLARIFIER TANK
5. TREATMENT TANK
3. TREATMENT TANK
RUNOFF
TANK
PLANT
NONCONNAH CREEK
GATE
OFFICE
GATE
PROPERTY BOUNDARY
SOUTHERN RAILWAY
PROPERTY BOUNDARY
3514'
BYHALIA ROAD
NORTH
CARRIER A/C CO.
PROPERTY BOUNDARY & PLANT LAYOUT
8/27/80
C. B.
1" = 400'-0" APPROX.

Site Sketch - Carrier Corporation Collierville Tn. 4/16/86



INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 1 OF 38
Job #409398.01.71.89

Sample Description: Five (5) soil samples received April 17, 1986

Concentration units are µg/gram (ppm)

	Carrier Air Conditioning				
	Field #1	Field #2	Field #3	Field #4	Field #4 Duplicate
Arsenic	17.	7.7	11.	9.0	8.9
Cadmium	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7.2	6.4	5.9	6.8	5.8
Copper	14.	8.4	11.	10.	13.
Lead	7.4	8.2	8.2	7.9	8.3
Mercury	<0.1	<0.2*	<0.1	<0.1	<0.2*
Nickel	8.4	5.7	6.9	6.4	8.0
Zinc	38.	19.	26.	28.	29.
Barium	73.	72.	67.	63.	72.
Cyanide	<0.5	<0.5	<0.5	<0.5	<0.5

*Higher than normal detection limits due to sample matrix interference.

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alice R. Moore
Approved by

Laboratory Manager
Title

Accredited by the American Association for Laboratory Accreditation in the chemical ... Directory of Accredited Laboratories

93-9-85

JUN 04 1986

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

RECEIVED JUN 02 1986

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

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	Field #1	Field #2	Field #3	Field #4	Field #4 Duplicate
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Cadmium	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium	7.2	6.4	5.9	6.8	5.8
Copper	14.	8.4	11.	10.	13.
Lead	7.4	8.2	8.2	7.9	8.3
Mercury	<0.1	<0.2*	<0.1	<0.1	<0.2*
Nickel	8.4	5.7	6.9	6.4	8.0
Zinc	38.	19.	26.	28.	29.
Barium	73.	72.	67.	63.	72.
Cyanide	<0.5	<0.5	<0.5	<0.5	<0.5

*Higher than normal detection limits due to sample matrix interference.

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Manske Jones
Notary Public

9398
Fed X
Don
cc Danny Brewer
Jackson

AALA Accredited by the American Association for Laboratory Accreditation in the chemical field of testing, as listed in the current AALA Directory of Accredited Laboratories

93-0-85

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353

Job #409398.01.71.89

Sample Description: Four (4) soil samples received April 17, 1986

Concentration units are µg/gram (ppm)

	Carrier Air Conditioning			
	Field #5	Field #6	Field #7	Field #8
Arsenic	11.	14.	10.	11.
Cadmium	<0.1	<0.1	<0.1	<0.1
Chromium	7.4	4.5	7.1	8.1
Copper	9.4	8.6	12.	10.
Lead	8.0	7.6	7.3	12.
Mercury	<0.2*	<0.1	<0.1	<0.1
Nickel	8.8	6.2	11.	6.0
Zinc	32.	24.	35.	28.
Barium	70.	79.	89.	56.
Cyanide	<0.5	<0.5	<0.5	0.55

*Higher than normal detection limits due to sample matrix interference.

Sworn to and subscribed before me this 23rd
day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alice L. Moore
Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

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TO: IT Corporation
ATTN: Cliff Vaughan
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 3 OF 38
Job #409398.01.71.89

Sample Description: Field #1, Carrier Air Conditioning, Background Soil Between Ballfield and Water Plant, 4-16-86, 0935

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 4 OF 38
Job #409398.01.71.89

Sample Description: Field #1, Carrier Air Conditioning, Background Soil Between Ballfield and Water Plant, 4-16-86, 0935

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit of five (5) times that listed.

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Approved by
Laboratory Manager
Title

Accredited by the American Association for Laboratory Accreditation in the chemical

93-9-85

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 5 OF 38
Job #409398.01.71.89

Sample Description: Field #1, Carrier Air Conditioning, Background Soil Between Ballfield and Water Plant, 4-16-86, 0935

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alyce R. Mansel
Approved by

Laboratory Manager
Title

Accredited by the American Association for Laboratory Accreditation in the chemical

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 6 OF 38
Job #409398.01.71.89

Sample Description: Field #1, Carrier Air Conditioning, Background Soil Between Ballfield and Water Plant, 4-16-86, 0935

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	ND
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	19.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	ND
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	ND
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alyce R. Moore
Approved by

Laboratory Manager
Title

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 7 OF 38
Job #409398.01.71.89

Sample Description: Field #2, Carrier Air Conditioning, Spill Area 20 ft. from Corner of A Building, 4-16-86, 1035

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alice R. Moore
Approved by

Laboratory Manager
Title

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PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 8 OF 38
Job #409398.01.71.89

Sample Description: Field #2, Carrier Air Conditioning, Spill Area 20 ft. from Corner of A Building, 4-16-86, 1035

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit of five (5) times that listed.

Sworn to and subscribed before me this 23rd day of May, 1986
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Janet Mancke Jones
Notary Public

Alyce R. Moore
Approved by

Laboratory Manager
Title

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 9 OF 38
Job #409398.01.71.89

Sample Description: Field #2, Carrier Air Conditioning, Spill Area 20 ft. from Corner of A Building, 4-16-86, 1035

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989
Janet Manecke Jones
Notary Public

Alice L. Moore
Approved by
Laboratory Manager
Title

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PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 10 OF 38
Job #409398.01.71.89

Sample Description: Field #2, Carrier Air Conditioning, Spill Area 20 ft. from Corner of A Building, 4-16-86, 1035

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	ND
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	18.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	<10.
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	ND
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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My commission expires July 23, 1989

Janet Marche Jones
Notary Public

Alice R. Maree
Approved by

Laboratory Manager
Title

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 11 OF 38
Job #409398.01.71.89

Sample Description: Field #3, Carrier Air Conditioning, Spill Area 60 ft. from Corner of A Building, 4-16-86, 1100

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alyce R. Maier
Approved by

Laboratory Manager
Title

Accredited by the American Association for Laboratory Accreditation in the chemical

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 12 OF 38
Job #409398.01.71.89

Sample Description: Field #3, Carrier Air Conditioning, Spill Area 60 ft. from Corner of A Building, 4-16-86, 1100

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit of five (5) times that listed.

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989

Janet Mancke Jones
Notary Public

Alyce R. Moore
Approved by

Laboratory Manager
Title

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INTERNATIONAL TECHNOLOGY CORPORATION

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PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 13 OF 38
Job #409398.01.71.89

Sample Description: Field #3, Carrier Air Conditioning, Spill Area 60 ft. from Corner of A Building, 4-16-86, 1100

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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Janet Mancke Jones
Notary Public

Alyce R. Moore
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PAGE 14 OF 38
Job #409398.01.71.89

Sample Description: Field #3, Carrier Air Conditioning, Spill Area 60 ft. from Corner of A Building, 4-16-86, 1100

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	10.
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	12.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	<10.
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	95.
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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Notary Public

Alyce L. Moore
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PAGE 15 OF 38
Job #409398.01.71.89

Sample Description: Field #4, Carrier Air Conditioning, Spill Area 50 yds. N. of Finning Bldg., 4-16-86, 1115

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

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Janet Marie Jones
Notary Public

Alyce L. Moore
Approved by
Laboratory Manager
Title

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PAGE 16 OF 38
Job #409398.01.71.89

Sample Description: Field #4, Carrier Air Conditioning, Spill Area 50 yds. N. of Finning Bldg., 4-16-86, 1115

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit of five (5) times that listed.

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Janet Marcke Jones
Notary Public

Approved by
Laboratory Manager
Title

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PAGE 17 OF 38
Job #409398.01.71.89

Sample Description: Field #4, Carrier Air Conditioning, Spill Area 50 yds. N. of Finning Bldg., 4-16-86, 1115

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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Notary Public

Alyce R. Moore
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ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 18 OF 38
Job #409398.01.71.89

Sample Description: Field #4, Carrier Air Conditioning, Spill Area 50 yds. N. of Finning Bldg., 4-16-86, 1115

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	170.
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	<10.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	ND
chloroform	<10.	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	69.
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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My commission expires July 23, 1989
Janet Manche Jones
Notary Public

Approved by
Laboratory Manager
Title

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CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 19 OF 38
Job #409398.01.71.89

Sample Description: Field #4 Duplicate, Carrier Air Conditioning, 50 yds. N. of Finning Bldg., 4-16-86, 1115

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

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Janet Manche Jones
Notary Public

Alice R. Moore
Approved by

Laboratory Manager
Title

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 20 OF 38
Job #409398.01.71.89

Sample Description: Field #4 Duplicate, Carrier Air Conditioning, 50 yds. N. of Finning Bldg., 4-16-86, 1115

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit of five (5) times that listed.

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 21 OF 38
Job #409398.01.71.89

Sample Description: Field #4 Duplicate, Carrier Air Conditioning, 50 yds. N. of Finning Bldg., 4-16-86, 1115

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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Janet Mancke Jones
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Alan L. Moore
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 22 OF 38
Job #409398.01.71.89

Sample Description: Field #4 Duplicate, Carrier Air Conditioning, 50 yds. N. of Finning Bldg., 4-16-86, 1115

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	53.
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	32.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	18.
chloroform	<10.	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	300.
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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Olga L. Mace
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 23 OF 38
Job #409398.01.71.89

Sample Description: Field #5, Carrier Air Conditioning, Runoff Area 50 yds. SE of Finning Bldg., 4-16-86, 1305

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

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Janet Mancke Jones
Notary Public

Alyce R. Moore
Approved by

Laboratory Manager
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 24 OF 38
Job #409398.01.71.89

Sample Description: Field #5, Carrier Air Conditioning, Runoff Area 50 yds. SE of Finning Bldg., 4-16-86, 1305

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
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* = This component has a quantitation limit of five (5) times that listed.

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PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 25 OF 38
Job #409398.01.71.89

Sample Description: Field #5, Carrier Air Conditioning, Runoff Area 50 yds. SE of Finning Bldg., 4-16-86, 1305

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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Janet Mancke Jones
Notary Public

Alyce L. Moore
Approved by
Laboratory Manager
Title

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 26 OF 38
Job #409398.01.71.89

Sample Description: Field #5, Carrier Air Conditioning, Runoff Area 50 yds. SE of Finning Blag., 4-16-86, 1305

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	ND
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	100.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	<10.
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	ND
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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Janet Marche Jones
Notary Public

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Laboratory Manager
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 27 OF 38
Job #409398.01.71.89

Sample Description: Field #6, Carrier Air Conditioning, Runoff Area 100 yds. SE of Finning Bldg., 4-16-86, 1330

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

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Janet Mancke Jones
Notary Public

Alyce L. Moore
Approved by
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 28 OF 38
Job #409398.01.71.89

Sample Description: Field #6, Carrier Air Conditioning, Runoff Area 100 yds. SE of Finning Bldg., 4-16-86, 1330

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit of five (5) times that listed.

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Alice L. Moore
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PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 29 OF 38
Job #409398.01.71.89

Sample Description: Field #6, Carrier Air Conditioning, Runoff Area 100 yds. SE of Finning Bldg., 4-16-86, 1330

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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Janet Mancke Jones
Notary Public

Alyce L. Mace
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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 30 OF 38
Job #409398.01.71.89

Sample Description: Field #6, Carrier Air Conditioning, Runoff Area 100 yds. SE of Finning Bldg., 4-16-86, 1330

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	ND
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	75.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	<10.
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	ND
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 31 OF 38
Job #409398.01.71.89

Sample Description: Field #7, Carrier Air Conditioning, Composite from N-S Transect Near Lagoon, 4-16-86, 1500

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
< = Detected but at a level less than the quantitation limit.
* = This component has a quantitation limit five (5) times that listed.
** = This component has a quantitation limit two (2) times that listed.
[1] Screened for as Azobenzene [2] Detected as Diphenylamine

Sworn to and subscribed before me this 23rd day of May, 1986
My commission expires July 23, 1989
Janet Mancke Jones
Notary Public

Alice L. Moore
Approved by
Laboratory Manager
Title

INTERNATIONAL TECHNOLOGY CORPORATION

ANALYTICAL SERVICES

5815 Middlebrook Pike • Knoxville, Tennessee 37921 • 615-588-6401

CERTIFICATE OF ANALYSIS

TO: IT Corporation
ATTN: Cliff Vaughan
312 Directors Drive
Knoxville, TN 37923

DATE REPORTED: May 23, 1986
PROJECT CODE: ITEK 22215
ORDER NUMBER: TN Contract FA-1353
PAGE 32 OF 38
Job #409398.01.71.89

Sample Description: Field #7, Carrier Air Conditioning, Composite from N-S Transect Near Lagoon, 4-16-86, 1500

ACID EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
4-chloro-3-methylphenol	ND	2-nitrophenol	ND
2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

Remarks: 1.0 = Quantitation limit.
ND = Not detected.
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Sample Description: Field #7, Carrier Air Conditioning, Composite from N-S Transect Near Lagoon, 4-16-86, 1500

PESTICIDES AND PCB's - PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
aldrin	ND	endrin aldehyde	ND
α-BHC	ND	heptachlor	ND
β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
4,4'-DDE	ND	PCB-(Aroclor)-1248	ND
4,4'-DDD	ND	PCB-(Aroclor)-1260	ND
dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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Notary Public

Alyce L. Moore
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PAGE 34 OF 38
Job #409398.01.71.89

Sample Description: Field #7, Carrier Air Conditioning, Composite from N-S Transect Near Lagoon, 4-16-86, 1500

VOLATILE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppb)	Compound	Concentration (ppb)
acrolein	ND	1,1-dichloroethene	ND
acrylonitrile	ND	trans-1,2-dichloroethene	ND
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	78.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	<10.
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	ND
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

Remarks: ND = Not detected.
<10. = Detected but at a level less than the quantitation limit. (Numerical value is the quantitation limit.)

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PAGE 35 OF 38
Job #409398.01.71.89

Sample Description: Field #8, Carrier Air Conditioning, Composite of E-W Transect Near Lagoon, 4-16-86, 1540

BASE/NEUTRAL EXTRACTABLE ORGANIC PRIORITY POLLUTANT ANALYSIS

Compound	Concentration (ppm)	Compound	Concentration (ppm)
acenaphthene	ND	3,3'-dichlorobenzidine **	ND
acenaphthylene	ND	diethyl phthalate	ND
anthracene	ND	dimethyl phthalate	ND
benzidine *	ND	2,4-dinitrotoluene	ND
benzo(a)anthracene	ND	2,6-dinitrotoluene	ND
benzo(b)fluoranthene	ND	di-n-octylphthalate	ND
benzo(k)fluoranthene	ND	1,2-diphenylhydrazine[1]	ND
benzo(a)pyrene	ND	fluoranthene	ND
benzo(g,h,i)perylene	ND	fluorene	ND
benzyl butyl phthalate	ND	hexachlorobenzene	ND
bis(2-chloroethoxy)methane	ND	hexachlorobutadiene	ND
bis(2-chloroethyl)ether	ND	hexachlorocyclopentadiene	ND
bis(2-chloroisopropyl)ether	ND	hexachloroethane	ND
bis(2-ethylhexyl)phthalate	ND	indeno(1,2,3-cd)pyrene	ND
4-bromophenyl phenyl ether	ND	isophorone	ND
2-chloronaphthalene	ND	naphthalene	ND
4-chlorophenyl phenyl ether	ND	nitrobenzene	ND
chrysene	ND	N-nitrosodimethylamine	ND
dibenzo(a,h)anthracene	ND	N-nitrosodi-n-propylamine	ND
di-n-butylphthalate	ND	N-nitrosodiphenylamine[2]	ND
1,2-dichlorobenzene	ND	phenanthrene	ND
1,3-dichlorobenzene	ND	pyrene	ND
1,4-dichlorobenzene	ND	1,2,4-trichlorobenzene	ND

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[1] Screened for as Azobenzene [2] Detected as Diphenylamine

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Laboratory Manager
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Compound	Concentration (ppm)	Compound	Concentration (ppm)
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2-chlorophenol	ND	4-nitrophenol	ND
2,4-dichlorophenol	ND	pentachlorophenol	ND
2,4-dimethylphenol	ND	phenol	ND
2,4-dinitrophenol *	ND	2,4,6-trichlorophenol	ND
2-methyl-4,6-dinitrophenol *	ND		

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Notary Public

Alyce R. Moore
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β-BHC	ND	heptachlor epoxide	ND
γ-BHC (lindane)	ND	PCB-(Aroclor)-1242	ND
δ-BHC	ND	PCB-(Aroclor)-1254	ND
chlordane	ND	PCB-(Aroclor)-1221	ND
4,4'-DDT	ND	PCB-(Aroclor)-1232	ND
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dieldrin	ND	PCB-(Aroclor)-1016	ND
α-endosulfan	ND	toxaphene	ND
β-endosulfan	ND		
endosulfan sulfate	ND		
endrin	ND		

Remarks: ND = Not detected at a level of 1.0 ppm (parts per million).

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acrylonitrile	ND	trans-1,2-dichloroethene	ND
benzene	ND	1,2-dichloropropane	ND
bromodichloromethane	ND	cis-1,3-dichloropropene	ND
bromoform	ND	trans-1,3-dichloropropene	ND
bromomethane	ND	ethyl benzene	ND
carbon tetrachloride	ND	methylene chloride	52.
chlorobenzene	ND	1,1,2,2-tetrachloroethane	ND
chloroethane	ND	tetrachloroethene	ND
2-chloroethylvinyl ether	ND	toluene	<10.
chloroform	ND	1,1,1-trichloroethane	ND
chloromethane	ND	1,1,2-trichloroethane	ND
dibromochloromethane	ND	trichloroethene	ND
1,1-dichloroethane	ND	vinyl chloride	ND
1,2-dichloroethane	ND		

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Alyce L. Moore
Approved by
Laboratory Manager
Title

Reference 8

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

FFICE CORRESPONDENCE

FROM	TO	DATE

DATE: September 11, 1986

TO: The File

FROM: William J. Forrester

SUBJECT: Telecon with James Mathis
September 11, 1986 1:05 pm

I called James Mathis, Public Works Director for the City of Collierville, Tennessee, to confirm well data on the four city water wells. Mr. Mathis informed me that the city's water plant number 1 located downtown Collierville houses two of the wells. The west well is 290 feet, gravel walled and has 80 feet of 8 inch shutter screen and 8 inch casing. The east well is 258 feet deep, gravel walled and has 12 inch casing and 40 feet of shutter screen.

Plant number 2 is located adjacent to the Carrier Air Conditioning Plant on Bayhalia Road and houses the remaining two city water wells. The east well is 281 feet deep, gravel walled with 12 inch casing and 40 feet of screen. The west well is gravel walled, 318 feet deep and has a 12 inch casing with 40 feet of shutter screen.

FROM	DATE

TO

PH-0001
SR 3/77

Reference 9

EFFECTS OF URBAN DEVELOPMENT ON THE AQUIFERS IN THE MEMPHIS AREA, TENNESSEE

David D. Graham

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations 82-4024

Prepared in cooperation with the

CITY OF MEMPHIS LIGHT, GAS AND WATER DIVISION

Memphis, Tennessee

1982

CONTENTS

	Page
Abstract	1
Introduction	2
Purpose and scope	2
Previous investigations	2
Aquifer systems	5
Geologic setting	5
Recharge	5
Pumpage and water levels	8
Pumpage	8
Water levels	8
Future water levels	12
Ground-water quality	12
General characteristics	12
Potential for contamination	14
Land subsidence	15
Extensometers	15
Summary and conclusions	17
Selected references	19

ILLUSTRATIONS

	Page
Figures 1-3. Maps showing:	
1. The Memphis area in the Mississippi embayment	3
2. The Memphis area with locations of Memphis Light, Gas and Water well fields and observation wells referred to in the text	4
3. The outcrop area of the Memphis Sand in West Tennessee	9
4. Graphs showing water level changes in selected observation wells in the Memphis area	11
5. Graphs showing measured compaction, water levels, and monthly pumpage in Mallory well field	16
Plate 1. Map showing the potentiometric surface of the Memphis Memphis Sand in the Memphis area, Tennessee, September 1980	In pocket

TABLES

Table 1. Post-Midway geologic units underlying the Memphis area and their hydrologic significance	6
2. Pumping rates from the Memphis Sand and Fort Pillow Sand by major users, 1976-1980	10
3. Minimum, median, and maximum values observed for selected common constituents and properties of water from the aquifers in the Memphis area	13

EFFECTS OF URBAN DEVELOPMENT ON THE AQUIFERS IN THE MEMPHIS AREA, TENNESSEE

David D. Graham

ABSTRACT

Ground-water withdrawals from aquifers in the Memphis area average about 190 Mgal/d. Potential problems associated with increases in pumpage and urban development are lowered water levels, contamination of the aquifers, and land subsidence.

Long-term water-level declines in the Memphis Sand, the principal artesian aquifer of the area, range from less than 0.1 foot per year near the outcrop area to about 1.8 feet per year near the center of pumping. A 1980 potentiometric map shows that small cones of depression around major pumping centers are superimposed on a regional cone. Except for increased pumping lift, few problems are expected from water-level declines in the Memphis Sand. There is at present very little pumpage from other aquifers in the area--the alluvium, the fluvial deposits, and the Fort Pillow Sand--and no long-term water-level declines are expected unless pumpage is increased significantly.

Low concentrations of leachates from waste-disposal sites in the area have been detected in the water-table aquifers near these sites, but no indication of contamination of the underlying artesian aquifers has yet been found.

Seasonal land-surface elevation changes of less than 0.03 foot have been recorded by an extensometer near the center of the major cone of depression of the Memphis Sand. These changes correlate with seasonal changes in artesian pressure in the Memphis Sand. Over the period of record no significant net change in land-surface elevation has been recorded, indicating that no permanent land subsidence due to declining water level is occurring.

INTRODUCTION

Ground water is the only source of potable water being used for municipal and industrial supplies in the Memphis area. Although a sufficient quantity of water that meets most water-quality criteria is available from depths of less than 2,000 feet, problems associated with resource development and management may occur as withdrawals are increased to meet the demands of a growing metropolitan area. Potential problems are: (1) the effects of the lowering of water levels, (2) possible contamination of the aquifer system as a result of man's activities, and (3) possible land subsidence caused by reductions in artesian pressures.

The term "Memphis area", as used in this report, refers to a 1,300 mi^2 area in the Mississippi embayment comprising parts of three states (fig. 1). It includes all of Shelby and parts of Fayette and Tipton Counties in Tennessee, DeSoto and Marshall Counties in Mississippi, and Crittenden and Mississippi Counties in Arkansas (fig. 2). The locations of wells discussed in the text are also shown in figure 2.

Purpose and Scope

A large amount of information has been and is being collected from the aquifers in the Memphis area. Much of this information has been published in several previous reports. The purpose of this report is to update some of this published information and present additional information pertinent to the potential problems associated with the increasing development of the ground-water resource.

To provide the background information necessary for evaluating changes that are occurring or might occur in the ground-water system, the Geological Survey, in cooperation with the City of Memphis, Memphis Light, Gas and Water Division (MLGW), currently is conducting the following data-collection activities: (1) a network of observation wells is maintained to define water-level trends and provide data necessary for the preparation of potentiometric surface maps, (2) a yearly inventory is conducted to provide information about the distribution and amounts of pumpage, (3) key wells are sampled yearly to monitor changes in water quality in the principal artesian aquifer, (4) wells close to areas of potential contamination from waste-disposal sites are sampled to determine the presence and quantities of hazardous constituents that have entered or might be entering the shallow water-table aquifer, and (5) two recording extensometers are operated to monitor possible land subsidence. Additionally, the Geological Survey makes geophysical logs in new municipal supply wells and other wells in the area to obtain information for use in further defining the subsurface geology.

Previous Investigations

The general hydrology and geology of the Memphis aquifer systems are described in reports by Schneider and Cushing (1948), Criner and Armstrong (1958), Criner and others (1964), and Bell and Nyman (1968). A series of potentiometric maps and a description of historic water-level changes and pumpage from the Memphis Sand and the Fort Pillow Sand are given in Criner and Parks (1976). The configuration of the potentiometric surface of the Memphis Sand for the year 1978 is shown in Graham (1979). Records of water levels

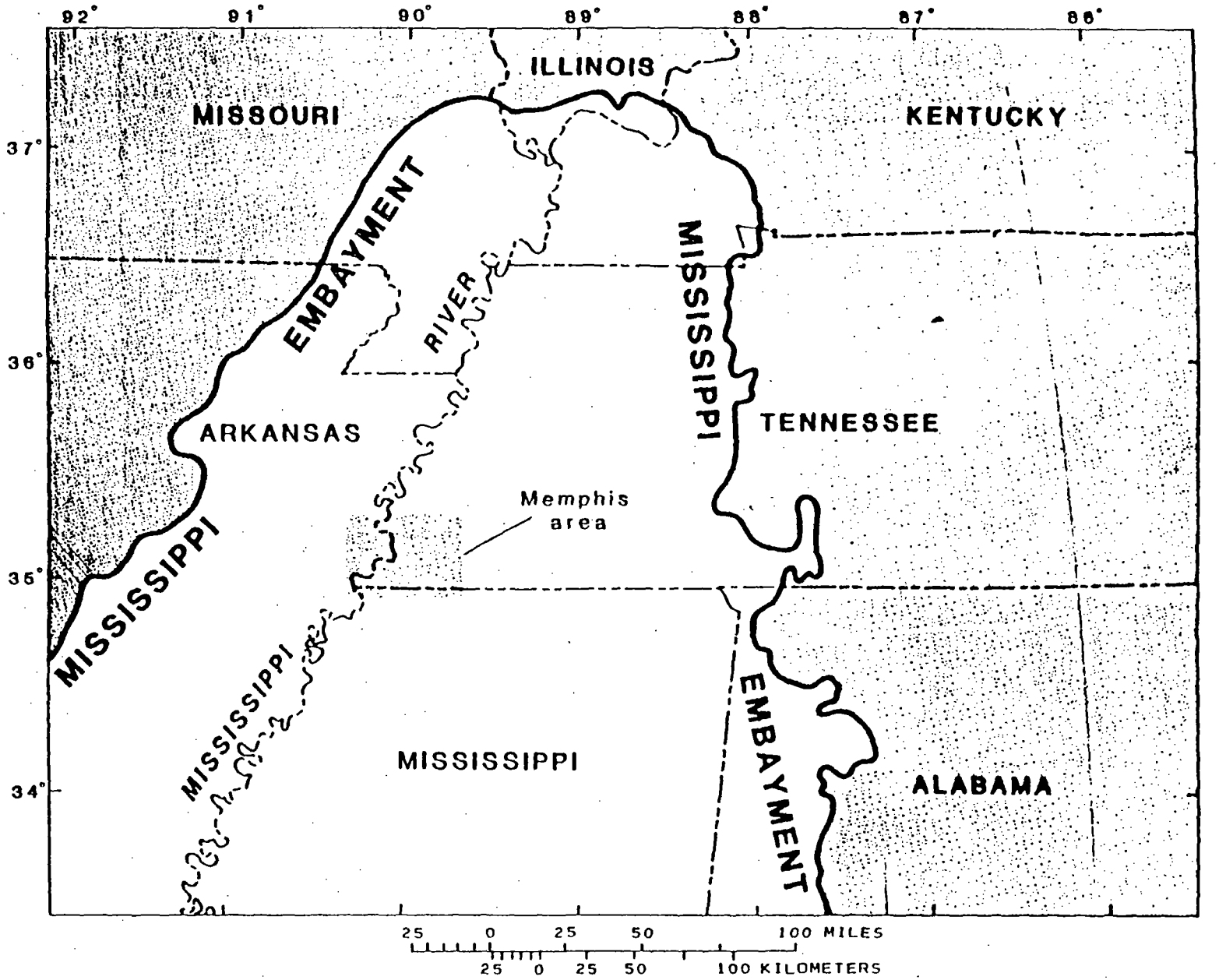


Figure 1.-- The Memphis area in the Mississippi embayment.

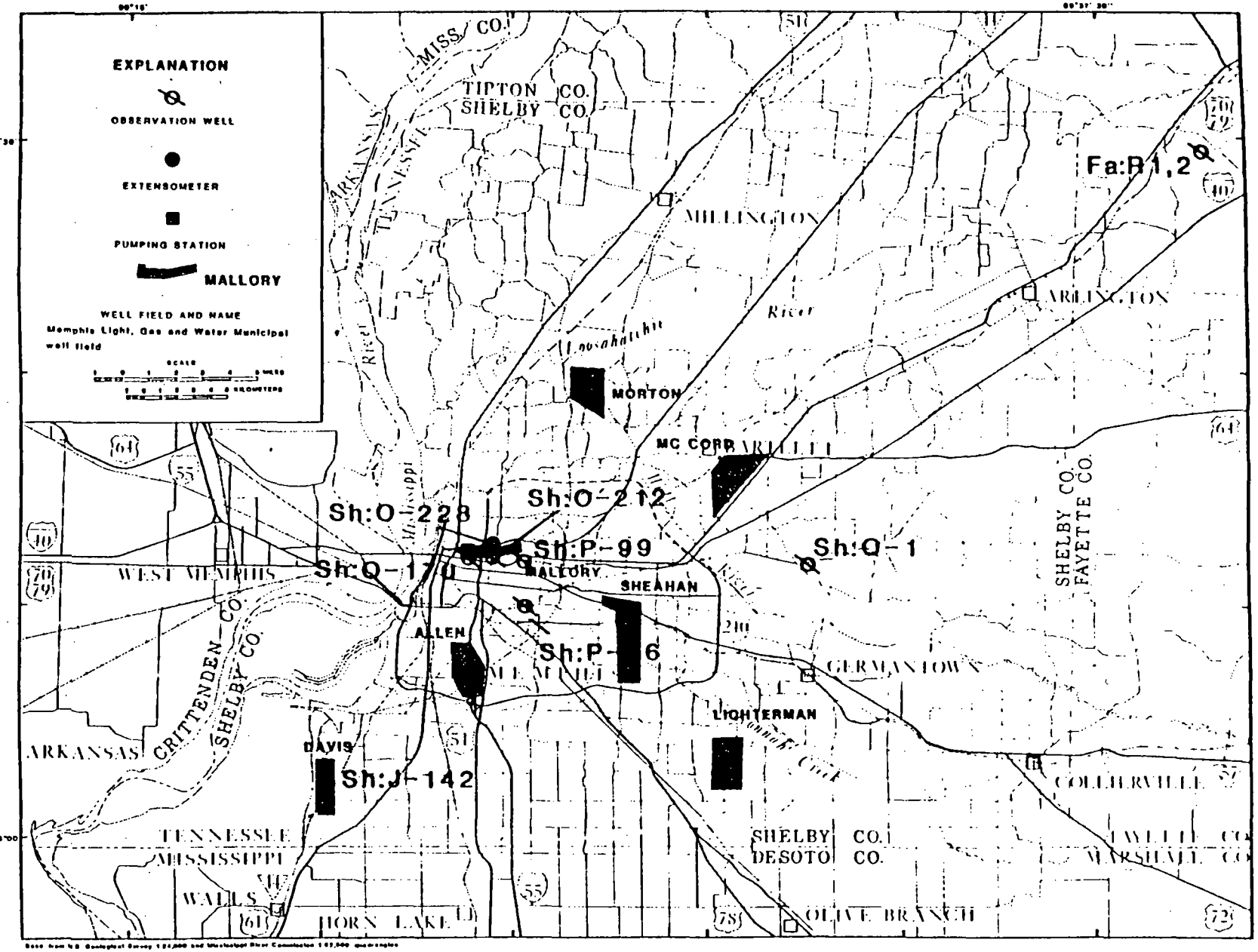


Figure 2.-- The Memphis area with locations of Memphis Light, Gas and Water Municipal well fields and observation wells referred to in the text.

from 1936 through 1973 are published in U.S. Geological Survey Water-Supply Papers 817, 840, 845, 886, 907, 937, 945, 987, 1017, 1024, 1072, 1097, 1127, 1157, 1166, 1192, 1222, 1266, 1322, 1405, 1538, 1803, 1978, and 2171. Information concerning the general quality of water in the aquifers of the Memphis area can be found in Wells (1933), Lanphere (1955), Criner and Armstrong (1958), Criner and others (1964), and Bell and Nyman (1968). Data for the years 1974 to 1979 are published in U.S. Geological Survey Water-Data Reports: Water Resources Data for Tennessee.

A two-dimensional digital computer flow model of the Memphis Sand is described by Brahana (1982). The application of this model as a predictive tool to estimate aquifer response to various hypothetical pumpage projections is described in the U.S. Army Corps of Engineers, Memphis Metropolitan Urban Area Water Resources Study (1981).

A summary of some of the current and possible future environmental problems related to geology and hydrology in the Memphis area is given in a report by Parks and Lounsbury (1976). A report by Parks and others (1982) describes the installation and sampling of observation wells at selected waste-disposal sites.

AQUIFER SYSTEMS

Geologic Setting

As much as 3,000 feet of unconsolidated deposits overlie the Paleozoic carbonate bedrock in the Memphis area. These unconsolidated deposits consist chiefly of sand, clay, gravel, silt, and lignite; they range from Late Cretaceous through Holocene in age. Only post-Midway formations (Wilcox Group and younger) will be considered in this report because they include the principal freshwater aquifers. Table 1 provides a summary of the hydrologic significance and stratigraphic relations of these formations.

The principal post-Midway aquifers are: (1) the alluvium, (2) the fluvial (terrace) deposits, (3) the Memphis Sand ("500-foot" sand), and (4) the Fort Pillow Sand ("1400-foot" sand). The alluvium and fluvial deposits make up the shallow water-table (unconfined) aquifers. The deeper Memphis Sand and equivalent deposits are artesian (confined) throughout most of the Memphis area, except in the southeastern part. The Fort Pillow Sand is artesian throughout the Memphis area. The Memphis Sand and the Fort Pillow Sand are separated from one another and, at most places, the shallow water-table aquifers are separated from the Memphis Sand by confining beds of significantly lower permeability.

Recharge

Recharge to the shallow water-table aquifers is provided by precipitation that falls on the land surface of the local area where the topography and surface conditions are favorable for infiltration. During the winter and spring when precipitation is greatest and evaporation and transpiration are least, recharge is greatest because more water is available for infiltration. During the summer and fall when precipitation is least and evaporation and transpiration are greatest, recharge is least.

Table 1.--Geologic and equivalent units underlying

[Modified from Parks

System	Series	Group	Stratigraphic unit	Thickness (ft)
Quaternary	Holocene and Pleistocene		Alluvium	0-175
	Pleistocene		Loess	0-65
Quaternary and Tertiary (?)	Pleistocene and Pliocene		Fluvial deposits (terrace deposits)	0-100
Tertiary	Eocene	?	Jackson Formation and upper part of Claiborne Group ("capping clay")	0-350
		Claiborne	Memphis Sand ("500-foot" sand)	500-880
		Wilcox	Flour Island Formation	160-350
	?		Fort Pillow Sand ("1,400-foot" sand)	210-280
	Paleocene		Old Breastworks Formation	200-250

the Memphis area and their hydrologic significance

and Lounsbury, 1976]

Lithology and environmental significance
Sand, gravel, silt, and clay. Underlies the Mississippi River alluvial plain and the flood plains of other streams in the area. Supplies water to a few domestic and industrial wells. Could be an important source of waer for irrigation and some industrial uses.
Wind-deposited silt; silty clay and minor sand. Forms a blanket over the fluvial deposits in upland area; topographically higher than alluvium. Thickest on the bluffs that border the Mississippi River alluvial plain; generally thinner towards the east. Not a source of ground water.
Sand and gravel; minor ferruginous sandstone. Underlies the upland areas in a broad, irregular belt east of the Mississippi River alluvial plain; may be locally absent. Supplies water to many shallow, small-capacity wells in suburban and county areas.
Gray, bluish-gray, greenish-gray, and tan clay; subordinate beds of fine-sands and fine-grained lignite. Supplies water to some small-capacity wells. Generally considered to be of low permeability and to confine water in Memphis Sand. Absent in southeastern part of Memphis area.
Fine to coarse sand; subordinate lenses of clay and minor amounts of lignite. Thick clay bed locally in lower part; coarse sand lenses locally at base. Very good aquifer supplying over 98 percent of water used in Memphis area.
Gray, greenish-gray, and brown carbonaceous clay. Locally contains fine-sand lenses and some lignite. Serves as lower confining bed for Memphis Sand and upper confining bed for Fort Pillow Sand.
Fine- to medium-grained sand; minor amounts of lignite and some clay lenses. Second most important aquifer but supplies less than 2-percent of water used in Memphis area.
Gray, greenish-gray, and brown carbonaceous clay. Contains some lignite and is sandy near top. Lower confining bed for water in Fort Pillow Sand.

Under natural conditions recharge to the Memphis Sand artesian aquifer generally occurs in areas where it lies at or close to the surface, principally along a broad belt trending northeastward across western Tennessee (fig. 3). Within this belt, recharge occurs by direct infiltration of rainfall through the sand formations. Water entering here moves slowly toward the axis of the Mississippi embayment. Conditions are similar in the Fort Pillow Sand, which crops out immediately east of the Memphis Sand.

Recent studies by the Geological Survey indicate that some of the recharge to the Memphis Sand may be by vertical leakage through the confining bed from the overlying water-table aquifers. Although there is no conclusive evidence that this is occurring at any one site, a strong indication of vertical leakage is that the regional cone of depression in the Memphis area is not as deep as would be expected for the amount of water that is being withdrawn. In order to simulate observed water levels during the calibration of a digital flow model of the Memphis Sand (Brahana, 1982), it was necessary to input a confining bed leakage factor. This factor averaged 20 percent of the recharge to the Memphis Sand over the entire Memphis area. Ongoing efforts by the Geological Survey to use this model along with information being obtained in a study of solute transport should provide additional understanding of the role that vertical leakage plays in determining the water quality of the Memphis Sand (J. V. Brahana, personal commun., 1982).

The stratigraphic relation of the two artesian aquifers in the subsurface in the eastern part of the recharge area is not well known. In this area, the Memphis Sand may overlap the confining bed separating these two aquifers and may directly overlie the Fort Pillow Sand. If so, the two artesian aquifers would share a common source of recharge.

PUMPAGE AND WATER LEVELS

Pumpage

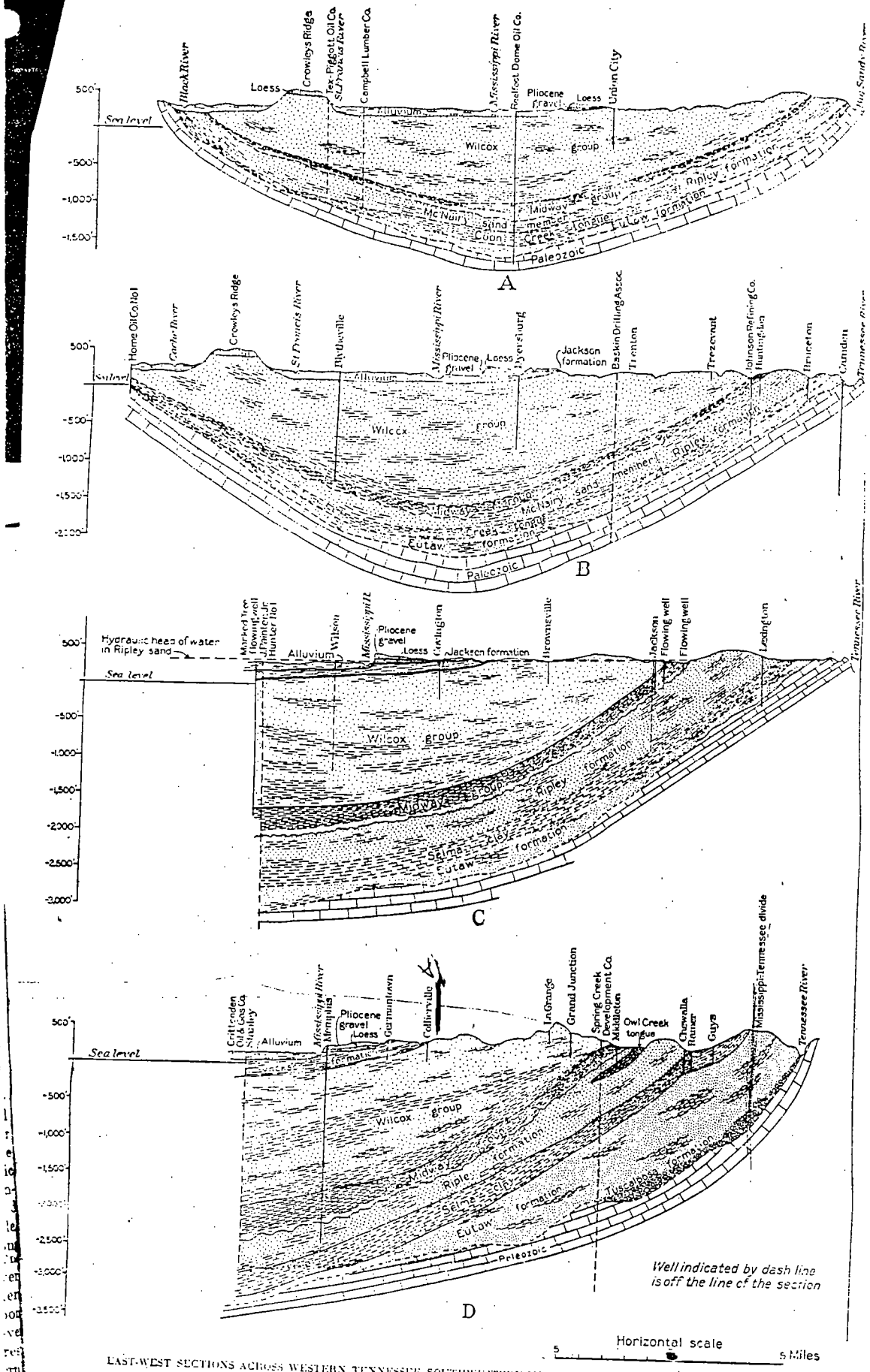
About 98 percent of the inventoried pumpage in the Memphis area, which totaled 193 million gallons per day (Mgal/d) in 1980, is from the Memphis Sand and 2 percent is from the Fort Pillow Sand. Not included in this inventory is water pumped by many small capacity farm and domestic wells in rural areas from fluvial deposits and Memphis Sand and a few industrial wells in the alluvium. Undocumented pumpage probably would add no more than a few million gallons per day to the total. Many of the domestic wells in rural areas are being abandoned as public water-supply systems are extended into these areas.

A historic account of the development of the ground-water resource including a tabulation of pumping rates for the years 1886-1975 is given in Criner and Parks (1976). The pumping rates for the major aquifers of the Memphis area for the years 1976-80 have been added (table 2).

Water Levels

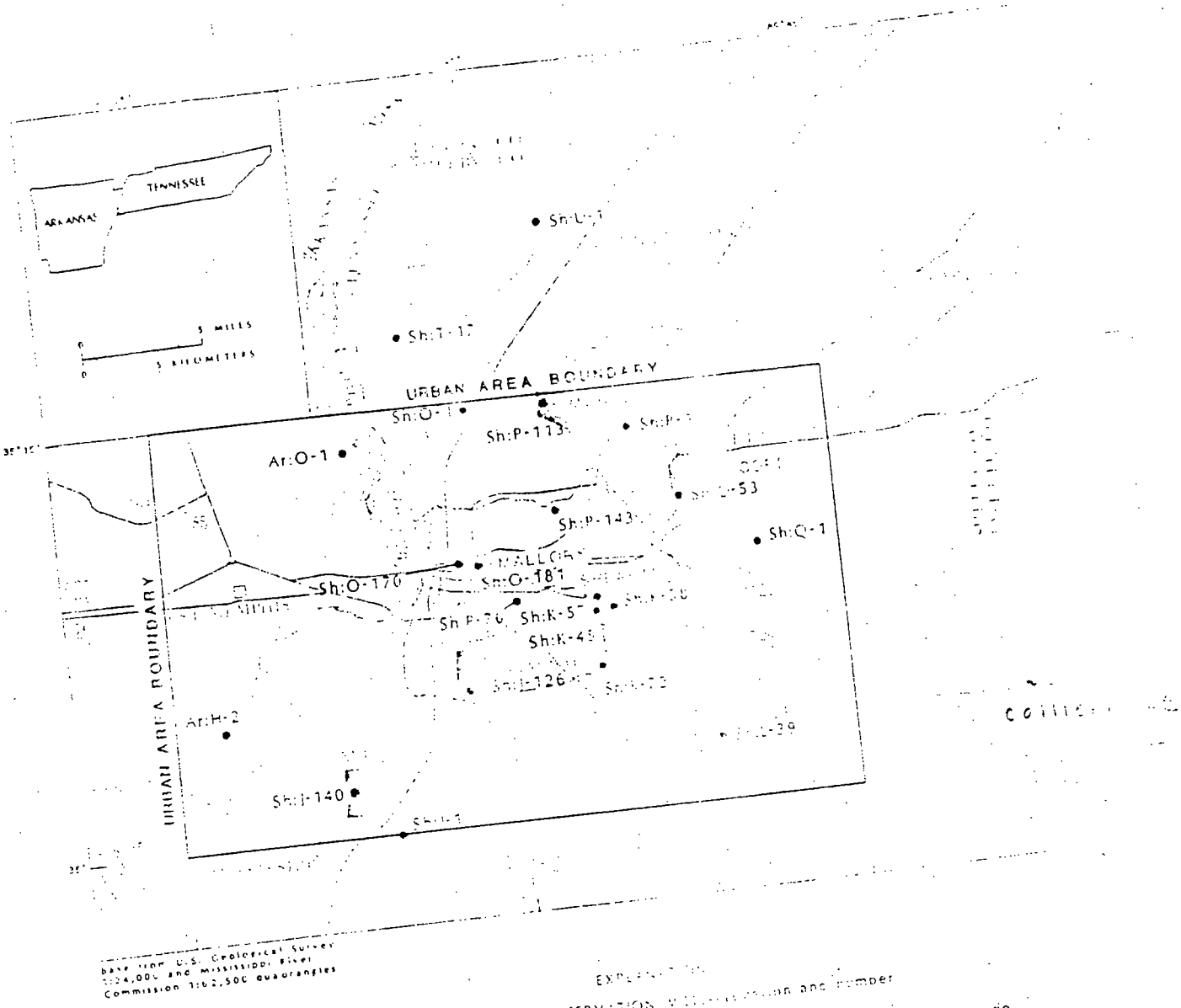
The water-table configuration in the shallow aquifers is a subdued replica of the topography. Water levels are generally at higher altitudes but at greater depths beneath land surface in upland areas than in valleys. Because pumping from the alluvium is negligible, except for a few irrigation wells in

F.G. Wells (1933)
Groundwater Resources
Western Tennessee



EAST-WEST SECTIONS ACROSS WESTERN TENNESSEE, SOUTHWESTERN MISSOURI, AND NORTHEASTERN ARKANSAS

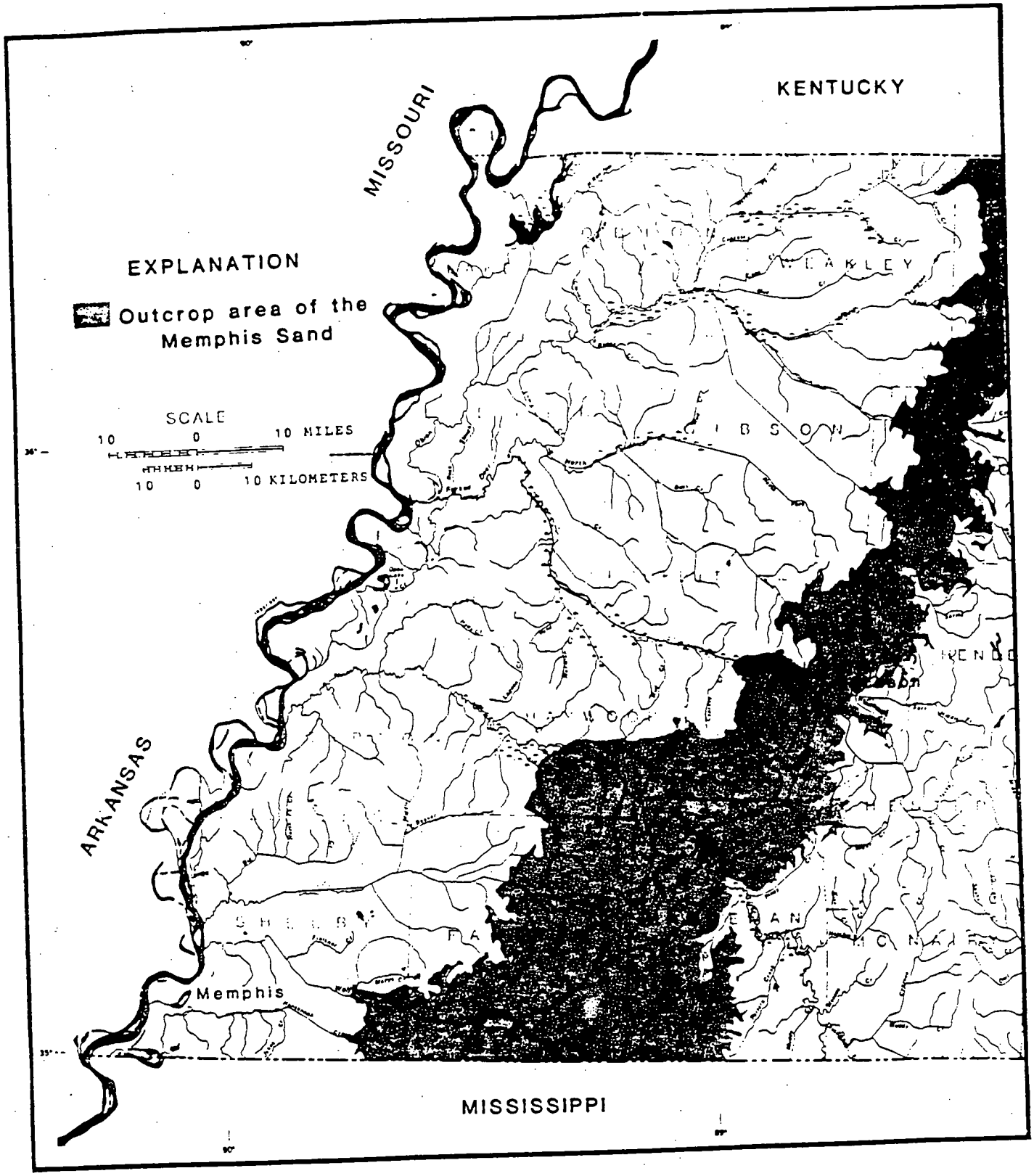
Section C illustrates conditions of artesian flow in western Tennessee.



EXPLANATION

● Sh:P-113 OBSERVATION WELL Identification and number

Figure 16.—Wells in the Memphis area in which geophysical temperature logs were made.



Base from U.S. Geological Survey
State base map, 1977

Figure 3. -- The outcrop area of the Memphis Sand (modified from Rima, 1979).

Arkansas, water-level changes reflect variations in the amount of rainfall and large, sustained changes in stages of nearby streams. Water-level changes in the fluvial deposits are a reflection of the combined effects of urbanization, channelization of streams, clearing of land, and variations in the amount of rainfall. A hydrograph of well Sh:P-99, screened in the fluvial deposits is shown in figure 4. This well is located in a wooded area of Overton Park surrounded by an older, urbanized section of Memphis. The hydrograph shows a definite correlation between the amount of water in storage from year to year in the fluvial deposits and variations in annual rainfall in the Memphis area.

Table 2.--Pumping rates from the Memphis and Fort Pillow Sands by major water users in the Memphis area, 1976-80

[million gallons per day]

	Pumping rates					
	Memphis Sand			Fort Pillow Sand		
Year	MLGW*	Industrial and other	Total	MLGW	Industrial and other	Total
1976	113	72	185	0	4.7	4.7
1977	120	69	189	0	4.5	4.5
1978	117	69	186	0	4.8	4.8
1979	119	69	188	0	5.9	5.9
1980	124	64	188	0	4.7	4.7

* Memphis Light, Gas and Water Division

Water levels in the Memphis Sand have declined in the Memphis area in response to long-term increases in pumping. Water-level declines have not been uniform throughout the area because of the non-uniform distribution of wells. A potentiometric map of the Memphis Sand based upon water-level measurements made in 1980 is shown in plate 1. A potentiometric map depicts an imaginary surface which fluctuates with time because of changes in pumpage and recharge to the aquifer. This map is based on water-level measurements made in wells screened in the Eocene Memphis Sand (formerly "500-foot sand"). Low water levels for the month of September 1980 from Geological Survey maintained recorder equipped wells and supplemental measurements made on Sept. 10, 15, and 16 of private and industrial wells were used as control. Water levels are commonly at their lowest for the year during late August or early September. Small cones of depression around major pumping centers are superimposed on a large regional cone which reflects the composite effect of pumpage. MLGW operates seven major municipal well fields (plate 1). These well fields, in order of their relative age are: (1) Mallory, (2) Sheahan, (3) Allen, (4) McCord, (5) Lichterman, (6) Davis, and (7) Morton. The Morton well field is not yet in production. The cones of depression not centered on municipal well fields are in areas of major industrial pumping.

Progressive water-level declines near pumping centers are caused by limitations on the ability of the aquifer to transmit water rapidly from areas of recharge to areas of concentrated pumping rather than by a lack of available recharge. Water levels are still high in the recharge areas and,

PRECIPITATION (INCHES)											
51.9	42.1	50.0	44.2	68.9	64.2	64.6	58.7	45.5	41.2	63.6	70.9	54.4
DEPARTURE FROM NORMAL											
2.1	-7.6	0.3	-5.4	9.1	14.6	15.5	9.6	-3.6	-7.9	14.7	21.8	5.3

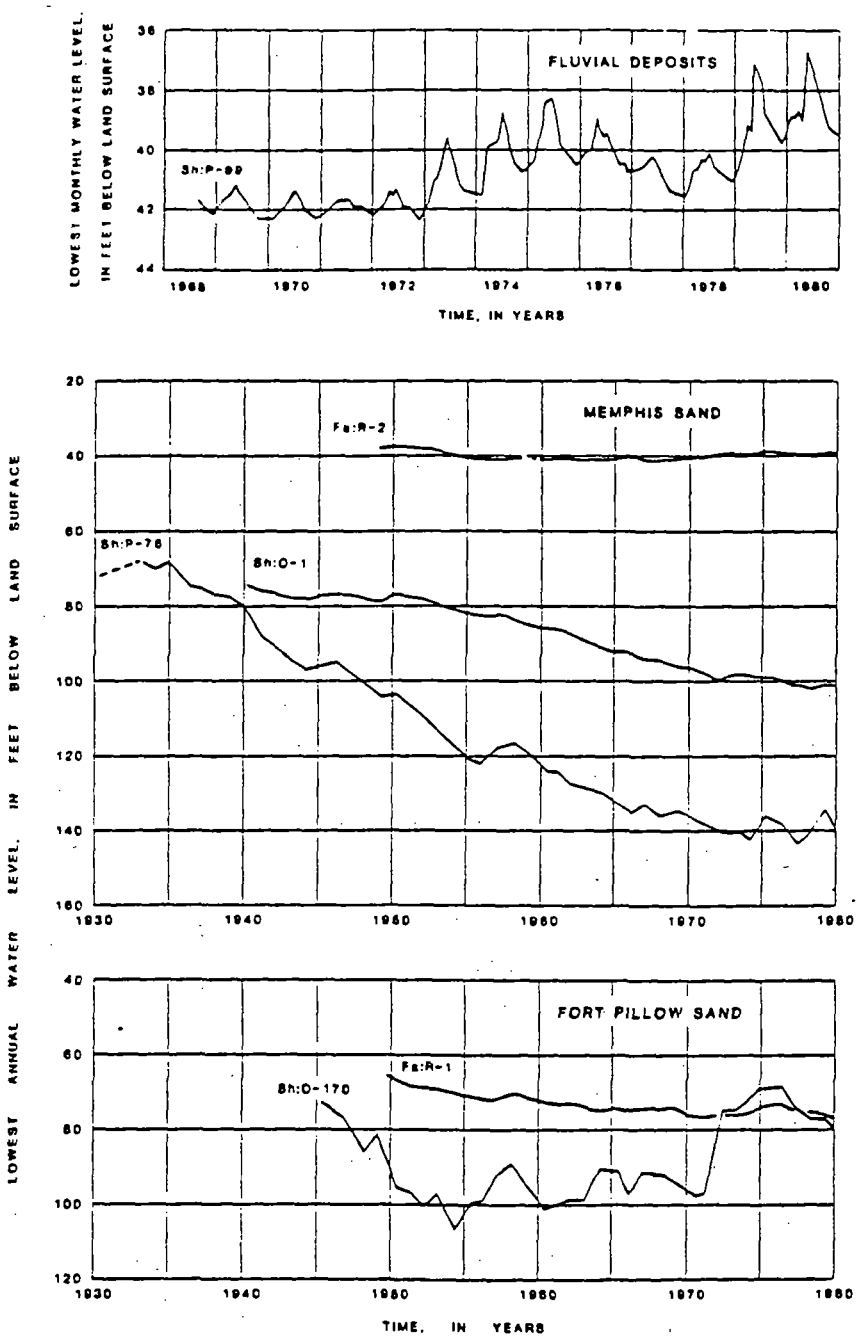


Figure 4.-- Water-level changes in selected observation wells in the Memphis area.

consequently, potential recharge is rejected and runs off as streamflow. In outlying parts of the Memphis area, annual water-level fluctuations are caused by variations in annual rainfall combined with a delayed response to distant pumping. Fluctuations in and near large well fields are caused largely by changes in pumping rates.

Hydrographs of selected observation wells in the Memphis Sand are shown in figure 4. Water levels in Fa:R-2, the most distant from the center of pumping, fluctuate only slightly and declined only 2 feet from 1949 to 1980. On the average, the rate of decline is less than 0.1 foot per year. Well Sh:Q-1, located at an intermediate distance from the center of pumping shows larger water-level fluctuations and a decline averaging about 0.7 foot per year from 1940 to 1980. Well Sh:P-76, located near the center of pumping, shows the largest fluctuations and a decline averaging 1.8 feet per year (ft/yr) since 1930.

Hydrographs for two wells screened in the Fort Pillow Sand are also shown in figure 4. The hydrograph for well Sh:O-170 in Mallory well field clearly shows, by an abrupt rise, a response to the cessation of all municipal pumping from this aquifer in the early 1970's. The hydrograph for well Fa:R-1, about 25 miles from the center of pumping shows a prolonged decline (about 0.4 feet per year) but a much less pronounced response to pumping changes. Current pumping from the aquifer is limited to an industrial area in Memphis and municipal pumping from West Memphis.

Future Water Levels

Unless pumpage from the shallow water-table aquifers or the Fort Pillow Sand increases significantly, large water-level changes in these aquifers are not expected. At the present rate of pumping, water levels in the Memphis Sand are expected to stabilize or show moderate declines. By the year 2000, declines of 25 to 35 feet below 1980 water levels near major pumping centers are predicted if pumping rates increase from about 190 Mgal/d to about 275 Mgal/d as projected by MLGW. At a distance of 10 miles from the main cone of depression, declines of 2 to 10 feet are predicted under these same conditions. These predictions are based on computer simulations by the Geological Survey (U.S. Army Corps of Engineers, Memphis Metropolitan Urban Area Water Resources Study, 1981). The Memphis Sand is expected to continue to provide an adequate supply of water for the Memphis area with few problems other than increased pumping lift being caused by water-level declines.

GROUND-WATER QUALITY

General Characteristics

Over the years, much water-quality information from the aquifers in the Memphis area has been obtained. Table 3 is a statistical summary of Geological Survey water-quality data for the years 1945-80. Although the water from each of the aquifers differs, there is considerable overlap in the ranges determined for many of the water-quality parameters.

The highest median concentrations of all constituents except sodium and chloride are found in water from the alluvium. Sodium is highest in the Fort

Table 3.--Minimum, median, and maximum values observed for selected common constituents and properties of water from the Memphis aquifer systems in the Memphis area.

[mg/L, milligrams per liter; µg/L, micrograms per liter; °C, degrees Celsius; µmho/cm, micromhos per centimeter]

	Silica, dissolved (mg/L as SiO_2)	Iron, dissolved (µg/L as Fe)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Potassium, dissolved (mg/L as K)	Alkalinity (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Nitrate, dissolved (mg/L as N)	Solids residue at 180°C (mg/L)	Hardness (mg/L as $CaCO_3$)	pH	Color (platinum-cobalt units)	Temperature (°C)	Specific conductance (µmhos/cm)
Alluvium																	
Minimum	28	12,000	104	30	5.9	3.6	464	2.8	5.8	0.2	0.2	418	400	6.5	5	16.1	664
Median	31	20,000	110	36	6.0	3.8	470	14	8.1	.2	1.8	460	410	6.8	5	16.1	748
Maximum	32	28,000	150	46	11	4.2	698	33	10	.4	4.0	674	560	6.8	10	16.7	1,160
Number of analyses.	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Fluvial (terrace) Deposits																	
Minimum	11	0	2.2	1.1	7.0	.3	74	0.0	1.9	0.0	0.1	75	14	5.7	0	16.0	88
Median	23	70	17	6.8	14	.7	92	7.6	9.0	.1	4.1	195	88	6.5	3	16.0	253
Maximum	45	2,400	78	42	56	5.5	459	51	89	0.6	75	388	367	7.3	7	17.2	689
Number of analyses.	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	30
Memphis Sand																	
Minimum	0.7	0	2.2	.70	3.3	.2	18	0.2	0.7	0.0	0.0	35	9	5.5	0	16.0	43
Median	12	410	12	4.8	8.1	.8	74	3.0	3.2	.1	.2	83	50	6.5	3	17.2	130
Maximum	29	16,000	41	18	16	3.7	212	18	22	0.7	4.0	380	164	7.9	18	18.9	350
Number of analyses.	57	77	76	58	50	52	67	82	74	59	55	61	78	65	53	47	56
Fort Pillow Sand																	
Minimum	8.5	180	1.8	0.7	31	1.5	96	4.2	1.0	0.0	0.0	105	8	7.2	9	21.1	145
Median	10	760	2.3	1.1	36	2.1	105	4.8	1.8	.1	0.2	114	10	7.6	25	21.7	174
Maximum	19	1,500	4.0	1.9	40	3.0	112	6.4	2.5	.1	0.4	118	17	7.9	60	22.2	186
Number of analyses.	11	16	16	16	6	6	16	16	16	6	16	16	16	16	11	16	11

Pillow Sand. Chloride is highest in the fluvial deposits. Dissolved solids is lowest in water from the Memphis Sand. Fluoride concentrations are low in water from all of the aquifers. The pH of water from the alluvium, the fluvial deposits, and the Memphis Sand is quite similar. It is markedly higher in water from the Fort Pillow Sand. Temperature of water in all of the aquifers increases with depth.

With the exception of the parameters noted above, the median concentrations of the constituents listed in table 3 generally decrease with increasing depth.

Because it is very hard and contains a high concentration of dissolved iron, water from the alluvium is less desirable for most purposes than water from the other aquifers. Water from the fluvial deposits generally meets most accepted criteria for domestic uses, although the lack of a capping layer makes proper well location and construction particularly important if contamination is to be avoided. Water from the two artesian aquifers, the Memphis Sand, and the Fort Pillow Sand requires minimal treatment for domestic and most industrial uses. High concentrations of dissolved iron are found in water from each of the aquifers. Aeration and filtration are frequently employed methods used to reduce the amount of dissolved iron.

Potential for Contamination

Historically, Memphis and Shelby County, along with commercial establishments and industries, have used dumps and landfills in the flood plains of nearby streams and in gravel pits in the upland areas to dispose of a variety of wastes including garbage, street refuse, construction materials, and chemical and industrial wastes. Although most of these dumps and landfills were closed in the early 1970's when the State began regulation of waste-disposal practices, leachates from these facilities have been and are entering the shallow water-table aquifers (Parks and others, 1982, p. 4).

Before contaminants from the waste-disposal sites of the area could possibly migrate to the Memphis Sand, they would first have to enter the water-table aquifers. Observation wells have been installed and sampled at six abandoned waste-disposal sites in the Memphis area. These sites have been identified as having received unknown quantities and types of industrial wastes. Concentrations of common constituents, selected trace constituents, and selected organic compounds were determined. The water contains constituents which indicate that leachates are entering the water-table aquifer in the immediate vicinity of the dumps (Parks and others, 1982). Several constituents, including chloride, color, iron, manganese, total dissolved solids, barium, cadmium, and endrin, exceed primary or secondary contaminant levels established by the Environmental Protection Agency (EPA) for drinking supplies (U. S. Environmental Protection Agency, 1976 and 1979); and some of the other constituents of EPA's list of priority pollutants such as chlordane, DDT, heptachlor epoxide, and toxaphene are present in trace amounts. All of these data are from wells screened in the upper part of the shallow aquifer, downgradient from the waste-disposal sites, and very close to them. Current investigation is being made at one of these sites to determine if contaminants have moved downward and concentrated at lower horizons in the water-table aquifer.

The Memphis Sand is thought to be separated from the water-table aquifers by a relatively thick and widespread confining bed consisting chiefly of clay (the Jackson Formation and upper part of the Claiborne Group). Locally, however, this confining bed may contain sand lenses or "windows" which could provide preferential paths for the movement of contaminated water from the shallower aquifers to the underlying Memphis Sand (Criner and other, 1964; Bell and Nyman, 1968; and Parks and Lounsbury, 1976). At present there is insufficient geologic information to locate or map these "windows" in the confining bed.

Eight deep wells in the Memphis Sand--one in each of the six MLGW well fields in production and two in outlying industrial areas--are sampled annually at the time of low water levels to monitor any changes in water quality. Since 1977, concentrations of common constituents and trace constituents have been determined. In 1980, concentrations of selected organic compounds were also determined. The results indicated no significant short-term changes in water quality. Moreover, a comparison of the recent values for common constituents with those from earlier analyses from the Memphis area, dating back to the 1930's, indicates no significant long-term changes. No traces of the selected organic compounds determined in 1980 were found. Therefore, based on available data, no indication of contamination of the Memphis Sand is evident.

LAND SUBSIDENCE

A lowering of the land surface, caused by the compaction of underlying material, is called land subsidence. The removal of fluids from the ground, usually water or oil, is one cause of land subsidence. The withdrawal of water from an aquifer causes a loss of the supporting pressure of the stored water and shifts more of the overburden weight to the aquifer skeleton. Where the skeleton consists of unconsolidated sediments, as in the Memphis area, this additional load, if great enough, can cause water to be squeezed out of the fine-grained sediments within and adjacent to the aquifer through a rearrangement of the previously stable configuration of the particle grains. This results in a reduction of porosity and volume which can eventually cause gradual subsidence of the land surface.

Extensometers

Two expanded-scale recording extensometers have been installed in the Memphis area to determine if pumping large quantities of water from the Memphis Sand is causing any detectable subsidence. These devices measure the movement of the land surface relative to fixed points beneath the compacting layer.

Extensometer Sh:O-228 was installed in 1978 in Mallory well field near the center of pumping for the Memphis area where the potential for land subsidence is greatest. It measures any movement that is occurring between land surface and a depth of 1,100 feet (fig. 5). Fluctuations in water levels for Sh:O-212, a nearby Memphis Sand observation well, and monthly pumpage totals for the Mallory well field are also included. Very small vertical land-surface movements are detected with this extensometer. Water levels in the observation well are a measure of artesian pressure. The parallel trends

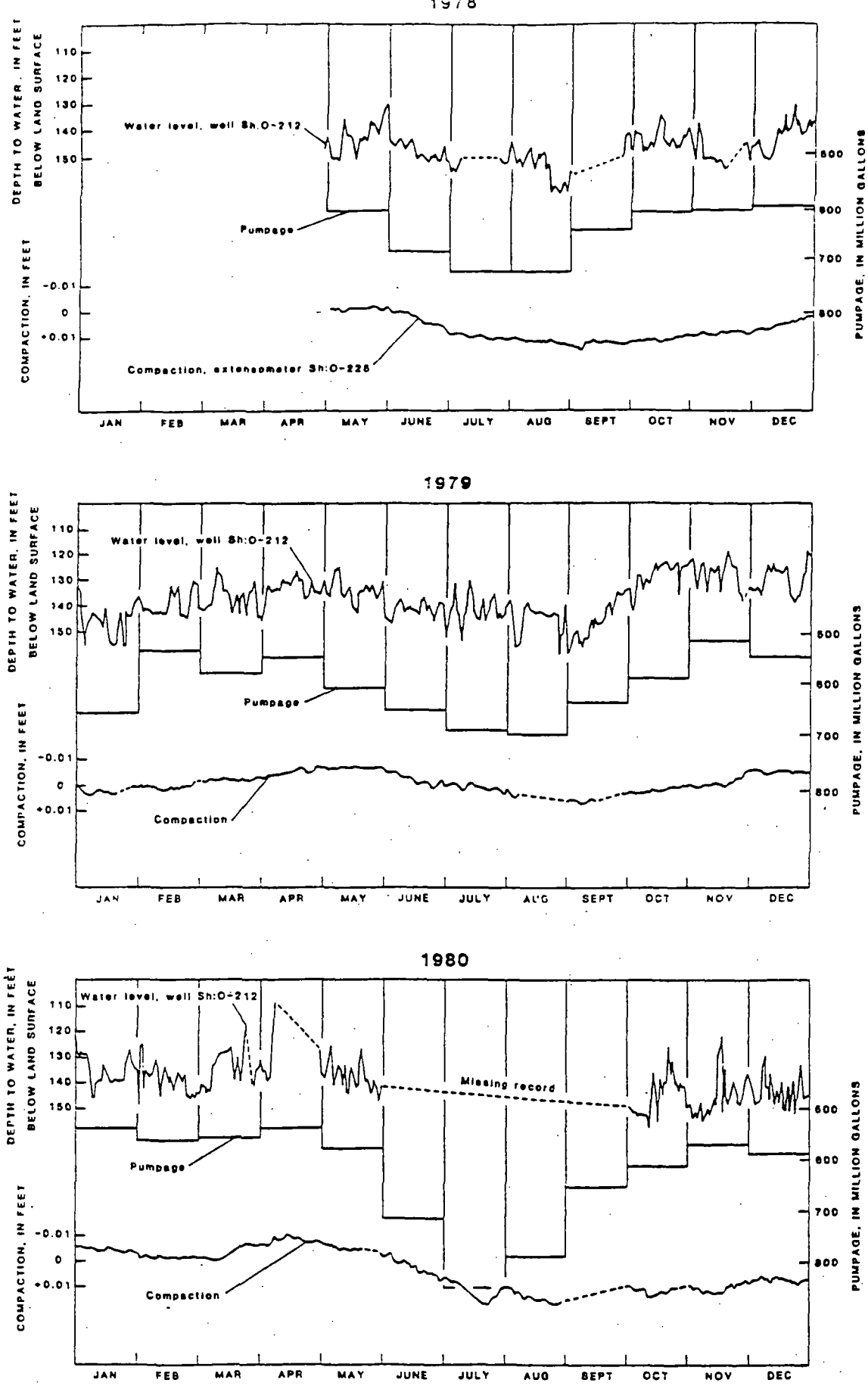


Figure 5. -- Measured compaction, water levels and monthly pumpage in Mallory well field.

of the extensometer record, the water-level hydrograph, and the pumpage bar graph show a relationship between artesian pressure and land-surface movement. Each year, the land surface is at its lowest during the summer months when pumpage is at peak and artesian pressure is lowest. In the spring, when artesian pressure is highest, after a period of less pumping, the land surface is at its highest. The maximum annual elevation change for the 2.5-year period of record has been less than 0.03 foot. This occurred in 1980. Over the period of record there has been no significant net gain or loss in land-surface elevation. Movement is therefore regarded as a result of a loss or gain of the supporting pressure of the water in the aquifer.

Extensometer Sh:J-142 was installed in 1969 in the Davis well field at the time the test holes for the water-supply wells were drilled. It measures movement between land surface and a depth of about 1,500 feet. This extensometer initially was installed to determine if any subsidence could be detected when the well field went into production. The record for Sh:J-142 shows a suggestion of the seasonal vertical land movements similar to those detected with Sh:O-228. However, Sh:J-142 was constructed according to an early design for extensometers and cannot determine very small movement on a long-term basis.

SUMMARY AND CONCLUSIONS

Ground water is the only source of water being used for municipal, industrial and domestic water supplies in the Memphis area. The major aquifers are: (1) the alluvium, (2) the fluvial (terrace) deposits, (3) the Memphis Sand, and (4) the Fort Pillow Sand. The alluvium and fluvial deposits are water-table aquifers, the Memphis and Fort Pillow Sands are artesian aquifers. Currently (1982) withdrawals average about 190 Mgal/d, nearly all of which is from the Memphis Sand. Potential problems associated with increases in pumpage and urban development are the lowering of water levels, contamination of the aquifers, and land subsidence.

Water levels in the Memphis Sand are declining at a rate that varies from less than 0.1 foot per year near the outcrop area to about 1.8 feet per year near the center of pumping. A map of the potentiometric surface of the Memphis Sand shows small cones of depression near major pumping centers superimposed on a large regional cone which reflects the composite effect of pumpage. If present pumping rates were maintained, water levels would stabilize or show moderate declines. A computer model of the Memphis Sand indicates that declines of 25 to 35 feet below 1980 water levels can be expected by the year 2000 near major pumping centers if pumping rates increase at rates projected by Memphis Light, Gas and Water Division.

Water levels in the water-table aquifers exhibit seasonal and annual fluctuations that correlate with variations in rainfall. No long-term declines are expected because there is negligible pumping from these aquifers. Water levels in the immediate Memphis area in the Fort Pillow Sand are currently higher than they were in the early 1970's due to the cessation of municipal pumping from the aquifer. A slight long-term decline of about 0.4 ft/yr is indicated in an observation well about 25 miles from the center of pumping. No long-term declines are expected unless pumping rates increase significantly.

Water taken from observation wells very close to abandoned waste-disposal sites in the Memphis area contains constituents which indicate that leachates are entering the water-table aquifers near these sites. No indications have been found that any of the contaminants from these sites are entering the deeper artesian aquifers.

A recording extensometer installed in the Memphis area indicates a seasonal land-surface elevation change of less than 0.03 foot. The elevation change correlates to seasonal changes in artesian pressure and pumping rates. No significant net gain or loss in land-surface elevation has been recorded over the period of record, indicating that no permanent land subsidence is occurring.

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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

90° 15'

EXPLANATION

210

POTENTIOMETRIC CONTOUR -- Shows altitude at which water level would have stood in tightly cased wells, August 1978; dashed where approximately located. Contour interval 10 feet, 3.048 meters. National geodetic vertical datum.

OBSERVATION WELL

DAVIS

MEMPHIS LIGHT, GAS AND WATER MUNICIPAL WELL FIELD

This map is based on water-level measurements made in wells screened in the Eocene Memphis Sand (formerly "500-foot sand"). Monthly low-water levels for the month of August, 1978 from USGS maintained recorder equipped wells and supplemental measurements made on August 22 and 23 of private and industrial wells were used as control. Water levels are commonly at their lowest for the year during late August or early September (Criner and Parks, 1976).

A potentiometric map depicts an imaginary surface which fluctuates with time because of changes in pumpage and recharge to the aquifer. Maps of the potentiometric surface of the Eocene Memphis Sand for the years 1886, 1960, 1970 and 1975 appear in Criner and Parks (1976). The purpose of this map and those in Criner and Parks (1976) is to show the status of development of the cone of depression caused by pumping in the Memphis area.

REFERENCE: Criner, J. H., and Parks, W. S., 1976, Historic water-level changes and pumpage from the principal aquifers of the Memphis area, Tennessee: 1886 - 1975, U.S. Geological Survey, Water Resources Investigation 76 - 67, 45 p.

SCALE 1:125 000

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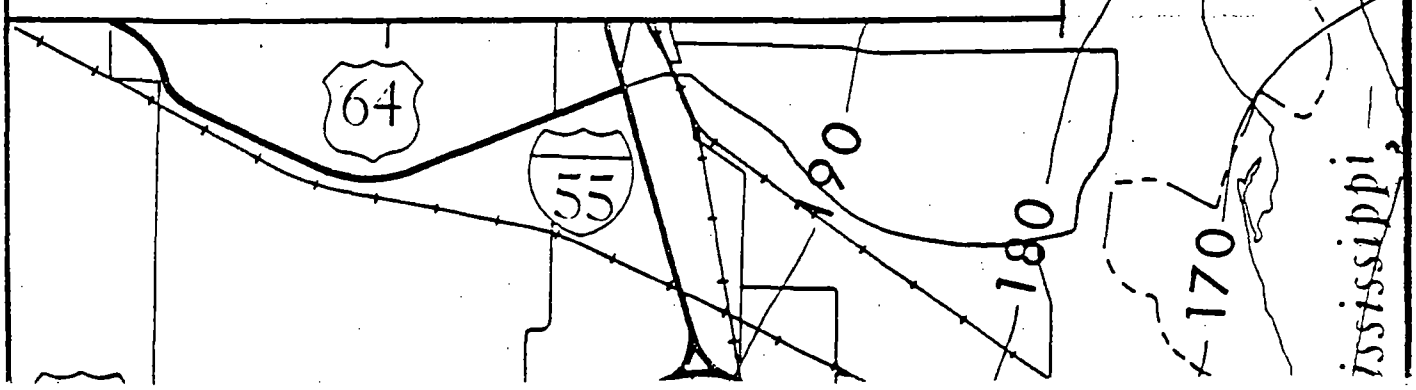

5°22'30"

pumping in the Memphis area.

REFERENCE: Criner, J. H., and Parks, W. S., 1976, Historic water-level changes and pumpage from the principal aquifers of the Memphis area, Tennessee: 1886 - 1975, U.S. Geological Survey, Water Resources Investigation 76 - 67, 45 p.

SCALE 1:125 000

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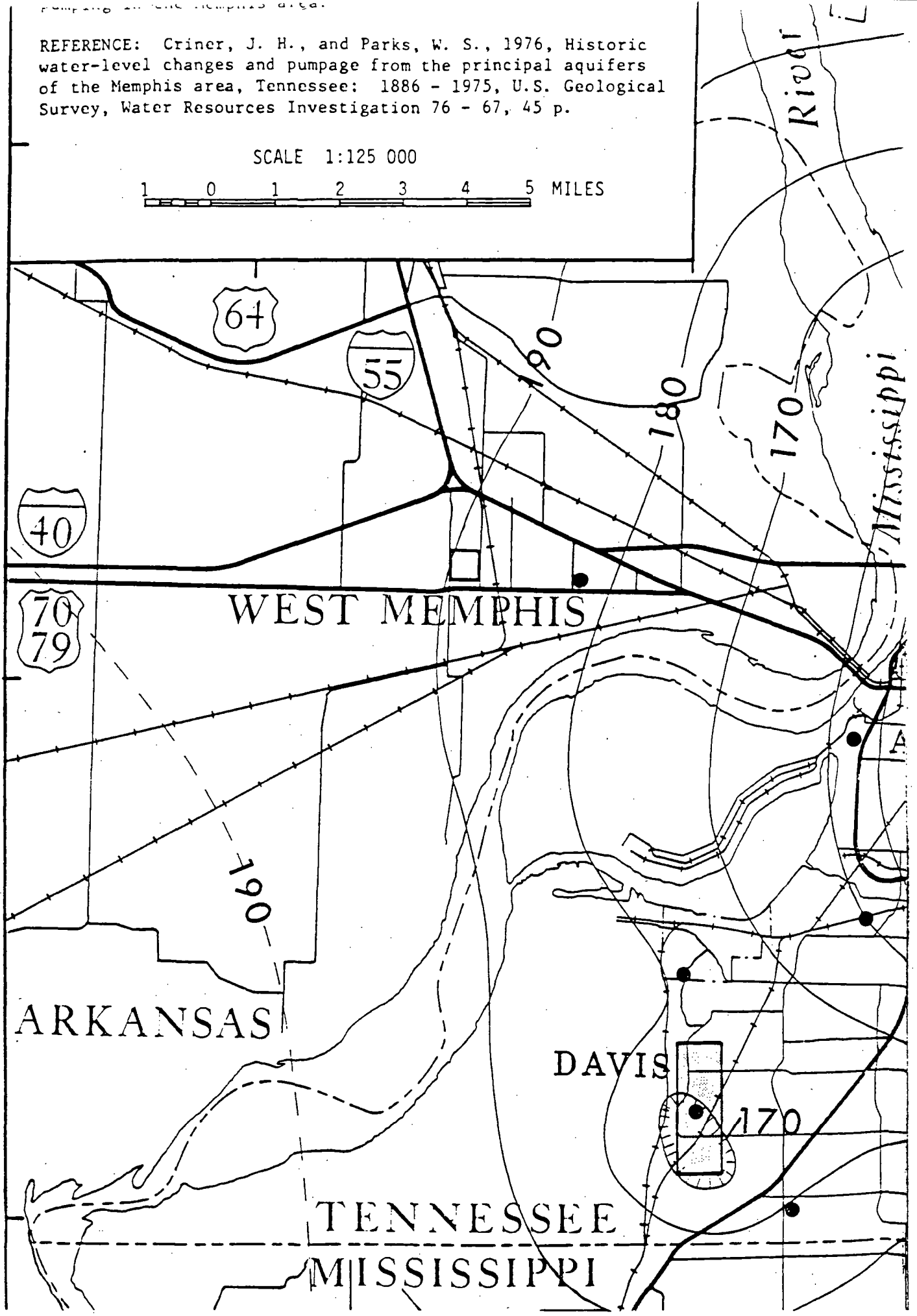

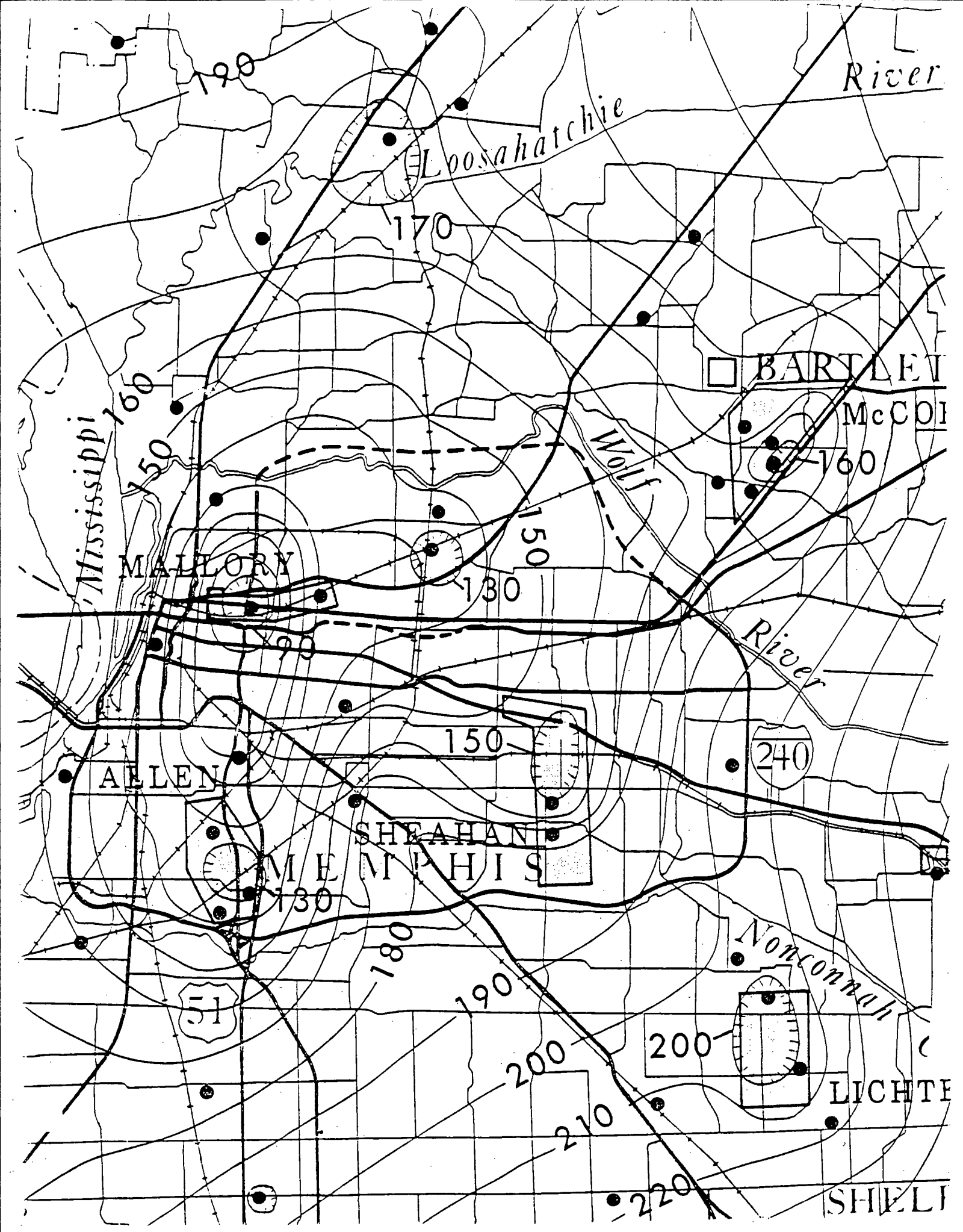

River
Loosahatchie
190
170
BARTLET
McCO
160
Mississippi
160
150
Wolf
150
MALLORY
130
90
River
150
240
ALLEN
SHEAHAN
MEMPHIS
130
Nonconnah
180
190
51
200
200
LICHTE
210
220
SHELI

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POTENTIAL FOR LEAKAGE AMONG PRINCIPAL AQUIFERS IN THE MEMPHIS AREA, TENNESSEE

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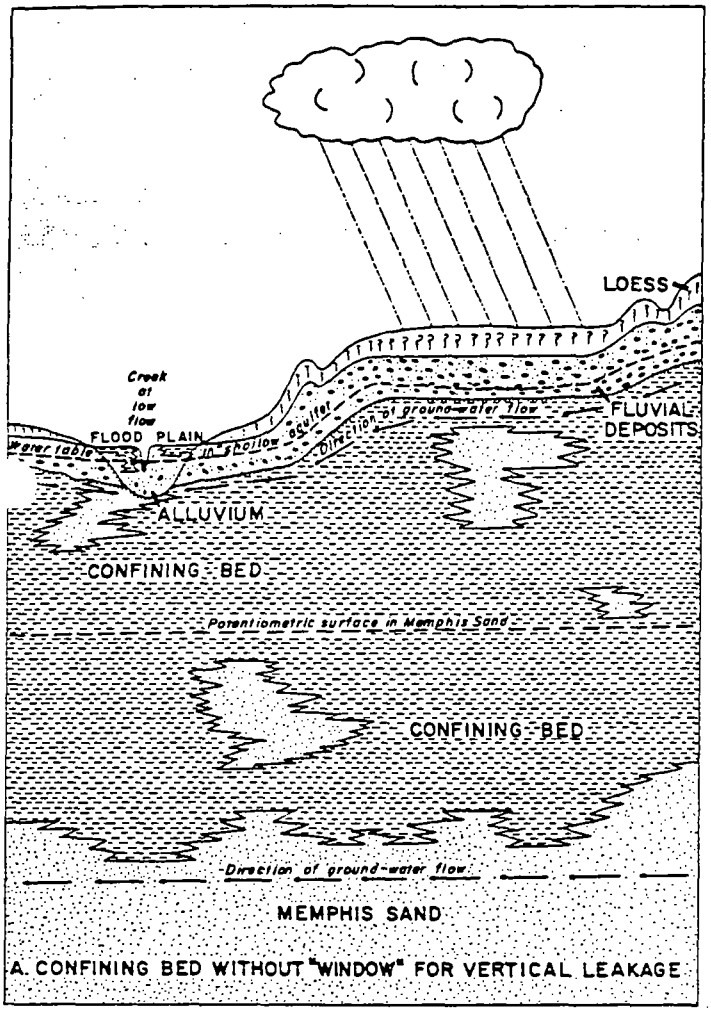
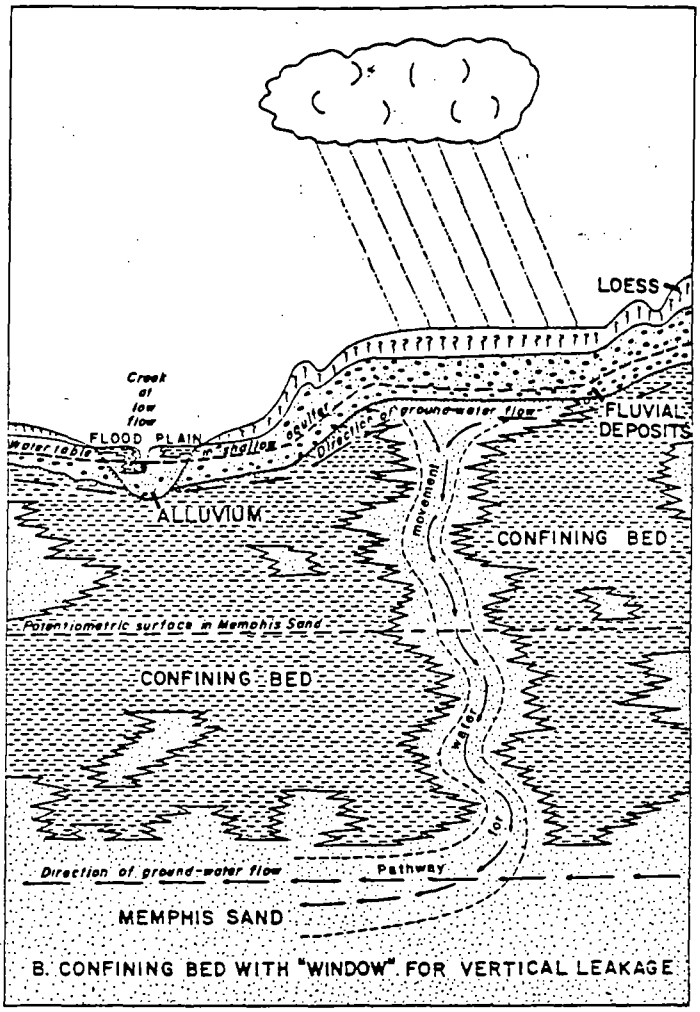


A. CONFINING BED WITHOUT "WINDOW" FOR VERTICAL LEAKAGE



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Prepared in cooperation with the

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT,
OFFICE OF WATER MANAGEMENT
and the

.TY OF MEMPHIS,
MEMPHIS LIGHT, GAS AND WATER DIVISION

POTENTIAL FOR LEAKAGE AMONG PRINCIPAL AQUIFERS IN THE MEMPHIS AREA, TENNESSEE

D. D. Graham and W. S. Parks

ABSTRACT

The principal aquifers in the Memphis area consist primarily of sand or sand and gravel, and the confining beds consist of clay, silt, sand, and lignite. Water-table aquifers are the alluvium and the fluvial deposits of Quaternary age; artesian aquifers are the Memphis Sand and the Fort Pillow Sand of Tertiary age. The Jackson Formation and upper part of the Claiborne Group serve as the confining bed separating the water-table aquifers from the Memphis Sand, and the Flour Island Formation separates the Memphis Sand from the Fort Pillow Sand.

Thickness of the Jackson-upper Claiborne confining bed ranges from 0 to 360 feet, and aggregate thickness of clay beds thicker than 10 feet in this confining bed ranges from 0 to 250 feet. The Jackson-upper Claiborne confining bed is thin or absent in, at least, four areas in the Memphis urban area--in the eastern part along Wolf River, in the southeastern part along Nonconnah Creek, in the south-central part along Nonconnah and Johns Creeks, and in the western part along the Mississippi River. Thickness of the Flour Island confining bed ranges from 160 to 310 feet, and aggregate thickness of clay beds thicker than 10 feet ranges from 70 to 240 feet.

Differences in total hydraulic head among the principal aquifers in the Memphis urban area result in vertical hydraulic gradients which create a potential for interaquifer exchange of water. Throughout this area, the gradient is downward from the water-table aquifers to the Memphis Sand. In the central part of the Memphis urban area, the vertical hydraulic gradient is upward from the Fort Pillow Sand to the Memphis Sand, and in the eastern and western parts, it is downward from the Memphis Sand to the Fort Pillow Sand.

The vertical distribution of carbon-14 data for water from the fluvial deposits, Memphis Sand, and Fort Pillow Sand shows an increase in the relative age of the water with depth. The areal distribution of carbon-14 data for water from the upper part of the Memphis Sand indicates that relatively recent water has been brought into the major cone of depression in the potentiometric surface of the Memphis Sand, either by horizontal movement or from downward vertical leakage. Carbon-14 and tritium isotope data indicate that some water derived from relatively recent precipitation has entered the Memphis Sand in the vicinity of the southern part of the Sheahan well field.

The normal, near-surface geothermal gradient in the Memphis area was determined to be 0.6 degrees Celsius per 100 feet. Deviations from the normal geothermal gradient, in areas affected by intense pumping from the Memphis Sand, indicate that downward vertical leakage occurs from the water-table aquifers through the Jackson-upper Claiborne confining bed to the Memphis Sand. The areal distribution of the depth to the coolest water in the Memphis urban area indicates that most of this leakage occurs within the major cone of depression in the potentiometric surface of the Memphis Sand.

The velocity of downward vertical leakage of water from the Memphis Sand through the Flour Island confining bed to the Fort Pillow Sand was determined to be 6.6×10^{-4} feet per day by analysis of borehole temperature data from an observation well in the northeastern part of the Memphis area. From this velocity and the head difference between the Memphis Sand and the Fort Pillow Sand at this locality, the hydraulic conductivity of the Flour Island confining bed was determined to be 1.14×10^{-2} feet per day.

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the confining bed may have
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arks (1976, p. 22) speculated
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occur if contaminants enter into and concentrate in the shallow water-table aquifers. "Windows" in the confining bed might then provide a pathway for the downward vertical movement of water and contaminants into the Memphis Sand. As a result of geological mapping of the Memphis urban area by Parks (1973, 1974, 1975, 1977, 1978, 1979a, 1979b), it was concluded that areas exist where the confining bed is thin or absent.

Purpose and Scope

The purpose of this investigation was to make an assessment of the potential for leakage of water among the principal aquifers in the Memphis area with special emphasis on the potential for downward vertical leakage from the water-table aquifers to the Memphis Sand. This investigation consisted of the following elements:

* geologic information from geophysical logs of wells and test holes was compiled and interpreted, and maps showing the thickness of the confining beds above and below the the Memphis Sand and the aggregate thickness of clay beds within these confining beds were prepared;
* water-level data from the shallow water-table aquifers, the Memphis Sand, and the Fort Pillow Sand were collected and maps showing the configuration of the water table and potentiometric surfaces in these aquifers along with derivative maps showing head differences between the aquifers were prepared;
* concentrations of selected isotopes of carbon and hydrogen in water from the principal aquifers were determined and the resulting information was evaluated for its relevance as an indication of leakage;
* temperature data, collected using bore-hole geophysical methods, were compiled and evaluated to establish the normal geothermal gradient in the area and to interpret deviations from the normal gradient as indications of vertical inter-aquifer water movement; and
* a summary assessment of the potential for leakage was made.

Table 1.--Post-Midway geologic units underlying the Memphis area and their hydrologic significance

[Alluvium is shown here in the conventional position as the youngest stratigraphic unit. Actually it almost nowhere overlies the loess but may overlie any of the older stratigraphic units]

System	Series	Group	Stratigraphic unit	Thickness	Lithology and hydrologic significance
Quaternary	Holocene and Pleistocene		Alluvium	0-175	Sand, gravel, silt, and clay. Underlies the Mississippi Alluvial Plain and alluvial plains of streams in the Gulf Coastal Plain. Thickest beneath the Alluvial Plain, where commonly between 100 and 150 feet thick; generally less than 50 feet thick elsewhere. Provides water to domestic, farm, industrial, and irrigation wells in the Mississippi Alluvial Plain.
	Pleistocene		Loess	0-60	Silt, silty clay, and minor sand. Principal unit at the surface in upland areas of the Gulf Coastal Plain. Thickest on the bluffs that border the Mississippi Alluvial Plain; thinner eastward from the bluffs. Tends to retard downward movement of water providing recharge to the fluvial deposits.
Quaternary and Tertiary(?)	Pleistocene and Pliocene(?)		Fluvial deposits (terrace deposits)	0-100	Sand, gravel, minor clay and ferruginous sandstone. Generally underlie the loess in upland areas, but are locally absent. Thickness varies greatly because of erosional surfaces at top and base. Provides water to many domestic and farm wells in rural areas.
Tertiary	Eocene	?	Jackson Formation and upper part of Claiborne Group, including Cockfield and Cook Mountain Formations (cap rock clay)	0-200	Clay, silt, sand, and lignite. Because of similarities in lithology, the Jackson Formation and upper part of the Claiborne Group cannot be reliably subdivided based on available information. Most of the preserved sequence is the Cockfield and Cook Mountain Formations undivided, but locally the Cockfield may be overlain by the Jackson Formation. Serves as the upper confining bed for the Memphis Sand.
		Claiborne	Memphis Sand ("500-foot" sand)	600-850	Sand, clay, and minor lignite. Thick body of sand with lenses of clay at various stratigraphic horizons and minor lignite. Thickest in the southwestern part of the Memphis area; thinnest in the northeastern part. Principal aquifer providing water for municipal and industrial supplies east of the Mississippi River; sole source of water for the City of Memphis.
	?	Wilcox	Flour Island Formation	100-340	Clay, silt, sand, and lignite. Consists primarily of silty clays and sandy silts with lenses and interbeds of fine sand and lignite. Serves as the lower confining bed for the Memphis Sand and the upper confining bed for the Fort Pillow Sand.
	Paleocene		Fort Pillow Sand ("1400-foot" sand)	300-325	Sand with minor clay and lignite. Sand is fine to medium. Thickest in the southwestern part of the the Memphis area; thinnest in the northern and northeastern parts. Once the second principal aquifer supplying the City of Memphis; still used by an industry. Principal aquifer providing water for municipal and industrial supplies west of the Mississippi River.
			Clayton Formation	150-250	Clay, silt, sand, and lignite. Consists primarily of silty clays and clayey silts with lenses and interbeds of fine sand and lignite. Serves as the lower confining bed for the Fort Pillow Sand, along with the underlying Porters Creek Clay and Clayton Formation of the Midway Group.

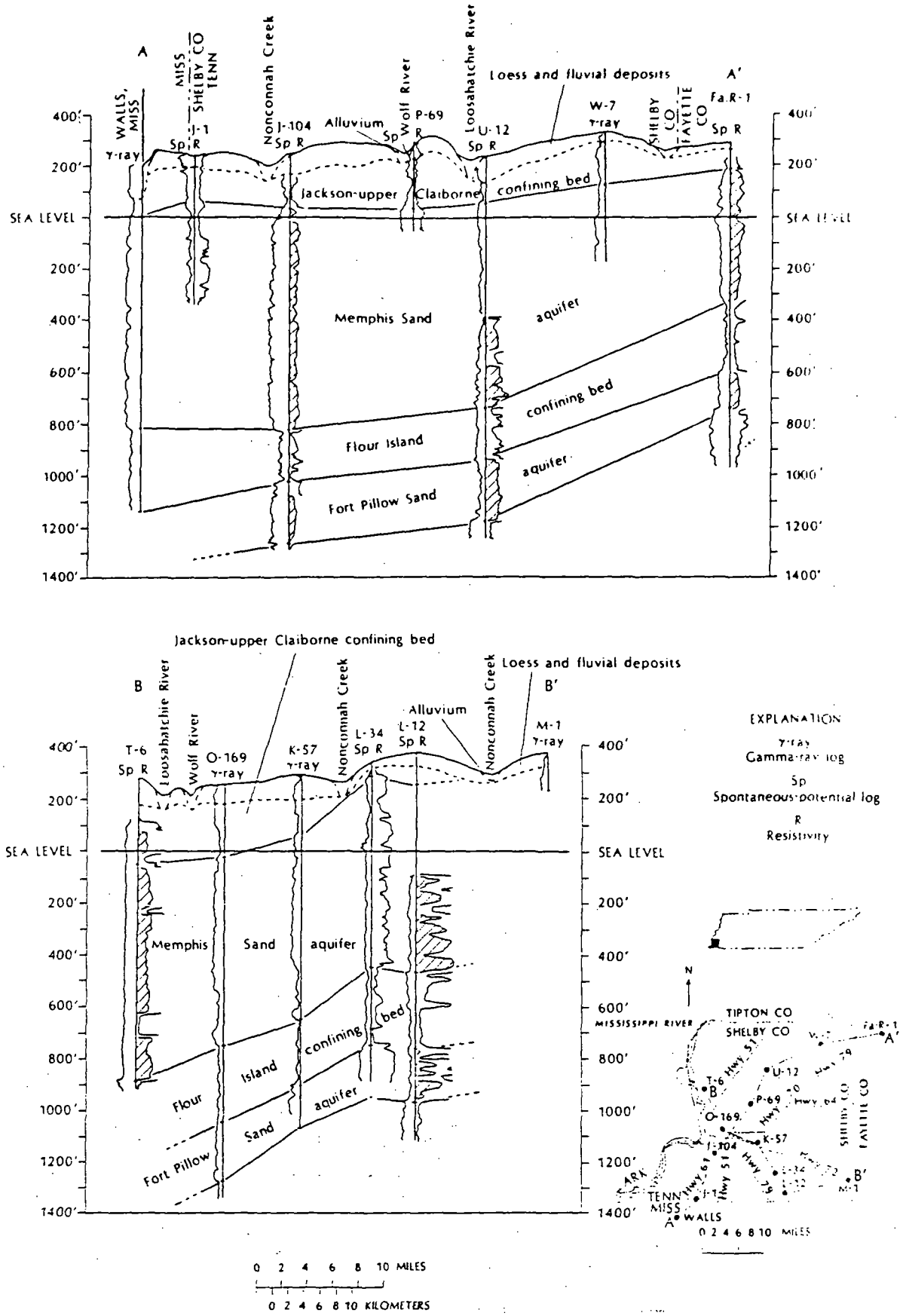


Figure 2.--Hydrogeologic sections showing the principal aquifers and confining beds in the Memphis area (modified from Criner and others, 1964, plate 1).

Pillow Sand and the Memphis Sand in the subsurface in the eastern part of the recharge area is not completely understood. In this area, the Memphis Sand may overlap the confining bed separating these two aquifers and may directly overlie the Fort Pillow Sand. If so, these two artesian aquifers would share a common source of recharge. Water entering at or near the outcrop area moves slowly westward towards the axis of the Mississippi embayment (Graham, 1982, p. 8).

Confining Beds

The principal artesian aquifers of the Memphis area are separated from one another and from the water-table aquifers by layers of sediments--clay, silt, fine sand, and lignite--of significantly lower hydraulic conductivity than the aquifer sediments--fine to very coarse sand and gravel (table 1). These layers of low hydraulic conductivity areally act as confining beds which inhibit vertical interaquifer exchange of water. These confining beds are variable in lithology and thickness, which results in local differences in the ability of the beds to retard movement of water from one aquifer to another. Principal confining beds in the Memphis area are the Jackson Formation-upper Claiborne Group and the Flour Island Formation. Maps of the thickness of these confining beds and clay beds thicker than 10 feet within the confining beds (figs. 3-6) are based on a correlation of electric and gamma-ray logs (fig. 2).

The Jackson Formation and upper part of the Claiborne Group serve as a confining bed between the water-table aquifers and the Memphis Sand. Because of lithologic similarities, the Jackson Formation and upper part of the Claiborne Group cannot be reliably subdivided in the subsurface of the Memphis area based on available information. This confining bed includes strata of the Cockfield and Cook Mountain Formations undivided in the upper part of the Claiborne Group, and locally, of the Jackson Formation. The Jackson-upper Claiborne confining bed consists primarily of clay, silt, and fine sand with minor lenses of lignite. Within the confining bed, the sediments are very lenticular, and locally, individual beds may not be areally extensive. The clays in the confining bed are predominantly of the montmorillonite type (Nyman, 1965, p. B5; Bell and Nyman, 1968, p. 20). For the present investigation, the clay, silt, sand, and lignite of the Jackson Formation and the upper part of the Claiborne Group were considered, for mapping purposes, to be a single hydrologic unit.

The thickness of the Jackson-upper Claiborne confining bed is highly variable in the Memphis urban area, ranging from 0 to 360 feet (fig. 3). Because this confining bed contains much fine sand and sandy silt, a better indicator of areal differences in its ability to retard the movement of water between the water-table aquifers and the Memphis Sand is the aggregate thickness of clay beds within the unit. Aggregate thickness of clay beds thicker than 10 feet in the Jackson-upper Claiborne confining bed ranges from 0 to 250 feet (fig. 4).

The Flour Island Formation underlies the Memphis Sand and separates it from the deeper Fort Pillow Sand. This lower confining bed of the Memphis Sand consists primarily of silty clay and sandy silt with lenses of fine sand and lignite that are not areally extensive. The thickness of the Flour Island Formation is variable in the Memphis urban area, ranging from 160 to 310 feet (fig. 5). The Flour Island is thickest in the southeastern and northwestern parts of the area and thinnest near the center. Aggregate thickness of clay beds thicker than 10 feet within this confining bed ranges from about 70 to 240 feet (fig. 6). Aggregate thickness of clays is least near the central and northeastern parts of the Memphis urban area and greatest in the southeastern part.

EVIDENCES FOR LEAKAGE

The principal evidences for leakage considered during the present investigation are: (1) variations in the thicknesses of the confining beds and the aggregate thicknesses of clay beds within the confining beds, (2) differences in hydraulic heads between the principal aquifers, (3) vertical and areal variations in carbon-14 and tritium concentrations in water from the aquifers, and (4) local deviations from the normal geothermal field as shown by geophysical temperature logs.

Thickness of confining beds

Four areas are obvious where the Jackson-upper Claiborne confining bed is thin or absent and contains little or no clay (figs. 3 and 4). These areas are: (1) in eastern part of the Memphis urban area along and north of the Wolf River, (2) in the southeastern part along Nonconnah Creek, (3) in the south-central part along Nonconnah and Johns Creeks in the vicinity of the southern part of the Sheahan well field, and (4) in the western part in a belt along the Mississippi River. These four areas are important because the thinness of the confining bed and lack of thick clay beds indicate areas with high potential for leakage. The existence and boundaries of these areas, particularly the belt along the Mississippi River, are highly interpretative because of the sparsity of geophysical-log control. The areas along the Wolf River and along Nonconnah Creek are the westward extensions of a much larger area in the southeastern part of the Memphis area where the confining bed overlying the Memphis Sand is known to be absent (Criner and Parks, 1976, figs. 4-7).

The Flour Island confining bed is relatively thick and contains much clay at most places (figs. 5 and 6). Therefore, downward leakage from the Memphis Sand to the Fort Pillow Sand or upward leakage from the Fort Pillow Sand to the Memphis Sand probably is small.

Water Levels

Differences in hydraulic head among the aquifers in the Memphis area result in vertical hydraulic gradients which create a potential for interaquifer exchange of water. To determine the areal distribution of the head differences between the various aquifers, water-level information for each of the aquifers was collected in the fall of 1984 and water-table and potentiometric maps were prepared (figs. 7, 9, and 10).

Water-Table Conditions

The water-table configuration in the shallow aquifers (fluvial deposits and alluvium) is a subdued replica of the land-surface topography (fig. 7). Water levels are generally at higher altitudes beneath land surface [illegible] areas than in valleys. The water-table [illegible] shows the altitude of the top of the saturated [illegible] water level as measured in unused wells [illegible] the water-table aquifers). The altitude of the water table ranges from 180 to 3[illegible] above sea level. Although the water-table map was drawn using water-level measurements [illegible] the fall of 1984 as primary control, low-[illegible] for unlined streams in the area and [illegible] water levels in wells no longer available [illegible] measurement were used as supplemental control.

Water-levels in the water-table aquifers, in areas unaffected by pumping, fluctuate both seasonally and over long periods in response to changes in the amount of water in storage. Water levels are low in the fall and early winter because of the depletion of water in storage by the contribution of water from the water-table aquifers to the base flow of streams during the summer and early fall. Water levels are high in the spring and early summer as a result of recharge from rainfall during the winter and spring. Long periods of excess or deficient rainfall also affect the amount of water in storage in the water-table aquifer. Water-level changes under these conditions are more gradual. Graham [illegible] has shown that the hydrograph of well [illegible] in the fluvial deposits in a wooded [illegible] Overton Park, Memphis, indicates a [illegible] correlation between the amount of water in storage from year to year and variations in annual rainfall in the Memphis area. A hydrograph of well [illegible] is shown in figure 8; location of the well is shown in figure 13.

A depression in the water-table surface is located in the southeastern part of the Memphis urban area in the south-central part of the Sheahan well field (fig. 7). Because there are no withdrawals from the water-table aquifer in this area, the presence of the cone of depression indicates that pumping stress in the Memphis Sand has lowered water levels in the overlying water-table aquifer. The long-term water-level data for well ShK-75 (fig. 8), on which this depression is primarily based, shows continuous declines dating back to 1951, almost to the beginning of pumping in the southern part of the Sheahan well field which began in 1948. This data for well ShK-[illegible] (fig. 8), in the northern part of Sheahan well field, shows similar declines in the Memphis Sa

These declines indicate that pumping in the Memphis Sand has induced leakage from the water-table aquifer.

Artesian Conditions

The potentiometric surface of the Memphis Sand indicates small cones of depression around major pumping centers that are superimposed on a large regional cone which reflects the composite effect of pumping in the Memphis area (fig. 9). The small cones of depression shown on the Memphis Sand potentiometric map are centered at MLGW well fields or areas of major industrial pumping. The altitude of the potentiometric surface in the Memphis Sand ranges from less than 130 to 270 feet above sea level with the lowest altitudes at Mallory and Allen well fields.

Water levels in the Memphis Sand are commonly at their lowest during August or early September and are commonly highest during March or April. Water levels in the Memphis Sand have declined in the Memphis area in response to long-term increases in pumping, but these declines have not been uniform throughout the area because of the non-uniform distribution of withdrawal from wells fields with time. Continued water-level declines near pumping centers are caused by limitations on the ability of the aquifer to transmit water rapidly from the recharge area to areas of concentrated pumping rather than by a lack of available recharge. This is indicated by the fact that water levels have not declined in the recharge area. In outlying parts of the Memphis area, annual water-level fluctuations are caused by variations in annual rainfall combined with a delayed response to distant pumping; fluctuations in and near large well fields are caused primarily by changes in pumping rates (Graham, 1982, p. 10-12).

The potentiometric surface of the Fort Pillow Sand slopes generally to the to the west (fig. 10). Distortions in this surface are caused by pumping at West Memphis, Ark., and by an industry at Memphis. These pumping centers cause local cones of depression in the potentiometric surface. The altitude of the potentiometric surface in the Fort Pillow Sand ranges from less than [illegible] to 220 feet above sea level with the lowest [illegible] at West Memphis, [illegible]

Water levels in the Fort Pillow [illegible] wells near the recharge area are commonly [illegible] each year during October or November [illegible] commonly highest during May or June. [illegible] to pumping centers, seasonal water-level [illegible] are generally obscured by the effects of pumping. Near the pumping centers, water-level fluctuations are caused primarily by changes in pumping rates.

Head Differences

Head differences between the water-table aquifers and the Memphis Sand were determined by overlaying the potentiometric map for the Memphis Sand (fig. 9) with the water-table map (fig. 7) and preparing a derivative map (fig. 11). Head differences between the Memphis Sand and the Fort Pillow Sand were similarly determined by overlying the potentiometric map for the Fort Pillow Sand (fig. 10) with the potentiometric map for the Memphis Sand (fig. 9) and preparing a derivative map (fig. 12).

Head differences between the water-table aquifers and the Memphis Sand range from 0 to 130 feet in the Memphis urban area (fig. 11). Areally, the total hydraulic head (as referred to altitude above sea level) in the water-table aquifers equals or is greater than total hydraulic head in the Memphis Sand. Therefore, throughout this area, the vertical hydraulic gradient is downward as is the movement of water from the water-table aquifers to the Memphis Sand. Head differences are generally greatest beneath the uplands, where the altitude of the water table in the fluvial deposits is high, and beneath MLGW well fields, where the potentiometric surface in the Memphis Sand has been lowered by pumping. Head differences are generally least beneath the Mississippi Alluvial Plain and the alluvial plains of major streams, where the altitude of the water table in the alluvium is low.

Head differences between the Memphis Sand and the Fort Pillow Sand range from minus 40 to plus 50 feet in the Memphis urban area (fig. 12). Throughout the central part of the Memphis urban

Table 3.--Summary of up-hole and down-hole temperatures from geophysical logs and calculated geothermal gradients in the [illegible] area

Well No.	Up-hole temperature at or below 100-foot depth[1]			Coolest temperature at or below 100-foot depth			Down-hole temperature at total depth logged			Geothermal gradient to total depth
	(°C)	Depth (feet)	Geologic unit[2]	(°C)	Depth (feet)	Geologic unit[2]	(°C)	Depth (feet)	Geologic unit[2]	(°C/100 ft)
[illegible]-2	16.3	100	Qal	16.3	100	Qal	18.0	510	Tm	0.41
[illegible]-1	16.2	100	Qal	16.2	100	Qal	17.6	499	Tm	.35
[illegible]-1	16.0	100	Tm	16.0	100	Tm	21.9	1083	Tob	.60
[illegible]-1	16.5	100	Tjc	16.0	260	Tm	16.0	389	Tm	- .21
[illegible]-126	16.3	120	Tjc	16.1	200	Tm	16.2	260	Tm	- .07
[illegible]-140	16.5	140	Tjc	16.2	260	Tm	17.3	550	Tm	.20
[illegible]-45	17.3	140	Tjc	16.4	300	Tm	21.5	1219	Tfp	.39
[illegible]-57	16.2	120	Tjc	16.4	380	Tm	22.0	1293	Tfp	.32
[illegible]-88	17.2	140	Tjc	16.4	320	Tm	22.2	1297	Tfp	.43
[illegible]-72	16.8	120	Tjc	16.1	230	Tm	16.1	293	Tm	- .40
[illegible]	16.5	180	Tm	16.4	230	Tm	16.7	347	Tm	.12
[illegible]	16.1	100	Tjc	16.1	100	Tjc	17.1	430	Tm	.33
[illegible]-170	17.4	140	Tjc	16.5	380	Tm	21.7	1330	Tfp	.36
[illegible]-181	17.0	110	Tjc	16.4	400	Tm	21.3	1266	Tfp	.34
[illegible]-1	16.2	140	Tjc	16.2	140	Tjc	16.3	340	Tm	.30
[illegible]-75	17.4	160	Tjc	16.5	370	Tm	16.9	463	Tm	- .17
[illegible]-113	16.5	180	Tjc	16.5	180	Tjc	17.5	531	Tm	.28
[illegible]-142	17.8	100	Tjc	16.5	280	Tm	16.9	441	Tm	- .28
[illegible]-1	17.4	120	Tjc	16.7	260	Tm	17.1	379	Tm	- .35
[illegible]	16.8	120	Tjc	16.3	300	Tm	16.4	797	Tm	.24
[illegible]-17	16.6	140	Tjc	16.6	140	Tjc	17.3	671	Tm	.33
[illegible]-1	16.2	100	Tjc	16.0	240	Tjc	18.2	838	Tm	.27

[1]Temperature in the earth at a depth of about 100 feet below land surface generally is thought to be unaffected by seasonal or short-term climatic variations and the temperature at this depth approximates the mean annual air temperature for the area. Therefore, the up-hole temperature was determined from geophysical logs at a depth of 100 feet, except where the water level (WL) in the well was below 100 feet. Then, the up-hole temperature was determined at a depth below the water level where the water temperature seemed unaffected by the air temperature in the well.

[2]Geologic unit at depth of the up-hole and down-hole temperatures are: Qal, Alluvium; Tjc, Jackson Formation-upper Claiborne Group; Tm, Memphis Sand; Tfp, Fort Pillow Sand; Tob, Old Breastworks Formation.

area total hydraulic head in the Fort Pillow Sand equals or is higher (plus) than the total hydraulic head in the Memphis Sand, and the vertical hydraulic gradient creates a potential for the upward movement of water from the Fort Pillow Sand to the Memphis Sand. Head differences in the central part of the Memphis urban area are generally highest in areas where intensive pumping from the Memphis Sand in MLGW well fields has caused lowering of the potentiometric surface. In the eastern and western parts of the Memphis urban area, the total hydraulic head in the Fort Pillow Sand is less (minus) than that of the Memphis Sand, and the vertical hydraulic gradient is downward. Movement of water is from the Memphis Sand into the Fort Pillow Sand. The greatest differences in head are near West Memphis, Ark., where pumping has lowered the potentiometric surface in the Fort Pillow Sand, and along the eastern boundary of the Memphis urban area, where the potentiometric surface of the Memphis Sand is high.

Isotope Data

Isotopes of carbon and hydrogen occur in trace amounts large enough to be determined quantitatively through routine analyses. Carbon isotopes can be used to approximate the apparent age of water; tritium can be used to give a qualitative indication of the presence of very recent recharge to an aquifer. In the present investigation, samples of ground water were analyzed to determine concentrations of two isotopes of carbon (carbon-14 and carbon-13) and one of hydrogen (tritium).

Carbon Isotopes

Carbon isotope data for water from 14 wells (fig. 13) in the Memphis area--one in the fluvial deposits, twelve in the Memphis Sand, and one in the Fort Pillow Sand--were obtained. Unadjusted carbon-14, carbon-13/carbon-12, and adjusted carbon-14 values are given in table 2, along with the correction factors used. Methodology for adjusting carbon-14 data is discussed in the section entitled "Supplemental Explanation of Isotope Data" at the end of this report.

The vertical distribution of the adjusted carbon-14 values in the aquifers as indicated by analyses of water from three wells, which are located close to one another near the center of pumping at Memphis, is shown in figure 14. These analyses indicate a vertical distribution of adjusted carbon-14 decreasing with increasing depth at this location.

Water from well Sh:P-99, in the fluvial deposits at a depth of 59 feet, had an adjusted carbon-14 of 118.1 (percent modern). Carbon-14 values can exceed 100 percent of the modern standard if some of the water post-dates the testing of thermonuclear weapons because the carbon-14 content of atmospheric carbon dioxide has, at times, been doubled by these weapons (Mook, 1980, p. 52). Graham (1982, p. 10-11) has shown a direct correlation between water levels in this well and variations in annual rainfall in the Memphis area, indicating that some water from this well is very recent. Carbon-14 derived from the dissolution of snail shells in the overlying loess also may have increased the adjusted carbon-14 value.

Water from well Sh:O-231, in the upper part of the Memphis Sand at a depth of 518 feet, had an adjusted carbon-14 of 75.0 (percent modern). Water from well Sh:P-23, in the Fort Pillow Sand at a depth of 1,414 feet, had the greatest apparent age with an adjusted carbon-14 of 12.[illegible] (percent modern).

Not shown in figure 14 are the adjusted carbon-14 concentrations for wells Sh:O-207 and Sh:O-223, both in the lower part of the Memphis Sand and about 1,200 feet apart in the Mallory well field. Water from Sh:O-207, at a depth of 778 feet, had an adjusted carbon-14 concentration of 95.6 (percent modern); water from Sh:O-223, at a depth of 772 feet, had an adjusted carbon-14 concentration of 95.2 (percent modern). These high values of adjusted carbon-14 are inconsistent with the other isotope data for the Memphis area, particularly when considering the depths of the wells. The values indicate the presence of recent water in the discharge from these two wells which is not explainable on the basis of available information.

hydraulic conductivity estimated above, along with information about the thickness of the confining bed (figs. 5 and 6) and head differences throughout the area (fig. 12), could be used to estimate the amount of water that is exchanged between these two aquifers. Such application is beyond the scope of this project.

An unsuccessful attempt was made to use the technique described above to provide an estimate of the vertical exchange of water between the fluvial deposits and the Memphis Sand. The temperature data obtained from geophysical logs indicate, in areas of intense pumping, the ground water is not in thermal equilibrium in the confining bed between the fluvial deposits and the Memphis Sand. This is indicated by the fact that in several of the wells the water gets colder with depth in the upper part of the well. The analytical solution used above is not straightforward in this situation, and more detailed information is needed before temperature-profile data can be used to quantitatively estimate the exchange of water between the fluvial deposits and the Memphis Sand.

The results of the present investigation indicate that a general component of downward vertical movement of water occurs from the water-table aquifers through the Jackson-upper Claiborne confining bed to the Memphis Sand. Maps showing the areal distribution of carbon isotope data from the upper part of the Memphis Sand (fig. 15) and the depth to the coolest temperature (fig. 16) indicate that pumping from the Memphis Sand has induced downward leakage in the area of the major cone of depression in the potentiometric surface of the Memphis Sand (fig. 9). Pumping from the Memphis Sand in MLGW well fields has also caused local increases in head differences between the water-table aquifers and the Memphis Sand and, thus, local increases in vertical hydraulic gradients. These increased hydraulic gradients create a potential for an accelerated downward movement of water through the Jackson-upper Claiborne confining bed. The isotope data (table 2) and geothermal data (table 3) indicate that downward vertical leakage occurs from the water-table aquifers through the confining bed to the Memphis Sand in MLGW well fields.

POTENTIAL FOR LEAKAGE

The confining beds overlying and underlying an artesian aquifer generally are not completely impermeable, and an interchange of water occurs naturally between the artesian aquifer and shallower or deeper aquifers by leakage through the confining beds. The amount of leakage that occurs depends on the thickness and hydraulic conductivity of the confining bed and the differences in hydraulic head between the aquifers. In the Memphis area, the potential for leakage is least where a confining bed is thick and contains much clay and where head differences are small, and it is greatest where a confining bed is thin or absent and where head differences are large. At most places, the potential for leakage falls between these extremes. Because the characteristics of the confining beds and the differences in the hydraulic heads can vary greatly over relatively short distances in the Memphis area, an assessment of the potential for leakage among the aquifers can only be generalized. Much additional work would be needed to assess specific areas or areas.

Four areas in the Memphis urban area were identified where the Jackson-upper Claiborne confining bed is thin or absent and a high potential exists for the movement of water from the water-table aquifers directly into the Memphis Sand (fig. 21). These areas are: (1) in the eastern part along and north of the Wolf River, (2) in the southeastern part along Nonconnah Creek, (3) in the south-central part along Nonconnah and Johns Creeks, and (4) in the western part in a belt along the Mississippi River. The identification of these areas is based primarily on a map of the thickness of the Jackson-upper Claiborne confining bed (fig. 3). Additional evidence is available that indicates water from the water-table aquifers is entering the Memphis Sand in the area in the south-central part along Nonconnah and Johns Creeks. This area is upgradient in the direction from which water moves through the Memphis Sand towards the southern part of the Sheahan well field (fig. 9). It may be the source of some of the water pumped by wells in this part of this well field.

Downward vertical leakage of water from the water-table aquifers to the Memphis Sand along

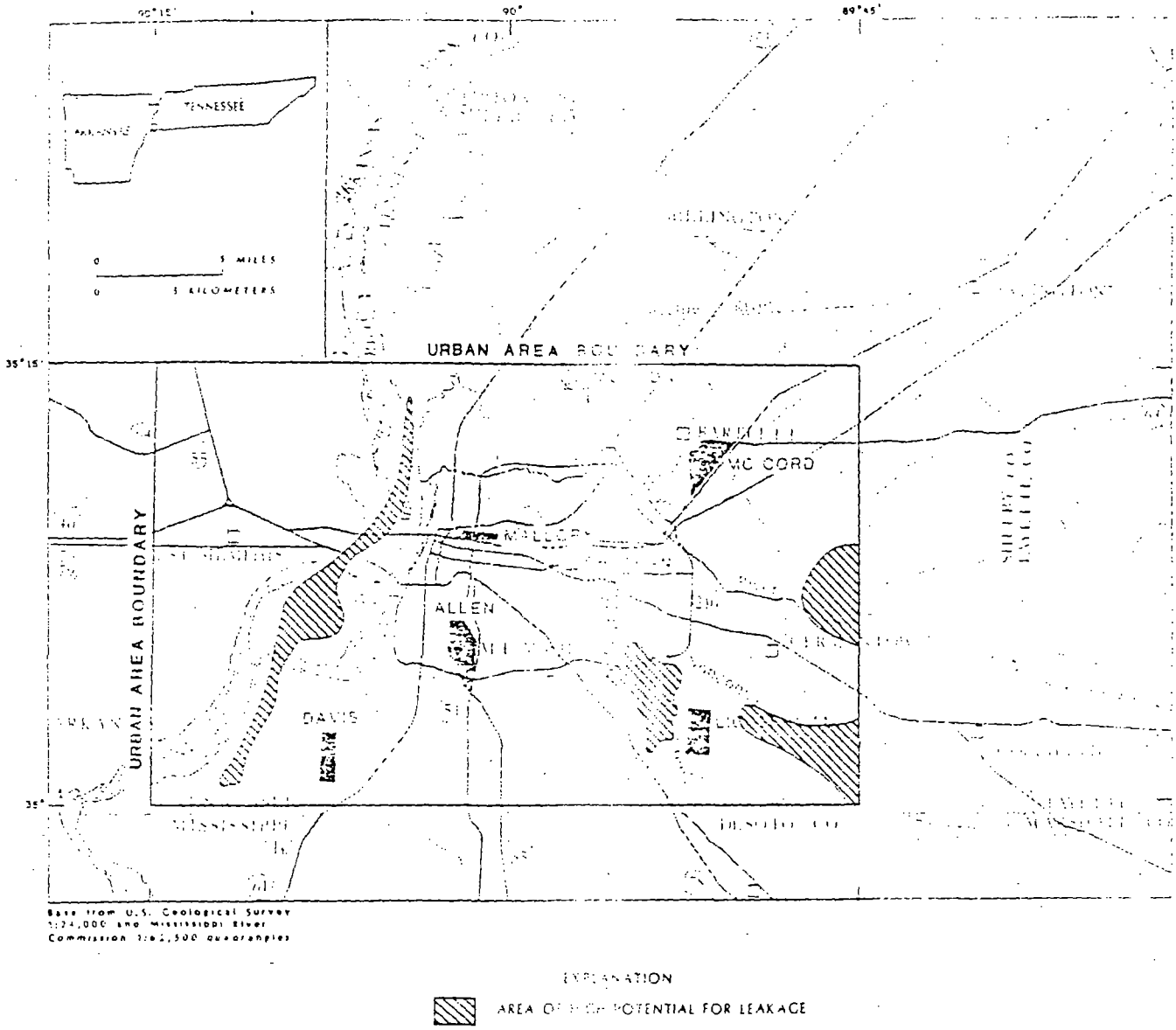


Figure 21.--Areas of high potential for downward vertical leakage from the water-table aquifers to the Memphis sand in the Memphis urban area.

Nonconnah Creek south of Sheahan well field has been previously suspected. According to Nyman (1965, p. B8), an interpretation of discharge measurements made along Nonconnah Creek suggested that 0.1 ft^3/s of water must have been diverted to underflow along a 1 1/2-mile segment of Nonconnah Creek south of the Sheahan well field. He also stated that for several years during the fall months the channel of Nonconnah Creek in this area was observed to be completely dry, although still farther upstream and downstream the channel had some flow. Since Nyman's investigation, the channel and flood plain of Nonconnah Creek has been greatly modified by dredging, the emplacement of fill, and construction of bridges and Interstate I-240.

Evidences, identified during the present investigation, that downward vertical leakage of water occurs from the water-table aquifers to the Memphis Sand in the southern part of the Sheahan well field near Nonconnah Creek are: (1) a map of the water-table surface indicates a depression in the water table (fig. 7); (2) the hydrograph of observation well Sh:K-75 shows a continuous decline of the water level in the water-table aquifer, dating back almost to the begining of pumping from the Memphis Sand in this area (fig. 8); (3) a map of the head differences between the water-table aquifers and the Memphis Sand show that these head differences range from 40 to 60 feet and provide a potential for downward vertical leakage (fig. 11); (4) isotope data,for both carbon-14 and tritium concentrations, indicate that recent water has entered the Memphis Sand in the vicinity of wells Sh:K-73 and Sh:K-74 (table 2); and (5) geothermal data show that in well Sh:K-72 the uphole temperature was 16.8 °C at a depth of 120 feet and the coolest temperature was 16.1 °C at 230 feet, which indicates downward vertical leakage (table 3).

In addition to downward vertical leakage from the water-table aquifers to the Memphis Sand, head differences between the Memphis Sand and the Fort Pillow Sand in the central part of the Memphis urban area indicate a vertical hydraulic gradient that creates a potential for upward vertical leakage from the Fort Pillow Sand through the Flour Island confining bed to the Memphis Sand (fig. 12). Because the Flour Island confining bed is relatively thick and contains much clay (figs. 5 and 6), upward leakage from the Fort Pillow Sand to the Memphis Sand is probably small.

SUMMARY AND CONCLUSIONS

The principal freshwater aquifers in the Memphis area are: (1)the alluvium, (2) the fluvial deposits, (3) the Memphis Sand, and (4) the Fort Pillow Sand. The alluvium and fluvial deposits make up the water-table (unconfined) aquifers, and the Memphis Sand and Fort Pillow Sand are the artesian (confined) aquifers. The Memphis Sand provides about 95 percent of the water used in the Memphis area for municipal and industrial water supplies, and the [illegible] Pillow Sand provides about 5 percent. [illegible] 1984 was about 19[illegible] Mgal/d from these [illegible]rs.

The principal [illegible] beds in the Memphis area are (1) the [illegible]nation and upper part of the Claiborne [illegible] (2) the Flour Island Formation. The [illegible]er Claiborne confining bed separates the [illegible]le aquifers from the Memphis Sand, the [illegible] island confining bed separates the Memphis [illegible] from the Fort Pillow Sand.

The Jackson-upper [illegible]iborne confining bed in the Memphis urban [illegible] ranges from 0 to 360 feet in thickness, and [illegible]ate thickness of clay beds thicker than 10 feet within this confining bed ranges from 0 to 2[illegible] feet. Four general areas in the Memphis urban area were identified where the Jackson-upper Claiborne confining bed is thin or absent; consequently, the potential for leakage from the water-table aquifers to the Memphis Sand is high. These general areas are: (1) in the eastern part of the Memphis urban area along and north of Wolf River, (2) in the southeastern part along Nonconnah Creek, (3) in the south-central part along Nonconnah and Johns Creeks in the vicinity of the southern part of the Sheahan well field, (4)in the western part in a belt along the Mississippi River. The existence and boundaries of these areas, particularly the belt along the Mississippi River, are highly interpretative because of the lack of geophysical logs of wells in these areas.

The Flour Island confining bed in the Memphis urban area ranges from 160 to 310 feet in thickness, and aggregate thickness of clay beds thicker than 10 feet ranges from 70 to 240 feet. The Flour Island confining bed is thickest in the southeastern and northwestern parts of the Memphis urban area and is thinnest in the central part. Aggregate thickness of clay beds thicker than 10 feet is greatest in the southeastern part and least in the central part.

A water-table map for the shallow aquifers--alluvium and fluvial deposits--shows a depression in the the water-level surface in the south-central part of the Memphis urban area in the southern part of the Sheahan well field. This depression, which is based mostly on the record of water

levels in one observation well, indicates that pumping stress in the Memphis Sand has lowered water levels in the overlying water-table aquifer.

Head differences between the water-table aquifers and the Memphis Sand range from 0 to 13[illegible] feet in the Memphis urban area. Areally, the total hydraulic head, as related to sea level, in the water-table aquifers equals or is greater than total hydraulic head in the Memphis Sand. Therefore, throughout the entire area, the vertical hydraulic gradient creates a potential for downward movement of water from the water-table aquifers to the Memphis Sand.

Head differences between the Memphis Sand and the Fort Pillow Sand range from about minus 40 to plus 50 feet in the Memphis urban area. Throughout the central part, total hydraulic head in the Fort Pillow Sand equals or is greater (plus) than total hydraulic head in the Memphis Sand, and the vertical hydraulic gradient creates a potential for upward movement of water from the Fort Pillow Sand to the Memphis Sand. In the eastern and western parts of the Memphis urban area, total hydraulic head in the Fort Pillow Sand is less (minus) than that of the Fort Pillow Sand, and the vertical hydraulic gradient creates a potential for downward movement of water from the Memphis Sand to the Fort Pillow Sand.

The vertical distribution of carbon-14 data from the fluvial deposits, Memphis Sand, and Fort Pillow Sand near the center of pumping at Memphis show an increase in the relative age of the water with depth. The areal distribution of carbon-14 data for water from the upper part of the Memphis Sand indicates that relatively recent water has been brought into the major cone of depression in the potentiometric surface of the Memphis Sand at Memphis, either by horizontal movement through the aquifer or by downward leakage. Carbon-14 and tritium isotope data indicate that some water from recent precipitation has entered the Memphis Sand in the southern part of the Sheahan well field.

The normal near-surface geothermal gradient in the Memphis area below a depth of 100 feet was determined to be 0.6 °C per 100 feet. Temperature logs made in observation wells in areas away from areas of intense pumping showed, with a few exceptions, normal geothermal gradients. Temperature logs made in abandoned wells and observation wells in MLGW well fields generally showed a pronounced distortion in the geothermal field. The coolest temperature recorded in the well fields was 1[illegible] °C, which is 1 °C cooler than the mean annual air temperature based on 52 years of record at Memphis, and the warmest temperature recorded was 18.2 °C. The geothermal gradients for wells in areas affected by pumping from the Memphis Sand are less than the normal gradient for the Memphis area, indicating recharge by downward vertical leakage.

The depth to the coolest temperature ranged from 100 to [illegible] feet below land surface in the Memphis area. The areal distribution of the depth to coolest temperature is similar to the potentiometric surface in major cone of depression in the Memphis Sand, indicating a general component of downward vertical leakage in the area of intense pumping from the Memphis Sand at Memphis.

From temperature data from an observation well in the northeastern part of the Memphis area about 25 miles from the center of pumping at Memphis, a velocity of 6.6 X 10^{-4} ft/d was determined for water moving from the Memphis Sand through the Flour Island confining bed into the Fort Pillow Sand. Using this velocity and measurement of head difference between these aquifers at this location, a hydraulic conductivity of the Flour Island confining bed was determined to be 1.14 X 10^{-3} ft/d. The hydraulic conductivity of the Jackson-upper Claiborne confining bed or the velocity of ground water moving through this confining bed cannot be determined using temperature data.

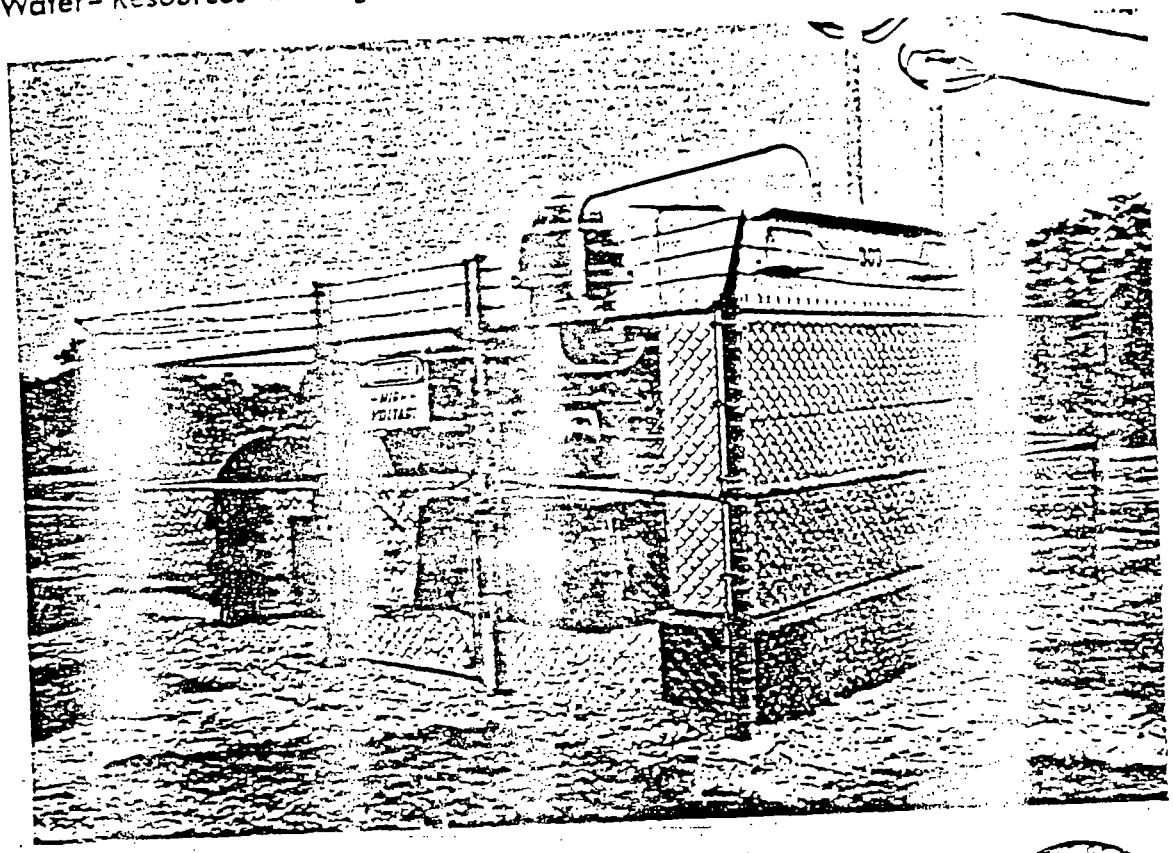
The results of the present and previous investigations indicate that a general component of downward vertical leakage from the water-table aquifers to the Memphis Sand occurs in the Memphis area. This downward vertical leakage probably is greatest in areas where the Jackson-upper Claiborne confining bed is thin or absent and in MLGW well fields where this leakage is induced by pumping stress in the Memphis Sand. Where the confining bed is absent, water moves directly from the water-table aquifers into the Memphis Sand. In the central part of the

9c

FILE COPY

HISTORIC WATER-LEVEL CHANGES AND PUMPAGE FROM THE PRINCIPAL AQUIFERS OF THE MEMPHIS AREA, TENNESSEE: 1886-1975

U. S. GEOLOGICAL SURVEY
Water-Resources Investigation 76-67



Prepared in cooperation with the

CITY OF MEMPHIS,

MEMPHIS LIGHT, GAS AND WATER DIVISION

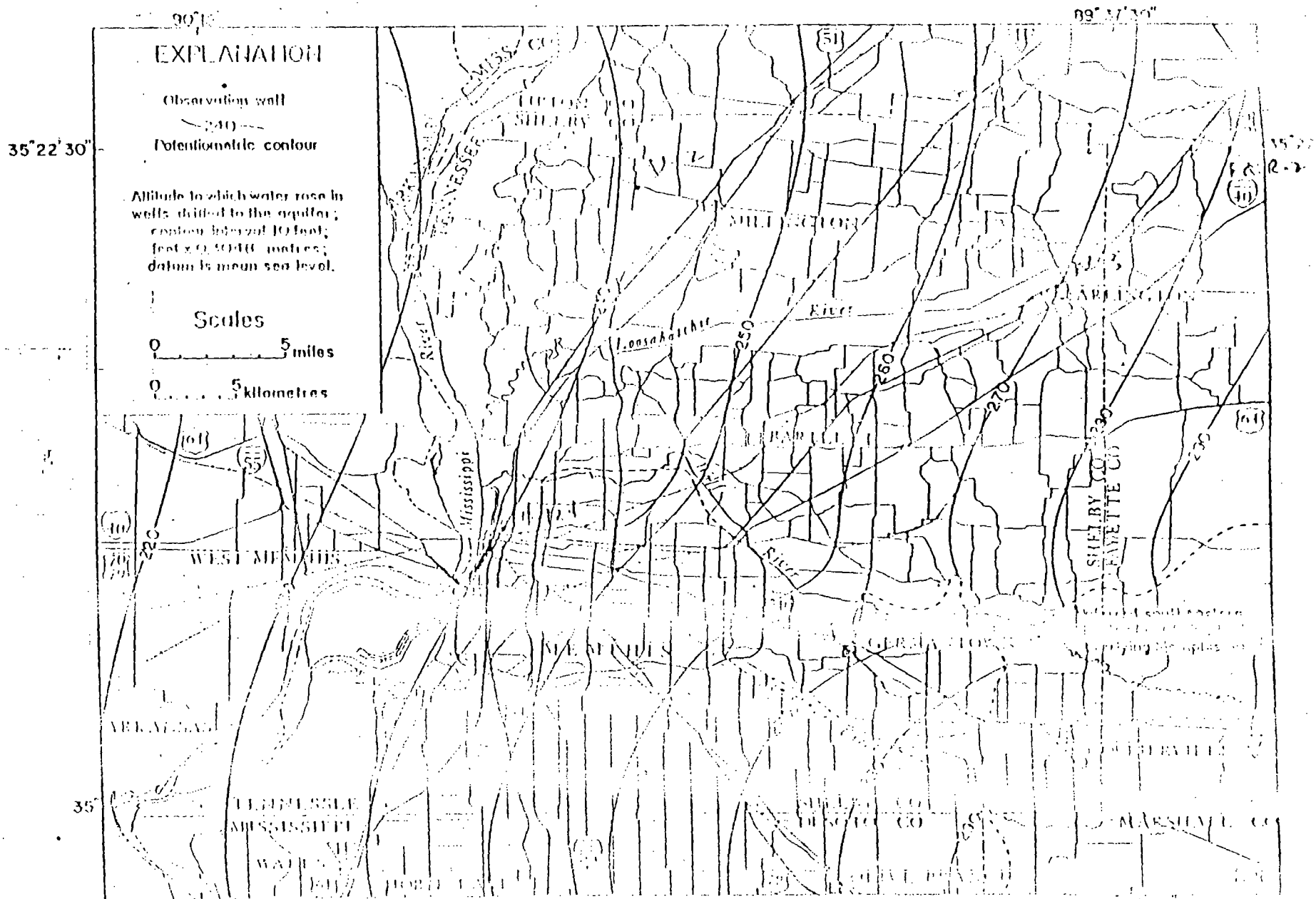


Figure 4.--Potentiometric surface of the Memphis Sand in 1886.

Dangerous Properties of Industrial Materials

Sixth Edition

N. IRVING SAX

Assisted by:

Benjamin Feiner/Joseph J. Fitzgerald/Thomas J. Haley/Elizabeth K. Weisburger

VAN NOSTRAND REINHOLD COMPANY
New York

skn-rbt 500 mg/24H MOD	28ZPAK -,28,72
eye-rbt 100 mg MLD	AIHAAP 19,353,58
eye-rbt 2 mg/24H SEV	28ZPAK -,28,72
ihl-man LCLo:27 gm/m3/10M	JOCMA7 8,358,66
ihl-man TCLo:350 ppm:PSY	WEHSAL 10,82,73
orl-hmn TDLo:670 mg/kg:GIT	NTIS** PB257-185
ihl-hmn TCLo:920 ppm/70M:CNS	AIHAAP 19,353,58
orl-rat LD50:10300 mg/kg	NTIS** PB257-185
ihl-rat LCLo:1000 ppm	FMCHA2 -,D317,80
ipr-rat LD50:5100 mg/kg	NTIS** PB257-185
orl-mus LD50:11240 mg/kg	NTIS** PB257-185
ihl-mus LCLo:11000 ppm/2H	HBTXAC 5,72,59
ipr-mus LD50:4700 mg/kg	TXAPA9 13,287,68
orl-dog LD50:750 mg/kg	FMCHA2 -,D317,80
ipr-dog LD50:3100 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo:95 mg/kg	HBTXAC 5,72,59
orl-rbt LD50:5660 mg/kg	AIHAAP 19,353,58
scu-rbt LDLo:500 mg/kg	HBTXAC 5,72,59
orl-gpg LD50:9470 mg/kg	AIHAAP 19,353,58

Aquatic Toxicity Rating: TLm96:100-10 ppm WQCHM* 3,-,74. Carcinogenic Determination: Indefinite IARC** 20,515,79.

TLV: Air: 350 ppm DTLVS* 4,269,80. *Toxicology Review:* FAZMAE 18,365,74; EATR** EB-TR-75047; AIHAAP 40,A46,79. OSHA Standard: Air: TWA 350 ppm (SCP-J) FEREAC 39,23540,74. DOT: ORM-A, Label: None FEREAC 41,57018,76. Occupational Exposure to 1,1,1-Trichloroethane recm std: Air: CL 350 ppm/15M NTIS**. NCI Carcinogenesis Bioassay Completed; Results Negative (NCITR* NCI-CG-TR-3,77). Currently Tested by NTP for Carcinogenesis by Standard Bioassay Protocol as of December 1980. "NIOSH Manual of Analytical Methods" VOL 1 127, VOL 3 S328. NIOSH Current Intelligence Bulletin 27, 1978. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45,13646,80.

THR: In hmn it causes PSY, GIT, CNS effects. A MOD skn irr, a SEV eye irr in rbts. LOW orl, ipr, ihl in rat, mus. MOD orl, ipr dog; Narcotic in high conc. Causes a proarrhythmic activity which sensitizes the heart to epinephrine-induced arrhythmias. This sometimes will cause a cardiac arrest particularly when this material is massively inhaled as in drug abuse for euphoria. Reacts violently with N_2O_4, O_2, O_2 liquid, Na, NaOH, Na-K alloy.

Disaster Hazard: Dangerous; see chlorides.

For further information see Vol. 2, No. 1 of *DPIM Report.*

1,1,2-TRICHLOROETHANE

CAS RN: 79005 NIOSH #: KJ 3150000

mf: $C_2H_3Cl_3$; mw: 133.40

Liquid, pleasant odor. bp: 114°, fp: −35°, d: 1.4416 @ 20°/4°, vap. press: 40 mm @ 35.2°.

SYNS:

ETHANE TRICHLORIDE
NCI-C04579
BETA-TRICHLOROETHANE
1,2,2-TRICHLOROETHANE
TROJCHLOROETAN(1,1,2) (POLISH)
VINYL TRICHLORIDE

TOXICITY DATA: 3	CODEN:
skn-rbt 500 mg open MLD	UCDS** 6/28/72
skn-rbt 810 mg/24H SEV	JETOAS 9,171,76
eye-rbt 162 mg MLD	JETOAS 9,171,76
skn-gpg 1440 mg/15M	APTOA6 41,298,77
cyt-gpg-skn 2880 ug/kg	APTOA6 41,298,77
orl-mus TDLo:76 gm/kg/78W-I:CAR	NCITR* NCI-CG-TR-74,78
orl-mus TD:152 gm/kg/78W-I:CAR	NCITR* NCI-CG-TR-74,78
orl-rat LD50:1140 mg/kg	UCDS** 6/28/72
ihl-rat LCLo:500 ppm/8H	AIHAAP 30,470,69
ipr-mus LD50:994 mg/kg	TXAPA9 9,139,66
scu-mus LD50:227 mg/kg	JPETAB 123,224,58
orl-dog LDLo:500 mg/kg	AJHYA2 16,325,32
ipr-dog LD50:450 mg/kg	TXAPA9 10,119,67
ivn-dog LDLo:95 mg/kg	QJPPAL 7,205,34
ihl-cat LCLo:13100 mg/m3/4.5H	AHBAAM 116,131,36
scu-rbt LDLo:500 mg/kg	QJPPAL 7,205,34

Aquatic Toxicity Rating: TLm96:100-10 ppm WQCHM* 3,-,74. Carcinogenic Determination: Animal Positive IARC** 20,533,79.

TLV: Air: 10 ppm (skin) DTLVS* 4,406,80. *Toxicology Review:* FAZMAE 18,365,74; AIHAAP 40,A46,79; 27ZTAP 3,146,69. OSHA Standard: Air: TWA 10 ppm (skin) (SCP-J) FEREAC 39,23540,74. NCI Carcinogenesis Bioassay Completed; Results Positive: Mouse (NCITR* NCI-CG-TR-74,78). NCI Carcinogenesis Bioassay Completed; Results Negative: Rat (NCITR* NCI-CG-TR-74,78). "NIOSH Manual of Analytical Methods" VOL 1 127, VOL 2 S134. NIOSH Current Intelligence Bulletin 27, 1978. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8(a) Preliminary Assessment Information Proposed Rule FERREAC 45, 13646,80.

THR: HIGH ivn, scu and MOD orl, ihl, ipr and dermal. MOD skn irr and SEV eye irr in rbts. Trichloroethane has narcotic properties and acts as a local irr to the eyes, nose and lungs. It may also be injurious to the liver and kidneys. A fumigant. An exper CARC. MUT data.

Disaster Hazard: Dangerous; see chlorides.

Incomp: K.

For further information see Vol. 2, No. 6 and Vol. 3, No. 2 of *DPIM Report.*

1,1,1-TRICHLOROETHANE mixed with TETRACHLOROETHYLENE (3:1)

NIOSH #: KJ 3950000

SYNS:

DOWCLENE
EC CLEANER

TOXICITY DATA: 2-1	CODEN:
orl-rat LD50:15 gm/kg	AIHAAP 24,541,63
ihl-rat LC50:3700 ppm/7H	AIHAAP 24,541,63
orl-mus LD50:10 gm/kg	AIHAAP 24,541,63
orl-rbt LD50:13 gm/kg	AIHAAP 24,541,63
orl-gpg LD50:6 gm/kg	AIHAAP 24,541,63

THR: LOW orl, ihl in rat; LOW orl in mus; orl in rbt and orl in gpg.

Disaster Hazard: When heated to decomp it emits very tox fumes of Cl^-.

TRICHLOROETHANOL

CAS RN: 115208 NIOSH #: KM 3850000
mf: $C_2H_3Cl_3O$; mw: 149.40

Liquid. mp: 17.8°, bp: 150° @ 765 mm, d: 1.54 @ 25°/4°, vap. press: 1 mm @ 20°, vap. d: 5.16.

SYNS:
2,2,2-TRICHLOROETHANOL
TRICHLOROETHYL ALCOHOL
2,2,2-TRICHLOROETHYL ALCOHOL

TOXICITY DATA: 3-2	CODEN:
mmo-asn 5 uL/plate/2H	CBINA8 30,9,80
orl-rat LD50:600 mg/kg	12VXAS 8,1069,68
ipr-rat LDLo:300 mg/kg	JPETAB 63,453,38
ivn-mus LD50:201 mg/kg	28ZPAK -,78,72
ivn-rbt LDLo:50 mg/kg	JPETAB 63,453,38

Reported in EPA TSCA Inventory, 1980.
THR: HIGH via ivn and ipr routes. MOD via oral route. An anesthetic. MUT data.
Disaster Hazard: Dangerous; see chlorides.

TRICHLOROETHENYLSILANE

CAS RN: 75945 NIOSH #: VV 6125000
mf: $C_2H_3Cl_3Si$; mw: 161.49

Fuming liquid. bp: 90.6°; d: 1.265 @ 25°/25°; flash p: 16°F.

SYNS:
TRICHLORO(VINYL)SILANE
TRICHLOROVINYL SILICANE
VINYLSILICON TRICHLORIDE
VINYL TRICHLOROSILANE

TOXICITY DATA: 2	CODEN:
skn-rbt 1 mg/24H	AMIHBC 10,61,54
skn-rbt 625 mg open SEV	UCDS** 1/19/72
eye-rbt 50 ug SEV	AMIHBC 10,61,54
orl-rat LD50:1280 mg/kg	AMIHBC 10,61,54
ihl-rat LCLo:500 ppm/4H	UCDS** 1/19/72
orl-mus LD50:3160 mg/kg	HYSAAV 34,334,69
ihl-mus LC50:3020 mg/m3/4H	HYSAAV 34,334,69
skn-rbt LD50:680 mg/kg	AMIHBC 10,61,54

Aquatic Toxicity Rating: TLm96:100-10 ppm WQCHM* 4,-,74. DOT: Flammable Liquid, Label: Flammable Liquid FEREAC 41,57018,76. Reported in EPA TSCA Inventory, 1980.
THR: MOD orl, ihl, skn. A skn, eye irr. See also chlorosilanes.
Fire Hazard: Dangerous; reacts violently with water, moist air.
Disaster Hazard: When heated to decomp it emits tox fumes of Cl^-. Will react with water or steam to produce tox and corrosive fumes.

2,2,2-TRICHLORO-1-ETHOXYETHANOL

CAS RN: 515833 NIOSH #: KM 4725000
mf: $C_4H_7Cl_3O_2$; mw: 193.46

Crystals, less sol in water than chloral hydrate, sol in organic solvents. d: 1.143, mp: 47.5°, bp: 116°.

SYNS:
CHLORAL ALCOHOLATE
CHLORAL ETHYLALCOHOLATE
CHLORAL, ETHYL HEMIACETAL
TRICHLOROACETALDEHYDE MONOETHYLACETAL

TOXICITY DATA: 2	CODEN:
orl-rat LD50:880 mg/kg	JPETAB 78,340,43
orl-dog LDLo:1200 mg/kg	JPETAB 78,340,43
orl-cat LDLo:500 mg/kg	JPETAB 78,340,43
orl-rbt LDLo:1100 mg/kg	JPETAB 78,340,43

Reported in EPA TSCA Inventory, 1980.
THR: MOD via oral route.
Disaster Hazard: When heated to decomp it emits tox fumes of Cl^-.

TRICHLOROETHYLAMINE

NIOSH #: KR 9850000
mf: $C_2H_4Cl_3N$; mw: 148.41

SYN: TCEA

TOXICITY DATA:	CODEN:
mmo-asn 1700 umol/L	SOGEBZ 6,220,70

THR: MUT data.
Disaster Hazard: When heated to decomp it emits very tox fumes of Cl^- and NO_x.

TRICHLOROETHYL CARBAMATE

CAS RN: 107697 NIOSH #: FD 1750000
mf: $C_3H_4Cl_3NO_2$; mw: 192.43

SYN: CARBAMIC ACID 2,2,2-TRICHLOROETHYL ESTER

TOXICITY DATA: 3	CODEN:
ipr-mus TDLo:3250 mg/kg/13W-I TFX:NEO	JNCIAM 8,99,47
ipr-mus LD50:500 mg/kg	JNCIAM 8,99,47

THR: An exper NEO. MOD ipr. See also esters, carbamates.
Disaster Hazard: When heated to decomp it emits very tox fumes of Cl^- and NO_x.

TRICHLORO ETHYLENE

CAS RN: 79-01-6 NIOSH #: KX 4550000
mf: C_2HCl_3; mw: 131.38

Mobile liquid; characteristic odor of chloroform. d: 1.4649 @ 20°/4°; bp: 86.7°; flash p: 89.6°F; lel = 12.5%; uel = 90% @ above 30°; mp: −73°; fp: −86.8°; autoign. temp.: 788°F; vap. press: 100 mm @ 32°; vap. d: 4.53.

SYNS:
ACETYLENE TRICHLORIDE
1-CHLORO-2,2-DICHLOROETHYLENE
1,1-DICHLORO-2-CHLOROETHYLENE
DOW-TRI
ETHYLENE TRICHLORIDE
NCI-C04546
TRICHLOORETHEEN (DUTCH)
TRICHLORAETHEN (GERMAN)
TRI-CLENE
TRICLORETENE (ITALIAN)
VESTROL

SKIN AND EYE IRRITATION DATA: 3	CODEN:
eye-hmn 5 ppm	JOCMA7 2,383,60
skn-rbt 500 mg/24H SEV	28ZPAK -,28,72
eye-rbt 20 mg/24HSEV	28ZPAK -,28,72

MUTATION DATA:	CODEN:
mmo-sat 100 uL/plate	NIOSH* 5AUG77
mma-sat 5 pph/2H	ARTODN 41,249,79
mma-smc 10 mL/L	MUREAV 48,173,77

slt-mus-ipr 1 mmol/L	MUREAV 46,202,77
dns-mus-orl 2500 mg/L	NTIS** AD-A080-636
dns-mus:bmr 1 mmol/L	NTIS** AD-A080-636
hma-mus/amc 400 mg/kg	JEPTDQ 1,411,78

REPRODUCTIVE EFFECTS

DATA:	CODEN:
ihl-rat TCLo:1800 ppm/24H (1-2D preg)	APTOD9 19,A22,80
ihl-rat TCLo:100 ppm/4H (6-22D preg)	JPHYA7 276,24P,78
ihl-rat TCLo:1800 ppm/6H (1-20D preg)	TXCYAC 14,153,79

TUMORGENIC DATA:	CODEN:
ihl-rat TCLo:500 ppm/6H/77W-I:ETA	ARTODN 43,237,80
orl-mus TDLo:455 g/kg/78W-I:CAR	NCITR* NCI-CG-TR-2,76
ihl-mus TCLo:100 ppm/6H/77W-I:ETA	ARTODN 43,237,80
ihl-ham TCLo:100 ppm/6H/77W-I:ETA	ARTODN 43,237,80
orl-mus TD:912 g/kg/78W-I:CAR	NCITR* NCI-CG-TR-2,76
ihl-mus TC:500 ppm/6H/77W-I:ETA	ARTODN 43,237,80

TOXICITY DATA:	CODEN:
orl-hmn LDLo:7 g/kg	ARTODN 35,295,76
ihl-hmn TCLo:6900 mg/M³/10M:CNS	AHBAAM 116,131,36
ihl-hmn TCLo:160 ppm/83M:CNS	AIHAAP 23,167,62
ihl-hmn TDLo:812 mg/kg:SYS	BMJOAE 2,689,45
ihl-man TCLo:110 ppm/8H:IRR	BJIMAG 28,293,71
ihl-man LCLo:2900 ppm	NZMJAX 50,119,51
orl-rat LD50:4920 mg/kg	AIHAAP 30,470,69
ihl-rat LCLo:8000 ppm/4H	AIHAAP 30,470,69
orl-mus LD50:2402 mg/kg	NTIS** AD-A080-636
ihl-mus LCLo:3000 ppm/2H	AEPPAE 141,19,29
ipr-mus LD50:3000 mg/kg	JETOAS 7(4),247,74
ivn-mus LD50:34 mg/kg	CBCCT* 6,141,54
orl-dog LDLo:5860 mg/kg	12VXA5 8,1069,68
ipr-dog LD50:1900 mg/kg	TXAPA9 10,119,67
scu-dog LDLo:150 mg/kg	HBTXAC 5,76,59
ivn-dog LDLo:150 mg/kg	QJPPAL 7,205,34
orl-cat LDLo:5866 mg/kg	NBTXAC 5,76,59
ihl-cat LCLo:32500 mg/M³/2H	AMBAAM 116,131,36
orl-rbt LDLo:7330 mg/kg	HBTXAC 5,76,59
scu-rbt LDLo:1800 mg/kg	QJPPAL 7,205,34
ihl-gpg LCLo:37200 ppm/40M	HBTXAC 5,76,59

Aquatic Toxicity Rating:TLm96:1000-100 ppm WQCHM* 3,-,74. Carcinogenic Determination: Animal Positive IARC** 20,545,79; IARC** 11,263, 76.

TLV: TWA 50 ppm; STEL 150 ppm DTLVS* 4,406, 80.

Toxicology Review: JTEHD6 2(3),671,77; CLPTAT 8, 91,67; JOCMA7 16(3),194,74; JOCMA7 17(9),603,75; FNSCA6 2,67,73; BNYMAM 54,413,78; 27ZTAP 3,146,69. OSHA Standard: Air: TWA 100 ppm; C1200; Pk 300/5M/2H (SCP-J) FEREAC 39,23540,74. DOT: ORM-A, Label: None FEREAC 41,57018,76. Occupational Exposure to Trichloroethylene recm std: Air: TWA 100 ppm; CL 150 ppm/10M NTIS**. Occupational Exposure to Waste Anesthetic Gases and Vapors recm std: Air: CL 2 ppm/1H NTIS**. NCI Carcinogenesis Bioassay Completed; Results Positive: Mouse (NCITR*NCI-CG-TR-2,76); Results Negative: Rat (NCITR(NCI-CG-TR-2,76). Currently tested by NTP for carcinogenesis by Standard Bioassay Protocol as of April 1982. NTP Carcinogenesis Bioassay Completed as of April 1982. "NIOSH Manual of Analytical Methods" VOL 1 127, Vol 3, S336. NIOSH Current Intelligence Bulletin 2, 1975. Reported in EPA TSCA Inventory, 1980. EPA TSCA 8e NO: 05780146. Followup sent as of April, 1979.

THR: A strong skn, eye irr. MUT data. An exper TER, ETA, CARC. HIGH ivn, scu, ihl; MOD ihl, orl, ipr; LOW orl, ihl. Inhal of high conc causes narcosis and anesthesia. A form of addiction has been observed in exposed workers. Prolonged inhal of mod conc causes headache and drowsiness. Fatalities following severe, acute exposure have been attributed to ventricular fibrillation resulting in cardiac failure. There is damage to liver and other organs from chronic exposure. Cases have been reported but are of questionable validity. Determination of the metabolites trichloracetic acid and trichloroethanol in urine reflects the absorption of trichloroethylene. A food additive permitted in food for human consumption. A common air contaminant.

Fire Hazard: Low, when exposed to heat or flame. High conc of trichloroethylene vapor in high-temp air can be made to burn mildly if plied with a strong flame. Though such a condition is difficult to produce, flames or arcs should not be used in closed equipment which contains any solvent residue or vapor.

Spontaneous Heating: No.

Disaster Hazard: Dangerous. When heated to decomp it emits tox fumes of Cl^-. See chlorides.

For further information see Vol. 1, No. 2 and Vol. 3, No. 1 of *DPIM Report.*

Incomp: Can react violently with Al, Ba, N_2O_4, Li, Mg, liquid O_2, O_3, KOH, KNO_3, Na, NaOH, Ti.

alpha-TRICHLOROETHYLIDENE GLYCEROL

CAS RN: 4692493 NIOSH #: JI 3380000
mf: $C_5H_7Cl_3O_3$; mw: 221.47

SYN: ALPHA-2-(TRICHLOROMETHYL)-1,3-DIOXOLANE-4-METHANOL

TOXICITY DATA: 2	CODEN:
ipr-mus LD50:920 mg/kg	JPETAB 81,72,44
ivn-mus LD50:520 mg/kg	JPETAB 81,72,44

THR: MOD ipr, ivn.

Disaster Hazard: When heated to decomp it emits tox fumes of Cl^-.

beta-TRICHLOROETHYLIDENE GLYCEROL

CAS RN: 4692493 NIOSH #: JI 3440000
mf: $C_5H_7Cl_3O_3$; mw: 221.47

SYN: BETA-2-(TRICHLOROMETHYL)-1,3-DIOXOLANE-4-METHANOL

TOXICITY DATA: 2	CODEN:
ipr-mus LD50:959 mg/kg	JPETAB 81,72,44
ivn-mus LD50:518 mg/kg	JPETAB 81,72,44

THR: MOD ipr, ivn.

Disaster Hazard: When heated to decomp it emits tox fumes of Cl^-.

Reference 11

Uncontrolled Hazardous Waste Site Ranking System

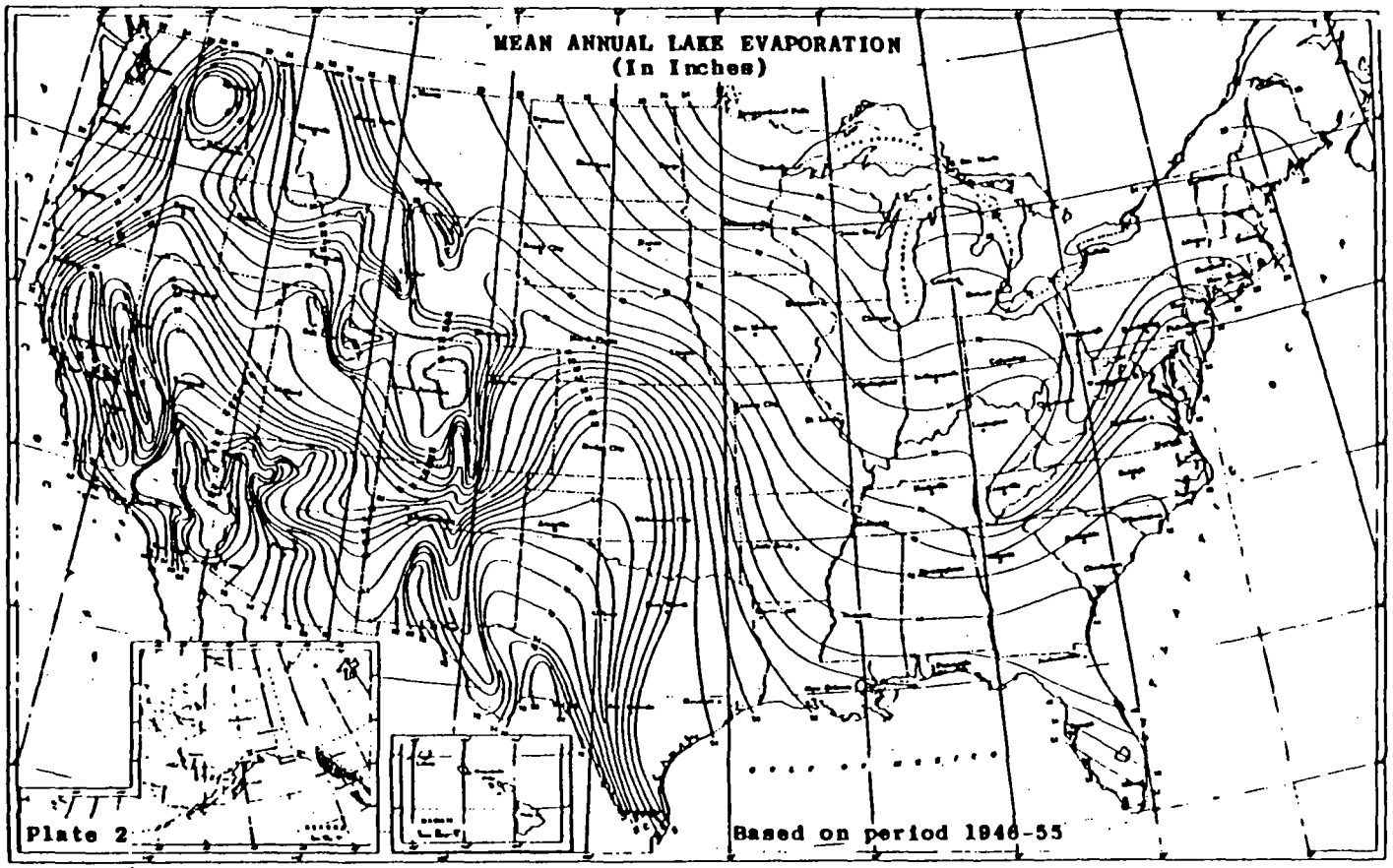
A Users Manual

(HW-10)

Originally Published in
the July 16, 1982, *Federal Register*

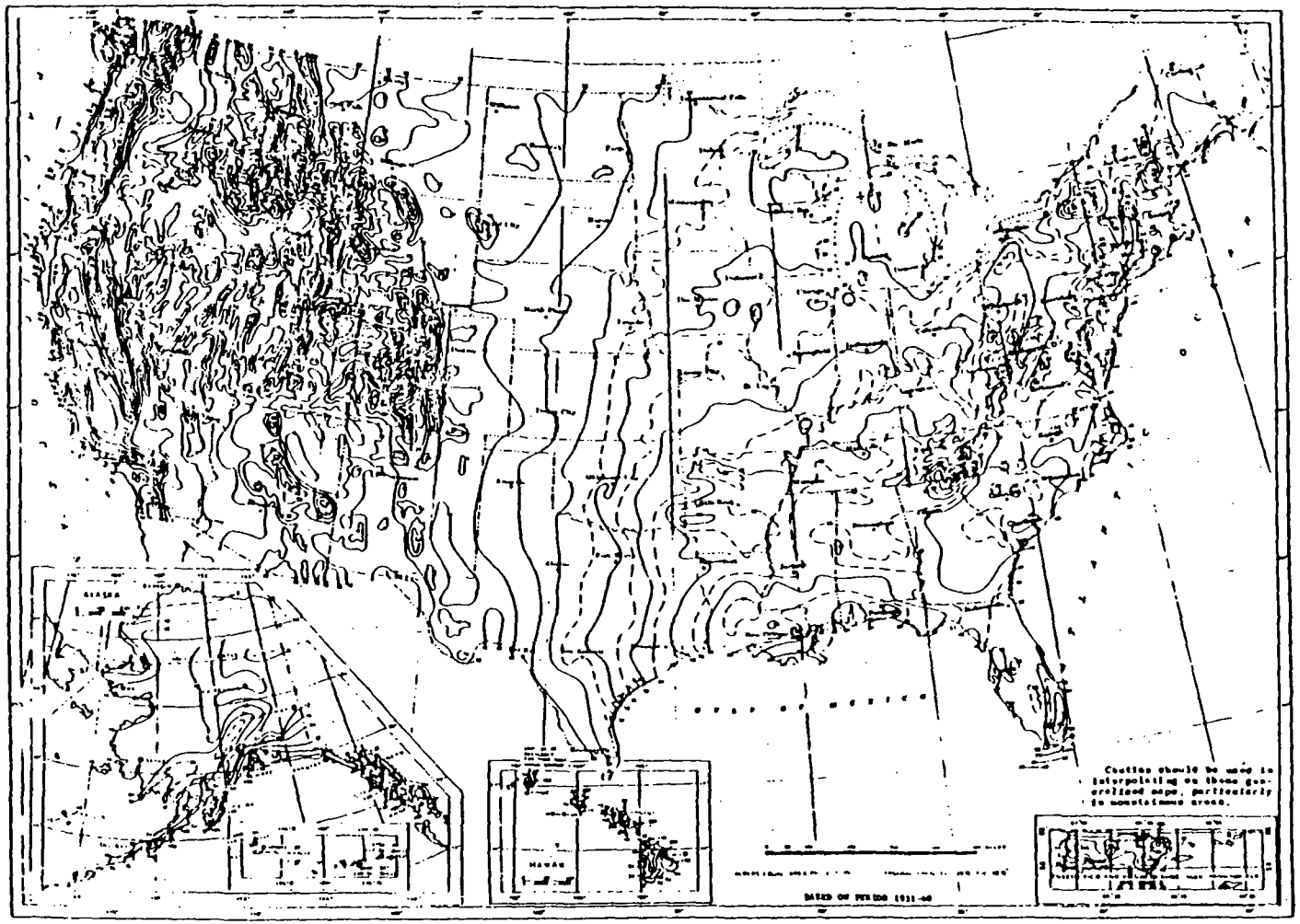
United States
Environmental Protection
Agency

1984



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Ashville, N.C., 1979.

FIGURE 4
MEAN ANNUAL LAKE EVAPORATION
(IN INCHES)



Source: Climatic Atlas of the United States, U.S. Department of Commerce, National Climatic Center, Asheville, N.C., 1979.

FIGURE 5
NORMAL ANNUAL TOTAL PRECIPITATION (INCHES)

TABLE 2

PERMEABILITY OF GEOLOGIC MATERIALS*

Type of Material	Approximate Range of Hydraulic Conductivity	Assigned Value
Clay, compact till, shale; unfractured metamorphic and igneous rocks	$<10^{-7}$ cm/sec	0
Silt, loess, silty clays, silty loams, clay loams; less permeable limestone, dolomites, and sandstone; moderately permeable till	$10^{-5} - 10^{-7}$ cm/sec	1
Fine sand and silty sand; sandy loams; loamy sands; moderately permeable limestone, dolomites, and sandstone (no karst); moderately fractured igneous and metamorphic rocks, some coarse till	$10^{-3} - 10^{-5}$ cm/sec	2
Gravel, sand; highly fractured igneous and metamorphic rocks; permeable basalt and lavas; karst limestone and dolomite	$>10^{-3}$ cm/sec	3

*Derived from:

Davis, S. N., Porosity and Permeability of Natural Materials in Flow-Through Porous Media, R.J.M. DeWest ed., Academic Press, New York, 1969

Freeze, R.A. and J.A. Cherry, Groundwater, Prentice-Hall, Inc., New York, 1979

TABLE 4
WASTE CHARACTERISTICS VALUES
FOR SOME COMMON CHEMICALS

CHEMICAL/COMPOUND	TOXICITY [1]	PERSISTENCE [2]	INFLAMMABILITY [3]	REACTIVITY [3]
Acetaldehyde	3	0	3	2
Acetic Acid	3	0	2	1
Acetone	2	0	3	0
Aldrin	3	3	1	0
Ammonia, Anhydrous	3	0	1	0
Aniline	3	1	2	0
Benzene	3	1	3	0
Carbon Tetrachloride	3	3	0	0
Chlordane	3	3	0*	0*
Chlorobenzene	2	2	3	0
Chloroform	3	3	0	0
Cresol-O	3	1	2	0
Cresol-MAP	3	1	1	0
Cyclohexane	2	2	3	0
Endrin	3	3	1	0
Ethyl Benzene	2	1	3	0
Formaldehyde	3	0	2	0
Formic Acid	3	0	2	0
Hydrochloric Acid	3	0	0	0
Isopropyl Ether	3	1	3	1
Lindane	3	3	1	0
Methane	1	1	3	0
Methyl Ethyl Ketone	2	0	3	0
Methyl Parathion in Xylene Solution	3	0Δ	3	2
Naphthalene	2	1	2	0
Nitric Acid	3	0	0	0
Parathion	3	0Δ	1	2
PCB	3	3	0Δ	0Δ
Petroleum, Kerosene (Fuel Oil No. 1)	3	1	2	0
Phenol	3	1	2	0
Sulfuric Acid	3	0	0	2
Toluene	2	1	3	0
Trichlorobenzene	2	3	1	0
α-Trichloroethane	2	2	1	0
Xylene	2	1	3	0

[1] Sax, N. I., Dangerous Properties of Industrial Materials, Van Nostrand Rheinhold Co., New York, 4th ed., 1975. The highest rating listed under each chemical is used.

[2] JRB Associates, Inc., Methodology for Rating the Hazard Potential of Waste Disposal Sites, May 5, 1980.

[3] National Fire Protection Association, National Fire Codes, Vol. 13, No. 49, 1977.

* Professional judgment based on information contained in the U.S. Coast Guard CHRIS Hazardous Chemical Data, 1978.

Δ Professional judgment based on existing literature.

TABLE 5

PERSISTENCE (BIODEGRADABILITY) OF SOME ORGANIC COMPOUNDS*

VALUE = 3 HIGHLY PERSISTENT COMPOUNDS

aldrin	heptachlor
benzopyrene	heptachlor epoxide
benzothiazole	1,2,3,4,5,7,7-heptachloronorbornene
benzothiophene	hexachlorobenzene
benzyl butyl phthalate	hexachloro-1,3-butadiene
bromochlorobenzene	hexachlorocyclohexane
bromoform butanal	hexachloroethane
bromophenyl phenyl ether	methyl benzothiazole
chlordane	pentachlorobiphenyl
chlorohydroxy benzophenone	pentachlorophenol
bis-chloroisoprophyl ether	1,1,3,3-tetrachloroacetone
m-chloronitrobenzene	tetrachlorobiphenyl
DDE	thiomethylbenzothiazole
DDT	trichlorobenzene
dibromobenzene	trichlorobiphenyl
dibutyl phthalate	trichlorofluoromethane
1, 4-dichlorobenzene	2,4,6-trichlorophenol
dichlorodifluoroethane	triphenyl phosphate
dieldrin	bromodichloromethane
diethyl phthalate	bromoform
di(2-ethylhexyl)phthalate	carbon tetrachloride
dihexyl phthalate	chloroform
di-isobutyl phthalate	chloromochloromethane
dimethyl phthalate	dibromodichloroethane
4,6-dinitro-2-aminophenol	tetrachloroethane
dipropyl phthalate	1,1,2-trichloroethane
endrin	

VALUE = 1 SOMEWHAT PERSISTENT COMPOUNDS

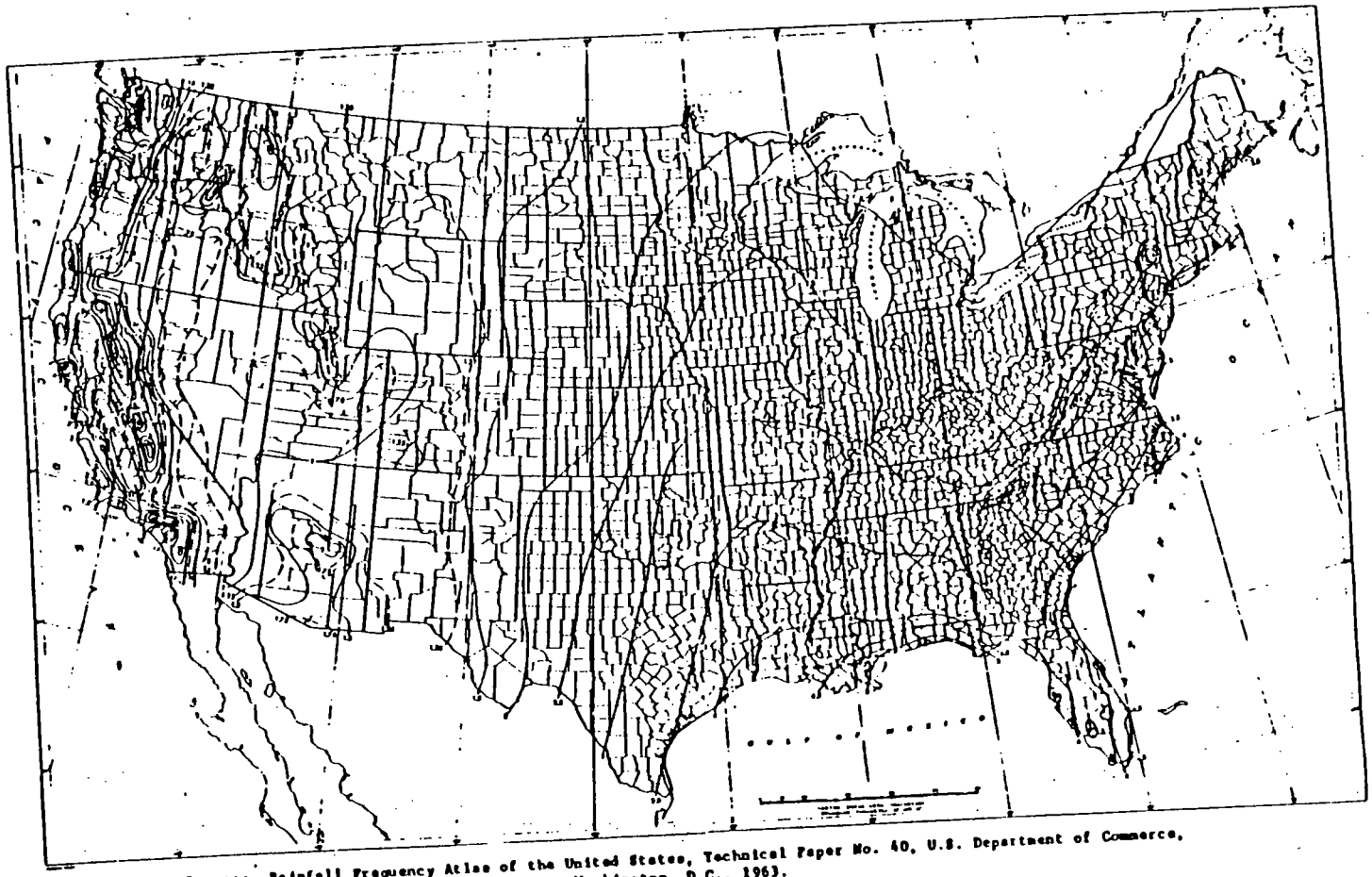
acetylene dichloride	limonene
behenic acid, methyl ester	methyl ester of lignoceric acid
benzene	methane
benzene sulfonic acid	2-methyl-5-ethyl-pyridine
butyl benzene	methyl naphthalene
butyl bromide	methyl palmitate
e-caprolactam	methyl phenyl carbinol
carbon-disulfide	methyl stearate
o-cresol	naphthalene
decane	nonane
1,2-dichloroethane	octane
1,2-dimethoxy benzene	octyl chloride
1,3-dimethyl naphthalene	pentane
1,4-dimethyl phenol	phenyl benzoate
dioctyl adipate	phthalic anhydride
n-dodecane	propylbenzene
ethyl benzene	1-terpineol
2-ethyl-n-hexane	toluene
o-ethyltoluene	vinyl benzene
isodecane	xylene
isoprophyl benzene	

VALUE = 2 PERSISTENT COMPOUNDS

acenaphthylene	cis-2-ethyl-4-methyl-1,3-dioxolane
atrazine	trans-2-ethyl-4-methyl-1,3-dioxolane
(diethyl) atrazine	guaiacol
barbital	2-hydroxyadiponitrile
borneol	isophorone
bromobenzene	indene
camphor	isobornaol
chlorobenzene	isopropenyl-r-isopropyl benzene
1,2-bis-chloroethoxy ethane	2-methoxy biphenyl
b-chloroethyl methyl ether	methyl biphenyl
chloromethyl ether	methyl chloride
chloromethyl ethyl ether	methylindene
3-chloropyridine	methylene chloride
di-t-butyl-p-benzoquinone	nitroanisole
dichloroethyl ether	nitrobenzene
dihyrocarvone	1,1,2-trichloroethylene
dimethyl sulfoxide	trimethyl-trioxo-hexahydro-triazine isomer
2,6-dinitrotoluene	

VALUE = 0 NONPERSISTENT COMPOUNDS

acetaldehyde	methyl benzoate
acetic acid	3-methyl butanol
acetone	methyl ethyl ketone
acetophenone	2-methylpropanol
benzoic acid	octadecane
di-isobutyl carbinol	pentadecane
docosane	pentanol
eicosane	propanol
ethanol	propylamine
ethylamine	tetradecane
hexadecane	n-tridecane
methanol	n-undecane



Source: Rainfall Frequency Atlas of the United States, Technical Paper No. 40, U.S. Department of Commerce, U.S. Government Printing Office, Washington, D.C., 1963.

FIGURE 8
1-YEAR 24-HOUR RAINFALL
(INCHES)

Reference 12

PREWAY
INDUSTRIES INC.
RR #1 Box 1-A 1600 Jones Road • Paragould, Arkansas 72450 U.S.A. • (501) 236-8731 • TELEX 78-3570 PREWAY PAGD

WJR 6/23

June 16, 1986

JUN 19 1986

Mr. Michael J. Higgs
Tennessee Department of Health and Environment
Division of Superfund
Customs House
701 Broadway
Nashville, Tennessee 37219-5403

Dear Mr. Higgs:

This letter is in response to the identification of documents found at United Technology Carrier during your investigation of their facility in Collierville, Tennessee.

The following is a description of each document in question.

A) Document #1- The partial minutes from a monthly Safety-Environment meeting held at Carrier in Collierville. Mr. Brewer at Carrier tape recorded these minutes and had them typed at a later date.

B) Document #2- Calation sheet for estimating the amount of sludge and soil removed. Calculations were done by myself in about October of 1980.

C) Document #3- Graph showing concentrations for chemicals in Lagoon sludge at various depths. This sheet was used to determine the final depth of excavation (depth of Lagoon at 'zero' amount of Trichloroethyene plus 1 foot of clean clay soil, see document page #2). This sheet was drawn by myself with analysis perfomed at Carrier in Syracuse, New York.

D) Document #4- Chemical concentration from samples taken by myself from Lagoon at Carrier in Collierville. Tests were performed at Carrier in Syracuse, New York, by Hank Balduzzi.

E) Document #5- A diagram of an unconfined aquifer drawdown using flow nets. This document is not related at all to Carrier in Collierville. I believe this was drawn by myself in preparation for the Professional Engineer's Exam.

If I can be of further assistance please contact me.

Sincerely,

Clifton H. Ritter
Senior Manufacturing Engineer

#1

12/09/80

The lagoon has been closed and the hazardous waste is piled beside the road and covered with plastic awaiting shipment to a hazardous waste land fill. Plans should be completed and the waste shipped in January 1981.

Soil borings will be taken between the closed lagoon and water well for the city of Collierville. Mr. Ritter said the borings and the testing are necessary to insure the hazardous waste is not migrating toward the well. He also stated that his study of the U.S. geodetic survey maps indicated that the waste that did seep into the soil would migrate in the opposite direction from the well. He pointed out that a siphoning effect could occur.

An analysis of Collierville water samples will be completed in December, 1980.

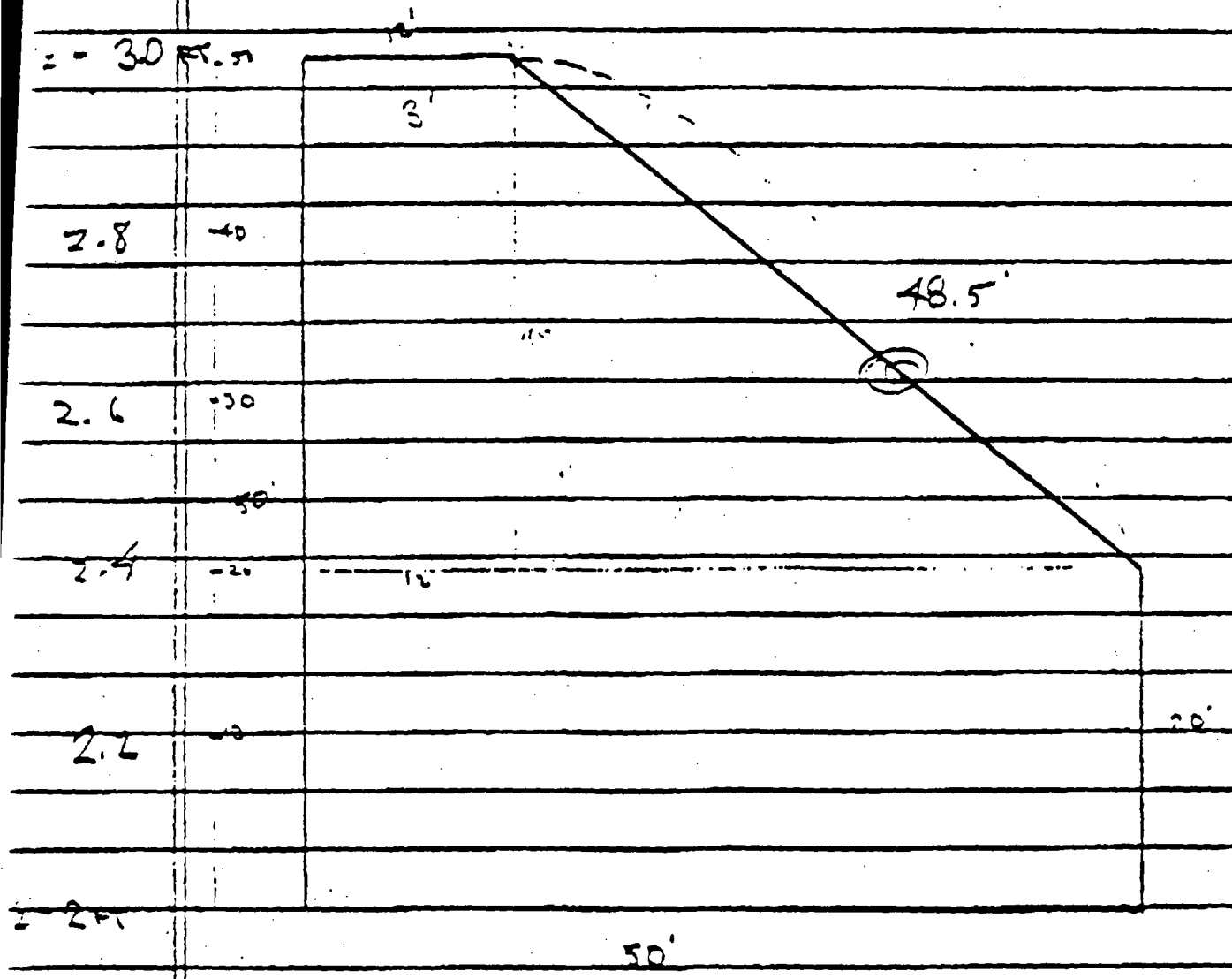
There was a discussion about a 2,000 to 5,000 gallon spill of trichloroethylene. Mr. Ritter believes that the trichlor would migrate towards the creek. Because there could be a siphoning effect, soil borings and the samplings would be necessary to determine which direction the trichlor is traveling.

#2

LAGOON DIMENSION

N

1930 FT² @ 3 [illegible]



SAND (6" → 12" SLUDGE + 1' GOOD SOIL) WAS [illegible]

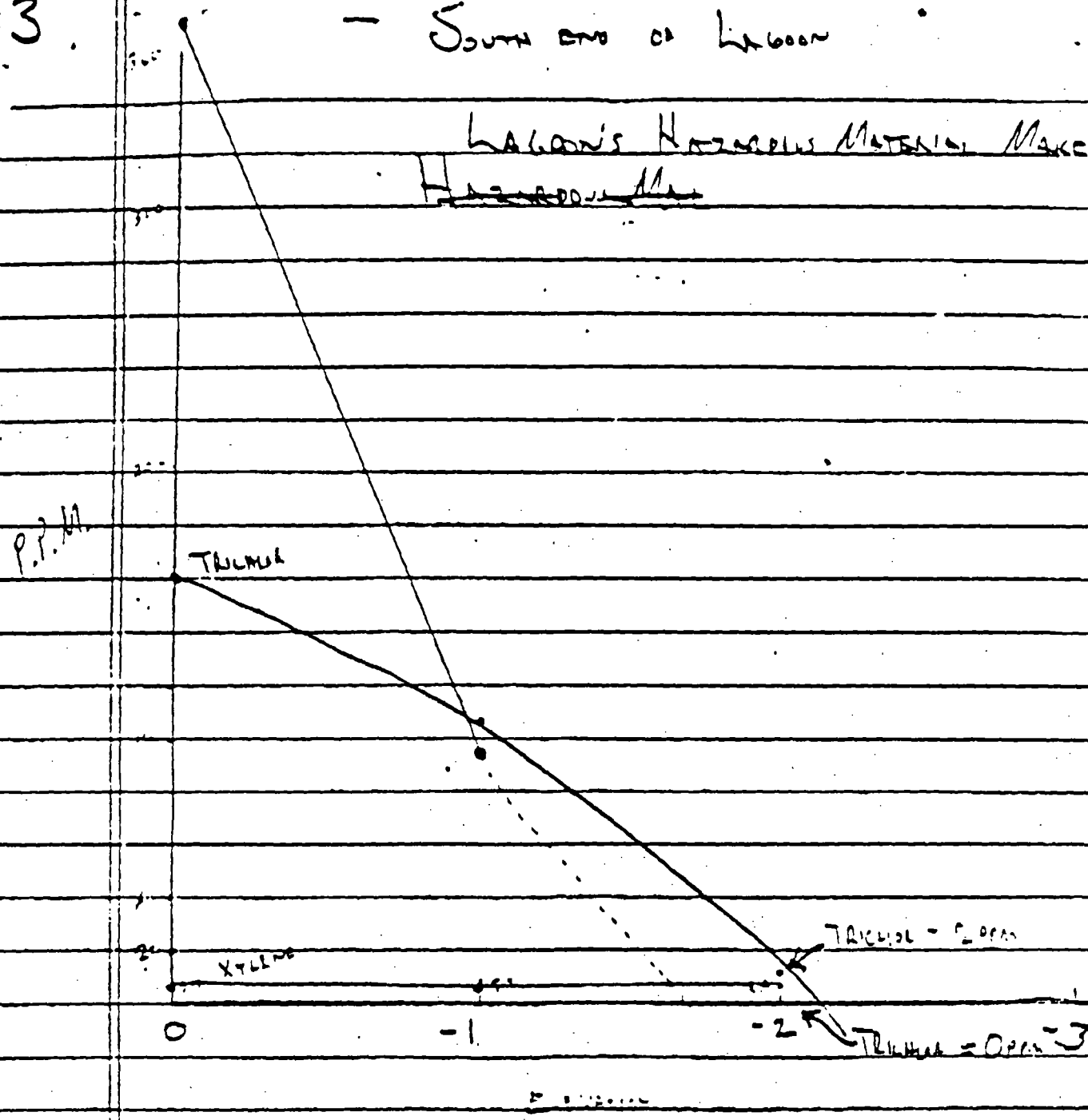
= 15040³

#3.

— North End of Lagoon
— South End of Lagoon

Lagoon's Hazardous Material Make-up

~~Hazardous Ma~~



Xylene Level no [illegible] @ S[illegible]

Cyanide Levels were no [illegible]

MEK [illegible] > 1 [illegible]

Toluene " " " " " "

Trichlor Levels - 12 ppm @ -2 ft N

= 0 ppm @ -2 ft S

#4

Percents (%) Oct 3

Syracuse

-368-6319-28645	Top of Tank	Bottom of Tank	Average
Specific Gravity			
pH			
Solvent Content			
Flash Point			
Water Content			
Trichloroethylene			

Lagoon Results in Solvents Sept. 20th

Content (mg/L)

Xylene	
Trichlor	
Toluene	
MEK	

	NT	N1'	N2'	ST	S1'	S2'
Pok Hank Balduzzi CN⁻	2.4 ppm	0.4 ppm	0.6 ppm	0.48 ppm	0.84 ppm	0.4 ppm
Trichlor	160 ppm mg/kg	106 mg/kg	12.3 mg/kg	369.0 mg/kg	93.7 mg/kg	—
Xylene ?	2.7 mg/kg	5.2 mg/kg	6.4 mg/kg	11.9 mg/kg		—
Toluene ?	1.8 mg/kg					—
MEK			2.5 mg/kg	7.8 mg/kg	1.4 mg/kg	—

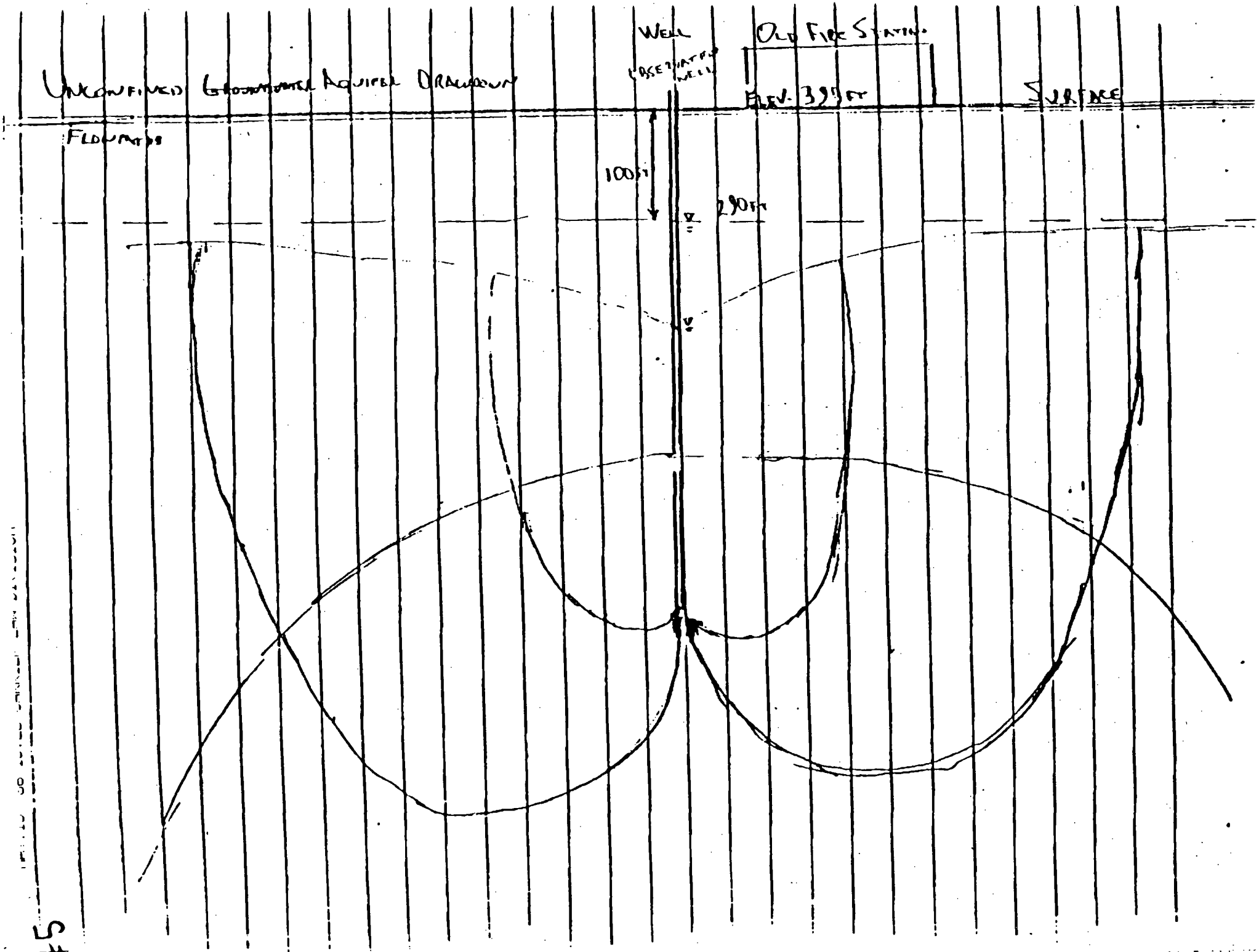
Abandoned Dump

Ba Cr

None exceed Arsenic → water sample

only .004 ppm water .02 ppm

#1 .28 ppm #4 .07 ppm


Unconfined Groundwater Aquifer Drawdown
Well
Observation Well
Old Fire Station
Elev. 395 ft
Surface
Flowpaths
100 ft
290 ft

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

OFFICE CORRESPONDENCE

File

FROM	TO	DATE
MJH	File	7/8/86

DATE: July 3, 1986 79-743

TO: The Carrier Air Conditioning Company - File

FROM: Michael J. Higgs MJH

SUBJECT: Water Use Survey in the vicinity of Collierville

On April 15, 1986, Michael Higgs and Gordon Caruthers conducted a water use survey in the vicinity of the Carrier Air Conditioning Company facility in Collierville in Shelby County, Tennessee. The purpose of the survey was to determine the uses of groundwater within a three mile radius of the facility and surface water within three miles downstream from the facility.

Mssrs. Higgs and Caruthers met with James Mathis, Director of Public Works for the City of Collierville. Mr. Mathis identified two wells approximately 1200 ft. NW of the Carrier facility as sources of drinking water for the City of Collierville, Mr. Mathis referred to these wells as "water plant #2" and estimated their depths as approximately 350 ft. with a 53 ft. static water level. At the request of Higgs and Caruthers, Mr. Mathis indicated upon the Collierville, Tennessee 9½ minute topographic quadrangle those areas served by the City of Collierville water system. Mr. Mathis also indicated those areas served by other utility districts. Mr. Mathis further stated that the City supplied 3217 water connections.

After meeting with Mr. Mathis, Higgs and Caruthers, using the information concerning service area supplied by Mr. Mathis, drove along all the roads within the three mile radius of the Carrier facility that are not served with water from a municipal supply system. Higgs and Caruthers counted 146 houses within the three mile radius as not being served by a municipal water system.

It is assumed that all houses outside the service area of the City of Collierville and other utility districts are using groundwater as a source of drinking water. With 146 houses and assuming 3.8 persons per house yield a count of 555 persons. Assuming 3.8 persons per connection for the City of Collierville water system yields 12,225 persons served by the City of Collierville wells. This yields a total population using as a source of drinking water wells within a three mile radius of the site of 12,780.

Higgs and Carruthers did not identify any surface water use for Nonconnah Creek within three miles downstream from the Carrier facility.

MH/lag CH #9

FROM	DATE

TO

PH-0001
SR 3/77

MISSING
REF
14

Reference 14

Reference 15

DEPARTMENT OF THE INTERIOR

Fish and Wildlife Service

50 CFR Part 17

Republication of the Lists of Endangered and Threatened Species

AGENCY: Fish and Wildlife Service, Interior.

ACTION: Final rule.

SUMMARY: The Service republishes the U.S. Lists of Endangered and Threatened Wildlife and Plants. The last complete republication was May 20, 1980 (45 FR 33768–33781). Minor changes, principally in names of the species, are incorporated in this republication.

DATES: This rule is effective on July 27, 1983.

ADDRESSES: Comments concerning this republication should be sent to the Associate Director—Federal Assistance, Fish and Wildlife Service, U.S. Department of the Interior, Washington, D.C. 20240.

FOR FURTHER INFORMATION CONTACT: Mr. John L. Spinks, Jr., Chief, Office of Endangered Species, U.S. Fish and Wildlife Service, Washington, D.C. 20240 (703/235–2771).

SUPPLEMENTARY INFORMATION:

Background

These lists contain the names of species officially listed as Endangered or Threatened under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531, *et seq.*) through the date of this republication. The listing regulations promulgated under that Act are found at 50 CFR Part 424 and are under revision to conform to the Endangered Species Act Amendments of 1982 (Pub. L. 97–304, 96 Stat. 1411). The previous compilation of these lists appears in the 1982 edition of the Code of Federal Regulations for Title 50, which was actually issued in early 1983. That compilation was effective through October 1, 1982. This republication of §§ 17.11 and 17.12 incorporates all subsequent changes (i.e., additions, reclassifications, and deletions) published as Final Rules in the Federal Register.

In addition to those changes, the Service has made extensive revisions on some of the entries. Most of these changes reflect current nomenclature. The entries for the common and scientific names of many plants and animals are amended by adding synonyms, indicated by the use of (=). Synonyms aid law enforcement officials, importers, exporters, and many others who routinely use these names by identifying alternative names that may appear in documents and other references.

The species named in these lists were placed there either by the U.S. Fish and Wildlife Service, Department of the Interior, or jointly by that Service and the National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Department of Commerce. References to "Services" in the text of §§ 17.11 and 17.12 refer to those two agencies. The Fish and Wildlife Service maintains the lists through republications and other administrative practices.

No entry to these lists has been added, deleted, or significantly altered by this republication. Such actions must be published as separate documents in the Federal Register.

Minor changes are made in §§ 17.11(d) and 17.12(d) to clarify that some of the data in these lists are provided for the information of the reader and may now be changed without public notice when the annual (October 1) compilation of Title 50 is being done. This procedure will annually save the government several thousand dollars in publication costs in the daily Federal Register by permitting such changes of a nonregulatory nature.

The Service finds for good cause that this document shall be effective upon publication and that notice and public comment are unnecessary. This action is merely a republication of existing, and previously published, requirements. By bringing earlier lists up to date, it will provide more timely guidance to the public. Readers are requested to advise the Service of any errors or omissions, particularly with regard to historic ranges and alternative names in these lists.

Authors

This document was compiled by the staff of the Office of Endangered Species, U.S. Fish and Wildlife Service, Washington, D.C. 20240 (703/235–1975).

List of Subjects in 50 CFR Part 17

Endangered and threatened species.

Dated: July 21, 1983.

J. Craig Potter,

Acting Assistant Secretary for Fish and Wildlife and Parks.

Regulations Promulgation

PART 17—[AMENDED]

Accordingly, the Service amends Part 17 of Title 50 of the Code of Federal Regulations as follows:

1. The authority citation for Part 17 reads as follows:

Authority: Pub. L. 93–205, 87 Stat. 884; Pub. L. 95–632, 92 Stat. 3751; Pub. L. 96–159, 93 Stat. 1241; and Pub. L. 97–304, 96 Stat. 1411 (16 U.S.C. 1531, *et seq.*).

2. Revise Subpart B of 50 CFR Part 17 to read as follows:

Subpart B—Lists

§ 17.11 Endangered and threatened wildlife.

(a) The list in this section contains the names of all species of wildlife which have been determined by the Services to be Endangered or Threatened. It also contains the names of species of wildlife treated as Endangered or Threatened because they are sufficiently similar in appearance to Endangered or Threatened species (see § 17.50 *et seq.*).

(b) The columns entitled "Common Name," "Scientific Name," and "Vertebrate Population Where Endangered or Threatened" define the species of wildlife within the meaning of the Act. Thus, differently classified geographic populations of the same vertebrate subspecies or species shall be identified by their differing geographic boundaries, even though the other two columns are identical. The term "Entire" means that all populations throughout the present range of a vertebrate species are listed. Although common names are included, they cannot be relied upon for identification of any specimen, since they may vary greatly in local usage. The Services shall use the most recently accepted scientific name. In cases in which confusion might arise, a synonym(s) will be provided in parentheses. The Services shall rely to the extent practicable on the *International Code of Zoological Nomenclature.*

(c) In the "Status" column the following symbols are used: "E" for Endangered, "T" for Threatened, and "E [or T] (S/A)" for similarity of appearance species.

(d) The other data in the list are nonregulatory in nature and are provided for the information of the reader. In the annual revision and compilation of this Title, the following information may be amended without public notice: the spelling of species' names, historical range, footnotes, references to certain other applicable portions of this Title, synonyms, and more current names. In any of these revised entries, neither the species, as defined in paragraph (b) of this section, nor its status may be changed without following the procedures of Part 424 of this Title.

(e) The "Historic Range" indicates the known general distribution of the

species or subspecies as reported in the current scientific literature. The present distribution may be greatly reduced from this historic range. This column does not imply any limitation on the application of the prohibitions in the Act or implementing rules. Such prohibitions apply to all individuals of the species, wherever found.

(f)(1) A footnote to the Federal Register publication(s) listing or reclassifying a species is indicated under the column "When Listed." Footnote numbers to §§ 17.11 and 17.12 are in the same numerical sequence, since plants and animals may be listed in the same Federal Register document. That document, at least since 1973, includes a statement indicating the basis for the listing, as well as the effective date(s) of said listing.

(2) The "Special Rules" and "Critical Habitat" columns provide a cross reference to other sections in Parts 17, 222, 226, or 227. The term "NA" (not applicable) appearing in either of these two columns indicates that there are no special rules and/or Critical Habitat for that particular species. However, all other appropriate rules in Parts 17, 217–227, and 402 still apply to that species. In addition, there may be other rules in this Title that relate to such wildlife, e.g., port-of-entry requirements. It is not intended that the references in the "Special Rules" column list all the regulations of the two Services which might apply to the species or to the regulations of other Federal agencies or State or local governments.

(g) The listing of a particular taxon includes all lower taxonomic units. For example, the genus *Hylobates* (gibbons) is listed as Endangered throughout its entire range (China, India, and SE Asia); consequently, all species, subspecies, and populations of that genus are considered listed as Endangered for the purposes of the Act. In 1978 (43 FR 6230–6233) the species *Haliaeetus leucocephalus* (bald eagle) was listed as Threatened in "USA (WA, OR, MN, WI, WI, MI)" rather than its entire population; thus, all individuals of the bald eagle found in those five States are considered listed as Threatened for the purposes of the Act.

(h) The "List of Endangered and Threatened Wildlife" is provided below:

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
MAMMALS							
Anoa, lowland	*Bubalus depressicornis* (=*B. anoa depressicornis*).	Indonesia	Entire	E	3	NA	NA
Anoa, mountain	*Bubalus quarlesi* (=*B. anoa quarlesi*).	do	do	E	15	NA	NA
Antelope, giant sable	*Hippotragus niger variani*	Angola	do	E	15	NA	NA
Argali	*Ovis ammon hodgsoni*	China (Tibet, Himalayas)	do	E	15	NA	NA
Armadillo, giant	*Priodontes maximus* (=*gigenteus*)	Venezuela and Guyana to Argentina.	do	E	15	NA	NA
Armadillo, pink fairy	*Chlamyphorus truncatus*	Argentina	do	E	3	NA	NA
Ass, African wild	*Equus asinus* (=*africanus*)	Somalia, Sudan, Ethiopia	do	E	3	NA	NA
Ass, Asian wild (=kulan, onager).	*Equus hemionus*	Southwestern and Central Asia	do	E	3	NA	NA
Avahi	*Avahi* (=*Lichanotus*) *laniger* (=*entire genus*).	Malagasy Republic (=Madagascar).	do	E	3	NA	NA
Aye-Aye	*Daubentonia madagascariensis*	Malagasy Republic (=Madagascar).	do	E	3	NA	NA
Babirusa	*Babyrousa babyrussa*	Indonesia	do	E	15	NA	NA
Bandicoot, barred	*Perameles bougainville*	Australia	do	E	4	NA	NA
Bandicoot, desert	*Perameles eremiana*	do	do	E	6	NA	NA
Bandicoot, lesser rabbit	*Macrotis leucura*	do	do	E	4	NA	NA
Bandicoot, pig-footed	*Chaeropus ecaudatus*	do	do	E	4	NA	NA
Bandicoot, rabbit	*Macrotis lagotis*	do	do	E	4	NA	NA
Banteng	*Bos javanicus* (=*banteng*)	Southeast Asia	do	E	3	NA	NA
Bat, gray	*Myotis grisescens*	Central and Southeastern U.S.A.	do	E	13	NA	NA
Bat, Hawaiian hoary	*Lasiurus cinereus semotus*	U.S.A. (Hawaii)	do	E	2	NA	NA
Bat, Indiana	*Myotis sodalis*	Eastern and Midwestern U.S.A.	do	E	1	17.95(a)	NA
Bat, Ozark big-eared	*Plecotus townsendii ingens*	U.S.A. (MO, OK, AR)	do	E	85	NA	NA
Bat, Virginia big-eared	*Plecotus townsendii virginianus*	U.S.A. (KY, WV, VA)	do	E	85	17.95(a)	NA
Bear, brown	*Ursus arctos pruinosus*	China (Tibet)	do	E	15	NA	NA
Bear, brown	*Ursus arctos arctos*	Palearctic	Italy	E	15	NA	NA
Bear, brown or grizzly	*Ursus arctos horribilis*	Canada, Western U.S.A.	U.S.A.—48 conterminous States	T	1, 2, 9	NA	17.40(b)
Bear, Mexican grizzly	*Ursus arctos nelsoni*	Mexico	Entire	E	3	NA	NA
Beaver	*Castor fiber birulai*	Mongolia	do	E	15	NA	NA
Bison, wood	*Bison bison athabascae*	Canada, Northwestern U.S.A.	Canada	E	3	NA	NA
Bobcat	*Felis rufus escuinapae*	Central Mexico	Entire	E	15	NA	NA
Bontebok (antelope)	*Damaliscus dorcas dorcas*	South Africa	do	E	15	NA	NA
Camel, Bactrian	*Camelus bactrianus* (=*ferus*)	Mongolia, China	do	E	15	NA	NA
Caribou, woodland	*Rangifer tarandus caribou*	Canada, U.S.A. (AK, ID, ME, MI, MN, MT, NH, VT, WA, WI).	Canada (that part of S.E. Brit. Col. bounded by the Can.-USA border, Columbia R., Kootenay R., Kootenay L., and Kootenai R.), U.S.A. (ID, WA).	E	128E	NA	NA
Cat, Andean	*Felis jacobita*	Chile, Peru, Bolivia, Argentina	Entire	E	15	NA	NA
Cat, black-footed	*Felis nigripes*	Southern Africa	do	E	15	NA	NA
Cat, flat-headed	*Felis planiceps*	Malaysia, Indonesia	do	E	15	NA	NA
Cat, Iriomote	*Felis* (*Mayailurus*) *iriomotensis*	Japan (Iriomote Island, Ryukyu Islands).	do	E	50	NA	NA
Cat, leopard	*Felis bengalensis bengalensis*	India, Southeast Asia	do	E	15	NA	NA
Cat, marbled	*Felis marmorata*	Nepal, Southeast Asia, Indonesia	do	E	15	NA	NA
Cat, Temminck's (=golden cat).	*Felis temminckii*	Nepal, China, Southeast Asia, Indonesia (Sumatra).	do	E	15	NA	NA
Cat, tiger	*Felis tigrinus*	Costa Rica to northern Argentina	do	E	5	NA	NA
Chamois, Apennine	*Rupicapra rupicapra ornata*	Italy	do	E	15	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Cheetah	*Acinonyx jubatus*	Africa to India	do	E	3, 5	NA	NA
Chimpanzee	*Pan troglodytes*	West and Central Africa	do	T	16	NA	17.40(c)
Chimpanzee, pygmy	*Pan paniscus*	Zaire	do	T	16	NA	17.40(c)
Chinchilla	*Chinchilla brevicaudata boliviana*	Bolivia	do	E	15	NA	NA
Civet, Malabar large-spotted	*Viverra megaspila civettina*	India	do	E	50	NA	NA
Cougar, eastern	*Felis concolor cougar*	Eastern North America	do	E	6	NA	NA
Deer, Bactrian	*Cervus elaphus bactrianus*	U.S.S.R., Afghanistan	do	E	50	NA	NA
Deer, Bawean	*Axis (=Cervus) porcinus kuhli*	Indonesia	do	E	3	NA	NA
Deer, Barbary	*Cervus elaphus barbarus*	Morocco, Tunisia, Algeria	do	E	50	NA	NA
Deer, Cedros Island mule	*Odocoileus hemionus cedrosensis*	Mexico (Cedros Island)	do	E	10	NA	NA
Deer, Columbian white-tailed	*Odocoileus virginianus leucurus*	U.S.A. (WA, OR)	do	E	1	NA	NA
Deer, Corsican red	*Cervus elaphus corsicanus*	Corsica, Sardinia	do	E	50	NA	NA
Deer, Eld's brow-antlered	*Cervus eldi*	India to Southeast Asia	do	E	3	NA	NA
Deer, Formosan sika	*Cervus nippon taiouanus*	Taiwan	do	E	50	NA	NA
Deer, hog	*Axis (=Cervus) porcinus annamiticus.*	Thailand, Indochina	do	E	15	NA	NA
Deer, key	*Odocoileus virginianus clavium*	U.S.A. (southern Florida)	do	E	1	NA	NA
Deer, marsh	*Blastocerus dichotomus*	Argentina, Uruguay, Paraguay, Bolivia, Brazil.	do	E	3	NA	NA
Deer, McNeill's	*Cervus elaphus macneilli*	China (Sinkiang, Tibet)	do	E	3	NA	NA
Deer, musk	*Moschus* spp. (all species)	Central and East Asia	Afghanistan, Bhutan, Burma, China (Tibet, Yunnan), India, Nepal, Pakistan, Sikkim.	E	15	NA	NA
Deer, North China sika	*Cervus nippon mandarinus*	China (Shantung and Chihli Provinces).	Entire	E	50	NA	NA
Deer, pampas	*Ozotoceros bezoarticus*	Brazil, Argentina, Uruguay, Bolivia, Paraguay.	do	E	15	NA	NA
Deer, Persian fallow	*Dama dama mesopotamica*	Iraq, Iran	do	E	3	NA	NA
Deer, Philippine	*Axis (=Cervus) porcinus calamianensis.*	Philippines (Calamian Islands)	do	E	15	NA	NA
Deer, Ryukyu sika	*Cervus nippon keramae*	Japan (Ryukyu Islands)	do	E	50	NA	NA
Deer, Shansi sika	*Cervus nippon grassianus*	China (Shansi Province)	do	E	50	NA	NA
Deer, South China sika	*Cervus nippon kopschi*	Southern China	do	E	50	NA	NA
Deer, swamp (=barasingha)	*Cervus duvauceli*	India, Nepal	do	E	3	NA	NA
Deer, Yarkand	*Cervus elaphus yarkandensis*	China (Sinkiang)	do	E	50	NA	NA
Dhole (=Asiatic wild dog)	*Cuon alpinus*	U.S.S.R., Korea, China, India, Southeast Asia.	do	E	3	NA	NA
Dibbler	*Antechinus apicalis*	Australia	do	E	4	NA	NA
Drill	*Papio leucophaeus*	Equatorial West Africa	do	E	16	NA	NA
Dugong	*Dugong dugon*	East Africa to southern Japan, including U.S.A. (Trust Territories).	do	E	4	NA	NA
Duiker, Jentink's	*Cephalophus jentinki*	Sierra Leone, Liberia, Ivory Coast	do	E	50	NA	NA
Eland, Western giant	*Taurotragus derbianus derbianus*	Senegal to Ivory Coast	do	E	50	NA	NA
Elephant, African	*Loxodonta africana*	Africa	do	T	40	NA	17.40(e)
Elephant, Asian	*Elephas maximus*	South-central and Southeast Asia	do	E	15	NA	NA
Ferret, black-footed	*Mustela nigripes*	Western U.S.A., Western Canada	do	E	1, 3	NA	NA
Fox, Northern swift	*Vulpes velox hebes*	U.S.A. (northern plains), Canada	Canada	E	3	NA	NA
Fox, San Joaquin kit	*Vulpes macrotis mutica*	U.S.A. (California)	Entire	E	1	NA	NA
Fox, Simien	*Canis (Simenia) simensis*	Ethiopia	do	E	50	NA	NA
Gazelle, Clark's (=Dibatag)	*Ammodorcas clarkei*	Somalia, Ethiopia	do	E	3	NA	NA
Gazelle, Cuvier's	*Gazella cuvieri*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Gazelle, Mhorr	*Gazella dama mhorr*	Morocco	do	E	3	NA	NA
Gazelle, Moroccan (=Dorcas)	*Gazella dorcas massaesyla*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Gazelle, Rio de Oro Dama	*Gazella dama lozanoi*	Western Sahara	do	E	3	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Gazelle, Arabian	*Gazella gazella*	Arabian Peninsula, Palestine, Sinai	do	E	50	NA	NA
Gazelle, sand	*Gazella subgutturosa marica*	Jordan, Arabian Peninsula	do	E	50	NA	NA
Gazelle, Saudi Arabian	*Gazella dorcas saudiya*	Israel, Iraq, Jordan, Syria, Arabian Peninsula.	do	E	50	NA	NA
Gazelle, Pelzeln's	*Gazella dorcas pelzelni*	Somalia	do	E	50	NA	NA
Gazelle, slender-horned (=Rhim).	*Gazella leptoceros*	Sudan, Egypt, Algeria, Libya	do	E	3	NA	NA
Gelada (baboon)	*Theropithecus gelada*	Northern Ethiopia	do	T	16	NA	17.40(c)
Gibbons	*Hylobates* spp. (including *Nomascus*).	China, India, Southeast Asia	do	E	3, 15	NA	NA
Goat, wild (=Chiltan markhor)	*Capra aegagrus* (=*falconeri chiltanensis*).	South Western Asia	Chiltan Range of west-central Pakistan.	E	15	NA	NA
Goral	*Nemorhaedus goral*	East Asia	Entire	E	15	NA	NA
Gorilla	*Gorilla gorilla*	Central and Western Africa	do	E	3	NA	NA
Hare, hispid	*Caprolagus hispidus*	India, Nepal, Bhutan	do	E	15	NA	NA
Hartebeest, Swayne's	*Alcelaphus buselaphus swaynei*	Ethiopia, Somalia	do	E	3, 50	NA	NA
Hartebeest, Tora	*Alcelaphus buselaphus tora*	Ethiopia, Sudan, Egypt	do	E	50	NA	NA
Hog, pygmy	*Sus salvanius*	India, Nepal, Bhutan, Sikkim	do	E	3	NA	NA
Horse, Przewalski's	*Equus przewalskii*	Mongolia, China	do	E	15	NA	NA
Huemul, North Andean	*Hippocamelus antisensis*	Ecuador, Peru, Chile, Bolivia, Argentina.	do	E	15	NA	NA
Huemul, South Andean	*Hippocamelus bisulcus*	Chile, Argentina	do	E	15	NA	NA
Hyena, Barbary	*Hyaena hyaena barbara*	Morocco, Algeria, Tunisia	do	E	3	NA	NA
Hyena, brown	*Hyaena brunnea*	Southern Africa	do	E	3	NA	NA
Ibex, Pyrenean	*Capra pyrenaica pyrenaica*	Spain	do	E	3	NA	NA
Ibex, Walia	*Capra walie*	Ethiopia	do	E	3	NA	NA
Impala, black-faced	*Aepyceros melampus petersi*	Namibia, Angola	do	E	3	NA	NA
Indri	*Indri indri* (=entire genus)	Malagasy Republic (=Madagascar).	do	E	3	NA	NA
Jaguar	*Panthera onca*	U.S.A. (TX, NM, AZ), Central and South America.	Mexico southward	E	5	NA	NA
Jaguarundi	*Felis yagouaroundi cacomitli*	U.S.A. (Texas), Mexico	Entire	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi fossata*	Mexico, Nicaragua	do	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi panamensis*	Nicaragua, Costa Rica, Panama	do	E	15	NA	NA
Jaguarundi	*Felis yagouaroundi tolteca*	U.S.A. (Arizona), Mexico	do	E	15	NA	NA
Kangaroo, eastern gray	*Macropus giganteus* (all subspecies except *tasmaniensis*).	Australia	do	T	7	NA	17.40(a)
Kangaroo, red	*Macropus* (*Megaleia*) *rufus*	do	do	T	7	NA	17.40(a)
Kangaroo, Tasmanian forester	*Macropus giganteus tasmaniensis*	Australia (Tasmania)	do	E	6	NA	NA
Kangaroo, western gray	*Macropus fuliginosus*	Australia	do	T	7	NA	17.40(a)
Kouprey	*Bos sauveli*	Vietnam, Laos, Cambodia, Thailand.	do	E	3	NA	NA
Langur, capped	*Presbytis pileata*	India, Burma, Bangladesh	do	E	15	NA	NA
Langur, entellus	*Presbytis entellus*	China (Tibet), India, Pakistan, Kashmir, Sri Lanka, Sikkim, Bangladesh.	do	E	15	NA	NA
Langur, Douc	*Pygathrix nemaeus*	Cambodia, Laos, Vietnam	do	E	3	NA	NA
Langur, Francois'	*Presbytis francoisi*	China (Kwangsi), Indochina	do	E	16	NA	NA
Langur, golden	*Presbytis geei*	India (Assam), Bhutan	do	E	15	NA	NA
Langur, long-tailed	*Presbytis potenziani*	Indonesia	do	T	16	NA	17.40(c)
Langur, Pagi Island	*Nasalis* (*Simias*) *concolor*	do	do	E	3	NA	NA
Langur, purple-faced	*Presbytis senex*	Sri Lanka (=Ceylon)	do	T	16	NA	17.40(c)
Langur, Tonkin snub-nosed	*Pygathrix* (*Rhinopithecus*) *avunculus*.	Vietnam	do	T	16	NA	17.40(c)

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Lechwe, red	*Kobus leche*	Southern Africa	do	T	3, 15, 106	NA	NA
Lemurs	*Lemuridae* (incl. *Cheirogaleidae, Lepilemuridae*); all members of genera *Lemur, Phaner, Hapalemur, Lepilemur, Microcebus, Allocebus, Cheirogaleus, Varecia.*	Malagasy Republic (=Madagascar).	do	E	3, 15	NA	NA
Leopard	*Panthera pardus*	Africa, Asia	Wherever found except where it is listed as Threatened as set forth below.	E	3, 5, 114	NA	NA
Leopard	*Panthera pardus*	Africa, Asia	In Africa, in the wild, south of a line running along the borders of the following countries: Gabon/Rio Muni; Gabon/Cameroon; Congo/Cameroon; Congo/Central African Republic; Zaire/Central African Republic; Zaire/Sudan; Uganda/Sudan; Kenya/Sudan; Kenya/Ethiopia; Kenya/Somalia.	T	3, 5, 114	NA	17.40(f)
Leopard, clouded	*Neofelis nebulosa*	Southeast and south-central Asia, Taiwan.	Entire	E	3, 15	NA	NA
Leopard, snow	*Panthera uncia*	Central Asia	do	E	5	NA	NA
Linsang, spotted	*Prionodon pardicolor*	Nepal, Assam, Vietnam, Cambodia, Laos, Burma.	do	E	15	NA	NA
Lion, Asiatic	*Panthera leo persica*	Turkey to India	do	E	3	NA	NA
Loris, lesser slow	*Nycticebus pygmaeus*	Indochina	do	T	16	NA	17.40(c)
Lynx, Spanish	*Felis (=Lynx) pardina*	Spain, Portugal	do	E	3	NA	NA
Macaque, Formosan rock	*Macaca cyclopis*	Taiwan	do	T	16	NA	17.40(c)
Macaque, Japanese	*Macaca fuscata*	Japan (Shikoku, Kyushu and Honshu Islands).	do	T	16	NA	17.40(c)
Macaque, lion-tailed	*Macaca silenus*	India	do	E	3	NA	NA
Macaque, stump-tailed	*Macaca arctoides*	India (Assam) to southern China	do	T	16	NA	17.40(c)
Macaque, Toque	*Macaca sinica*	Sri Lanka (=Ceylon)	do	T	16	NA	17.40(c)
Manatee, Amazonian	*Trichechus inunguis*	South America (Amazon River Basin).	do	E	3	NA	NA
Manatee, West African	*Trichechus senegalensis*	West Coast of Africa from Senegal River to Cuanza River.	do	T	52	NA	NA
Manatee, West Indian (Florida)	*Trichechus manatus*	U.S.A. (southeastern), Caribbean Sea, South America.	do	E	1, 3	17.95(a)	NA
Mandrill	*Papio sphinx*	Equatorial West Africa	do	E	16	NA	NA
Mangabey, Tana River	*Cercocebus galeritus*	Kenya	do	E	3	NA	NA
Mangabey, white-collared	*Cercocebus torquatus*	Senegal to Ghana; Nigeria to Gabon.	do	E	16	NA	NA
Margay	*Felis wiedii*	U.S.A. (Texas), Central and South America.	Mexico southward	E	5	NA	NA
Markhor, Kabal	*Capra falconeri megaceros*	Afghanistan, Pakistan	Entire	E	15	NA	NA
Markhor, straight-horned	*Capra falconeri jerdoni*	do	do	E	15	NA	NA
Marmoset, cotton-top	*Saguinus oedipus*	Costa Rica to Colombia	do	E	16	NA	NA
Marmoset, Goeldi's	*Callimico goeldii*	Brazil, Colombia, Ecuador, Peru, Bolivia.	do	E	3	NA	NA
Marsupial, eastern jerboa	*Antechinomys laniger*	Australia	do	E	4	NA	NA
Marsupial-mouse, large desert	*Sminthopsis psammophila*	do	do	E	4	NA	NA
Marsupial-mouse, long-tailed	*Sminthopsis longicaudata*	do	do	E	4	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Marten, Formosan yellow-throated.	*Martes flavigula chrysospila*	Taiwan	do	E	3	NA	NA
Monkey, black colobus	*Colobus satanas*	Equatorial Guinea, People's Republic of Congo, Cameroon, Gabon.	do	E	16	NA	NA
Monkey, black howler	*Alouatta pigra*	Mexico, Guatemala, Belize	do	T	16	NA	17.40(c)
Monkey Diana	*Cercopithecus diana*	Coastal West Africa	do	E	16	NA	NA
Monkey, howler	*Alouatta palliata* (=*villosa*)	Mexico to South America	do	E	15	NA	NA
Monkey, L'hoest's	*Cercopithecus lhoesti*	Upper Eastern Congo Basin, Cameroon.	do	E	16	NA	NA
Monkey, proboscis	*Nasalis larvatus*	Borneo	do	E	15	NA	NA
Monkey, red-backed squirrel	*Saimiri oerstedii*	Costa Rica, Panama	do	E	3	NA	NA
Monkey, red-bellied	*Cercopithecus erythrogaster*	Western Nigeria	do	E	16	NA	NA
Monkey, red-eared nose-spotted.	*Cercopithecus erythrotis*	Nigeria, Cameroon, Fernando Po	do	E	16	NA	NA
Monkey, spider	*Ateles geoffroyi frontatus*	Costa Rica, Nicaragua	do	E	3	NA	NA
Monkey, spider	*Ateles geoffroyi panamensis*	Costa Rica, Panama	do	E	3	NA	NA
Monkey, Tana River red colobus.	*Colobus rufomitratus* (=*badius*) *rufomitratus*.	Kenya	do	E	3, 16	NA	NA
Monkey, woolly spider	*Brachyteles arachnoides*	Brazil	do	E	3	NA	NA
Monkey, yellow-tailed woolly	*Lagothrix flavicauda*	Andes of northern Peru	do	E	16	NA	NA
Monkey, Zanzibar red colobus	*Colobus kirki*	Tanzania	do	E	3	NA	NA
Mouse, Australian native	*Zyzomys* (=*Notomys*) *pedunculatus*.	Australia	do	E	15	NA	NA
Mouse, Australian native	*Notomys aquilo*	do	do	E	15	NA	NA
Mouse, Field's	*Pseudomys fieldi*	do	do	E	4	NA	NA
Mouse, Gould's	*Pseudomys gouldii*	do	do	E	6	NA	NA
Mouse, New Holland	*Pseudomys novaehollandiae*	do	do	E	4	NA	NA
Mouse, salt marsh harvest	*Reithrodontomys raviventris*	U.S.A. (California)	do	E	2	NA	NA
Mouse, Shark Bay	*Pseudomys praeconis*	Australia	do	E	4	NA	NA
Mouse, Shortridge's	*Pseudomys shortridgei*	do	do	E	4	NA	NA
Mouse, Smoky	*Pseudomys fumeus*	do	do	E	4	NA	NA
Mouse, western	*Pseudomys occidentalis*	do	do	E	4	NA	NA
Muntjac, Fea's	*Muntiacus feae*	Northern Thailand, Burma	do	E	50	NA	NA
Native-cat, eastern	*Dasyurus viverrinus*	Australia	do	E	6	NA	NA
Numbat	*Myrmecobius fasciatus*	do	do	E	4, 6	NA	NA
Ocelot	*Felis pardalis*	U.S.A. (TX, AZ) south through Central America to South America.	do	E	5, 119	NA	NA
Orangutan	*Pongo pygmaeus*	Borneo, Sumatra	do	E	3	NA	NA
Oryx, Arabian	*Oryx leucoryx*	Arabian Peninsula	do	E	3	NA	NA
Otter, Cameroon clawless	*Aonyx* (*Paraonyx*) *congica microdon*.	Cameroon, Nigeria	do	E	3	NA	NA
Otter, giant	*Pteronura brasiliensis*	South America	do	E	3	NA	NA
Otter, long-tailed (incl. giant)	*Lutra longicaudis* (incl. *platensis*)	do	do	E	3, 15	NA	NA
Otter, marine	*Lutra felina*	Peru south to Straits of Magellan	do	E	15	NA	NA
Otter, southern river	*Lutra provocax*	Chile, Argentina	do	E	15	NA	NA
Otter, southern sea	*Enhydra lutris nereis*	West coast U.S.A. (WA, OR, CA) south to Mexico (Baja California).	do	T	21	NA	NA
Pangolin (=scaly anteater)	*Manis temmincki*	Africa	do	E	15	NA	NA
Panther, Florida	*Felis concolor coryi*	U.S.A. (LA and AR east to SC and FL).	do	E	1	NA	NA
Planigale, little	*Planigale ingrami subtilissima* (for-	Australia	do	E	4	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	
Common name	Scientific name						
Planigale, southern	*Planigale tenuirostris*	do	do	E	4	NA	NA
Porcupine, thin-spined	*Chaetomys subspinosus*	Brazil	do	E	3	NA	NA
Possum, mountain pygmy	*Burramys parvus*	Australia	do	E	4	NA	NA
Possum, scaly-tailed	*Wyulda squamicaudata*	do	do	E	4	NA	NA
Prairie dog, Mexican	*Cynomys mexicanus*	Mexico	do	E	3	NA	NA
Prairie dog, Utah	*Cynomys parvidens*	U.S.A. (Utah)	do	E	6	NA	NA
Pronghorn, peninsular	*Antilocapra americana peninsularis*	Mexico (Baja California)	do	E	10	NA	NA
Pronghorn, Sonoran	*Antilocapra americana sonoriensis*	U.S.A. (AZ), Mexico	do	E	1, 3	NA	NA
Pudu	*Pudu pudu*	Southern South America	do	E	15	NA	NA
Puma, Costa Rican	*Felis concolor costaricensis*	Nicaragua, Panama, Costa Rica	do	E	15	NA	NA
Quokka	*Setonix brachyurus*	Australia	do	E	6	NA	NA
Rabbit, Ryukyu	*Pentalagus furnessi*	Japan (Ryukyu Islands)	do	E	50	NA	NA
Rabbit, volcano	*Romerolagus diazi*	Mexico	do	E	3	NA	NA
Rat, false water	*Xeromys myoides*	Australia	do	E	4	NA	NA
Rat, stick-nest	*Leporillus conditor*	do	do	E	6	NA	NA
Rat, Morro Bay kangaroo	*Dipodomys heermanni morroensis*	U.S.A. (California)	do	E	2	17.95(a)	NA
Rat—kangaroo, brush-tailed	*Bettongia penicillata*	Australia	do	E	4	NA	NA
Rat—kangaroo, Gaimard's	*Bettongia gaimardi*	do	do	E	6	NA	NA
Rat—kangaroo, Lesuer's	*Bettongia lesueur*	do	do	E	4	NA	NA
Rat—kangaroo, plain	*Caloprymnus campestris*	do	do	E	4	NA	NA
Rat—kangaroo, Queensland	*Bettongia tropica*	do	do	E	4	NA	NA
Rhinoceros, black	*Diceros bicornis*	Sub-Saharan Africa	do	E	97	NA	NA
Rhinoceros, great Indian	*Rhinoceros unicornis*	India, Nepal	do	E	4	NA	NA
Rhinoceros, Javan	*Rhinoceros sondaicus*	Indonesia, Indochina, Burma, Thailand, Sikkim, Bangladesh, Malaysia.	do	E	3	NA	NA
Rhinoceros, northern white	*Ceratotherium simum cottoni*	Zaire, Sudan, Uganda, Central African Republic.	do	E	3	NA	NA
Rhinoceros, Sumatran	*Dicerorhinus (=Didermoceros) sumatrensis.*	Bangladesh to Vietnam to Indonesia (Borneo).	do	E	3	NA	NA
Saiga, Mongolian (antelope)	*Saiga tatarica mongolica*	Mongolia	do	E	15	NA	NA
Saki, white-nosed	*Chiropotes albinasus*	Brazil	do	E	3	NA	NA
Seal, Caribbean monk	*Monachus tropicalis*	Caribbean Sea, Gulf of Mexico	do	E	1, 2, 45	NA	NA
Seal, Hawaiian monk	*Monachus schauinslandi*	Hawaiian Archipelago	do	E	18	NA	NA
Seal, Mediterranean monk	*Monachus monachus*	Mediterranean, Northwest African Coast and Black Sea.	do	E	3	NA	NA
Seledang (=Gaur)	*Bos gaurus*	Bangladesh, Southeast Asia, India	do	E	3	NA	NA
Serow, Sumatran	*Capricornis sumatrensis*	Sumatra	do	E	15	NA	NA
Serval, Barbary	*Felis serval constantina*	Algeria	do	E	3	NA	NA
Shapo	*Ovis vignei vignei*	Kashmir	do	E	15	NA	NA
Shou	*Cervus elaphus wallichi*	Tibet, Bhutan	do	E	3	NA	NA
Siamang	*Symphalangus syndactylus*	Malaysia, Indonesia	do	E	15	NA	NA
Sifakas	*Propithecus* spp. (all species)	Malagasy Republic (=Madagascar).	do	E	4	NA	NA
Sloth, Brazilian three-toed	*Bradypus torquatus*	Brazil	do	E	3, 4	NA	NA
Solenodon, Cuban	*Solendon (Atopogale) cubanus*	Cuba	do	E	3	NA	NA
Solenodon, Haitian	*Solenodon paradoxus*	Dominican Republic, Haiti	do	E	3	NA	NA
Squirrel, Delmarva Peninsula fox.	*Sciurus niger cinereus*	U.S.A. (DelMarVa Peninsula to Southeast PA).	do	E	1	NA	NA
Stag, Barbary	*Cervus elaphus barbarus*	Tunisia, Algeria	do	E	3	NA	NA
Stag, Kashmir	*Cervus elaphus hanglu*	Kashmir	do	E	3	NA	NA
Suni, Zanzibar	*Neotragus (Nesotragus) moschatus moschatus.*	Zanzibar (and nearby islands)	do	E	50	NA	NA
Tahr, Arabian	*Hemitragus jayakari*	Oman	do	E	50	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Tamaraw	*Bubalus mindorensis*	Philippines	do	E	4	NA	NA
Tamarin, golden-rumped (=golden-headed Tamarin; =golden-lion Marmoset).	*Leontopithecus* (=*Leontideus*) spp. (all species).	Brazil	do	E	3	NA	NA
Tamarin, pied	*Saguinus bicolor*	Northern Brazil	do	E	16	NA	NA
Tamarin, white-footed	*Saguinus leucopus*	Northern Colombia	do	T	16	NA	17.40(c)
Tapir, Asian	*Tapirus indicus*	Burma, Laos, Cambodia, Vietnam, Malaysia, Indonesia, Thailand.	do	E	15	NA	NA
Tapir, Brazilian	*Tapirus terrestris*	Colombia and Venezuela south to Paraguay and Argentina.	do	E	3	NA	NA
Tapir, Central American	*Tapirus bairdii*	Southern Mexico to Colombia and Ecuador.	do	E	3	NA	NA
Tapir, mountain	*Tapirus pinchaque*	Colombia, Ecuador and possibly Peru and Venezuela.	do	E	3	NA	NA
Tarsier, Philippine	*Tarsius syrichta*	Philippines	do	T	16	NA	17.40(c)
Tiger	*Panthera tigris*	Temperate and Tropical Asia	do	E	3, 5	NA	NA
Tiger, Tasmanian (=Thylacine).	*Thylacinus cynocephalus*	Australia	do	E	3	NA	NA
Uaksari (all species)	*Cacajao* spp. (all species)	Peru, Brazil, Ecuador, Columbia, Venezuela.	do	E	3	NA	NA
Urial	*Ovis musimon* (=*orientalis*) *ophion*.	Cyprus	do	E	15	NA	NA
Vicuna	*Vicugna vicugna*	South America (Andes)	do	E	3	NA	NA
Wallaby, banded hare	*Lagostrophus fasciatus*	Australia	do	E	4	NA	NA
Wallaby, brindled nail-tailed	*Onychogalea fraenata*	do	do	E	4	NA	NA
Wallaby, crescent nail-tailed	*Onychogalea lunata*	do	do	E	4	NA	NA
Wallaby, Parma	*Macropus parma*	do	do	E	4	NA	NA
Wallaby, Western hare	*Lagorchestes hirsutus*	do	do	E	4	NA	NA
Wallaby, yellow-footed rock	*Petrogale xanthopus*	do	do	E	6	NA	NA
Whale, blue	*Balaenoptera musculus*	Oceanic	do	E	3	NA	NA
Whale, bowhead	*Balaena mysticetus*	Oceanic (north latitudes only)	do	E	3	NA	NA
Whale, finback	*Balaenoptera physalus*	Oceanic	do	E	3	NA	NA
Whale, gray	*Eschrichtius robustus*	North Pacific Ocean: coastal and Bering Sea.	do	E	3	NA	NA
Whale, humpback	*Megaptera novaeangliae*	Oceanic	do	E	3	NA	NA
Whale, right	*Balaena glacialis*	do	do	E	3	NA	NA
Whale, Sei	*Balaenoptera borealis*	do	do	E	3	NA	NA
Whale, sperm	*Physeter catodon*	do	do	E	3	NA	NA
Wolf, gray	*Canis lupus*	Holarctic	U.S.A. (48 conterminous States other than MN), Mexico.	E	1, 6, 13, 15, 35	17.95(a)	NA
Wolf, gray	*Canis lupus*	do	U.S.A. (MN)	T	35	17.95(a)	17.40(d)
Wolf, maned	*Chrysocyon brachyurus*	Argentina, Bolivia, Brazil, Paraguay, Uruguay.	Entire	E	4	NA	NA
Wolf, red	*Canis rufus*	U.S.A. (southeastern U.S.A. west to central TX).	do	E	1	NA	NA
Wombat, hairy-nosed (=Barnard's and Queensland hairy-nosed).	*Lasiorhinus krefftii* (formerly *L. barnardi* and *L. gillespiei*).	Australia	do	E	4, 6	NA	NA
Yak, wild	*Bos grunniens*	China (Tibet), India	do	E	3	NA	NA
Zebra, Grevy's	*Equus grevyi*	Kenya, Ethiopia, Somalia	do	T	54	NA	NA
Zebra, Hartmann's mountain	*Equus zebra hartmannae*	Namibia, Angola	do	T	54, 111	NA	NA
Zebra, mountain	*Equus zebra zebra*	South Africa	do	E	15, 111	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	
Common name	Scientific name						
Birds							
Akepa, Hawaii (honeycreeper)	*Loxops coccineus coccineus*	U.S.A. (Hawaii)	do	E	2	NA	NA
Akepa, Maui (honeycreeper)	*Loxops coccineus ochraceus*	do	do	E	2	NA	NA
Akialoa, Kauai (honeycreeper)	*Hemignathus procerus*	do	do	E	1	NA	NA
Akiapolaau (honeycreeper)	*Hemignathus munroi* (=*wilsoni*)	do	do	E	1	NA	NA
Albatross, short-tailed	*Diomedea albatrus*	North Pacific Ocean: Japan, U.S.S.R., U.S.A. (AK, CA, HI, OR, WA).	Entire, except U.S.A.	E	3	NA	NA
Blackbird, yellow-shouldered	*Agelaius xanthomus*	U.S.A. (Puerto Rico)	Entire	E	17	17.95(b)	NA
Bobwhite, masked (quail)	*Colinus virginianus ridgwayi*	U.S.A. (Arizona), Mexico (Sonora)	do	E	1, 3	NA	NA
Booby, Abbott's	*Sula abbotti*	Indian Ocean: Christmas Island	do	E	15	NA	NA
Bristlebird, western	*Dasyornis brachypterus longirostris*	Australia	do	E	3	NA	NA
Bristlebird, western rufous	*Dasyornis broadbenti littoralis*	do	do	E	15	NA	NA
Bulbul, Mauritius olivaceous	*Hypsipetes borbonicus olivaceus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Bullfinch, Sao Miguel (finch)	*Pyrrhula pyrrhula murina*	Eastern Atlantic Ocean: Azores	do	E	3	NA	NA
Bushwren, New Zealand	*Xenicus longipes*	New Zealand	do	E	3	NA	NA
Bustard, great Indian	*Choriotis nigriceps*	India, Pakistan	do	E	3	NA	NA
Cahow (=Bermuda Petrel)	*Pterodroma cahow*	North Atlantic Ocean: Bermuda	do	E	3	NA	NA
Condor, Andean	*Vultur gryphus*	Colombia to Chile and Argentina	do	E	4	NA	NA
Condor, California	*Gymnogyps californianus*	U.S.A. (OR, CA), Mexico (Baja California).	do	E	1	17.95(b)	NA
Coot, Hawaiian (=Alae keokeo).	*Fulica americana alai*	U.S.A. (Hawaii)	do	E	2	NA	NA
Cotinga, banded	*Cotinga maculata*	Brazil	do	E	15	NA	NA
Cotinga, white-winged	*Xipholena atropurpurea*	do	do	E	15	NA	NA
Crane, black-necked	*Grus nigricollis*	China (Tibet)	do	E	15	NA	NA
Crane, Cuba sandhill	*Grus canadensis nesiotes*	West Indies: Cuba	do	E	15	NA	NA
Crane, hooded	*Grus monacha*	Japan, U.S.S.R.	do	E	4	NA	NA
Crane, Japanese	*Grus japonensis*	China, Japan, Korea, U.S.S.R.	do	E	3	NA	NA
Crane, Mississippi sandhill	*Grus canadensis pulla*	U.S.A. (Mississippi)	do	E	6	17.95(b)	NA
Crane, Siberian white	*Grus leucogeranus*	U.S.S.R. (Siberia) to India, including Iran and China.	do	E	4	NA	NA
Crane, white-naped	*Grus vipio*	Mongolia	do	E	15	NA	NA
Crane, whooping	*Grus americana*	Canada, U.S.A. (Rocky Mountains east to Carolinas), Mexico.	do	E	1, 3	17.95(b)	NA
Creeper, Hawaii	*Oreomystis* (=*Loxops*) *mana*	U.S.A. (Hawaii)	do	E	10	NA	NA
Creeper, Molokai (=Kakawahie).	*Oreomystis* (=*Loxops*) *flammea*	do	do	E	2	NA	NA
Creeper, Oahu (=alauwahio)	*Oreomystis* (=*Loxops*) *maculata*	do	do	E	2	NA	NA
Crow, Hawaiian (='alala)	*Corvus tropicus*	do	do	E	1	NA	NA
Cuckoo-shrike, Mauritius	*Coracina* (=*Coracina*) *typicus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Cuckoo-shrike, Reunion	*Coracina* (=*Coracina*) *newtoni*	Indian Ocean: Reunion	do	E	3	NA	NA
Curassow, razor-billed	*Mitu* (=*Crax*) *mitu mitu*	Brazil (Eastern)	do	E	15	NA	NA
Curassow, red-billed	*Crax blumenbachii*	Brazil	do	E	4	NA	NA
Curassow, Trinidad white-headed.	*Pipile pipile pipile*	West Indies: Trinidad	do	E	3	NA	NA
Curlew, Eskimo	*Numenius borealis*	Alaska and northern Canada to Argentina.	do	E	1, 3	NA	NA
Dove, cloven-feathered	*Drepanoptila holosericea*	Southwest Pacific Ocean: New Caledonia.	do	E	3	NA	NA
Dove, Grenada	*Leptotila wellsi*	West Indies: Grenada	do	E	3	NA	NA
Dove, Palau ground	*Gallicolumba canifrons*	West Pacific Ocean: U.S.A. (Palau Islands).	do	E	3	NA	NA
Duck, Hawaiian (=koloa)	*Anas wyvilliana*	U.S.A. (Hawaii)	do	E	1	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Duck, Laysan	*Anas laysanensis*	do	do	E	1	NA	NA
Duck, pink-headed	*Rhodonessa caryophyllacea*	India	do	E	15	NA	NA
Duck, white-winged wood	*Cairina scutulata*	India, Malaysia, Indonesia, Thailand.	do	E	3	NA	NA
Eagle, Greenland white-tailed	*Haliaeetus albicilla groenlandicus*	Greenland and adjacent Atlantic Islands.	do	E	15	NA	NA
Eagle, harpy	*Harpia harpyja*	Mexico south to Argentina	do	E	15	NA	NA
Eagle, Philippine (=monkey-eating).	*Pithecophaga jefferyi*	Philippines	do	E	3	NA	NA
Eagle, bald	*Haliaeetus leucocephalus*	North America south to northern Mexico.	U.S.A. (conterminous States, except WA, OR, MN, WI, MI).	E	1, 34	NA	NA
Eagle, bald	*Haliaeetus leucocephalus*	do	U.S.A. (WA, OR, MN, WI, MI)	T	34	NA	17.41(a)
Eagle, Spanish imperial	*Aquila heliaca adalberti*	Spain, Morocco, Algeria	Entire	E	3	NA	NA
Egret, Chinese	*Egretta eulophotes*	China, Korea	do	E	3	NA	NA
Falcon, American peregrine	*Falco peregrinus anatum*	Canada, U.S.A., Mexico	do	E	2, 3	17.95(b)	NA
Falcon, Arctic peregrine	*Falco peregrinus tundrius*	Alaska to Greenland, south to Argentina.	do	E	2, 3	NA	NA
Falcon, Eurasian peregrine	*Falco peregrinus peregrinus*	Europe, Eurasia south to Africa and Mideast.	do	E	15	NA	NA
Finch, Laysan (honeycreeper)	*Telespyza (=Psittirostra) cantans*	U.S.A. (Hawaii)	do	E	1	NA	NA
Finch, Nihoa (honeycreeper)	*Telespyza (=Psittirostra) ultima*	do	do	E	1	NA	NA
Flycatcher, Euler's	*Empidonax euleri johnstonei*	West Indies: Grenada	do	E	3	NA	NA
Flycatcher, Palau fantail	*Rhipidura lepida*	West Pacific Ocean: U.S.A. (Palau Islands).	do	E	3	NA	NA
Flycatcher, Seychelles paradise.	*Terpsiphone corvina*	Indian Ocean: Seychelles	do	E	3	NA	NA
Flycatcher, Tahiti	*Pomarea nigra*	South Pacific Ocean: Tahiti	do	E	3	NA	NA
Flycatcher, Tinian monarch	*Monarcha takatsukasae*	Western Pacific Ocean: U.S.A. (Mariana Islands).	do	E	3	NA	NA
Fody, Seychelles (weaver-finch).	*Foudia sechellarum*	Indian Ocean: Seychelles	do	E	3	NA	NA
Frigatebird, Andrew's	*Fregata andrewsi*	East Indian Ocean	do	E	15	NA	NA
Gallinule, Hawaiian (moorhen)	*Gallinula chloropus sandvicensis*	U.S.A. (Hawaii)	do	E	1	NA	NA
Goose, Aleutian Canada	*Branta canadensis leucoparela*	Western U.S.A. (AK, CA, OR, WA), Japan.	do	E	1, 3	NA	NA
Goose, Hawaiian (=nene)	*Nesochen (=Branta) sandvicensis*	U.S.A. (Hawaii)	do	E	1	NA	NA
Goshawk, Christmas Island	*Accipiter fasciatus natalis*	Indian Ocean: Christmas Island	do	E	3	NA	NA
Grackle, slender-billed	*Quiscalus (=Cassidix) palustris*	Mexico	do	E	3	NA	NA
Grasswren, Eyrean (flycatcher)	*Amytornis goyderi*	Australia	do	E	3	NA	NA
Grebe, Atitlan	*Podilymbus gigas*	Guatemala	do	E	3	NA	NA
Greenshank, Nordmann's	*Tringa guttifer*	U.S.S.R., Japan, south to Malaya, Borneo.	do	E	15	NA	NA
Guan, horned	*Oreophasis derbianus*	Guatemala, Mexico	do	E	3	NA	NA
Gull, Audouin's	*Larus audouinii*	Mediterranean Sea	do	E	3	NA	NA
Gull, relict	*Larus relictus*	India, China	do	E	15	NA	NA
Hawk, Anjouan Island sparrow	*Accipiter francesii pusillus*	Indian Ocean: Comoro Islands	do	E	3	NA	NA
Hawk, Galapagos	*Buteo galapagoensis*	Ecuador (Galapagos Island)	do	E	3	NA	NA
Hawk, Hawaiian (=io)	*Buteo solitarius*	U.S.A. (Hawaii)	do	E	1	NA	NA
Hermit, hook-billed (hummingbird).	*Glaucis (=Ramphodon) dohrnii*	Brazil	do	E	15	NA	NA
Honeycreeper, crested (='akohekohe).	*Palmeria dolei*	U.S.A. (Hawaii)	do	E	1	NA	NA
Hornbill, helmeted	*Rhinoplax vigil*	Thailand, Malaysia	do	E	15	NA	NA
Honeyeater, helmeted	*Meliphaga cassidix*	Australia	do	E	4	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	[illegible]
Common name	Scientific name						
Ibis, Japanese crested	*Nipponia nippon*	China, Japan, U.S.S.R., Korea	do	E	3	NA	NA
Kagu	*Rhynochetos jubatus*	Southwestern Pacific Ocean: New Caledonia.	do	E	3	NA	NA
Kakapo (=owl parrot)	*Strigops habroptilus*	New Zealand	do	E	3	NA	NA
Kestrel, Mauritius	*Falco punctatus*	Indian Ocean: Mauritius	do	E	3	NA	NA
Kestrel, Seychelles	*Falco araea*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Kite, Cuba hook-billed	*Chondrohierax uncinatus wilsonii*	West Indies: Cuba	do	E	3	NA	NA
Kite, Grenada hook-billed	*Chondrohierax uncinatus minus*	West Indies: Grenada	do	E	3	NA	NA
Kite, Everglade (snail kite)	*Rostrhamus sociabilis plumbeus*	U.S.A. (Florida)	do	E	1	17.95(b)	NA
Kokako (wattlebird)	*Callaeas cinerea*	New Zealand	do	E	3	NA	NA
Macaw, glaucous	*Anodorhynchus glaucus*	Paraguay, Uruguay, Brazil	do	E	15	NA	NA
Macaw, indigo	*Anodorhynchus leari*	Brazil	do	E	15	NA	NA
Macaw, little blue	*Cyanopsitta spixii*	do	do	E	15	NA	NA
Magpie-robin, Seychelles (thrush).	*Copsychus sechellarum*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Malkoha, red-faced (cuckoo)	*Phaenicophaeus pyrrhocephalus*	Sri Lanka (=Ceylon)	do	E	3	NA	NA
Mallard, Mariana	*Anas oustaleti*	West Pacific Ocean: U.S.A. (Guam, Mariana Islands).	do	E	23	NA	NA
Megapode, La Perouse's	*Megapodius laperouse*	West Pacific Ocean: U.S.A. (Palau Island, Mariana Islands).	do	E	3	NA	NA
Megapode, Maleo	*Macrocephalon maleo*	Indonesia (Celebes)	do	E	3	NA	NA
Millerbird, Nihoa (willow warbler).	*Acrocephalus familiaris kingi*	U.S.A. (Hawaii)	do	E	1	NA	NA
Nukupu'u (honeycreeper)	*Hemignathus lucidus*	do	do	E	1, 2	NA	NA
'O'o, Kauai (='O'o 'A'a) (honeyeater).	*Moho braccatus*	do	do	E	1	NA	NA
Ostrich, Arabian	*Struthio camelus syriacus*	Jordan, Saudi Arabia	do	E	3	NA	NA
Ostrich, West African	*Struthio camelus spatzi*	Spanish Sahara	do	E	3	NA	NA
'O'u (honeycreeper)	*Psittirostra psittacea*	U.S.A. (Hawaii)	do	E	1	NA	NA
Owl, Anjouan scops	*Otus rutilus capnodes*	Indian Ocean: Comoro Island	do	E	3	NA	NA
Owl, giant scops	*Otus gurneyi*	Philippines: Marinduque and Mindanao Island.	do	E	15	NA	NA
Owl, Palau	*Otus podargina*	West Pacific Ocean: U.S.A. (Palau Islands).	do	E	3	NA	NA
Owl, Seychelles	*Otus insularis*	Indian Ocean: Seychelles Islands	do	E	3	NA	NA
Owlet, Mr. Morden's	*Otus ireneae*	Kenya	do	E	3	NA	NA
Palila (honeycreeper)	*Loxioides (=Psittirostra) bailleui*	U.S.A. (Hawaii)	do	E	1	17.95(b)	NA
Parakeet, Forbes'	*Cyanoramphus auriceps forbesi*	New Zealand	do	E	3, 15	NA	NA
Parakeet, golden	*Aratinga guarouba*	Brazil	do	E	4	NA	NA
Parakeet, golden-shouldered (=hooded).	*Psephotus chrysopterygius*	Australia	do	E	3	NA	NA
Parakeet, Mauritius	*Psittacula echo*	Indian Ocean: Mauritius	do	E	3	NA	NA
Parakeet, ochre-marked	*Pyrrhura cruentata*	Brazil	do	E	3	NA	NA
Parakeet, orange-bellied	*Neophema chrysogaster*	Australia	do	E	4	NA	NA
Parakeet, paradise (=beautiful).	*Psephotus pulcherrimus*	do	do	E	4	NA	NA
Parakeet, scarlet-chested (=splendid).	*Neophema splendida*	do	do	E	4	NA	NA
Parakeet, turquoise	*Neophema pulchella*	do	do	E	3	NA	NA
Parrot, Australian	*Geopsittacus occidentalis*	do	do	E	3	NA	NA
Parrot, Bahaman or Cuban	*Amazona leucocephala*	West Indies: Cuba, Bahamas, Caymans.	do	E	3, 15	NA	NA
Parrot, ground	*Pezoporus wallicus*	Australia	do	E	6	NA	NA
Parrot, imperial	*Amazona imperialis*	West Indies: Dominica	do	E	3	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Parrot, Puerto Rican	*Amazona vittata*	U.S.A. (Puerto Rico)	do	E	1	NA	NA
Parrot, red-browed	*Amazona rhodocorytha*	Brazil	do	E	3	NA	NA
Parrot, red-capped	*Pionopsitta pileata*	do	do	E	15	NA	NA
Parrot, red-necked	*Amazona arausiaca*	West Indies: Dominica	do	E	50	NA	NA
Parrot, red-spectacled	*Amazona pretrei pretrei*	Brazil, Argentina	do	E	15	NA	NA
Parrot, St. Lucia	*Amazona versicolor*	West Indies: St. Lucia	do	E	3	NA	NA
Parrot, St. Vincent	*Amazona guildingii*	West Indies: St. Vincent	do	E	3	NA	NA
Parrot, thick-billed	*Rhynchopsitta pachyrhyncha*	Mexico, U.S.A. (AZ, NM)	Mexico	E	3	NA	NA
Parrot, vinaceous-breasted	*Amazona vinacea*	Brazil	Entire	E	15	NA	NA
Parrotbill, Maui (honeycreeper)	*Pseudonestor xanthophrys*	U.S.A. (Hawaii)	do	E	1	NA	NA
Pelican, brown	*Pelecanus occidentalis*	U.S.A (Carolinas to Texas, CA), West Indies, Central and South America: Coastal.	do	E	2, 3	NA	NA
Penguin, Galapagos	*Spheniscus mendiculus*	Ecuador (Galapagos Island)	do	E	3	NA	NA
Petrel, Hawaiian dark-rumped	*Pterodroma phaeopygia sandwichensis.*	U.S.A. (Hawaii)	do	E	2, 4, 1	NA	NA
Pheasant, bar-tailed	*Symaticus humiae*	Burma, China	do	E	3	NA	NA
Pheasant, Blyth's tragopan	*Tragopan blythii*	Burma, China, India	do	E	3	NA	NA
Pheasant, brown eared	*Crossoptilon mantchuricum*	China	do	E	3	NA	NA
Pheasant, Cabot's tragopan	*Tragopan caboti*	do	do	E	3	NA	NA
Pheasant, Chinese monal	*Lophophorus lhuysii*	do	do	E	3	NA	NA
Pheasant, Edward's	*Lophura edwardsi*	Vietnam	do	E	3	NA	NA
Pheasant, Elliot's	*Syrmaticus elliotii*	China	do	E	15	NA	NA
Pheasant, imperial	*Lophura imperialis*	Vietnam	do	E	3	NA	NA
Pheasant, Mikado	*Syrmaticus mikado*	Taiwan	do	E	3	NA	NA
Pheasant, Palawan peacock	*Polyplectron emphanum*	Philippines	do	E	3	NA	NA
Pheasant, Sclater's monal	*Lophophorus sclateri*	Burma, China, India	do	E	3	NA	NA
Pheasant, Swinhoe's	*Lophura swinhoii*	Taiwan	do	E	3	NA	NA
Pheasant, western tragopan	*Tragopan melanocephalus*	India, Pakistan	do	E	3	NA	NA
Pheasant, white eared	*Crossoptilon crossoptilon*	China (Tibet), India	do	E	4	NA	NA
Pigeon, Azores wood	*Columba palumbus azorica*	East Atlantic Ocean: Azores	do	E	3	NA	NA
Pigeon, Chatham Island	*Hemiphaga novaeseelandiae chathamensis.*	New Zealand	do	E	3	NA	NA
Pigeon, Mindoro zone-tailed	*Ducula mindorensis*	Philippines	do	E	15	NA	NA
Pigeon, Puerto Rican plain	*Columba inornata wetmorei*	U.S.A. (Puerto Rico)	do	E	2	NA	NA
Piping-guan, black-fronted	*Pipile jacutinga*	Argentina	do	E	15	NA	NA
Pitta, Koch's	*Pitta kochi*	Philippines	do	E	15	NA	NA
Plover, New Zealand shore	*Thinornis novaeseelandiae*	New Zealand	do	E	3	NA	NA
Po'ouli (honeycreeper)	*Melamprosops phaeosoma*	U.S.A. (Hawaii)	do	E	10	NA	NA
Prairie-chicken, Attwater's greater.	*Tympanuchus cupido attwateri*	U.S.A. (Texas)	do	E	1	NA	NA
Quail, Merriam's Montezuma	*Cyrtonyx montezumae meriami*	Mexico (Vera Cruz)	do	E	15	NA	NA
Quetzel, resplendent	*Pharomachrus mocinno*	Mexico to Panama	do	E	15	NA	NA
Rail, Aukland Island	*Rallus pectoralis muelleri*	New Zealand	do	E	3	NA	NA
Rail, California clapper	*Rallus longirostris obsoletus*	U.S.A. (California)	do	E	2	NA	NA
Rail, light-footed clapper	*Rallus longirostris levipes*	U.S.A. (California), Mexico (Baja California).	do	E	2	NA	NA
Rail, Lord Howe wood	*Tricholimnas sylvestris*	Australia (Lord Howe Island)	do	E	15	NA	NA
Rail, Yuma clapper	*Rallus longirostris yumanensis*	Mexico, U.S.A. (AZ, CA)	do	E	1	NA	NA
Rhea, Darwin's	*Pterocnemia pennata*	Argentina, Bolivia, Peru, Uruguay	do	E	3	NA	NA
Robin, Chatham Island	*Petroica traversi*	New Zealand	do	E	3	NA	NA
Robin, scarlet-breasted (fly-catcher).	*Petroica multicolor multicolor*	Australia (Norfolk Island)	do	E	3	NA	NA

Species name	Scientific name	Historic rar	Vertebrate population where endangered or threatened	Status	listed	habitat	Uses
Rockfowl, white-necked	*Picathartes gymnocephalus*	Africa: Togo to Sierra Leone	do	E	3	NA	NA
Roller, long-tailed ground	*Uratelornis chimaera*	Malagasy Republic (=Madagascar).	do	E	3	NA	NA
Scrub-bird, noisy	*Atrichornis clamosus*	Australia	do	E	3	NA	NA
Shama, Cebu black (thrush)	*Copsychus niger cebuensis*	Philippines	do	E	3	NA	NA
Shearwater, Newell's (Townsend's, formerly Manx) (='A'o).	*Puffinus auricularis* (formerly *puffinus*) *newelli.*	U.S.A. (Hawaii)	do	T	10	NA	NA
Shrike, San Clemente loggerhead.	*Lanius ludovicianus mearnsi*	U.S.A. (California)	do	E	26	NA	NA
Siskin, red	*Carduelis* (=*Spinus*) *cucullatus*	South America	do	E	15	NA	NA
Sparrow, Cape Sable seaside	*Ammospiza maritima mirabilis*	U.S.A. (Florida)	do	E	1	17.95(b)	NA
Sparrow, dusky seaside	*Ammospiza maritima nigrescens*	do	do	E	1	17.95(b)	NA
Sparrow, San Clemente sage	*Amphispiza belli clementeae*	U.S.A. (California)	do	T	26	NA	NA
Sparrow, Santa Barbara song	*Melospiza melodia graminea*	do	do	E	6	NA	NA
Starling, Ponape mountain	*Aplonis pelzelni*	West Pacific Ocean: U.S.A. (Caroline Island).	do	E	3	NA	NA
Starling, Rothschild's (myna)	*Leucopsar rothschildi*	Indonesia (Bali)	do	E	3	NA	NA
Stilt, Hawaiian (=Ae'o)	*Himantopus himantopus knudseni*	U.S.A. (Hawaii)	do	E	2	NA	NA
Stork, oriental white	*Ciconia ciconia boyciana*	China, Japan, Korea, U.S.S.R.	do	E	3	NA	NA
Teal, Campbell Island flightless.	*Anas aucklandica nesiotis*	New Zeland (Campbell Island)	do	E	15	NA	NA
Tern, California least	*Sterna antillarum* (=*albifrons*) *browni.*	Mexico, U.S.A. (CA)	do	E	2, 3	NA	NA
Thrasher, white-breasted	*Ramphocinclus brachyurus*	West Indies: St. Lucia, Martinique	do	E	3	NA	NA
Thrush, large Kauai	*Phaeomis obscurus myadestina*	U.S.A. (Hawaii)	do	E	2	NA	NA
Thrush, Molokai (=oloma'o)	*Phaeomis obscurus rutha*	do	do	E	2	NA	NA
Thrush, New Zealand (wattlebird).	*Turnagra capensis*	New Zealand	do	E	3	NA	NA
Thrush, small Kauai (=puaiohi).	*Phaeomis palmeri*	U.S.A. (Hawaii)	do	E	1	NA	NA
Tinamou, solitary	*Tinamus solitarius*	Brazil, Paraguay, Argentina	do	E	15	NA	NA
Trembler, Martinique brown (thrasher).	*Cinclocerthia ruficauda gutturalis*	West Indies: Martinique	do	E	3	NA	NA
Wanderer, plain (collared-hemipode).	*Pedionomous torquatus*	Australia	do	E	6	NA	NA
Warbler (wood), Bachman's	*Vermivora bachmanii*	U.S.A (Southeastern), Cuba	do	E	1, 3	NA	NA
Warbler (wood), Barbados yellow.	*Dendroica petechia petechia*	West Indies: Barbados	do	E	3	NA	NA
Warbler (wood), Kirtland's	*Dendroica kirtlandii*	U.S.A. (principally MI), Canada, West Indies: Bahama Islands.	do	E	1, 3	NA	NA
Warbler (willow), reed	*Acrocephalus luscinia*	Western Pacific Ocean: U.S.A. (Mariana Islands).	do	E	3	NA	NA
Warbler (willow), Rodriques	*Bebromis rodericanus*	Mauritius (Rodrigues Islands)	do	E	3	NA	NA
Warbler (wood), Semper's	*Leucopeza semperi*	West Indies: St. Lucia	do	E	3	NA	NA
Warbler (willow), Seychelles	*Bebromis sechellensis*	Indian Ocean: Seychelles Island	do	E	3	NA	NA
Whipbird, Western	*Psophodes nigrogularis*	Australia	do	E	3	NA	NA
Whip-poor-will, Puerto Rican	*Caprimulgus noctitherus*	U.S.A. (Puerto Rico)	do	E	6	NA	NA
White-eye, Norfolk Island	*Zosterops albogularis*	Indian Ocean: Norfolk Islands	do	E	15	NA	NA
White-eye, Ponape great	*Rukia longirostra* (=*sanfordi*)	West Pacific Ocean: U.S.A. (Caroline Islands).	do	E	3	NA	NA
White-eye, Seychelles	*Zosterops modesta*	Indian Ocean: Seychelles	do	E	3	NA	NA
Woodpecker, Imperial	*Campephilus imperialis*	Mexico	do	E	3	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Woodpecker, ivory-billed	*Campephilus principalis*	U.S.A. (southcentral and southeastern), Cuba.	do	E	1, 3	NA	NA
Woodpecker, red-cockaded	*Picoides (=Dendrocopos) borealis*	U.S.A. (southcentral and southeastern).	do	E	2	NA	NA
Woodpecker, Tristam's	*Dryocopus javensis richardsi*	Korea	do	E	3	NA	NA
Wren, Guadeloupe house	*Troglodytes aedon guadeloupensis*	West Indies: Guadeloupe	do	E	3	NA	NA
Wren, St. Lucia house	*Troglodytes aedon mesoleucus*	West Indies: St. Lucia	do	E	3	NA	NA
REPTILES							
Alligator, American	*Alligator mississippiensis*	Southeastern U.S.A	Wherever found in wild except those areas where listed as threatened as set forth below.	E	1, 11, 51, 60, 113	NA	NA
Do	do	do	U.S.A. (FL and certain areas of GA, SC, and TX, as set forth in 17.42(a)(1)).	T	20, 47, 51, 60	NA	17.42(a)
Do	do	do	U.S.A. (LA)	T(S/A)	11, 47, 51, 60, 113	NA	17.42(a)
Do	do	do	In captivity wherever found	T(S/A)	11, 47, 51	NA	17.42(a)
Alligator, Chinese	*Alligator sinensis*	China	Entire	E	15	NA	NA
Anole, Culebra Island giant	*Anolis roosevelti*	U.S.A. (Puerto Rico: Culebra Island).	do	E	25	17.95(c)	NA
Boa, Jamaican	*Epicrates subflavus*	Jamaica	do	E	3	NA	NA
Boa, Mona	*Epicrates monensis monensis*	U.S.A. (Puerto Rico)	do	T	33	17.95(c)	NA
Boa, Puerto Rico	*Epicrates inornatus*	do	do	E	2	NA	NA
Boa, Round Island (no common name).	*Casarea dussumieri*	Indian Ocean: Mauritius	do	E	88	NA	NA
Boa, Round Island (no common name).	*Bolyeria multocarinata*	Indian Ocean: Mauritius	do	E	88	NA	NA
Boa, Virgin Islands tree	*Epicrates monensis granti*	U.S. and British Virgin Islands	do	E	2, 88	NA	NA
Caiman, Apaporis River	*Caiman crocodilus apaporiensis*	Colombia	do	E	15	NA	NA
Caiman, black	*Melanosuchus niger*	Amazon basin	do	E	15	NA	NA
Caiman, broad-snouted	*Caiman latirostris*	Brazil, Argentina, Paraguay, Uruguay.	do	E	15	NA	NA
Caiman, Yacare	*Caiman crocodilus yacare*	Bolivia, Argentina, Peru, Brazil	do	E	3	NA	NA
Chuckwalla, San Esteban Island.	*Sauromalus varius*	Mexico	do	E	88	NA	NA
Crocodile, African dwarf	*Osteolaemus tetraspis tetraspis*	West Africa	do	E	15	NA	NA
Crocodile, African slender-snouted.	*Crocodylus cataphractus*	Western and central Africa	do	E	5	NA	NA
Crocodile, American	*Crocodylus acutus*	U.S.A. (FL), Mexico, South America, Central America, Caribbean.	do	E	10, 87	17.95(c)	NA
Crocodile, Ceylon mugger	*Crocodylus palustris kimbula*	Sri Lanka	do	E	15	NA	NA
Crocodile, Congo dwarf	*Osteolaemus tetraspis osborni*	Congo River drainage	do	E	15	NA	NA
Crocodile, Cuban	*Crocodylus rhombifer*	Cuba	do	E	3	NA	NA
Crocodile, Morelet's	*Crocodylus moreletii*	Mexico, Belize, Guatemala	do	E	3	NA	NA
Crocodile, mugger	*Crocodylus palustris palustris*	India, Pakistan, Iran, Bangladesh	do	E	15	NA	NA
Crocodile, Nile	*Crocodylus niloticus*	Africa	do	E	3	NA	NA
Crocodile, Orinoco	*Crocodylus intermedius*	South America: Orinoco River Basin.	do	E	3	NA	NA
Crocodile, Philippine	*Crocodylus novaeguineae mindorensis*	Philippine Islands	do	E	15	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	[illegible]
Common name	Scientific name						
Crocodile, saltwater (=estuarine).	*Crocodylus porosus*	Southeast Asia, Australia, Papua-New Guinea, Pacific Islands.	Entire, except Papua-New Guinea	E	87	NA	NA
Crocodile, Siamese	*Crocodylus siamensis*	Southeast Asia, Malay Peninsula	Entire	E	15	NA	NA
Gavial (=gharial)	*Gavialus gangeticus*	Pakistan, Burma, Bangladesh, India.	do	E	3, 15	NA	NA
Gecko, day	*Phelsuma edwardnewtoni*	Indian Ocean: Mauritius	do	E	3	NA	NA
Gecko, Monito	*Sphaerodactylus micropithecus*	U.S.A. (Puerto Rico)	do	E	125	17.95(c)	NA
Gecko, Round Island day	*Phelsuma guentheri*	Indian Ocean: Mauritius	do	E	3	NA	NA
Gecko, Serpent Island	*Cyrtodactylus serpensinsula*	do	do	T	129	NA	NA
Iguana, Acklins ground	*Cyclura nileyi nuchalis*	West Indies: Bahamas	do	T	129	NA	NA
Iguana, Allen's Cay	*Cyclura cychlura inornata*	do	do	T	129	NA	NA
Iguana, Andros Island ground	*Cyclura cychlura cychlura*	do	do	T	129	NA	NA
Iguana, Anegada ground	*Cyclura pinguis*	West Indies: British Virgin Islands (Anegada Island).	do	E	3	NA	NA
Iguana, Barrington land	*Conolophus pallidus*	Ecuador (Galapagos Island)	do	E	3	NA	NA
Iguna, Cayman Brac ground	*Cyclura nubila caymanensis*	West Indies: Cayman Islands	do	T	129	NA	NA
Iguana, Cuban ground	*Cyclura nubila nubila*	Cuba	Entire (excluding population introduced in Puerto Rico).	T	129	NA	NA
Iguana, Exuma Island	*Cyclura cychlura figginsi*	West Indies: Bahamas	Entire	T	129	NA	NA
Iguana, Fiji banded	*Brachylophus fasciatus*	Pacific: Fiji, Tonga	do	E	88	NA	NA
Iguana, Fiji crested	*Brachylophus vitiensis*	Pacific: Fiji	do	E	88	NA	NA
Iguana, Grand Cayman ground	*Cyclura nubila lewisi*	West Indies: Cayman Islands	do	E	129	NA	NA
Iguana, Jamaican	*Cyclura collei*	West Indies: Jamaica	do	E	129	NA	NA
Iguana, Mayaguana	*Cyclura carinata bartschi*	West Indies: Bahamas	do	T	129	NA	NA
Iguana, Mona ground	*Cyclura stejnegeri*	U.S.A. (Puerto Rico: Mona Island)	do	T	33	17.95(c)	NA
Iguana, Turks and Caicos	*Cyclura carinata carinata*	West Indies: Turks and Caicos Islands.	do	T	129	NA	NA
Iguana, Walling Island ground	*Cyclura nileyi nileyi*	West Indies: Bahamas	do	E	129	NA	NA
Iguana, White Cay ground	*Cyclura nileyi cristata*	do	do	T	129	NA	NA
Lizard, blunt-nosed leopard	*Gambelia (=Crotaphytus) silus*	U.S.A. (California)	do	E	1	NA	NA
Lizard, Coachella Valley fringe-toed.	*Uma inornata*	do	do	T	105	17.95(c)	NA
Lizard, Island night	*Xantusia (=Klauberina) riversiana*	do	do	T	26	NA	NA
Lizard, St. Croix ground	*Ameiva polops*	U.S.A. (Virgin Islands: Green Cay, Protestant Cay).	do	E	24	17.95(c)	NA
Monitor, Bengal	*Varanus bengalensis*	Iran, Iraq, India, Sri Lanka, Malaysia, Afghanistan, Burma, Vietnam, Thailand.	do	E	15	NA	NA
Monitor, desert	*Varanus griseus*	North Africa to Neareast, Caspian Sea through U.S.S.R. to Pakistan, Northwest India.	do	E	15	NA	NA
Monitor, Komodo Island	*Varanus komodoensis*	Indonesia (Komodo, Rintja, Padar, and western Flores Island.	do	E	15	NA	NA
Monitor, yellow	*Varanus flavescens*	West Pakistan through India to Bangladesh.	do	E	15	NA	NA
Python, Indian	*Python molurus molurus*	Sri Lanka and India	do	E	15	NA	NA
Rattlesnake, Aruba Island	*Crotalus unicolor*	Aruba Island (Netherland Antilles)	do	T	129	NA	NA
Rattlesnake, New Mexican ridge-nosed.	*Crotalus willardi obscurus*	U.S.A. (NM), Mexico	do	T	43	17.95(c)	NA
Skink, Round Island	*Leiolopisma telfaini*	Indian Ocean: Mauritius	do	T	129	NA	NA
Snake, Atlantic salt marsh	*Nerodia fasciata taeniata*	U.S.A. (Florida)	do	T	30	NA	NA
Snake, eastern indigo	*Drymarchon corais couperi*	U.S.A. (AL, FL, GA, MS, SC)	do	T	32	NA	NA
Snake, San Francisco garter	*Thamnophis sirtalis tetrataenia*	U.S.A. (California)	do	E	1	NA	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Tartaruga	*Podocnemis expansa*	South America: Orinoco and Amazon River basins.	do	E	3	NA	NA
Terrapin, river (=Tuntong)	*Batagur baska*	Malaysia, Bangladesh, Burma, India, Indonesia.	do	E	3	NA	NA
Tomistoma	*Tomistoma schlegelii*	Malaysia, Indonesia	do	E	15	NA	NA
Tortoise, angulated	*Geochelone yniphora*	Malagasy Republic (=Madagascar).	do	E	15	NA	NA
Tortoise, Bolson	*Gopherus flavomarginatus*	Mexico	do	E	46	NA	NA
Tortoise, desert	*Scaptochelys (=Gopherus) agassizii.*	U.S.A. (UT, AZ, CA, NV); Mexico	Beaver Dam Slope, Utah	T	103	17.95(c)	NA
Tortoise, Galapagos	*Geochelone elephantopus*	Ecuador (Galapagos Islands)	Entire	E	3	NA	NA
Tortoise, Indian flap-shell	*Lissemys punctata punctata*	India, Pakistan, Bangladesh	do	E	15	NA	NA
Tortoise, radiated	*Geochelone (=Testudo) radiata*	Malagasy Republic (=Madagascar).	do	E	3	NA	NA
Tracaja	*Podocnemis unifilis*	South America: Orinoco and Amazon River basins.	do	E	3	NA	NA
Tuatara	*Sphenodon punctatus*	New Zealand	do	E	3	NA	NA
Turtle, aquatic box	*Terrapene coahuila*	Mexico	do	E	6	NA	NA
Turtle, black softshell	*Trionyx nigricans*	Bangladesh	do	E	15	NA	NA
Turtle, Burmese peacock	*Morenia ocellata*	Burma	do	E	15	NA	NA
Turtle, Central American river	*Dermatemys mawii*	Mexico, Belize, Guatemala	do	E	129	NA	NA
Turtle, Cuatro Cienegas softshell.	*Trionyx ater*	Mexico	do	E	15	NA	NA
Turtle, geometric	*Psammobates geometricus (=Geochelone geometrica).*	South Africa	do	E	15	NA	NA
Turtle, green sea	*Chelonia mydas*	Circumglobal in tropical and temperate seas and oceans.	Wherever found except where listed as endangered below.	T	42	NA	17.42(b) and Parts 220 and 227.
Turtle, green sea	*Chelonia mydas*	do	Breeding colony populations in FL and on Pacific coast of Mexico.	E	42	NA	NA
Turtle, hawksbill sea (=carey)	*Eretmochelys imbricata*	Tropical seas	Entire	E	3	17.95(c)	NA
Turtle, Indian sawback	*Kachuga tecta tecta*	India	do	E	15	NA	NA
Turtle, Indian softshell	*Trionyx gangeticus*	Pakistan, India	do	E	15	NA	NA
Turtle, Kemp's (=Atlantic) Ridley sea.	*Lepidochelys kempii*	Tropical and temperate seas	do	E	4	NA	NA
Turtle, leatherback sea	*Dermochelys coriacea*	Tropical, temperate, and subpolar seas.	do	E	3	17.95(c)	NA
Turtle, loggerhead sea	*Caretta caretta*	Circumglobal in tropical and temperate seas and oceans.	do	T	42	NA	17.42(b) and Parts 220 and 227.
Turtle, Olive (Pacific) Ridley sea.	*Lepidochelys olivacea*	do	Wherever found except where listed as endangered below.	T	42	NA	17.42(b) and Parts 220 and 227.
Turtle, Olive (Pacific) Ridley sea.	*Lepidochelys olivacea*	do	Breeding colony populations on Pacific coast of Mexico.	E	42	NA	NA
Turtle, peacock softshell	*Trionyx hurum*	India, Bangladesh	Entire	E	15	NA	NA
Turtle, Plymouth red-bellied	*Pseudemys (=Chrysemys) rubriventris bangsi.*	U.S.A. (Massachusetts)	do	E	90	17.95(c)	NA

Species: Common name	Species: Scientific name	Historic	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Turtle, short-necked or western swamp.	*Pseudemydura umbrina*	Australia	do	E	3	NA	NA
Turtle, spotted pond	*Geoclemys (=Damonia) hamiltonii*	North India, Pakistan	do	E	15	NA	NA
Turtle, three-keeled Asian	*Melanochelys (=Geoemyda, Nicoria) tricarinata.*	Central India to Bangladesh and Burma.	do	E	15	NA	NA
Viper, Lar Valley	*Vipera latifii*	Iran	do	E	129	NA	NA
AMPHIBIANS							
Coqui, golden	*Eleutherodactylus jasperi*	U.S.A. (Puerto Rico)	do	T	29	17.95(d)	NA
Frog, Israel painted	*Discoglossus nigriventer*	Israel	do	E	3	NA	NA
Frog, Panamanian golden	*Atelopus varius zeteki*	Panama	do	E	15	NA	NA
Frog, Stephen Island	*Leiopelma hamiltoni*	New Zealand	do	E	3	NA	NA
Salamander, Chinese giant	*Andrias davidianus davidianus*	Western China	do	E	15	NA	NA
Salamander, desert slender	*Batrachoseps aridus*	U.S.A. (California)	do	E	6	NA	NA
Salamander, Japanese giant	*Andrias davidianus japonicus*	Japan	do	E	15	NA	NA
Salamander, Red Hills	*Phaeognathus hubrichti*	U.S.A. (Alabama)	do	T	19	NA	NA
Salamander, San Marcos	*Eurycea nana*	U.S.A. (Texas)	do	T	98	17.95(d)	17.43(a)
Salamander, Santa Cruz long-toed.	*Ambystoma macrodactylum croceum.*	U.S.A. (California)	do	E	1	NA	NA
Salamander, Texas blind	*Typhlomolge rathbuni*	U.S.A. (Texas)	do	E	1	NA	NA
Toad, African viviparous	*Nectophrynoides* spp.	Tanzania, Guinea, Ivory Coast, Cameroon, Liberia, Ethiopia.	do	E	15	NA	NA
Toad, Cameroon	*Bufo superciliaris*	Equatorial Africa	do	E	15	NA	NA
Toad, Houston	*Bufo houstonensis*	U.S.A. (Texas)	do	E	2	17.95(d)	NA
Toad, Monte Verde	*Bufo periglenes*	Costa Rica	do	E	15	NA	NA
Treefrog, pine barrens	*Hyla andersonii*	U.S.A. (FL, AL, NC, SC, NJ)	Florida	E	29	17.95(d)	NA
FISHES							
Ala Balik (trout)	*Salmo platycephalus*	Turkey	Entire	E	3	NA	NA
Ayumodoki (loach)	*Hymenophysa (=Botia) curta*	Japan	do	E	3	NA	NA
Blindcat, Mexican (catfish)	*Prietella phreatophila*	Mexico	do	E	3	NA	NA
Bonytail, Pahranagat	*Gila robusta jordani*	U.S.A. (Nevada)	do	E	2	NA	NA
Bonytongue, Asian	*Scleropages formosus*	Thailand, Indonesia, Malaysia	do	E	15	NA	NA
Catfish (no common name)	*Pangasius sanitwongsei*	Thailand	do	E	3	NA	NA
Catfish, giant	*Pangasianodon gigas*	do	do	E	3	NA	NA
Cavefish, Alabama	*Speoplatyrhinus poulsoni*	U.S.A. (Alabama)	do	T	28	17.95(e)	NA
Chub, bonytail	*Gila elegans*	U.S.A. (AZ, CA, CO, NV, UT, WY)	do	E	92	NA	NA
Chub, Borax Lake	*Gila boraxobius*	U.S.A. (Oregon)	do	E	124	17.95(e)	NA
Chub, humpback	*Gila cypha*	U.S.A. (AZ, CO, UT, WY)	do	E	1	NA	NA
Chub, Mohave tui	*Gila bicolor mohavensis (=G. mohavensis).*	U.S.A (California)	do	E	2	NA	NA
Chub, slender	*Hybopsis cahni*	U.S.A. (TN, VA)	do	T	28	17.95(e)	17.44(c)
Chub, spotfin	*Hybopsis monacha*	U.S.A. (AL, GA, NC, TN, VA)	do	T	28	17.95(e)	17.44(c)
Cicek (minnow)	*Acanthorutilus handlirschi*	Turkey	do	E	3	NA	NA
Cisco, longjaw	*Coregonus alpenae*	U.S.A. and Canada (Lakes Michigan, Huron, Erie).	do	E	1, 4	NA	NA
Cui-ui	*Chasmistes cujus*	U.S.A. (Nevada)	do	E	1	NA	NA
Dace, Ash Meadows speckled	*Rhinichthys osculus nevadensis*	do	do	E	117E, 127E	17.95(e)	NA
Dace, Kendall Warm Springs	*Rhinichthys osculus thermalis*	U.S.A. (Wyoming)	do	E	2	NA	NA
Dace, Moapa	*Moapa coriacea*	U.S.A. (Nevada)	do	E	1	NA	NA
Darter, bayou	*Etheostoma rubrum*	U.S.A. (Mississippi)	do	T	10	NA	17.44(h)
Darter, fountain	*Etheostoma fonticola*	U.S.A. (Texas)	do	E	2	17.95(e)	NA
Darter, leopard	*Percina pantherina*	U.S.A. (AR, OK)	do	T	31	17.95(e)	17.44(d)

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Darter, Maryland	*Etheostoma sellare*	U.S.A. (Maryland)	do	E	1	NA	NA
Darter, Okaloosa	*Etheostoma okaloosae*	U.S.A. (Florida)	do	E	6	NA	NA
Darter, slackwater	*Etheostoma boschungi*	U.S.A. (AL, TN)	do	T	28	17.95(e)	17.44(c)
Darter, snail	*Percina tanasi*	U.S.A. (AL, GA, TN)	do	E	12	17.95(c)	NA
Darter, watercress	*Etheostoma nuchale*	U.S.A. (Alabama)	do	E	2	NA	NA
Gambusia, Big Bend	*Gambusia gaigei*	U.S.A. (Texas)	do	E	1	NA	NA
Gambusia, Clear Creek	*Gambusia heterochir*	do	do	E	1	NA	NA
Gambusia, Amistad (=Goodenough).	*Gambusia amistadensis*	do	do	E	93	NA	NA
Gambusia, Pecos	*Gambusia nobilis*	U.S.A. (NM, TX)	do	E	2	NA	NA
Gambusia, San Marcos	*Gambusia georgei*	U.S.A. (Texas)	do	E	98	17.95(e)	NA
Killifish, Pahrump	*Empetrichthys latos*	U.S.A. (Nevada)	do	E	1	NA	NA
Madtom, Scioto	*Noturus trautmani*	U.S.A. (Ohio)	do	E	10	NA	NA
Madtom, yellowfin	*Noturus flavipinnis*	U.S.A. (GA, TN, VA)	do	T	28	17.95(e)	17.44(c)
Nekogigi (catfish)	*Coreobagrus ichikawai*	Japan	do	E	3	NA	NA
Pike, blue	*Stizostedion vitreum glaucum*	U.S.A. and Canada (Lakes Erie, Ontario).	do	E	1	NA	NA
Pupfish, Ash Meadows Amargosa.	*Cyprinodon nevadensis mionectes*	U.S.A. (Nevada)	do	E	117E, 127E	17.95(e)	NA
Pupfish, Comanche Springs	*Cyprinodon elegans*	U.S.A. (Texas)	do	E	1	NA	NA
Pupfish, Devils Hole	*Cyprinodon diabolis*	U.S.A. (Nevada)	do	E	1	NA	NA
Pupfish, Leon Springs	*Cyprinodon bovinus*	U.S.A. (Texas)	do	E	102	17.95(e)	NA
Pupfish, Owens River	*Cyprinodon radiosus*	U.S.A. (California)	do	E	1	NA	NA
Pupfish, Warm Springs	*Cyprinodon nevadensis pectoralis*	U.S.A. (Nevada)	do	E	2	NA	NA
Squawfish, Colorado	*Ptychocheilus lucius*	U.S.A. (AZ, CA, CO, NM, NV, UT, WY), Mexico.	do	E	1	NA	NA
Stickleback, unarmored threespine.	*Gasterosteus aculeatus williamsoni*	U.S.A. (California)	do	E	2	NA	NA
Sturgeon, shortnose	*Acipenser brevirostrum*	U.S.A. and Canada (Atlantic Coast)	do	E	1	NA	NA
Tango, Miyako (Tokyo bitterling).	*Tanakia tanago*	Japan	do	E	3	NA	NA
Temolek, Ikan (minnow)	*Probarbus jullieni*	Thailand, Cambodia, Vietnam, Malaysia, Laos.	do	E	15	NA	NA
Topminnow, Gila	*Poeciliopsis occidentalis*	U.S.A. (AZ, NM), Mexico	do	E	1	NA	NA
Totoaba (seatrout or weakfish)	*Cynoscion macdonaldi*	Mexico (Gulf of California)	do	E	45	NA	NA
Trout, Apache (=Arizona)	*Salmo apache*	U.S.A. (Arizona)	do	T	1, 8	NA	17.44(a)
Trout, Gila	*Salmo gilae*	U.S.A. (New Mexico)	do	E	1	NA	NA
Trout, greenback cutthroat	*Salmo clarki stomias*	U.S.A. (Colorado)	do	T	1, 38	NA	17.44(f)
Trout, Lahontan cutthroat	*Salmo clarki henshawi*	U.S.A. (CA, NV)	do	T	2, 8	NA	17.44(a)
Trout, Little Kern golden	*Salmo aguabonita whitei*	U.S.A. (California)	do	T	37	17.95(e)	17.44(a)
Trout, Paiute cutthroat	*Salmo clarki seleniris*	do	do	T	1, 8	NA	17.44(a)
Woundfin	*Plagopterus argentissimus*	U.S.A. (AZ, NV, UT)	do	E	2	NA	NA
SNAILS							
Snail, Chittenango ovate amber.	*Succinea chittenangoensis*	U.S.A. (New York)	NA	T	41	NA	NA
Snail, flat-spired three-toothed	*Triodopsis platysayoides*	U.S.A. (West Virginia)	NA	T	41	NA	NA
Snail, Iowa Pleistocene	*Discus macclintocki*	U.S.A. (Iowa)	NA	E	41	NA	NA
Snail, Manus Island tree	*Papustyla pulcherrima*	Admiralty Islands (Manus Islands)	NA	E	3	NA	NA
Snail, noonday	*Mesodon clarki nantahala*	U.S.A. (North Carolina)	NA	T	41	NA	NA
Snail, Oahu tree	*Achatinella* spp. (all species)	U.S.A. (Hawaii)	NA	E	108, 112	NA	NA
Snail, painted snake coiled	*Anguispira picta*	U.S.A. (Tennessee)	NA	T	41	NA	NA

Species: Common name	Species: Scientific name	Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	[illegible]
Snail, Virginia fringed mountain	*Polygyriscus virginianus*	U.S.A. (Virginia)	NA	E	41	NA	NA
CLAMS							
Pearly mussel, Alabama lamp	*Lampsilis virescens*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, Appalachian monkeyface.	*Quadrula sparsa*	U.S.A. (TN, VA)	NA	E	15	NA	NA
Pearly mussel, birdwing	*Conradilla caelata*	do	NA	E	15	NA	NA
Pearly mussel, Cumberland bean.	*Villosa (=Micromya) trabalis*	U.S.A. (Kentucky)	NA	E	15	NA	NA
Pearly mussel, Cumberland monkeyface.	*Quadrula intermedia*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pearly mussel, Curtis'	*Epioblasma (=Dysnomia) florentina curtisi.*	U.S.A. (Missouri)	NA	E	15	NA	NA
Pearly mussel, dromedary	*Dromus dromas*	U.S.A. (TN, VA)	NA	E	15	NA	NA
Pearly mussel, green-blossom	*Epioblasma (=Dysnomia) torulosa gubernaculum.*	do	NA	E	15	NA	NA
Pearly mussel, Higgins' eye	*Lampsilis higginsi*	U.S.A. (IL, IA, MN, MO, NE, WI)	NA	E	15	NA	NA
Pearly mussel, Nicklin's	*Megalonaias nicklineana*	Mexico	NA	E	15	NA	NA
Pearly mussel, orange-footed	*Plethobasus cooperianus*	U.S.A. (AL, IN, IA, KY, OH, PA, TN).	NA	E	15	NA	NA
Pearly mussel, pale lilliput	*Toxolasma (=Carunculina) cylindrella.*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, pink mucket	*Lampsilis orbiculata*	U.S.A. (AL, IL, IN, KY, MO, OH, PA, TN, WV).	NA	E	15	NA	NA
Pearly mussel, Sampson's	*Epioblasma (=Dysnomia) sampsoni.*	U.S.A. (IL, IN)	NA	E	15	NA	NA
Pearly mussel, Tampico	*Cyrtonaias tampicoensis tecomatensis.*	Mexico	NA	E	15	NA	NA
Pearly mussel, tubercled-blossom.	*Epioblasma (=Dysnomia) torulosa torulosa.*	U.S.A. (IL, KY, TN, WV)	NA	E	15	NA	NA
Pearly mussel, turgid blossom	*Epioblasma (=Dysnomia) turgidula.*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, white cat's paw	*Epioblasma (=Dysnomia) sulcata delicata.*	U.S.A. (IN, MI, OH)	NA	E	15	NA	NA
Pearly mussel, white warty-back.	*Plethobasus cicatricosus*	U.S.A. (AL, TN)	NA	E	15	NA	NA
Pearly mussel, yellow-blossom	*Epioblasma (=Dysnomia) florentina florentina.*	do	NA	E	15	NA	NA
Pigtoe, fine-rayed	*Fusconaia cuneolus*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pigtoe, rough	*Pleurobema plenum*	U.S.A. (KY, TN, VA)	NA	E	15	NA	NA
Pigtoe, shiny	*Fusconaia edgariana*	U.S.A. (AL, TN, VA)	NA	E	15	NA	NA
Pocketbook, fat	*Potamilus (=Proptera) capax*	U.S.A. (AR, IN, MO, OH)	NA	E	15	NA	NA
Riffle shell, tan	*Epioblasma walkeri*	U.S.A. (KY, TN, VA)	NA	E	27	NA	NA
CRUSTACEANS							
Amphipod, Hay's spring	*Stygobromus hayi*	U.S.A. (District of Columbia)	NA	E	115	NA	NA
Isopod, Madison Cave	*Antrolana lira*	U.S.A. (VA)	NA	T	123	NA	17.46(e)
Isopod, Socorro	*Thermosphaeroma (=Exosphaeroma) thermophilus.*	U.S.A. (New Mexico)	NA	E	36	NA	NA
INSECTS							
Beetle, Delta green ground	*Elaphrus viridis*	U.S.A. (California)	NA	T	100	17.95(i)	NA
Beetle, valley elderberry longhorn.	*Desmocerus californicus dimorphus.*	do	NA	T	99	17.95(i)	NA

Species		Historic range	Vertebrate population where endangered or threatened	Status	When listed	Critical habitat	Special rules
Common name	Scientific name						
Butterfly, Bahama swallowtail	*Papilio andraemon bonhotei*	U.S.A. (FL), Bahamas	NA	T	13	NA	17.47(a)
Butterfly, El Segundo blue	*Euphilotes (=Shijimiaeoides) battoides allyni.*	U.S.A. (California)	NA	E	14	NA	NA
Butterfly, Lange's metalmark	*Apodemia mormo langei*	do	NA	E	14	NA	NA
Butterfly, Lotis blue	*Lycaeides argyrognomon lotis*	do	NA	E	14	NA	NA
Butterfly, mission blue	*Icaricia icarioides missionensis*	do	NA	E	14	NA	NA
Butterfly: Oregon silverspot	*Speyeria zerene hippolyta*	U.S.A. (OR, WA)	NA	T	95	17.95(i)	NA
Butterfly: Palos Verdes blue	*Glaucopsyche lygdamus palosverdesensis.*	U.S.A. (California)	NA	E	96	17.95(i)	NA
Butterfly, San Bruno elfin	*Callophrys mossii bayensis*	do	NA	E	14	NA	NA
Butterfly, Schaus swallowtail	*Papilio aristodemus ponceanus*	U.S.A. (Florida)	NA	T	13	NA	17.47(a)
Butterfly, Smith's blue	*Euphilotes (=Shijimiaeoides) enoptes smithi.*	U.S.A. (California)	NA	E	14	NA	NA
Moth, Kern primrose sphinx	*Euproserpinus euterpe*	do	NA	T	91	NA	NA

#—Indicates FR where species was delisted; relisting of the species is indicated by subsequent number(s).
E—Indicates Emergency rule publication (see FR document for effective dates); subsequent number(s) indicate FR final rule, if applicable.
EFFECTIVE DATE NOTE: At 48 FR 612, January 5, 1983, the Ash Meadows speckled dace and the Ash Meadows Amargosa pupfish were again added by an emergency rule to the Endangered Species list. This emergency determination was effective January 5, 1983, and will expire September 2, 1983.

EDITORIAL NOTE: For "When listed" citations, see list following.

1—32 FR 4001; March 11, 1967.
2—35 FR 16047; October 13, 1970.
3—35 FR 8495; June 2, 1970.
4—35 FR 18320; December 2, 1970.
5—37 FR 6476; March 30, 1972.
6—38 FR 14678; June 4, 1973.
7—39 FR 44991; December 30, 1974.
8—40 FR 29864; July 16, 1975.
9—40 FR 31736; July 28, 1975.
10—40 FR 44151; September 25, 1975.
11—40 FR 44418; September 26, 1975.
12—40 FR 47506; October 9, 1975.
13—41 FR 17740; April 28, 1976.
14—41 FR 22044; June 1, 1976.
15—41 FR 24064; June 14, 1976.
16—41 FR 45993; October 19, 1976.
17—41 FR 51021; November 19, 1976.
18—41 FR 51612; November 23, 1976.
19—41 FR 53034; December 3, 1976.
20—42 FR 2076; January 10, 1977.
21—42 FR 2968; January 14, 1977.
23—42 FR 28137; June 2, 1977.
24—42 FR 28545; June 3, 1977.
25—42 FR 37373; July 21, 1977.
26—42 FR 40685; August 11, 1977.
27—42 FR 42353; August 23, 1977.
28—42 FR 45528; September 9, 1977.
29—42 FR 58755; November 11, 1977.
30—42 FR 60745; November 29, 1977.
31—43 FR 3715; January 27, 1978.
32—43 FR 4028; January 31, 1978.
33—43 FR 4621; February 3, 1978.
34—43 FR 6233; February 14, 1978.
35—43 FR 9612; March 9, 1978.
36—43 FR 12691; March 27, 1978.
37—43 FR 15429; April 13, 1978.
38—43 FR 16345; April 18, 1978.
40—43 FR 20504; May 12, 1978.
41—43 FR 28932; July 3, 1978.
42—43 FR 32808; July 28, 1978.
43—43 FR 34479; August 4, 1978.
44—43 FR 44612; September 28, 1978.
45—44 FR 21289; April 10, 1979.
46—44 FR 23064; April 17, 1979.
48—44 FR 29480; May 21, 1979.
50—44 FR 37126; June 25, 1979.
51—44 FR 37132; June 25, 1979.
52—44 FR 42911; July 20, 1979.
54—44 FR 49220; August 21, 1979.
55—44 FR 54007; September 17, 1979.
60—44 FR 59084; October 12, 1979.
85—44 FR 69208; November 30, 1979.
86—44 FR 70677; December 7, 1979.
87—44 FR 75076; December 18, 1979.
88—45 FR 19010; March 20, 1980.
90—45 FR 21833; April 2, 1980.
91—45 FR 24090; April 8, 1980.
92—45 FR 27713; April 23, 1980.
93—45 FR 28722; April 30, 1980.
94—45 FR 35821; May 28, 1980.
95—45 FR 44935; July 2, 1980.
96—45 FR 44939; July 2, 1980.
97—45 FR 47352; July 14, 1980.
98—45 FR 47355; July 14, 1980.
99—45 FR 52803; August 8, 1980.
100—45 FR 52807; August 8, 1980.
102—45 FR 54678; August 15, 1980.
103—45 FR 55654; August 20, 1980.
105—45 FR 63812; September 25, 1980.
106—45 FR 65132; October 1, 1980.
108—46 FR 3178; January 13, 1981.
111—46 FR 11665; February 10, 1981.
112—46 FR 40025; August 6, 1981.
113—46 FR 40664; August 10, 1981.
114—47 FR 4204; January 28, 1982.
115—47 FR 5425; February 5, 1982.
117—47 FR 19995; May 10, 1982.
119—47 FR 31670; July 21, 1982.
123—47 FR 43701; October 4, 1982.
124—47 FR 43962; October 5, 1982.
125—47 FR 46093; October 15, 1982.
127—48 FR 612; January 5, 1983.
128—48 FR 1726; January 14, 1983.
129—48 FR 28464; June 22, 1983.

§ 17 Endangered and threatened

(a) The list in this section contains the names of all species of plants which have been determined by the Services to be Endangered or Threatened. It also contains the names of species of plants treated as Endangered or Threatened because they are sufficiently similar in appearance to Endangered or Threatened species (see § 17.50 *et seq.*).

(b) The columns entitled "Scientific Name" and "Common Name" define the species of plant within the meaning of the Act. Although common names are included, they cannot be relied upon for identification of any specimen, since they may vary greatly in local usage. The Services shall use the most recently accepted scientific name. In cases in which confusion might arise, a synonym(s) will be provided in parentheses. The Services shall rely to the extent practicable on the *International Code of Botanical Nomenclature.*

(c) In the "Status" column the following symbols are used: "E" for Endangered, "T" for Threatened, and "E [or T] (S/A)" for similarity of appearance species.

(d) The other data in the list are nonregulatory in nature and are provided for the information of the reader. In the annual revision and compilation of this Title, the following information may be amended without public notice: the spelling of species' names, historical range, footnotes, references to certain other applicable portions of this Title, synonyms, and more current names. In any of these revised entries, neither the species, as defined in paragraph (b) of this section, nor its status may be changed without following the procedures of Part 424 of this Title.

(e) The "Historic Range" indicates the known general distribution of the species or subspecies as reported in the current scientific literature. The present distribution may be greatly reduced from this historic range. This column does not imply any limitation on the application of the prohibitions in the Act or implementing rules. Such prohibitions apply to all individuals of the plant species, wherever found.

(f)(1) A footnote to the Federal Register publication(s) listing or reclassifying a species is indicated under the column "When Listed." Footnote numbers to §§ 17.11 and 17.12 are in the same numerical sequence, since plants and animals may be listed in the same Federal Register document. That document, at least since 1973, includes a statement indicating the basis for the listing, as well as the effective date(s) of said listing.

(2) The "Special Rules" and "Critical Habitat" columns provide a cross reference to other sections in Parts 17, 222, 226, or 227. The term "NA" (not applicable) appearing in either of these two columns indicates that there are no special rules and/or Critical Habitat for that particular species. However, all other appropriate rules in Parts 17, 217–227, and 402 still apply to that species. In addition, there may be other rules in this Title that relate to such plants, e.g., port-of-entry requirements. It is not intended that the references in the "Special Rules" column list all the regulations of the two Services which might apply to the species or to the regulations of other Federal agencies or State or local governments.

(g) The listing of a particular taxon includes all lower taxonomic units (see § 17.11(g) for examples).

(h) The "List of Endangered and Threatened Plants" is provided below:

Species		Historic range	Status	When listed	Critical habitat	Special rules
Scientific name	Common name					
Alismataceae—Water-plantain family:						
Sagittaria fasciculata	Bunched arrowhead	U.S.A. (NC, SC)	E	53	NA	NA
Asteraceae—Aster family:						
Echinacea tennesseensis	Tennessee purple coneflower	U.S.A. (TN)	E	49	NA	NA
Urochaeta venosa	None	U.S.A. (HI)	E	73	NA	NA
Stephanomeria malheurensis	Malheur wire-lettuce	U.S.A. (OR)	E	126	17.96(a)	NA
Berberidaceae—Barberry family:						
Mahonia sonnei (=*Berberis s.*)	Truckee barberry	U.S.A. (CA)	E	76	NA	NA
Betulaceae—Birch family:						
Betula uber	Virginia round-leaf birch	U.S.A. (VA)	E	39	NA	NA
Brassicaceae—Mustard family:						
Arabis mcdonaldiana	McDonald's rock-cress	U.S.A. (CA)	E	44	NA	NA
Erysimum capitatum var. *angustatum*	Contra Costa wallflower	do	E	39	17.96(a)	NA
Cactaceae—Cactus family:						
Ancistrocactus tobuschii (=*Echinocactus t.*, *Mammillaria t.*).	Tobusch fishhook cactus	U.S.A. (TX)	E	80	NA	NA
Coryphantha minima (=*C. neliae*, *Escobaria n.*, *Mammillaria n.*).	Nellie cory cactus	do	E	81	NA	NA
Coryphantha ramillosa	Bunched cory cactus	U.S.A. (TX), Mexico (Coahuila)	T	77	NA	NA
Coryphantha sneedii var. *leei* (=*Escobaria l.*, *Mammillaria l.*).	Lee pincushion cactus	U.S.A. (NM)	T	61	NA	NA
Coryphantha sneedii var. *sneedii* (=*Escobaria s.*, *Mammillaria s.*).	Sneed pincushion cactus	U.S.A. (TX, NM)	E	82	NA	NA
Echinocactus horizonthalonius var. *nicholii*.	Nichol's Turk's head cactus	U.S.A. (AZ)	E	71	NA	NA
Echinocereus engelmannii var. *purpureus*	Purple-spined hedgehog cactus	U.S.A. (UT)	E	58	NA	NA
Echinocereus fendleri var. *kuenzleri* (=*E. kuenzleri*, *E. hempelii* of authors, not Fobe).	Kuenzler hedgehog cactus	U.S.A. (NM)	E	70	NA	NA
Echinocereus lloydii (=*E. roetteri* var. *l.*)	Lloyd's hedgehog cactus	U.S.A. (TX)	E	67	NA	NA
Echinocereus reichenbachii var. *albertii* (=*E. melanocentrus*).	Black lace cactus	do	E	68	NA	NA
Echinocereus triglochidiatus var. *arizonicus* (=*E. arizonicus*).	Arizona hedgehog cactus	U.S.A. (AZ)	E	62	NA	NA
Echinocereus triglochidiatus var. *inermis* (=*E. coccineus* var. *i.*, *E. phoeniceus* var. *i.*).	Spineless hedgehog cactus	U.S.A. (CO, UT)	E	83	NA	NA
Echinocereus viridiflorus var. *davisii* (=*E. davisii*).	Davis' green pitaya	U.S.A. (TX)	E	81	NA	NA
Neolloydia mariposensis (=*Echinocactus m.*, *Echinomastus m.*).	Lloyd's Mariposa cactus	do	T	77	NA	NA
Pediocactus bradyi (=*Toumeya b.*)	Brady pincushion cactus	U.S.A. (AZ)	E	63	NA	NA
Pediocactus knowltonii (=*Toumeya k.*)	Knowlton cactus	U.S.A. (NM, CO)	E	72	NA	NA
Pediocactus peeblesianus var. *peeblesianus* (=*Echinocactus p.*, *Navajoa p.*, *Toumeya p.*, *Utahia p.*).	Peebles Navajo cactus	U.S.A. (AZ)	E	69	NA	NA
Pediocactus sileri (=*Echinocactus s.*, *Utahia s.*).	Siler pincushion cactus	U.S.A. (AZ, UT)	E	64	NA	NA
Sclerocactus glaucus (=*Echinocactus g.*,	Uinta Basin hookless cactus	U.S.A. (CO, UT)	T	59	NA	NA

Species		Historic range	Status	When listed	Critical habitat	[illegible]
Scientific name	Common name					
Sclerocactus mesae-verdae (=*Coloradoa m.*, *Echinocactus m.*, *Pediocactus m.*).	Mesa Verde cactus	U.S.A. (CO, NM)	T	75	NA	NA
Sclerocactus wrightiae (=*Pediocactus w.*).	Wright fishhook cactus	U.S.A. (UT)	E	58	NA	NA
Cistaceae—Rockrose family:						
Hudsonia montana	Mountain golden heather	U.S.A. (NC)	T	107	17.96(a)	NA
Crassulaceae—Stonecrop family:						
Dudleya traskiae	Santa Barbara Island liveforever	U.S.A. (CA)	E	39	NA	NA
Cupressaceae—Cypress family:						
Fitzroya cupressoides	Chilean false larch (=alerce)	Chile, Argentina	T	79	NA	NA
Ericaceae—Heath family:						
Arctostaphylos hookeri ssp. *ravenii*	Raven's manzanita	U.S.A. (CA)	E	65	NA	NA
Rhododendron chapmanii	Chapman rhododendron	U.S.A. (FL)	E	47	NA	NA
Euphorbiaceae—Spurge family:						
Euphorbia skottsbergii var. *kalaeloana*	'Ewa Plains 'akoko	U.S.A. (HI)	E	120	NA	NA
Fabaceae—Pea family:						
Astragalus perianus	Rydberg milk-vetch	U.S.A. (UT)	T	39	NA	NA
Baptisia arachnifera	Hairy rattleweed	U.S.A. (GA)	E	39	NA	NA
Lotus dendroideus (=*scoparius*) ssp. *traskiae*.	San Clemente Island broom	U.S.A. (CA)	E	26	NA	NA
Vicia menziesii	Hawaiian vetch	U.S.A. (HI)	E	39	NA	NA
Hydrophyllaceae—Waterleaf family:						
Phacelia argillacea	None	U.S.A. (UT)	E	44	NA	NA
Phacelia formosula	North Park phacelia	U.S.A. (CO)	E	121	NA	NA
Lamiaceae—Mint family:						
Haplostachys haplostachya var. *angustifolia*.	None	U.S.A. (HI)	E	73	NA	NA
Hedeoma apiculatum	McKittrick pennyroyal	U.S.A. (TX, NM)	T	118	17.96(a)	NA
Hedeoma todsenii	Todsen's pennyroyal	U.S.A. (NM)	E	110, 112	17.96(a)	NA
Pogogyne abramsii	San Diego mesa mint	U.S.A. (CA)	E	44	NA	NA
Stenogyne angustifolia var. *angustifolia*	None	U.S.A. (HI)	E	73	NA	NA
Liliaceae—Lily family:						
Harperocallis flava	Harper's beauty	U.S.A. (FL)	E	57	NA	NA
Trillium persistens	Persistent trillium	U.S.A. (GA, SC)	E	39	NA	NA
Malvaceae—Mallow family:						
Callirhoe scabriuscula	Texas poppy-mallow	U.S.A. (TX)	E	109, 112	NA	NA
Kokia cookei	Cooke's kokio	U.S.A. (HI)	E	74	NA	NA
Malacothamnus clementinus	San Clemente Island bush-mallow	U.S.A. (CA)	E	26	NA	NA
Nyctaginaceae—Four-o'clock family:						
Mirabilis macfarlanei	MacFarlane's four-o'clock	U.S.A. (ID, OR)	E	66	NA	NA
Onagraceae—Evening-primrose family:						
Oenothera avita ssp. *eurekensis*	Eureka Valley evening primrose	U.S.A. (CA)	E	39	NA	NA
Oenothera deltoides ssp. *howellii*	Antioch Dunes evening-primrose	do	E	39	17.96(a)	NA

Rd 16

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

OFFICE CORRESPONDENCE

FROM	TO
WJF	FILE
	79-55

DATE: January 20, 1987

TO: MEMO TO THE FILE

FROM: William Forrester

SUBJECT: Carrier Airconditioner, Collerville, TN. TND-04 406 22[illegible]

TIME: 10:20 A.M.
WF

I called John Brewer, Safety and Security Coordinator for Carrier Corporation, Collierville, Tennessee, concerning the lagoon referenced in Tennessees' final investigation report on Carrier, dated September 15, 1986. The original report did not specify whether the lagoon did or did not have any type of containment liner. Mr. Brewer informed me during this conversation that the lagoon did not have a containment liner.

FROM	DATE

TO