ANNUAL REPORT

by

Chief Engineer
S. A. LUBETKIN

to the

PASSAIC VALLEY
SEWERAGE COMMISSIONERS

FOR THE YEAR

1972

Violation and Elimination - Stepan Chemical Co.- continued

The odors diminished rapidly during April, and the samples of April 27 and all of May were satisfactory, therefore, the pollution was considered eliminated.

Violation and Elimination - Tenneco Chemicals, Inc., Garfield, N.J.
December 28-29, 1972 (J. Perrapato)

✓

A leak developed in this company's sewer line under River Road. As soon as it was detected the line was sealed and a contractor J. Cascone was hired to make repairs. Mr. Cuccinelli, when passing by on 1:30 P.M. on December 28, saw the contractor pumping the by-passed waste into a storm sewer thence to the Passaic River. Mr. Cuccinello had them redivert the flow to a sanitary sewer thus halting the pollution.

The sewer was repaired on Friday, December 29, 1972 at 1:40 P.M.

Violation and Elimination - Three County Volkswagon, 701 Riverside Ave., Lyndhurst, N.J.
April 3 - May 1, 1972 (F. Cupo)

Mr. Steve Roemer, a Colgate pre-med student, living in Summit, New Jersey, decided to test several outlets which discharged to the Passaic River. With a La Motte field test kit, he checked several sources on April 3, 1972.

He contacted Mr. Goldberg on the afternoon of April 7, and reported the following pollutions:

1. Lawyer's Ditch in Newark at the Essex Public Service Generating Station.
2. Volkswagon dealer in Lyndhurst.
3. Storm sewer at East Rutherford.
4. Ciba Pharmaceuticals in Summit.

Mr. Goldberg referred him to the State Department of Environmental Protection for item 4 and contacted Mr. Cuccinello to check and sample the other three. No pollution was detected in items 1 and 3, however, when the inspector checked item 2 (although no flow was discharging at the time) he noted that the macadam had the appearance of recent work on the 8" line that extended to the river. A Mr. Kaluza informed Mr. Cupo that the line had

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to the

PASSAIC VALLEY SEWERAGE COMMISSIONERS

FOR THE YEAR

1973

Violation - Tenneco Chemicals, Inc., Intermediates Division, 290 River Drive, Garfield, N. J. 07026

November 29 to December 31, 1973 (J. Perrapato)

The Tenneco Chemical Company has a 2-inch boiler blow down line to the Passaic River. Since, generally speaking, boiler blow downs are polluting, the inspector was asked to check and get a sample.

He confirmed this discharge, and he informed Mr. Dege, Plant Engineer, that it was polluting and should not be discharged to the river. Mr. Lubetkin wrote to the company on December 13, 1973, directing them to halt this pollution.

On December 26, 1973, Mr. A. W. Dege, Plant Manager, replied that they were taking immediate action to purchase and install the necessary equipment to divert the discharge of this material into the sanitary sewer. They expect delivery of the material about March 1, 1974, and expect to have the unit installed by May 1, 1974.

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to the

PASSAIC VALLEY SEWERAGE COMMISSIONERS

FOR OPERATIONS DURING
THE YEAR

1974

Violation and Elimination - Tenneco Chemicals, Inc., Intermediates Division, 290 River Drive, Garfield, N. J.
November 29, 1973 - June 6, 1974 (J. Perrapato)

The Tenneco Chemical Company had a 2 inch boiler blowdown line to the Passaic River. Since, generally speaking, boiler blowdowns are polluting, the inspector was asked to check and get a sample.

He confirmed this discharge, and he informed Mr. Dege, Plant Engineer, that it was polluting and should not be discharged to the river. Mr. Lubetkin wrote to the company on December 13, 1973, directing them to halt this pollution.

On December 26, 1973, Mr. M. Dege, Plant Manager, replied that they were taking immediate action to purchase and install the necessary equipment to divert the discharge of this material into the sanitary sewer. They expected delivery of the material about May 1, 1974, and expected to have the unit installed by June 1, 1974.

The inspector reported that the work was completed and the violation eliminated on June 6, 1974.

Violation and Elimination - Thoro Cleaning Products Co., 692 Passaic Avenue, Nutley, N. J.
May 7, 1974 (A. Dondero)

Inspector Dondero, while on a routine check on Third River, noted an employee cleaning a piece of machine equipment with a steam cleaner, with the liquid detergent running off into a nearby storm drain and into a catch basin, thence to Third River. The inspector contacted the owner, Mr. Frank Lindsey, and informed him that this pollution was a violation of law and should cease immediately. Mr. Lindsey had the man stop at that time.

Mr. Lubetkin wrote to this company on May 22, 1974, serving notice that the discharge was illegal and they were directed to cease this type of operation at once. Mr. Lubetkin requested a reply which would inform the PVSC what would be done to see that this type of pollution is not repeated. No reply was ever received.

ANNUAL REPORT

by

Chief Engineer

S. A. LUBETKIN

to the

PASSAIC VALLEY
SEWERAGE COMMISSIONERS

FOR OPERATIONS DURING
THE YEAR

1976

Violation & Elimination - The Seton Company (con't.)

Investigation revealed that in 1972, after the previous problem, the Seton Company had installed bar screens to keep skins, etc., from entering the sanitary sewer. Mr. Jamison, Plant Engineer, reported to Inspectors McLaughlin and Colello that one of the four bar screens had malfunctioned and had been removed on May 28 and sent out for repairs. The drain was thus unprotected and on June 8 the pollution occurred. On June 9 the screen was returned and installed. Since this type of problem could occur again at any time a bar screen was removed, Mr. D'Ascensio wrote to Mr. Van Vleck on June 24 asking what action Seton Company intended to take to prevent a recurrence and suggested that a spare bar screen be kept on hand to replace any taken out for repairs. Mr. Jamison replied that Seton Leather Company had constructed a spare screen to be used should any screen need replacement.

PVSC billed and Seton Company paid $177.18 for PVSC labor costs in removing the cow hide from the line.

Violation and Elimination - Standard Dyeing and Finishing Co., Inc. 1 Van Houten St., Paterson, N.J.
September 14-20, 1976 (M. Tomaro)

On September 14, 1976, during a routine inspection of the Passaic River in Paterson, Inspector Tomaro observed a blue colored liquid seeping into the Passaic River at the rear of the Allied Textile Print Company, 1 Van Houten St. Upon investigation he was informed by Mr. Sherb, Allied Plant Engineer, that the seepage was coming from a leak in a 16 inch industrial sewer line used by Standard Dyeing and Finishing Co. The material seeped into the river under the Allied Textile cooling water line. Mr. Wax, owner of Standard Dyeing and Mr. Sherb of Allied, at a meeting with Inspector Tomaro, agreed to excavate the line in order to make repairs. Part of the line was exposed on September 15. A delay arose later in the day due to a disagreement between the two companies over the responsibility of each. Inspector Tomaro got Mr. Wax and Mr. Sherb together and pointed out that the pollution had to be halted. Work then continued on September 16 and on September 20 a two inch hole in the line was sealed eliminating the violation.

Violation and Elimination - Tenneco Chemicals, Inc. 290 River Road, Garfield, N.J.
September 1-2, 1976 J. Perrapato & J. Parr)

On September 1, 1976 at 5 P.M. PVSC received a complaint of suds in the Passaic River caused by Tenneco Chemicals. Inspectors Perrapato and Parr investigated, arriving at the plant at 5:45 P.M. requested the Security Guard call Mr. La Bue, Works Manager

Violation & Elimination - Tenneco Chemicals (con't.)

back to the plant. Mr. La Bue returned to the plant and ordered all valves to the outlet pipe closed, stopping the violation. They returned the following morning and met with Mr. Howard Schrenk, Supt. of Maintenance and Mr. Douglas Jacobsen, Plant Production Supt. These men explained that prior to the pollution Reactor No 1 (a 2000 gallon vessel) located on the fourth floor, was being cleaned with a standard liquid detergent. When they drained the solution to the sanitary sewer the high flow rate overloaded the sewer on the first floor. This caused the sewer to backup and the soapy water overflowed off a loading platform, into a yard storm drain and then into the Passaic River. Mr. Schrenk stated that they would use a separate hose for draining these tanks until they check for blockage in the sewer line. A sample taken on September 8 from the storm sewer was acceptable.

Violation and Elimination - Tungsten Products Corp.
185 Scoles Ave., Clifton, N.J.
April 1-7, 1976 (J. Parr, L. Cuccinello)

On April 1, 1976 PVSC received a call from Mr. Robert Holster, Director of Community Affairs, City of Passaic, concerning a pollution of Mc Donald Brook and Hughes Lake. Supervisor of River Inspectors Cuccinello and Inspector Fiore immediately proceeded to the area and met with Mr. Holster and Mr. Sam Alaimo, Passaic Superintendent of Sewers. They noticed an industrial odor and a slight oily substance in Mc Donald Brook and by lifting manhole covers, checking catch basins, and following the odor upstream, they traced the pollution to Tungsten Products, Inc. (a Division of Duro-Test), 185 Scoles Ave., Clifton. The plant is located west of Dumont Election Tubes Co. plant.

They contacted the Plant Manager, Mr. Thomas Emidy, and proceeded to the west end of the plant. At that location, next to the Erie Lackawanna Railroad right of way, the company had stored several drums containing a mixture of Xylol, Butanol and used vacuum pump oil. This material was stored until removed by Gaess Environmental Service of Passaic every few weeks. However, it was obvious that some of this waste material had spilled onto the ground and flowed into a nearby catch basin. This catch basin was piped into a storm drain which went through the Dumont property thence to Mc Donald Brook on Scoles Avenue (where McDonald Brook is piped underground). Mr. Emidy was directed to clean the area so that no further material could reach the catch basin. Inspector Parr returned on April 2 and 7 and determined that the area was clean and free of polluting material. Although Mr. D'Ascensio had not received a reply to his letter to Mr. Emidy requesting information on action taken by Tungsten to avoid future pollutions, the violation is considered eliminated as of April 7, 1976. On August 4, Mr. Emidy wrote to Mr. D'Ascensio and stated that Tungsten Products had constructed a retaining wall around the storage area to contain any spillage. PVSC inspected the installation on August 6 and found it acceptable.

GARFIELD FIRE DEPT.

1987 DEC 22 2047 RECEIVED
1987 DEC 22 2047 DISPATCHED
1987 DEC 22 2049 ARRIVED
1987 DEC 22 2052 COMPLETED

LOCATION OF FIRE

Kalama Chemical

☒ FIRE CO. *1
☒ FIRE CO. *2
☒ FIRE CO. *3
☐ FIRE CO. *4
☐ FIRE CO. *5
☐ GENERAL ALARM

OTHER AGENCIES NOTIFIED

PSE&G Co. ______ TIME   AMBULANCE ______ TIME
B.C. ARSON UNIT ______ TIME   N.J. BELL ______ TIME
MUTUAL AID ______ TIME
OTHER ______ TIME

TYPE OF FIRE

☐ STRUCTURE ☐ VEHICLE
☐ BRUSH ☒ MISC.

REMARKS:

Heavy smoke condition reported.

10-7

GARFIELD FIRE DEPT.

239

1992 AUG 05 2036 RECEIVED
1992 AUG 05 2036 DISPATCHED
1992 AUG 05 2036 ARRIVED
1992 AUG 06 0223 COMPLETED

LOCATION OF FIRE

Kalama

☐ FIRE CO. *1
☐ FIRE CO. *2
☐ FIRE CO. *3
☐ FIRE CO. *4
☐ FIRE CO. *5
☑ GENERAL ALARM

OTHER AGENCIES NOTIFIED

PSE&G Co. 2242 TIME   AMBULANCE 2040 TIME
B.C. ARSON UNIT 2150 TIME   N.J. BELL ______ TIME
MUTUAL AID 2036 Lodi + Saddle Brook TIME
OTHER Hazmat Box 54 TIME
Dep# 92-8-5-2046-41

TYPE OF FIRE

☑ STRUCTURE ☐ VEHICLE
☐ BRUSH ☐ MISC.

REMARKS:

Chemical fire
and explosion

PRELIMINARY INVESTIGATION OF SOIL QUALITY CONDITIONS AT THE KALAMA CHEMICAL, INC. FACILITY IN GARFIELD, NEW JERSEY

INTRODUCTION

In June 1986, Geraghty & Miller, Inc. was retained by Kalama Chemical, Inc. to conduct a preliminary soil sampling and analysis program at the Kalama Chemical, Inc. facility in Garfield, New Jersey. The purpose of this preliminary investigation was to assess soil quality conditions as a result of past plant activities.

Background

The Kalama Chemical, Inc. facility has been the site of chemical manufacture for at least 80 years. Kalama Chemical, Inc. bought the facility in 1982; prior to that time, the facility was operated by several previous owners. Several organic chemicals have been manufactured at the facility; current production is greatly reduced from what was normal under previous ownership.

Scope of Work

The program consisted of the drilling of five (5) soil borings from land surface to the top of the water table or a maximum depth of twelve (12) feet, and the collection of soil samples for chemical analysis. The investigation was focused on areas where chemicals were transferred to or stored in underground tanks, or where spills may have occurred in the past. One sample was submitted for analysis from each boring; the individual samples were analyzed for parameters that would reflect materials handled at each location.

In addition, one fluid sample was collected from the subsurface at the location of Boring B-4. Boring B-4 is located in the benzaldehyde production area.

FIELD PROGRAM

Soil Sampling

On June 25, 1986, five soil borings were drilled by Environmental Drilling, Inc. of Mt. Arlington, New Jersey, under the supervision of a Geraghty & Miller, Inc. scientist and Mr. Hari Goel, Technical Superintendant at the Kalama Chemical, Inc. facility. The location of the boreholes are shown on Figure 1. The soil sampling locations were selected in accordance with the following criteria:

- Borings located a safe distance from potential dangers such as buried utility lines and pipes. These utilities were delineated by plant personnel.
- Completion of as many borings as possible in one day of field work.
- Borings located where spills, chemical transfer or storage took place, and where the potential for past spills exists.

The rationale for the selection of boring locations was as follows:

B-1: This area has been used as a shipping/transfer area for chemicals.

B-2: Underground storage tanks containing methanol and fuel oil are located in this area.

B-3: This location has been used for loading and unloading chemicals, primarily formaldehyde, from and to rail cars.

B-4: Benzaldehyde production area.

B-5: Chemical transfer area, primarily formaldehyde.

The borings were drilled with a hollow stem auger rig, to depths of 8 to 12 feet below ground surface, in order to obtain samples of the geologic materials in the unsaturated zone, above the water table. Soil samples were collected continuously in two-feet intervals with split-spoon samplers. Prior to drilling and sampling at each boring location, the auger flytes and split-spoons were decontaminated in order to prevent cross-contamination between borings.

At each boring, the soil samples were described by the Geraghty & Miller, Inc. hydrogeologist, and screened with a portable organic vapor analyzer (OVA) meter. The geologic boring logs are presented in Appendix A. The samples with the greatest indications of potential contamination were transferred to 40 ml vials and 120 ml jars for analysis; the soil samples were delivered to General Testing Corporation of Hackensack, New Jersey. All of the soil samples were analyzed for volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPHC). At locations where certain chemicals were known to be stored, transported, or used, additional parameters were selected for analysis.

In addition, a fluid sample was collected at Boring B-4, as water was encountered at a relatively shallow depth (2.5 feet below land surface). The fluid sample was transferred to a 40 ml. vial, and submitted for a VOC analysis.

At the completion of sampling at each boring location, the holes were backfilled and sealed with bentonite.

Analytical Results

The results of the analysis of the soil and fluid samples are summarized in Tables 1, 2, and 3; the complete laboratory reports are presented in Appendix B. The results indicate the presence of a variety of base/neutral extractable organic compounds at location B-2. Toluene was detected in all soil samples and the fluid sample from Boring B-4. The soil and fluid samples from Boring B-4 had toluene concentrations of approximately 0.2 percent and 0.5 percent, respectively. Phenol (at a concentration of 19.8 ppm) was detected in the soil sample from Boring B-5.

Respectfully Submitted,

GERAGHTY & MILLER, INC.

Jeffrey T. Melby

Jeffrey T. Melby,
Scientist

Daniel A. Nachman
Senior Scientist

Vincent W. Uhl, Jr.
Associate

Table 1: Concentrations of Miscellaneous Parameters in Soil Samples

	B-1	B-2	B-3	B-4*	B-5*
Total Petroleum Hydrocarbons	<47.9	<40.9	1070	236	100
Benzoic Acid				<100	
Benzaldehyde			< 200	<200	
Formaldehyde			< 100		< 100
Total Phenolics			9.6		9.3
Alcohols		<100			< 100

Notes:

Blank = not analyzed
* Composite sample.
All concentrations in ppm.
Analysis performed by General Testing Corporation of Hackensack, NJ.

State of New Jersey
Department of Environmental Protection

Christine Todd Whitman
Governor

Robert C. Shinn, Jr.
Commissioner

IN THE MATTER OF
TENNECO POLYMERS, INC. AND
KALAMA CHEMICAL INC.

: AMENDMENT TO
: REMEDIATION AGREEMENT

ISRA CASE # 86B73

The following FINDINGS are made and ORDER is issued pursuant to the authority vested in the Commissioner of the New Jersey Department of Environmental Protection (hereinafter "NJDEP") by N.J.S.A. 13:1D-1 et seq. and the Industrial Site Recovery Act (ISRA), N.J.S.A. 13:1K-6 et seq., and duly delegated to the Assistant Director within the Division of Responsible Party Site Remediation pursuant to N.J.S.A. 13:1B-4. Any references below, to the Environmental Cleanup Responsibility Act (ECRA) or its successor legislation, the Industrial Site Recovery Act (ISRA) P.L. 1993 c.139 shall be construed as ECRA, N.J.S.A. 13:1K-6 et. seq. and N.J.A.C. 7:26B, as amended by ISRA.

FINDINGS

1. Kalama Chemical Inc. ("Kalama") operated a medicinal and industrial organic chemical facility located at 290 River Drive, Garfield, New Jersey ("Bergen facility"). Kalama acquired the real property pursuant to the terms of a certain Asset Sales Agreement dated December 1, 1982 ("Asset Agreement") between Kalama and Tenneco Chemicals, Inc. In 1983, Tenneco Chemicals, Inc. changed its name to Tenneco Resins, Inc. ("Resins"). On August 26, 1985, Resins dissolved. Effective August 25, 1988, Tenneco Polymers, Inc. ("Tenneco") was substituted in place of Resins, with respect to Resins' obligations under the Asset Agreement relating to the real property.

2. Kalama entered into a Remediation Agreement ("RA"), formerly known as Administrative Consent Order, with NJDEP effective December 8, 1988 (the "Kalama RA"), ISRA Case #86B73, to allow Kalama to complete a stock tender prior to the completion of the standard ISRA administrative process. Kalama is the Responsible Party under the Kalama RA. Operations continued at the Bergen facility.

3. On or about April 28, 1994, Kalama and Tenneco entered into a Settlement Agreement in connection with the real property at the Bergen facility. In accordance with the Settlement Agreement, Tenneco agreed to petition NJDEP to add Tenneco as the lead responsible party for the ongoing remediation under the Kalama RA. In addition, Tenneco has agreed to assume Kalama's remediation funding source obligation under the Kalama RA.

4. On or about May 10, 1994, Kalama submitted to NJDEP the General Information Notice for its cessation of operations at the Bergen facility, ISRA Case #94187. On April 3, 1995, Kalama submitted to NJDEP a "Certification In Support of Early Review Request" in connection with ISRA Case # 94187. On or about April 28, 1995, NJDEP granted ISRA approval to Kalama's cessation of operations.

5. On or about May 16, 1994, Kalama submitted to NJDEP the General Information Notice for its Stock transfer ("1994 Stock Transfer"), ISRA Case # 94198. On or about May 26, 1994, NJDEP granted ISRA approval to Kalama's 1994 Stock transfer.

6. Kalama and Tenneco have requested that NJDEP prepare an Amendment to the Kalama RA to include Tenneco as the lead responsible party and to allow Kalama to be released from its remediation funding source obligation prior to completion of the standard ECRA administrative process in accordance with the Kalama RA. Additionally, this Amendment to the Kalama RA will bring Kalama into compliance for the 1994 Stock transfer and the cessation of operations at the Bergen facility.

ORDER

NOW, THEREFORE, IT IS ORDERED AND AGREED THAT:

7. The provisions of this Amendment to the Kalama RA ("Amendment") shall become part of the Kalama RA. The Kalama RA as amended, shall remain in full force and effect.

8. Responsibility of the Responsible Parties

   A. Kalama and Tenneco ("Responsible Parties") have informed NJDEP that Tenneco shall be the lead party for contact with NJDEP and for compliance with the terms and conditions of the Kalama RA and this Amendment. NJDEP and the Responsible Parties have agreed that the Responsible Parties shall be responsible, each of them jointly, severally and individually, for performance of all obligations listed in the Kalama RA and this Amendment.

   B. NJDEP and the Responsible Parties mutually agree that in the event the Responsible Parties fail or refuse to perform any ISRA obligations, as determined by NJDEP, NJDEP may exercise full discretion concerning the ISRA obligations of the Responsible Parties for ISRA compliance. The Responsible Parties expressly agree that in the event that the Responsible Parties fail or refuse to perform any obligation(s) under the Kalama RA or this Amendment as determined by NJDEP, NJDEP shall have the right to exercise any option or combination of options available to NJDEP under this Remediation Agreement, ISRA, the Regulations or any other statute to ensure full and complete ISRA compliance by the Responsible Parties.

9. NJDEP agrees to release Kalama's remediation funding source in the form of self-guarantee upon receipt of an alternative remediation funding source from Tenneco.

10. Tenneco and Kalama agree not to contest the authority or jurisdiction of the Department to issue this Amendment. The Responsible Parties further agree not to contest the terms or conditions of this Amendment except as to interpretation or application of such terms and conditions in any action brought by the NJDEP to enforce the provisions of this Amendment.

11. Any signatory to this Amendment, who is executing this Amendment on behalf of an entity other than that individual, shall provide to NJDEP appropriate documentary evidence as specified in N.J.A.C. 7:26B-1.13 authorizing the signatory to bind the entity to the provisions of this Amendment. This documentary evidence shall be submitted to NJDEP along with this executed Amendment.

12. Any Responsible Party to this Amendment shall provide to NJDEP at least thirty (30) days prior written notice of the dissolution of its corporate identity or liquidation of its assets, and shall provide immediate written notice to NJDEP of filing of a petition for bankruptcy no later than the day after filing. Upon receipt of notice of dissolution of corporate identity, liquidation of assets or filing of a petition for bankruptcy, NJDEP may request and within fourteen (14) days of NJDEP's written request a Responsible Party shall obtain and submit to NJDEP, additional remediation funding source pursuant to this Amendment.

13. Except as otherwise set forth herein, by the execution of this Amendment the Department does not release any person from any liabilities or obligations such person may have pursuant to ISRA and the Regulations, or any other applicable authority, nor does the NJDEP waive any of its' rights or remedies pursuant thereto.

14. This Amendment shall take effect upon the execution of this Amendment by the Responsible Parties. This Amendment shall be null and void unless the Responsible Parties submit this signed Amendment to NJDEP within forty five (45) days of signing of this Amendment by NJDEP. The Responsible Parties shall submit a fully executed Amendment to NJDEP within five (5) business days from the effective date.

NEW JERSEY DEPARTMENT OF
ENVIRONMENTAL PROTECTION

Date: 8/29/96

By: Ronald T Corcory
RONALD T. CORCORY, ASSISTANT DIRECTOR
RESPONSIBLE PARTY CLEANUP ELEMENT

TENNECO POLYMERS, INC.

Date: 9/4/96

By: Robert G. Simpson EBW
Name: Robert G. Simpson
Title: Vice President

KALAMA CHEMICAL INC.

Date: 9/13/96

By:
Name: Robert A. Kirchner
Title: President

Let's protect our earth

CN 028
nton, N.J. 08625-0028

(609)633-7141

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF HAZARDOUS WASTE MANAGEMENT

Michele M. Putnam
Deputy Director
Hazardous Waste Operations

John J. Trela, Ph.D., Director

Lance R. Miller
Deputy Director
Responsible Party Remedial Action

IN THE MATTER OF : ADMINISTRATIVE
KALAMA CHEMICAL, INC. : CONSENT ORDER
ECRA CASE #86B73 :

The following FINDINGS are made and ORDER is issued pursuant to the authority vested in the Commissioner of the New Jersey Department of Environmental Protection (hereinafter "NJDEP") by N.J.S.A. 13:1D-1 et seq. and the Environmental Cleanup Responsibility Act, N.J.S.A. 13:1K-6 et seq., and duly delegated to the Assistant Director for the Industrial Site Evaluation Element within the Division of Hazardous Waste Management pursuant to N.J.S.A. 13:1B-4.

FINDINGS

1. The Environmental Cleanup Responsibility Act, N.J.S.A. 13:1K-6 et seq. ("ECRA" or "the Act"), was signed into New Jersey State Law by Governor Thomas H. Kean on September 2, 1983, and took effect on December 31, 1983.

2. ECRA required the NJDEP to adopt rules and regulations to implement the Act. On December 21, 1987, NJDEP adopted the Final ECRA Regulations, N.J.A.C. 7:26B ("Regulations") in compliance with the Administrative Procedure Act, N.J.S.A. 52:14B-1 et seq., upon acceptance for filing by the Office of Administrative Law pursuant to N.J.A.C. 1:30-4.4(d). On January 1, 1988, the Regulations became effective and concurrently repealed N.J.A.C. 7:1-3, the Interim ECRA Regulations.

3. ECRA requires that the owner or operator of an industrial establishment planning to sell or close or transfer operations (a) notify the NJDEP in writing within five (5) days of the execution of the agreement of sale or public release of its decision to close pursuant to N.J.A.C. 7:26B-1.6, (b) submit within sixty (60) days prior to transfer of title or closing operations, a Negative Declaration or Cleanup Plan to the NJDEP for approval, and (c) obtain, upon approval of any necessary Cleanup Plan by the NJDEP, a surety bond or other financial security approved by the NJDEP guaranteeing performance of the Cleanup Plan in an amount equal to the cost estimate for the approved Cleanup Plan.

4. N.J.S.A. 13:1K-13 provides that failure to submit a Negative Declaration or Cleanup Plan pursuant to ECRA is grounds for voiding the sale by NJDEP. Any person who knowingly gives or causes to be given any false information or who fails to comply with the provisions of ECRA is liable for a penalty of not more than $25,000.00 for each

occurrence, and each day of a violation of a continuing nature constitutes an additional and separate offense as specified in N.J.A.C. 7:26B-9.3. Furthermore, any officer or management official of an industrial establishment who knowingly directs or authorizes the violation of any provisions of the Act shall be personally liable for the $25,000.00 penalties for each violation described above.

5. On October 17, 1988, Kalama Chemical, Inc. ("Ordered Party") submitted to NJDEP an application for an Administrative Consent Order ("ACO") pursuant to N.J.A.C. 7:26B-7.2. The ACO application is incorporated herein by reference and includes the following information:

A. Industrial Establishment

ECRA Case #86B73 SIC #:2833, 2865, 2869
Facility Name: Kalama Chemical, Inc.
"Bergen facility"
Facility Location: 290 River Drive
Garfield, Bergen County

Block: 50.01 Lot: 1
Block: 50.02 Lot: 2

Initial Notice Status: Complete and Assigned

Owner: Kalama Chemical, Inc., a Washington Corporation
Operator: Kalama Chemical, Inc.

B. Transaction:

Seller: Kalama Chemical, Inc.
Buyer: B.C. Sugary Refinery, Limited

Description: Under the terms of a tender offer agreement dated November 14, 1986, and subsequent amended agreement dated December 11, 1986, the B.C. Sugary Refinery, Limited ("B.C. Sugary"), acquired 49% of the outstanding common stock of Kalama Chemical, Inc. ("Kalama"), a Washington Corporation, and $900,000.00 of convertible subordinated notes. B.C. Sugary intends to conclude the transaction through conversion of the notes to common stock thereby providing B.C. Sugary with ownership of approximately 55% of Kalama. Kalama will continue operations at the Bergen facility.

6. The Transaction described in Paragraph 5.B above is the sale, transfer and/or closing of an Industrial Establishment as defined by ECRA and the Regulations. NJDEP and the Ordered Party(ies) expressly agree that the Transaction is subject to ECRA and the Regulations. The Ordered Party(ies) has requested that NJDEP prepare an ACO which, when effective, will allow the Transaction to be consummated prior to the completion of all administrative requirements.

7. In circumstances as referenced in N.J.A.C. 7:26B-7.1(a)1 through 10, NJDEP, in its discretion, may enter into an ACO so that the closing,

terminating or transferring of operations may occur prior to completing the ECRA obligations. The ACO specifies a time schedule for completion of ECRA requirements by the Ordered Party(ies) and provides for financial assurance in a form and amount acceptable to NJDEP prior to consummation of any transactions subject to ECRA. Failure to fully comply with all the terms and conditions of the ACO shall subject the Ordered Party(ies) to the full range of penalties and remedies prescribed in the Act, the Regulations, specifically N.J.A.C. 7:26B-9.3, and the ACO.

ORDER

NOW, THEREFORE, IT IS ORDERED AND AGREED THAT:

8. ECRA Program Requirements for the Ordered Party(ies)'s Industrial Establishment.

   A. The Ordered Party(ies) shall complete the Initial Notice (commonly referred to as ECRA I and II) required by N.J.A.C. 7:26B-3 within thirty (30) days from the effective date of this ACO.

   B. Within one hundred twenty (120) days from receipt of NJDEP's written approval of the Sampling Plan prepared pursuant to N.J.A.C. 7:26B-3.2(b)11 and N.J.A.C. 7:26B-4.2, the Ordered Party(ies) shall initiate, complete, and submit to NJDEP the results from any NJDEP-approved Sampling Plan including, but not limited to, complete delineation of environmental contamination on-site, and any off-site environmental contamination resulting from discharges of hazardous wastes or substances on or from the subject Industrial Establishment. These results shall be accompanied by a proposed negative declaration, cleanup plan or revised sampling plan pursuant to N.J.A.C. 7:26B-4.3. Any negative declaration or cleanup plan submitted to NJDEP shall conform to N.J.A.C. 7:26B-5.

   C. NJDEP and the Ordered Party(ies) recognize that additional sampling may be necessary during the various stages of the implementation of this ACO and ECRA, including during the implementation of a Cleanup Plan, at the subject Industrial Establishment to delineate fully the nature and extent of environmental contamination on-site, and any off-site environmental contamination resulting from discharges of hazardous substances or wastes on or from the subject Industrial Establishment. Therefore, the Ordered Party(ies) agrees to submit any additional sampling plans for NJDEP review and approval required by NJDEP in writing during the various stages of the implementation of this ACO and ECRA, including during the implementation of a Cleanup Plan, to further delineate the nature and extent of environmental contamination on or from the subject Industrial Establishment. NJDEP and the Ordered Party(ies) mutually agree that the Ordered Party(ies) shall submit to NJDEP any required additional sampling plans for review and approval within thirty (30) days of the receipt of said written request. Within ninety (90) days from receipt of NJDEP's written approval of any additional sampling plans, the Ordered Party(ies) shall initiate, complete and submit to NJDEP the results from any additional NJDEP-approved sampling plan required pursuant to this paragraph accompanied by a proposed negative declaration, cleanup plan, or revised sampling plan pursuant to N.J.A.C. 7:26B-4.3.

D. The Ordered Party(ies) shall implement any NJDEP-approved Cleanup Plan in accordance with the approved time schedule or defer implementation of all or part of the Cleanup Plan subject to NJDEP approval pursuant to N.J.A.C. 7:26B-5.5.

E. Should NJDEP determine that any submittal made under Paragraph 8 of this ACO is inadequate or incomplete, then NJDEP shall provide the Ordered Party(ies) with written notification of the deficiency(ies), and the Ordered Party(ies) shall revise and resubmit the required information within a reasonable period of time not to exceed thirty (30) days from receipt of such notification.

F. All submissions required pursuant to Paragraph 8 or any other provision of this ACO shall be accompanied by all appropriate fees required pursuant to N.J.A.C. 7:26B-1.10.

9. Conditions for Financial Assurance

A. The Ordered Party(ies) shall obtain and provide to NJDEP financial assurance in a form acceptable to NJDEP in the amount of $3,000,000.00. The financial assurance must conform with the requirements of N.J.S.A. 13:1K-9(b)3, N.J.A.C. 7:26B-6 and this ACO. This financial assurance shall be submitted to NJDEP along with a fully executed ACO pursuant to Paragraph 14.A of this ACO.

B. The Ordered Party(ies) shall establish and submit to NJDEP a standby trust fund pursuant to N.J.A.C. 7:26B-6.7 within seven (7) days from the effective date of this ACO. The financial institution which issues the financial assurance shall agree to promptly and directly deposit all amounts up to the total value of the financial assurance into the standby trust fund upon demand by NJDEP.

C. Upon NJDEP approval of a Cleanup Plan, the Ordered Party(ies) shall amend the amount of the financial assurance, specified in Paragraph 9.A above, to equal the estimated cost of implementation of the approved Cleanup Plan, or shall provide such other financial assurance as may be approved by NJDEP in an amount equal to the estimated cost of implementation of the approved Cleanup Plan.

D. In the event that NJDEP determines that the Ordered Party(ies) has failed to perform any of its obligations under this ACO or ECRA, NJDEP may draw on the financial assurance; provided, however, that before any such demand is made, NJDEP shall notify the Ordered Party(ies) in writing of the obligation(s) with which it has not complied, and the Ordered Party(ies) shall have reasonable time, not to exceed fourteen (14) days, to perform such obligation(s) to NJDEP's satisfaction. Nothing in this paragraph shall prevent NJDEP from collecting stipulated penalties pursuant to the terms of this ACO for cause.

E. Upon NJDEP's written approval of a Negative Declaration, the Ordered Party(ies) shall be relieved of any further obligation to maintain in full force and effect the financial assurance required by this ACO for the facility which is the subject of the NJDEP approved Negative Declaration. Upon NJDEP's written approval of the completion of any cleanup required by this ACO, as verified by final site inspection pursuant to N.J.A.C. 7:26B-5.7 and upon the Ordered Party(ies)'s satisfaction of all financial obligations in connection therewith, the Ordered Party(ies) shall be relieved of any further obligation to maintain in full force and effect the financial assurance required by this ACO for the facility at which the approved cleanup has been completed.

10. Additional Conditions of Consent

A. The Ordered Party(ies) shall allow NJDEP access to the subject Industrial Establishment pursuant to N.J.A.C. 7:26B-1.12 for the purpose of undertaking all necessary monitoring and environmental cleanup activities. The Ordered Party(ies) has provided NJDEP with appropriate documentation that the Buyer shall allow the NJDEP access required herein.

B. Compliance with the terms of this ACO shall not excuse the Ordered Party(ies) from obtaining and complying with any applicable federal, state or local permits, statutes, regulations and/or orders while carrying out the obligations imposed by ECRA through this ACO. The execution of this ACO shall not excuse the Ordered Party(ies) from compliance with all other applicable environmental permits, statutes, regulations and/or orders and shall not preclude NJDEP from requiring that the Ordered Party(ies) obtain and comply with any permits, and/or orders issued by NJDEP under the authority of the Water Pollution Control Act, N.J.S.A. 58:10A-1 et seq., the Solid Waste Management Act, N.J.S.A. 13:1E-1 et seq., and the Spill Compensation and Control Act ("Spill Act") N.J.S.A. 58:10-23.11 et seq., for the matters covered herein. The terms and conditions of any such permit shall not be preempted by the terms and conditions of this ACO if the terms and conditions of any such permit are more stringent than the terms and conditions of this ACO. Should any of the measures to be taken by the Ordered Party(ies) during the remediation of any ground water and surface water pollution result in a new or modified discharge as defined in the New Jersey Pollutant Discharge Elimination System ("NJPDES") regulations, N.J.A.C. 7:14A-1 et seq., then the Ordered Party(ies) shall obtain a NJPDES permit or permit modification from NJDEP prior to commencement of said activity.

C. NJDEP reserves the right to stop any construction, improvement(s), or change(s) at the Industrial Establishment(s) subject to this

ACO, due to the presence of hazardous substances or wastes, the disturbance of which, prior to implementation of NJDEP-approved Cleanup Plan, has the potential to cause harm to public health, safety and welfare as determined by the NJDEP.

D. NJDEP agrees that it will not bring any action, nor will it recommend that the Attorney General's Office bring any action, including monetary penalties, for the Ordered Party's(ies') failure to comply with (a) the time requirements in N.J.S.A. 13:1K-9(b)1 that NJDEP be notified within five (5) days of execution of an agreement of sale or public release of its decision to close, and (b) the time requirement in N.J.S.A. 13:1K-9(b)2 that a Negative Declaration or Cleanup Plan be submitted sixty (60) days prior to transfer of title or closing operations for the transaction described in Paragraph 5.B above.

E. No obligations imposed by this ACO (other than by Paragraph 10.G below) are intended to constitute a debt, claim, penalty or other civil action which could be limited or discharged in a bankruptcy proceeding. All obligations imposed by this ACO shall constitute continuing regulatory obligations imposed pursuant to the police power of the State of New Jersey, intended to protect the public health, safety and welfare.

F. This ACO imposes certain requirements and deadlines upon the Ordered Party(ies). The Ordered Party(ies) agrees to use its best efforts to comply with said requirements and NJDEP agrees not to act unreasonably in the enforcement and implementation of this ACO.

G. In the event that the Ordered Party(ies) fails to comply with any of the provisions of this ACO, the Ordered Party(ies) shall pay to NJDEP stipulated penalties in the amount not less than $1,000.00 nor more than $5,000.00 as specified in N.J.A.C. 7:26B-7.4(a) for each day on which the Ordered Party(ies) fails to comply with any obligation under this ACO. No such stipulated penalty shall be payable by the Ordered Party(ies) with respect to such period that said failure to comply results from <u>Force Majeure</u>. The Ordered Party(ies) waives its rights to contest NJDEP's exercise of discretion concerning the amount of any penalty assessed by NJDEP pursuant to N.J.A.C. 7:26B-9.3 and N.J.A.C. 7:26B-7.4(a).

H. The provisions of this ACO shall be binding upon the Ordered Party(ies) and its successors in interest, assigns, tenants, and any trustee in bankruptcy or receiver appointed pursuant to a proceeding in law or equity. Any officer or management official of the Ordered Party(ies) who knowingly directs or authorizes the violation of any provision of ECRA or the Regulations shall be personally liable for the penalty established pursuant to N.J.S.A. 13:1K-13 and N.J.A.C. 7:26B-9.3.

I. Any signatory to this ACO, who is executing this ACO on behalf of an entity other than that individual, shall provide to NJDEP appropriate documentary evidence as specified in N.J.A.C. 7:26B-1.13 and N.J.A.C. 7:26B-7.5 authorizing the signatory to bind the entity to the provisions of this ACO. This documentary evidence shall be submitted to NJDEP along with a fully executed ACO pursuant to Paragraph 14.A of this ACO.

J. NJDEP and the Ordered Party(ies) expressly agree that NJDEP will not exercise its right to void the Transaction described in Paragraph 5.B above, except in the event that the Ordered Party(ies) fails to submit an approvable Negative Declaration or Cleanup Plan pursuant to Paragraph 8.B above. NJDEP's right to void the subject sale or transfer shall terminate upon NJDEP's written approval of an appropriate Negative Declaration or Cleanup Plan submitted by the Ordered Party(ies) pursuant to this ACO and ECRA.

K. Any Ordered Party to this ACO shall provide to NJDEP at least thirty (30) days prior written notice of the dissolution of its corporate identity or liquidation of its assets, and shall provide immediate written notice to NJDEP of filing of a petition for bankruptcy no later than the day after filing. Upon receipt of notice of dissolution of corporate identity, liquidation of assets or filing of a petition for bankruptcy, NJDEP may request and, within fourteen (14) days of NJDEP's written request, the Ordered Party(ies) shall obtain and submit to NJDEP additional financial assurance pursuant to this ACO.

L. Any submission to be made to NJDEP in accordance with this ACO shall be directed to:

Joseph R. Fallon, Assistant Director
Industrial Site Evaluation Element
Division of Hazardous Waste Management
CN 028
Trenton, NJ 08625

11. Force Majeure

If any fire, flood, storm, riot, strike, or other circumstance determined by NJDEP to beyond the control of the Ordered Party(ies) occurs which causes or may cause delays in the achievement of any deadline contained in this ACO, the Ordered Party(ies) shall notify NJDEP in writing within ten (10) days of the delay or anticipated delay, as appropriate, referencing this Paragraph and describing the anticipated length, precise cause or causes, measures taken or to be taken and the time required to minimize the delay. The Ordered Party(ies) shall adopt all necessary measures to prevent or minimize any delay. If any delay or anticipated delay has been or will be caused by fire, flood, storm, riot, strike or other circumstances determined by NJDEP to be beyond the control of the Ordered Party(ies), then the time for performance hereunder shall be extended by NJDEP for a period no longer than the delay resulting from such circumstances, provided that NJDEP may grant additional extensions for good cause. If the events causing such delay are not found by NJDEP to be beyond the control of the Ordered Party(ies), failure to comply with the provisions of the ACO shall constitute a breach of the ACO's requirements. The burden of proving that any delay is caused by circumstances beyond the Ordered Party(ies)'s control and the length of such delay attributable to those circumstances shall rest with the Ordered Party(ies). Increases in the costs or expenses incurred in fulfilling the requirements contained herein shall not be a basis for an extension of time. Similarly, delay in completing an interim requirement shall not automatically justify or excuse delay in the attainment of subsequent requirements.

12. Reservation of Rights

This ACO shall be fully enforceable in the New Jersey Superior Court having jurisdiction over the subject matter and signatory parties upon the filing of a summary action for compliance pursuant to ECRA. This ACO may be enforced in the same manner as an Administrative Order issued by NJDEP pursuant to other statutory authority and shall not preclude NJDEP from taking whatever action it deems appropriate to enforce the environmental protection laws of the State of New Jersey. It is expressly recognized by NJDEP and the Ordered Party(ies) that nothing in this ACO shall be construed as a waiver by NJDEP of its rights with respect to enforcement of ECRA on bases other than those set forth in the ECRA Program Requirements section of this ACO or by the Ordered Party(ies) of its right to seek review of any enforcement action as provided by the Administrative Procedure Act, N.J.S.A. 52:14B-1 et seq. Furthermore, nothing in this ACO shall constitute a waiver of any statutory right of NJDEP to require the Ordered Party(ies) to implement additional remedial measures should NJDEP determine that such measures are necessary to protect the public health, safety and welfare.

13. The Ordered Party(ies) agrees not to contest the authority or jurisdiction of the Department to issue this ACO and also agrees not to contest the terms of this ACO.

14. A. This ACO shall be effective upon the execution of this ACO by NJDEP and the Ordered Party(ies). The Ordered Party(ies) shall return a fully executed ACO to NJDEP together with the financial assurance required by Paragraph 9.A above, and signature authorization required by Paragraph 10.I above within one (1) business day from the effective date.

    B. This ACO shall be null and void unless executed by the Ordered Party(ies) within 30 days of NJDEP signing.

C. Upon the effective date of this ACO, the Ordered Party(ies) may complete the Transaction described in Paragraph 5.B above subject to the conditions of this ACO.

NEW JERSEY DEPARTMENT OF
ENVIRONMENTAL PROTECTION

Date: 11-10-88

By:
JOSEPH R. FALLON, ASSISTANT DIRECTOR
INDUSTRIAL SITE EVALUATION ELEMENT

KALAMA CHEMICAL, INC.
(Ordered Party)

Date: 12-8-88

By: L.C. Macomber

Name: L.C. MACOMBER

Title: VICE PRESIDENT-ADMIN.

BC Sugar

P.O. BOX 2150 VANCOUVER, B.C. CANADA V6B 3V2 TELEPHONE (604) 253-1131 FAX (604) 253-2517 TELEX 04-508715

November 22, 1988

Mr. Joseph R. Fallon
Asst. Director
New Jersey Dept. of Environmental Protection
Industrial Site Evaluation Element
Division of Hazardous Waste Management
CN 028
Trenton, NJ 08625
U.S.A.

Dear Mr. Fallon:

Re: <u>Administrative Consent Order in the Matter of Kalama Chemical, Inc. ECRA Case #86B73</u>

BC Sugar Refinery, Limited will, upon the effective date of the referenced ACO, acquire controlling interest in Kalama Chemical, Inc. through conversion of the $900,000 note to common stock as described in Section 5B of the order.

As required of the buyer under Section 10A of the Order, BC Sugar Refinery, Limited hereby grants to the New Jersey Department of Environmental Protection full right of access to the Kalama Chemical, Inc. facility located at 290 River Drive, Garfield, Bergen County, New Jersey, for the purpose of undertaking all necessary monitoring and cleanup activities while the order is in full force and effect.

Sincerely,

John Cochrane

John G. Cochrane
Vice President, Finance

JGC/rg

KALAMA CHEMICAL INC.
1110 BANK OF CALIFORNIA CENTER
SEATTLE, WA 98164

PHONE 206 682-7890
TWX 910-444-2294
FAX 206 682-1907

December 8, 1988

Mr. Joseph R. Fallon, Asst. Director
New Jersey Dept. of Environmental Protection
Industrial Site Evaluation
Division of Hazardous Waste Management
401 East State Street, 5th Floor
Trenton, New Jersey 08625

Re: Administrative Consent Order for Kalama Chemical, Inc.
ECRA Case #86B73

Dear Mr. Fallon:

Enclosed are the following documents:

1. Executed and dated original Administrative Consent Order.

2. Executed Letter of Credit

3. Certificate of Incumbency

4. Right of Access letter from B. C. Sugar

The Standby Trust Agreement between Kalama Chemical, Inc. and U.S. Bank of Oregon will follow shortly.

Please let us know if you have any questions or require additional documentation.

Sincerely,

L. C. Macomber

L. C. Macomber
Vice President
Administration

LCM:cla

Enclosures

cc: Norman Schlesinger, Esq.
John Cochrane, V.P., B. C. Sugar

KALAMA CHEMICAL INC.
1110 BANK OF CALIFORNIA CENTER
SEATTLE, WA 98164

PHONE 206 682-7890
TWX 910-444-2294
FAX 206 682-1907

CERTIFICATE OF INCUMBENCY

The undersigned, L. C. Macomber, does hereby certify that:

1. The following named persons were duly elected at a meeting of the Kalama Chemical, Inc. Board of Directors on September 15, 1988 to the respective offices set opposite their names, and

2. Each of them have the requisite authority to exeucte any and all documents for and on behalf of the Corporation.

Chairmand of the Board and Chief Executive Officer	Ted W. Palmer
President and Chief Operating Officer	Robert A. Kirchner
Vice President - Administraton	L. C. Macomber
Vice President - Finance	John P. Fairman
Vice President - Marketing	James H. Harris
Vice President - Manufacturing and Maintenance	Wayne H. Ostermiller
Vice President - Engineering and Technical Services	Jarl L. Opgrande
Secretary	L. C. Macomber
Treasurer	John P. Fairman

IN WITNESS WHEREOF, the undersigned has hereunto set his hand and affixed the Seal of the Corporation this 22nd day of November, 1988.

L. C. Macomber

L. C. Macomber
Secretary

Change of buyer

KALAMA CHEMICAL INC.
1110 BANK OF CALIFORNIA CENTER
SEATTLE, WA 98164

PHONE 206 682-7890
TWX 910-444-2294
FAX 206 682-1907

November 18, 1988

Ms. Barbara Strollo
New Jersey Dept. of Environmental Protection
Division of Hazardous Waste Management
Bureau of ECRA Applicability and Compliance
CN 028
Trenton, NJ 08625-0028

Re: Administrative Consent Order in the Matter of Kalama Chemical, Inc. 26373

Dear Ms. Strollo:

Since preparing and filing the Administrative Consent Order affidavit on September 15, 1988, The British Columbia Sugar Refining Company, Ltd. identified in Paragraph M of the Affidavit as the party acquiring a majority interest in the referenced company through conversion of the $900,000 convertible note, has assigned its interest in the note to B. C. Sugar Refinery, Limited, the parent company of British Columbia Sugar Refining Company, Ltd.

NOV 28 2 26 PM '88

All other details of the affidavit remain the same, it being the intent of the buyer to conclude the transaction as described.

We will appreciate your acceptance of the enclosed substitute page 4 of the affidavit reflecting the change in names. NJDEP may rely on the certification of the undersigned as to the accuracy and completeness of the foregoing.

Sincerely,

L. C. Macomber

L. C. Macomber
Vice President
Administration

LCM:cla

Enclosure

cc: Norman Schlesinger

M. Purchaser or new tenant (Attach additional sheets, if necessary):

Name B. C. Sugar Refinery, Limited

Address P.O. Box 2150

City or Town Vancouver, B.C. ~~State~~ Canada Zip Code V6B 3V2

State of Incorporation N/A

N. PARTNERSHIPS: If the owner, operator, and/or ordered party is a partnership, give type of partnership (limited/general) and state where registered. Attach a list of the names and addresses of all current general partners.

O. Is the Economic Development Authority (EDA) providing financing for this transaction?

___ Yes x No

Date on which the EDA gave final Board approval ___

EDA Application Number ___

Last day for closing title to obtain EDA financing ___

Provide documentation of final EDA Board approval.

Name of EDA representative ___

Address ___

City or Town ___ State ___ Zip Code ___

Phone Number ___

P. Source(s) of Environmental Concern - Check all applicable categories concerning the Industrial Establishment.

___Drum Storage
___Discharge
___Injection Well
___Roof Drain
x Spill (possible)
___Vents

___Waste Pile
x Monitor Well (A)
___Floor Drain
___Septic System
___Loading Docks
___Pumping Station

___Seepage Pit
___Dumpster
___Bldg. Decontam.
___Asbestos
___Rail Sidings
___Landfill

___Tank Farm
x Transformer
x UGST
___Lagoon
___Impoundments

Other *(Explain)* (A) Monitoring wells have been sunk in an effort to determine the extent of any contamination.

SAIBER SCHLESINGER SATZ & GOLDSTEIN
ATTORNEYS AT LAW
ONE GATEWAY CENTER
NEWARK, N.J. 07102-5311

(201) 622-3333
TELECOPIER: (201) 622-3349

NORMAN E. SCHLESINGER
DAVID M. SATZ, JR.
GERALD P. SEID
BRUCE I. GOLDSTEIN+
WILLIAM F. MADERER+
DAVID J. D'ALOIA°
JAMES H. AIBEL

SAMUEL S. SAIBER
OF COUNSEL

STEVEN S. GOLDENBERG
SEAN R. KELLY
ROBIN B. HORN
DAVID J. SATZ
JOAN M. SCHWAB
NANCY SIVILLI
ROBERT B. WEINSTOCK
LOUIS H. MIRON
MARY FRAN FARLEY
ROBERT B. NUSSBAUM

+CERTIFIED CIVIL AND CRIMINAL TRIAL ATTORNEY
°CERTIFIED CIVIL TRIAL ATTORNEY

October 12, 1988

Department of Environmental Protection
New Jersey Division of Hazardous
Waste Management
401 East State Street
CN 028
Trenton, New Jersey 08625-0028

Attention: John A. DeFina, Section Chief

Re: Kalama Chemical, Inc.
Case Number 86 B 73

Gentlemen:

As attorneys for Kalama Chemicals, Inc., we are sending you the enclosed Administrative Consent Order Affidavit and $1,000 Rainier Bank cashier's check dated June 10, 1988. We request that an Administrative Consent Order be issued to allow the change in ownership of the company as described in the enclosed affidavit and previously filed Initial Notice to occur as soon as possible.

Based upon the most reliable information available to our client, it is estimated that the cost for the remaining work to be done in connection with a cleanup plan should not exceed $500,000. Therefore, if it is determined that financial assurance for the cleanup be provided in connection with issuance of the Administrative Consent Order, a letter of credit for that amount would be provided.

We request that you acknowledge receipt of this letter and the enclosed filing on the copy of this letter and return it to us in the enclosed, stamped, self-addressed envelope.

Very truly yours,

Norman E. Schlesinger

Norman E. Schlesinger

NES/jhg
Enclosures

ECRA-012
12/87

NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF HAZARDOUS WASTE MANAGEMENT
INDUSTRIAL SITE EVALUATION ELEMENT
CN 028, TRENTON, N.J. 08625

ENVIRONMENTAL CLEANUP RESPONSIBILITY ACT (ECRA)

ADMINISTRATIVE CONSENT ORDER AFFIDAVIT

*The purpose of this application is to solicit an Administrative Consent Order (ACO) from the New Jersey Department of Environmental Protection. The ACO will allow the transaction or closing to occur prior to full compliance with the act. In return, the ordered party agrees to fully comply with the ACO time requirements in accordance with the schedules agreed to in the ACO. Fee is **$1,000 (ACO) or $500 (Amendment)**.*

PLEASE TYPE OR PRINT

Date September 15, 1988

A. Has an ACO previously been executed for this site? ____ Yes X No

If yes:
Case Number ____
Ordered Party ____
Date of Execution ____

B. Has an Initial Notice been filed for this transaction? X Yes ____ No

If yes: Case Number 86B73

If no, attach a completed ECRA 1, **General Information Submission** (N.J.A.C. 7:26B-3.2), to this application for each facility to be included in the ACO along with appropriate fees pursuant to N.J.A.C. 7:26B-1.10. If the applicant is proposing a financial assurance less than $100,000 for this site, include a fully completed **Site Evaluation Submission** in accordance with N.J.A.C. 7:26B-7.3(b).

C. The lead (ordered) party in this ACO will be the following:

Name Kalama Chemical, Inc.

Address 1110 Bank of California Center

City or Town Seattle State WA Zip Code 98164

State of Incorporation, if applicable Washington

D. Industrial Establishment(s) in New Jersey: *(Attach additional sheets if there are more than one to be included in this ACO.)*

Name Kalama Chemical, Inc.

Street Address 290 River Drive

City or Town Garfield

Municipality Garfield County Bergen

Block(s) 50.01
50.02 Lot(s) Lot 1
Lot 2

State(s) of Incorporation Washington

E. Description of Industrial Establishment operations *(be specific)*, include Standard Industrial Classification Number (SIC) *(Use additional sheets if more than one Industrial Establishment.)*:

The referenced establishment manufactures the following products: Salicylic Acid and derivatives and various esters of Para Hydroxy Benzoic Acid. The products are covered by SIC codes 2865, 2869 and 2833.

F. Current owner of the property for which this ACO is requested *(Use additional sheets if more than one)*:

Name Kalama Chemical, Inc.
Street Address 1110 Bank of California Center
City or Town Seattle State WA Zip Code 98164
State of Incorporation, if applicable Washington

G. Current operator(s) (Lessee) of the Industrial Establishment for which this ACO is requested, if applicable: *(Additional sheets if more than one)*

Name Same as (F) above
Address
City or Town State Zip Code
State of Incorporation, if applicable

H. Site Boundaries for which the Lessee has responsiblity (Attach maps if necessary):

N/A

I. Individual submitting this request:

Name L. C. Macomber, Vice President - Administration

Affiliation Kalama Chemical, Inc.

Address 1110 Bank of California Center

City or Town Seattle State WA Zip Code 98164

Phone Number (206)682-7890

Who do you represent? Owner

NOTE: The Department will only review ACO applications submitted to the Department by the owner and/or the operator or their authorized agent pursuant to N.J.A.C. 7:26B-1.13(d). The appropriate documentation shall accompany this application.

J. Describe, in detail, the transaction for which this ACO is requested (closing, selling; stock purchase, etc.). Attach additional sheets, if necessary.

Under the terms of a tender offer Agreement, the British Columbia Sugar Refining Company, Ltd. acquired 49% of the outstanding common stock of Kalama Chemical, Inc., and $900,000 of convertible subordinated notes. It is the mutual desire of the parties to conclude the transaction originally contemplated through conversion of the notes to common stock thereby providing B. C. Sugar with ownership of approximately 55% of Kalama Chemical, Inc.

K. Attach any agreement(s), termination notices, or letter(s) of intent for this sale, stock purchase, leasehold termination, or closing, if not previously submitted as part of the Initial Notice.

Date the agreement or Letter of Intent was signed November 14, 1986, amended Dec. 11, 1986

Date for closing the transaction September 30, 1988 or as soon as practical

Date for cessation of operations Operations will continue

Is the closing of the transaction dependent on compliance with ECRA? x Yes ____ No

L. State the criteria as listed in N.J.A.C. 7:26B-7.1, upon which this ACO is being requested and appropriate justification to support the criteria.

1. Tender offer (friendly) for stock and exercise of right to convert notes to stock.

2. This transaction involves multiple sites, most of which are not located in the State of New Jersey.

3. It is unlikely that ECRA cleanup will be accomplished before conclusion of the transaction.

M. Purchaser or new tenant (Attach additional sheets, if necessary):

Name British Columbia Sugar Refining Company, Ltd.

Address P.O. Box 2150

City or Town Vancouver, B.C. ~~State~~ Canada Zip Code V6B 3V2

State of Incorporation N/A

N. PARTNERSHIPS: If the owner, operator, and/or ordered party is a partnership, give type of partnership (limited/general) and state where registered. Attach a list of the names and addresses of all current general partners.

O. Is the Economic Development Authority (EDA) providing financing for this transaction?

___Yes x No

Date on which the EDA gave final Board approval ___

EDA Application Number ___

Last day for closing title to obtain EDA financing ___

Provide documentation of final EDA Board approval.

Name of EDA representative ___

Address ___

City or Town ___ State ___ Zip Code ___

Phone Number ___

P. Source(s) of Environmental Concern - Check all applicable categories concerning the Industrial Establishment.

___Drum Storage
___Discharge
___Injection Well
___Roof Drain
x Spill (possible)
___Vents

___Waste Pile
x Monitor Well (A)
___Floor Drain
___Septic System
___Loading Docks
___Pumping Station

___Seepage Pit
___Dumpster
___Bldg. Decontam.
___Asbestos
___Rail Sidings
___Landfill

___Tank Farm
x Transformer
x UGST
___Lagoon
___Impoundments

Other *(Explain)* (A) Monitoring wells have been sunk in an effort to determine the extent of any contamination.

Q. Purchaser or New Lessee Authorization:

I am the purchaser X and/or new lessee ____ of this Industrial Establishment. I have read this application and am aware of the requirements and conditions of ECRA Administrative Consent Orders. I agree to allow the seller, previous owner, or previous tenant plus the Department of Environmental Protection the right to enter the Industrial Establishment after I own it or lease it for the purpose of Environmental investigation and cleanup, if required.

British Columbia Sugar Refining Company Ltd.

Sworn to and Subscribed Before Me
on this ____
Date of 9-20, 19 88

John Hochreze
Notary Public

By: ____
Signature President

W C Brown
Printed Name

September 20 1988
Date

R. Owner and Operator Authorization:

I hereby certify that I am fully aware of the requirements of the Environmental Cleanup Responsibility Act in particular the owner/operator responsibilities pursuant to the ECRA regulation, N.J.A.C. 7:26B-1. I acknowledge that an Administrative Consent Order has been requested to allow this transaction to proceed prior to full ECRA compliance and that the ordered party is agreeing to resolve all ECRA matters. I further acknowledge that the execution of an ACO by the ordered party shall not release me from any responsibilities I have pursuant to ECRA and the regulations.

KALAMA CHEMICAL, INC.

L. C. Macomber
Signature - Property Owner

L. C. Macomber
Printed Name

September 19, 1988
Date

KALAMA CHEMICAL, INC.

L. C. Macomber
Signature - Operator of Industrial Establishment

L. C. Macomber
Printed Name

September 19, 1988
Date

Sworn to and Subscribed Before Me

on this ____

Date of 9-19 1988

Carolyn L. Anderson
Notary Public

Sworn to and Subscribed Before Me

on this ____

Date of 9-19 1988

Carolyn L. Anderson
Notary Public

1. The following certification shall be signed by the highest ranking individual at the site with overall responsibility for that site or activity. Where there is no individual at the site with overall responsibility for that site or activity, this certification shall be signed by the individual having responsibility for the overall operation of the site or activity.

   I certify under penalty of law that the information provided in this document is true, accurate and complete. I am aware that there are significant civil penalties for knowingly submitting false, inaccurate or incomplete information and that I am committing a crime of the fourth degree if I make a written false statement which I do not believe to be true. I am also aware that if I knowingly direct or authorize the violation of N.J.S.A. 13:1K-6 <u>et seq.</u>, I am personally liable for the penalties set forth at N.J.S.A. 13:1K-8.

   Typed/Printed Name Thomas J. LoBue Title Plant Manager

   Signature Thomas J. LoBue Date 10/5/88

   Sworn to and Subscribed Before Me
   on this fifth
   Date of Oct. 19 88

   Doris F. Williams
   Notary

   DORIS F. WILLIAMS
   NOTARY PUBLIC OF NEW JERSEY
   MY COMMISSION EXPIRES DEC. 8, 1992

2. The following certification shall be signed as follows:

   1. For a corporation, by a principal executive officer of at least the level of vice president;
   2. For a partnership or sole proprietorship, by a general partner or the proprietor, respectively; or
   3. For a municipality, State, Federal or other public agency, by either a principal executive officer or ranking elected official.

   I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate and complete. I am aware that there are significant civil penalties for knowingly submitting false, inaccurate, or incomplete information and that I am committing a crime of the fourth degree if I make a written false statement which I do not believe to be true. I am also aware that if I knowingly direct or authorize the violation of N.J.S.A. 13:1K-6 <u>et seq.</u>, I am personally liable for the penalties set forth at N.J.S.A. 13:1K-8.

   Typed/Printed Name L. C. Macomber Title V.P. - Administration

   Signature L. C. Macomber Date SEPTEMBER 19, 1988

   Sworn to and Subscribed Before Me
   on this /
   Date of 9-19- 19 88

   Carolyn L. Anderson
   Notary

Have you enclosed a check or money order for $1,000 (ACO) or $500 (Amendment)?

X Yes ____ No

Let's protect our earth

DCS000769

CN 028
enton, N.J. 08625-0028

(609)633-7141

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF HAZARDOUS WASTE MANAGEMENT

Michele M. Putnam
Deputy Director
Hazardous Waste Operations

John J. Trela, Ph.D., Director

Lance R. Miller
Deputy Director
Responsible Party Remedial Action

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

OCT 18 1988

Mr. L. C. Macomber
Vice President - Administration
Kalama Chemical, Inc.
1110 Bank of California Center
Seattle, WA 98164

RE: Application for an Administrative Consent Order (ACO)
Kalama Chemical, Inc.
ECRA Case Number: 86B73

Dear Mr. Macomber:

The Department has determined that your application is complete and meets the established criteria for granting an ACO. An ACO will be ready for this case within three weeks of this approval date.

Should you have any questions, you may contact Jeanette Cleary of my staff, who has been assigned to this matter, at (609) 633 - 7141.

Sincerely,

Barbara Strollo

Barbara Strollo, Supervisor
Bureau of ECRA Applicability and Compliance

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ECRA SOIL AND GROUND-WATER INVESTIGATION AT THE KALAMA CHEMICAL, INC. FACILITY, GARFIELD, NEW JERSEY

June 1988

Geraghty & Miller, Inc.
7 Atlantic Street
Hackensack, New Jersey 07601

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FACILITY, GARFIELD, NEW JERSEY

INTRODUCTION

In March 1987, Geraghty & Miller, Inc. was retained by Kalama Chemical, Inc. to design and conduct an investigation of soil and ground-water quality conditions at the Kalama facility in Garfield, New Jersey in compliance with New Jersey's Environmental Cleanup Responsibility Act (ECRA) under N.J.A.C. 7:1-3 and 4. A workplan was prepared based on information provided by Kalama personnel and data collected during a preliminary soil boring program conducted by Geraghty & Miller, Inc. in 1985. The results of this preliminary program were included in the workplan, which was submitted to the New Jersey Department of Environmental Protection (NJDEP) for review on August 13, 1987. Since the NJDEP indicated that it would not review the workplan for at least six months, Kalama Chemical, Inc. decided to implement the workplan prior to the assignment of an ECRA case manager. The field work was carried out from September 1987 to March 1988. This report summarizes the results of the implementation of the investigation workplan.

FIELD PROGRAM

The ECRA site investigation was carried out by implementing several tasks, including:

- The removal of 11 of the 27 underground storage tanks, and the collection of soil samples in the tank excavations. Additional tanks are scheduled to be removed in the near future.
- The installation and sampling of seven shallow and two deeper monitoring wells.
- The collection of soil samples at 13 locations for chemical analysis.
- The measurement of three synoptic rounds of ground-water levels in the nine monitoring wells.

Underground Storage Tank Removal Program

There were a total of 27 underground storage tanks at the Kalama facility, with capacities ranging from 500 to 16,000 gallons. All the tanks were made of steel of varying thicknesses and were used to store a variety of products. Kalama was using only seven tanks at the time of the initiation of this program. The remaining tanks were either empty or filled with water. The tank removal program began in late September 1987; to date, 11 tanks have been removed from the ground. Additional tanks are scheduled to be removed in 1988.

The cleaning of the tanks, the excavation prior to removal, and the cutting and disposal of the tanks were carried out by a contractor under the supervision of Kalama personnel. A Geraghty & Miller, Inc. representative was on site during the tank removal program to document tank conditions, photograph the tanks and excavations, and collect soil samples from the excavated pits for chemical analysis. Table 1 summarizes pertinent information regarding tank dimensions, products stored, and the number and depth of collected soil samples.

The number of soil samples collected from each tank excavation was based on the size of the tank and the relative location/orientation of the tank with respect to other tanks in a tank farm. The locations and depths of the collected soil samples are shown in the location sketches provided in Appendix A.

The soil samples were collected from the excavation with either a hand-held auger, a backhoe bucket, or a combination of both. The backhoe bucket was cleaned between individual tank locations. The hand-held bucket auger and other sampling gear were decontaminated prior to and in between sampling events by washing with a laboratory grade detergent and rinsing with potable water, followed by a rinse with distilled water.

Monitoring Well Installation

Nine monitoring wells were drilled at seven locations from December 2 to December 17, 1987 by a licensed driller in the employ of Environmental Drilling, Inc. of Mount Arlington, New Jersey. Geologic samples were described and monitoring well construction details were documented by an attending Geraghty & Miller, Inc. scientist. The wells were drilled by the hollow-stem auger method, using 6-1/4 inch inside diameter hollow-stem augers. The wells were constructed of four-inch diameter, 0.020-inch slot, PVC screen and four-inch diameter PVC casing. Well construction details are summarized in Table 2; individual monitoring well construction diagrams are presented in Appendix B. Monitoring well locations are shown on Figure 1.

Continuous geologic samples were collected at each monitoring well location from ground surface to the water table. Formation samples were collected at approximately five-foot intervals below the water table. Geologic logs for monitoring wells are included in Appendix C. The shallow monitoring wells were constructed with ten or fifteen feet of well screen, set with a few feet of the screen above the water table.

The monitoring wells were developed on December 21, 1987 by Environmental Drilling, Inc. under the supervision of a Geraghty & Miller, Inc. representative. The wells were developed by working a surge block up and down in the well and by pumping with a centrifugal or submersible pump. Monitoring wells MW-2, MW-3, and MW-4, completed in clay and/or silt, went dry several times during development. The tops of the monitoring well casings were surveyed relative to mean sea level by a New Jersey-licensed surveyor.

Soil Borings

Soil samples were collected from three monitoring well and ten soil boring locations between December 10 and 18, 1987. Of the ten soil borings, eight were collected with a drilling rig using 3-3/4 inch internal diameter hollow-stem augers; the remaining samples were collected with a bucket-type hand auger. The soil samples collected from the borings for two monitoring wells, MW-1 and MW-7, were designated as S-3 and S-1, respectively. The soil sample from monitoring well MW-5 was designated as MW-5.

No soil sample was taken from the boring of monitoring well MW-4, (as originally specified in the workplan) as the top of the water table was encountered immediately below the concrete surface at a depth of approximately 1.5 feet below ground surface. The material above the water table was primarily concrete and gravel and no soil was available for sampling. Geologic logs for soil borings are included in Appendix C.

Soil samples were collected in accordance with the protocol presented in Appendix C of the workplan (Geraghty & Miller, Inc., 1987). Analytical parameters, sample depths, and other pertinent information for each soil sample are summarized in Table 3.

A field blank was collected for the analysis of volatile organic compounds. All samples were submitted to Envirotech Research of Edison, New Jersey for chemical analysis.

Collection of Ground-Water Samples

The monitoring wells were sampled on January 5 and 6, 1988 for the parameters listed in Table 4. The water-level in each well was measured prior to well evacuation and sampling. The monitoring wells were evacuated in accordance with protocols presented in Appendix D of the sampling plan (Geraghty & Miller, Inc., 1987). Pumping rates in low yielding wells were kept to a minimum to prevent the wells from going dry rapidly. Wherever possible, three to five times the volume of standing water in each well was evacuated prior to sampling. Wells that went dry repeatedly (even at low pumping rates) were allowed to recover prior to sampling.

A replicate sample was collected from monitoring well MW-1 for the parameters listed in Table 4 and was labelled MW-8. A field blank sample was collected using blank water supplied by Envirotech Research of Edison, New Jersey to document the thoroughness of equipment decontamination procedures. Travel blanks were also enclosed for analysis. All samples were submitted for chemical analysis to Envirotech Research. Field parameters (pH, specific conductance, and temperature) were measured with portable field instruments.

Water-Level Measurements

Ground-water levels in the nine monitoring wells were measured during three synoptic events; these water-level data are summarized in Table 5.

HYDROGEOLOGIC CONDITIONS

Geology

The Kalama facility was built over a sequence of unconsolidated deposits consisting of fine to coarse sand, silt, and clay. Large portions of the site are paved with asphalt; imported fill consisting of mixtures of sand, gravel, crushed stone, and brick fragments were encountered underneath the asphalt in places. The thickness of the unconsolidated deposits under the site ranges from 32 to 40 feet.

Underlying the unconsolidated deposits is a bedrock formation consisting of red and brown sandstones and shales. This bedrock formation is referred to as the Brunswick Formation of Triassic age. The top of the bedrock is weathered, consisting of rock fragments in a mixture of clay, silt, and sand.

Ground-Water Flow Conditions

The water-level data collected on March 11, 1988 were used to prepare the water-level contour map shown on Figure 2. The horizontal component of ground-water flow in the uppermost saturated unit is generally from northeast to southwest, discharging to the Passaic River. Relatively elevated water levels have consistently been observed in monitoring well MW-4. Elevated water levels in this area have apparently created a "mound" in the water table under the southeastern portion of the facility; ground water flows radially in all directions from this mound until being deflected to flow with the prevailing northeast to southwest flow regime.

The two monitoring well clusters (MW-3/3D and MW-6/6D) indicate that there is a downward component to ground-water flow under portions of the facility. The downward component is slight at the MW-6/6D cluster, and is more pronounced at the MW-3/3D cluster. The difference in the magnitude of the vertical component to ground-water flow at these two clusters may be due to the presence of a low permeability clay layer at the location of MW-3/3D. The shallow monitoring well (MW-3) is screened above this clay layer, while the deeper well (MW-3D) is screened in a sand and silt unit below the clay layer (see Figure B-3 in Appendix B).

SOIL QUALITY

Underground Storage Tank Program

Analytical data for soil samples collected during the tank excavation program are presented in Table 6. Soil samples collected around tanks that held fuel oil or gasoline were analyzed for total petroleum hydrocarbons (TPHC), while samples collected around tanks that held toluene or methanol were analyzed for those specific target compounds. For each tank excavation, soil sample locations are shown on the location sketches included in Appendix A. The data summarized in Table 6 indicate that soil-quality conditions around all the tanks, with the exception of Tank A-25 and possibly Tanks C-3 and A-27, have been impacted to some degree by the products stored in the tanks.

Exploratory Soil Boring Program

The analytical results for soil samples collected during the soil boring program are summarized in Table 7; the complete laboratory reports are presented in Appendix E. Soil boring locations are shown on Figure 1; the dates and depths of sample collection are summarized in Table 3.

Toluene was the volatile organic compound (VOC) detected in highest concentrations, and was found at relatively high levels in soil samples collected from the southeastern portion of the facility (soil samples S-1, S-2, S-7, and S-8). Benzene was also detected in high concentrations in soil samples S-7 and S-8.

Several base/neutral extractable organic (B/N) compounds were detected in soil samples collected from the southern half of the facility. Of the detected compounds, a number of them were below the method detection limit. Detectable levels of TPHC were found in soil samples S-1, S-2, S-3, S-7, S-8, and S-12. Total phenols were detected in samples S-1 and S-2 at concentrations of 8.7 and 200 mg/kg, respectively.

GROUND-WATER QUALITY

Concentrations of organic constituents in ground-water samples are summarized in Table 8. Benzene and toluene and were the principal VOCs detected in monitoring well samples. In addition, monitoring well MW-5 showed the presence of trichloroethene. Other VOCs detected at lower concentrations (below or approximately near the detection limits) include chlorobenzene, trans-1,2-dichloroethene, ethylbenzene, tetrachloroethene, and total xylenes. Monitoring wells MW-2, MW-6, and MW-6D had total VOC concentrations of less than 10 ug/L, while MW-3D had one VOC (ethylbenzene) at a concentration of 23 ug/L.

A sample of the product layer floating on the water table was collected from monitoring well MW-7; no ground-water sample was collected from this well, since the possibility of introducing droplets of the floating product layer into the water sample could not be precluded. The results of the analysis of the product sample is summarized in Table 9. Toluene was detected in the product phase of this product sample at a concentration of 541,000 mg/kg, indicating that apparently 54 percent of the mass of this product phase consists of toluene. The TPHC concentration was reported as 408,900 mg/L, equivalent to approximately 41 percent (by mass).

Several B/N compounds were detected in relatively low concentrations (slightly above to below the detection limits) in all monitoring well samples. Benzaldehyde was detected in the sample collected from monitoring well MW-5 at a concentration of 570 ug/L. The sample of the floating product phase collected from MW-7 indicated the presence of several B/N compounds.

Due to a high measured field conductivity, a sample collected from monitoring well MW-3 was analyzed for selected inorganic parameters. The results of this inorganic analysis, summarized in Table 10, indicate that sulfate, sodium, and iron account for the majority of the dissolved solids in this ground-water sample.

Total phenols were detected in samples from monitoring wells MW-3, MW-3D, and MW-4 at concentrations of 2570, 122 and 4.65 mg/L, respectively. All other monitoring wells showed phenol concentrations below 1 mg/L. No formaldehyde was detected in the sample from monitoring well MW-1; no other samples were analyzed for this parameter. Methanol was analyzed in the samples from monitoring wells MW-1, MW-2, and MW-3 and was detected at concentrations of 5.9, less than 2.0, and 120 mg/L, respectively. Complete laboratory reports for ground-water samples are presented in Appendix F.

DATA GAPS

At present, there are several uncertainties regarding ground-water flow conditions and the extent of ground-water quality problems underlying the Kalama facility. These data gaps include the following:

- Currently, none of the installed monitoring wells serve as a true upgradient well for the facility. Monitoring well MW-3 is not upgradient of the entire facility and monitoring well MW-5 appears to be downgradient of the mound in the water table that apparently exists in the vicinity of monitoring well MW-4.

- The cause of the apparent mounding of the water table in the vicinity of MW-4 cannot be determined at present. Possible factors creating elevated water levels in this area could include a source of artificial recharge (e.g. leaking water lines) located on-site, or possibly a leaking water main or some other source of artificial recharge on Hudson Street, to the south of the facility.

- The horizontal extent of the floating product layer detected in monitoring well MW-7 has not been defined. The extent of elevated concentrations of toluene in ground water detected in the northeastern portion of the facility (monitoring well MW-3) and the southeastern portion of the facility (monitoring wells MW-5 and MW-4) is not currently known.

ADDITIONAL INVESTIGATIVE PROGRAM

The information compiled through the implementation of the sampling plan has been used to develop a preliminary understanding of ground-water flow and quality conditions underlying the site, and has also led to the identification of certain ground-water quality problems. Additional data will be needed to fully delineate the extent of these problems, to determine the cause of the elevated water levels detected in the southeast portion of the plant, and to establish ground-water quality conditions upgradient of the facility. The following program is proposed to address the water-quality problems and other issues identified in the section entitled "Data Gaps".

Resampling of Selected Wells

The initial round of ground-water sampling has indicated potential ground-water quality problems in portions of the facility. Prior to developing a detailed program for additional monitoring wells to refine the delineation of the extent of these problems, or a program designed to assess the feasibility of ground-water remediation, a second round of ground-water samples will be collected from selected monitoring wells and analyzed for VOCs. The wells to be resampled will be those that have shown elevated VOC concentrations: MW-1, MW-3, MW-4, and MW-5. Based on the analytical results, the need to conduct additional investigative work will be assessed.

Floating Product Recovery

A program has been initiated to remove the floating product from monitoring well MW-7. This monitoring well (MW-7) is being used as a recovery well on a regular basis. Prior to product recovery, the thickness of the floating layer is measured. The product is being removed with a centrifugal pump, and the amount of product removed is being measured and recorded. The thickness of the product layer after bailing is also being measured and noted. The data collected in the first three episodes are summarized in Table 11.

The use of monitoring well MW-7 as a recovery well will continue for several weeks. Based on the amount of product removed and the observed persistence of this product layer, the effectiveness of using this well for recovery will be evaluated and the need for additional monitoring wells or recovery points will be assessed. The results from the three recovery episodes indicate a significant decrease in measured product thickness in monitoring well MW-7.

Additional Monitoring Wells

The results of the second round of ground-water sampling will be utilized to evaluate the need for additional monitoring wells to better delineate the extent of tentatively identified problems and data gaps. At present, it appears that none of the existing monitoring wells serves as an upgradient well, as monitoring well MW-3 has shown potential ground-water quality impacts from plant activities. It appears that an upgradient well can only be located off Kalama property; the installation of this well will be contingent on obtaining permission from the City of Garfield to install the well on a public sidewalk.

As stated earlier, a mound of elevated ground-water levels has been identified in the southeast portion of the facility, near monitoring well MW-4. Kalama is currently investigating the possibility of a leak in an underground water pipe or a break in the Passaic Valley water header that is located on Hudson Street, along the south side of the property. Based on these investigations, and the results of the second round of sampling, the need for additional monitoring wells will be addressed.

Respectfully Submitted,

GERAGHTY & MILLER, INC.
Chittaranjan Ray /DN.
Chittaranjan Ray
Staff Scientist

Daniel A. Nachman
Associate

Vincent W. Uhl, Jr.
Vice President

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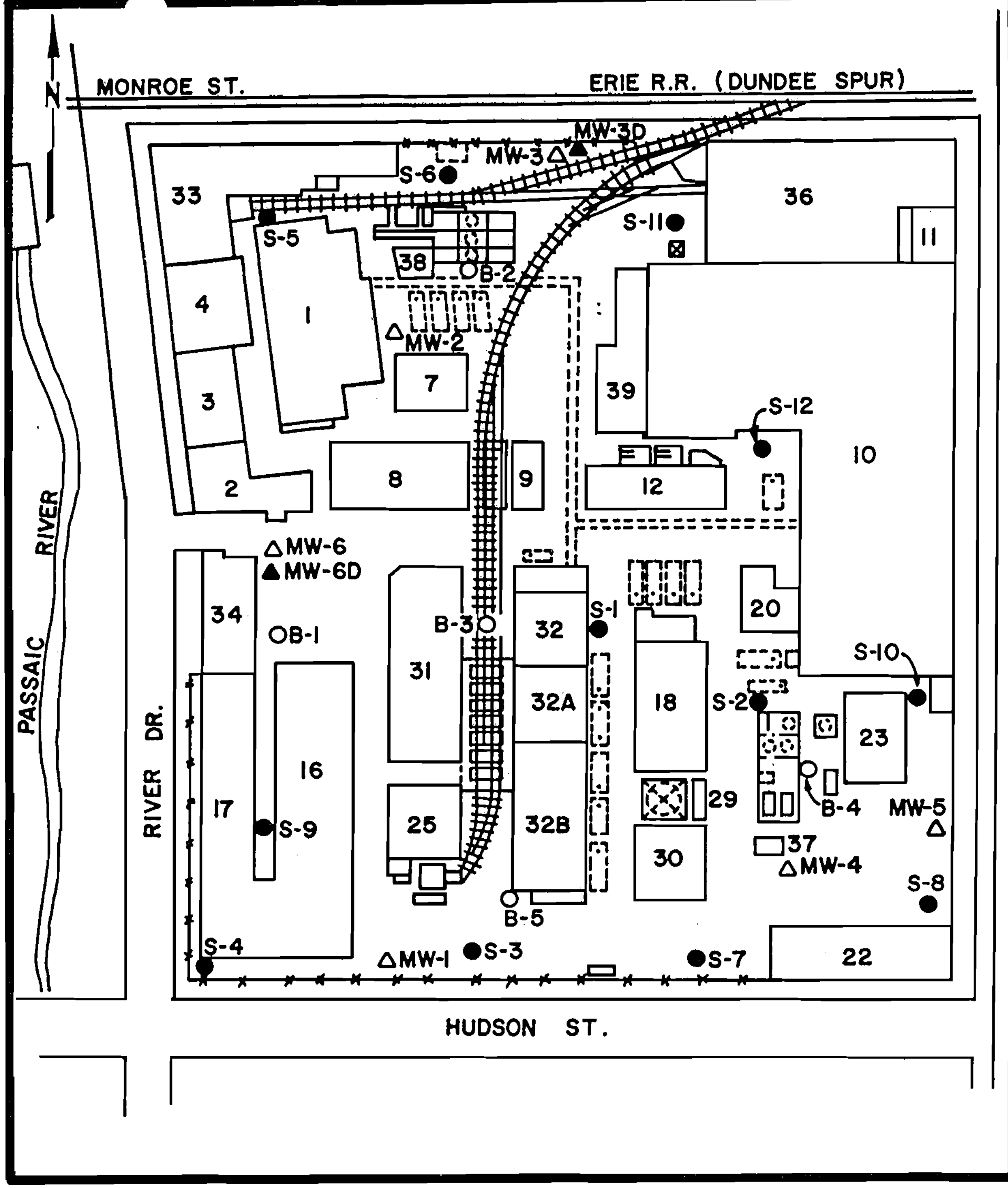

EXPLANATION

○B-3	BORING FROM PREVIOUS INVESTIGATION
●S-11	PROPOSED SOIL BORING LOCATION
△MW-3	PROPOSED SHALLOW MONITORING WELL LOCATION
▲MW-3D	PROPOSED DEEP MONITORING WELL LOCATION
⬚	UNDERGROUND STORAGE TANK
-x-x-x-x-	FENCE
7	BUILDING WITH NUMBER

DCS000787

SCALE 0 100 FT.

SUBJECT

SITE PLAN AND SAMPLE LOCATION MAP

PREPARED FOR

KALAMA CHEMICAL, INC.

Geraghty & Miller, Inc.	COMPILED BY	C.R.	SCALE SHOWN	FIGURE 2
	PREPARED BY	R.M.M.	DATE 7·21·87	
	PROJECT MGR	D.A.N.		

REVISED ECRA SAMPLING PLAN INVESTIGATION REPORT KALAMA CHEMICAL, INC. FACILITY GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

VOLUME 1 OF 2

September 1991

Prepared for

Kalama Chemical, Inc.
Seattle, Washington

Prepared by

Geraghty & Miller, Inc.
201 West Passaic Street
Rochelle Park, New Jersey 07662
(201) 909-0700

REVISED SAMPLING PLAN
INVESTIGATION REPORT
KALAMA CHEMICAL, INC. FACILITY
GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

September 6, 1991

Geraghty & Miller, Inc. is submitting this report to Kalama Chemical, Inc. for work performed at the Garfield, New Jersey facility. The report was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that the report meets the highest standards in terms of the methods used and the information presented. If you have any questions or comments concerning this report, please contact one of the individuals listed below.

Respectfully submitted,

GERAGHTY & MILLER, INC.

Robert Burns

Robert Burns
Staff Scientist/Geologist

Christopher J. Motta
Senior Scientist/Project Manager

Joseph Minster

Joseph Minster
Senior Project Advisor/Project Officer

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TABLES (Continued)

TABLE (Continued)

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FIGURES (Continued)

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D. Monitoring Well Forms A and B.

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F. Summary of Tentatively Identified Compounds.

G. Monitoring Well Purging and Sampling Data

REVISED SAMPLING PLAN
INVESTIGATION REPORT
KALAMA CHEMICAL, INC. FACILITY
GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

EXECUTIVE SUMMARY

This report is submitted pursuant to the requirements of the Administrative Consent Order between Kalama Chemical, Inc. of Seattle, Washington (Kalama) and the New Jersey Department of Environmental Protection (NJDEP), dated December 8, 1988.

The subject of this report is a 100-year old chemical manufacturing facility which occupies a 6.4-acre site located at 290 River Drive, Garfield, New Jersey, approximately 100 feet east of the Passaic River. The facility has been owned and operated by Kalama since December 1982. Buildings occupy approximately 50 percent of the facility; paved areas cover an estimated 25 percent of the facility. The facility has a extensive network of underground pipes and structures. River outfalls and intake lines, sewerage lines, and potable water lines cross the facility boundaries. The facility is active and tank trucks, tractor trailers and rail cars move around it regularly.

Since retained by Kalama in June 1986, Geraghty & Miller, Inc. (Geraghty & Miller) conducted three investigations at the Kalama facility in Garfield, New Jersey (facility or site):

- o The Preliminary Investigation in 1986.
- o The ECRA Sampling Plan Investigation in 1987-1988.
- o The present Revised ECRA Sampling Plan Investigation.

From 1986 to the present, Geraghty & Miller completed the following investigative work:

- Drilled and sampled 64 soil borings, and analyzed the soil samples for various chemical constituents.

- Installed 21 monitoring wells (18 shallow wells and three deep wells), collected two rounds of samples from nine wells and one round of samples from 12 wells, and analyzed the ground-water samples for various chemical constituents.

- Conducted a well search within a 0.5-mile radius of the facility.

- Reviewed historical aerial photographs of the facility from 1947, 1973, and 1982.

- Conducted 13 rounds of ground-water level measurements in monitoring wells.

- Conducted field permeability slug tests in 14 monitoring wells.

- Conducted pumping tests in two monitoring wells.

- Conducted two soil vapor extraction pilot tests (the results will be submitted with the cleanup plan).

- Installed a cluster of two piezometers to investigate further the apparent water-table mound in the southeastern section of the facility. (the results will be presented in the proposed Sampling Plan Addendum No. 2 Investigation Report).

- Conducted a preliminary survey of underground utilities.

In addition to the investigative work, the following remedial work was completed:

- From September 1987 through February 1990, 27 underground storage tanks (USTs) were removed, and post-excavation soil samples were collected and analyzed based on the former contents of the USTs. The UST removal program was conducted by Kalama and the prior facility owner, Tenneco, Inc.

- Kalama recovered a light non-aqueous phase liquid from a monitoring well located in the southeastern section of the facility by pumping intermittently during the period of May through November 1988. A sample of the liquid, collected prior to recovery, contained approximately 54 percent toluene and 41 percent petroleum hydrocarbons. In 1990, a similar liquid was recovered from a monitoring well also located in the southeastern section of the facility.

- In 1990 and 1991, Kalama reconstructed significant portions of the sewerage lines and associated catch basins.

- In 1991, Kalama took Building 16 (which had been leased to a third party) through a separate ECRA closure, which included asbestos removal.

Based on the results of the investigative and remedial work, Geraghty & Miller has concluded the following:

1. With the exception of several buildings and the benzoic acid/benzaldehyde production facility which no longer exist, the site surface conditions have changed little over the past 44 years.

2. There are no private or public supply wells within a 0.25-mile radius from the Kalama site. Additional well search activities are proposed in the "Sampling Plan Addendum No. 2."

3. The geology of the Kalama site is characterized by approximately 25 to 35 feet of unconsolidated deposits which are underlain by the Brunswick Formation shales and sandstones. The unconsolidated deposits generally include approximately 3 feet to 8 feet of fill over natural sand, silt, and clay. The lithology of the unconsolidated deposits varies significantly, both horizontally and vertically, across the site.

4. There is a single water-bearing zone in the unconsolidated deposits. The depth to the water table is generally 7 feet to 10 feet below ground surface and increases toward the Passaic River where the ground water discharges. There are tidal effects on ground water in the unconsolidated deposits within approximately 150 feet of the river. The significance of the tidal fluctuations for off-site contaminant migration and potential remedial alternatives for the facility is not understood at this time. Tidal fluctuations will be monitored further in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

5. There is some evidence that the apparent water-table mound in the southeastern section of the facility is a perched water body. The extent to which the anomalous ground-water conditions observed in the southeastern section of the facility impact off-site contaminant migration will be investigated further in accordance with the "Sampling Plan Addendum No. 2."

6. The general direction of ground-water flow is to the west/southwest, toward the Passaic River.

7. The soil hydraulic conductivity, based on slug tests, ranges from 0.3 feet/day (1.2 x 10^{-4} centimeters/second) to 13 feet/day (4.6 x 10^{-3} centimeters/second) with an average of 3 feet/day (1.1 x 10^{-3} centimeters/second). These values are typical for silty and clayey sands, which comprise a significant portion of the soils on the site. The overall ground-water flow gradient across the site is approximately 0.01. The hydraulic conductivity and ground-water flow gradient may range significantly across

the site. Geraghty & Miller did not calculate ground-water flow velocities because of the high inhomogeneity of the unconsolidated deposits, the potential presence of preferential pathways, and tidal influences. Those conditions tend to render ground-water flow velocities unreliable for predicting ground-water time of travel.

8. The pumping tests indicate that the water-bearing zone yields variable and relatively low volumes of water to wells (0.5 gallons per minute and 3 gallons per minute). The results of the pumping tests are inconclusive. An additional pumping test will be conducted in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

9. The results of the post-excavation soil sampling and analysis program indicate the following:

   o The locations of the former methanol, methyl isobutyl ketone and hexene USTs are not areas of concern.

   o The former toluene, fuel oil and gasoline USTs appear to have been sources of soil contamination. Toluene was detected in post-excavation soil samples at concentrations up to 805 milligrams/kilogram (mg/kg). Total petroleum hydrocarbons (PHCs) were detected in concentrations up to 24,000 mg/kg. The locations of the former toluene, fuel oil and gasoline USTs are areas of concern.

   o The UST excavations were partially backfilled with the excavated soils. Soil contamination associated with the former toluene, fuel oil and gasoline USTs will be addressed in the cleanup plan.

10. The results of the soil boring sampling and analysis program indicate the following:

- Constituents, including toluene, benzene, total polycyclic aromatic hydrocarbons (PAHs), and total PHCs exceed the NJDEP-ECRA guidance levels by a significant margin at several soil sampling locations.

  - Toluene was detected in soil at concentrations up to 20,000 mg/kg.

  - Benzene was detected in soil at concentrations up to 80 mg/kg.

  - Total PAHs were detected in soil at concentrations up to 71 mg/kg.

  - Total PHCs were detected in soil at concentrations up to 4,670 mg/kg.

- The southeastern section of the facility, which includes the locations of the former toluene USTs and former production facilities that used benzene and toluene, is an area of concern because of the high concentrations of toluene, benzene and PAHs in soil. The major portion of this area of concern extends 250 feet south of the location of the former toluene USTs. Sources other than the former USTs, such as spills and leaks, probably contributed to the toluene contamination in soil.

- Total PHCs were detected at high concentrations throughout the facility and therefore are a constituent of concern in soil.

- Polychlorinated biphenyls (PCBs) and metals are not constituents of concern at the facility.

- Because of the high concentrations of certain constituents, samples were diluted to facilitate laboratory analysis. Other constituents potentially present may not have been detected due to sample dilution and associated elevated detection limits.

- o Significant levels (up to 15,150 mg/kg) of tentatively identified (TID) compounds occur in soil.

- o Additional soil sampling is proposed in the "Sampling Plan Addendum No. 2."

- o The need for, and extent of, soil remediation will be addressed in the cleanup plan.

11. The results of the ground-water sampling and analysis program indicate the following:

- o Toluene, phenol, benzene, and trichloroethane (TCE) are constituents of concern in ground water.

- o Toluene is present in ground water throughout the facility. Toluene, concentrations up to 110,000 micrograms/liter were detected in ground-water samples from the southern half of the facility. The toluene area of concern for soil appears to be one of the source areas for toluene in ground water. Other potential sources of toluene contamination will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- o Phenol is present in ground water throughout the facility. Phenol concentrations up to 930,000 ug/L were detected in samples from monitoring wells along the northern facility boundary. Concentrations of phenol up to 120,000 ug/L were detected in the southern half of the facility. The source(s) of phenol contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- o The areas of toluene and phenol contamination in ground water extend to, and probably cross, the northern, southern and western boundaries of the facility. Additional off-site and downgradient monitoring wells will be installed as part of the work proposed in the "Sampling Plan Addendum No. 2."

- Benzene is present in ground water in the southern half of the facility at a maximum concentration of 3,500 ug/L. The area of benzene contamination in ground water extends to, and probably crosses, the southern and western facility boundaries. The source(s) of benzene contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- TCE and other chlorinated organic compounds are present in ground water at various locations across the facility. TCE was detected onsite in ground water at concentrations up to 2,700 ug/L. TCE was detected "upgradient" in an off-site monitoring well at a concentration of 260 ug/L. The apparent water-table mound in the southeastern section of the facility could be responsible for this apparent upgradient and off-site contaminant migration. TCE was detected downgradient/offsite at a concentration of 18 ug/L. The source(s) of TCE and the chlorinated organic compound contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- Because of the high concentrations of certain constituents, samples were diluted to facilitate laboratory analysis. Other constituents potentially present may not have been detected due to sample dilution and associated elevated detection limits.

- Significant levels (up to 599,785 ug/L) of TID compounds occur in ground water.

- o The need for, and extent of, ground-water remediation will be addressed in the cleanup plan.

12. The presence of non-aqueous phase liquids will continue to be monitored in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

13. A dense, non-aqueous phase liquid, which probably contains TCE, was detected at the bottom of one monitoring well located in the southeastern corner of the facility. The presence, nature, extent, and source of this non-aqueous phase liquid will be investigated further in accordance with work proposed in the "Sampling Plan Addendum No. 2."

14. A feasible and effective cleanup plan can only be developed after completion of additional investigative work. Geraghty & Miller recommends that the work proposed in the "Sampling Plan Addendum No. 2" be implemented.

REVISED SAMPLING PLAN
INVESTIGATION REPORT
KALAMA CHEMICAL, INC. FACILITY
GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

INTRODUCTION

PURPOSE

In June 1986, Geraghty & Miller, Inc. (Geraghty & Miller) was retained by Kalama Chemical, Inc. of Seattle, Washington (Kalama) to conduct an environmental sampling and analysis program at its chemical manufacturing facility in Garfield, New Jersey. The purpose of the program was to evaluate the environmental conditions of the facility in support of the requirements under New Jersey's Environmental Cleanup Responsibility Act (ECRA). Kalama submitted the General Information Submission (GIS) to the New Jersey Department of Environmental Protection (NJDEP) in 1986. Kalama submitted the Site Evaluation Submission (SES) and the Request for Hydrogeologic Assessment to the NJDEP in January 1987 and August 1987, respectively. An Administrative Consent Order (ACO) was executed between Kalama and the NJDEP in December 1988.

From June 1986 through June 1991, Geraghty & Miller conducted three ECRA-related investigations at the facility. Those investigations are described in a subsequent section entitled "History of Investigations."

This report was prepared for the following purpose:

- To summarize the findings of all Geraghty & Miller ECRA-related investigations at the Kalama facility, including the present Revised ECRA Sampling Plan Investigation.

- To provide the information necessary to design and implement an additional investigative program which is required to develop a feasible and effective cleanup plan.

FACILITY LOCATION

The Kalama facility is located in the City of Garfield, Bergen County, New Jersey. The property owned by Kalama is designated as Block 50.01 Lot 1 and Block 50.02 Lot 1 on the assessment map for the City of Garfield. Block 50.01 Lot 1 is approximately 500 feet by 560 feet (6.4 acres) and is occupied by the manufacturing facilities. The area of manufacturing (i.e., Block 50.01 Lot 1) is referred to as the site, facility or plant.

The second lot, Block 50.02 Lot 1, is approximately 40 feet by 560 feet (0.5 acres) and is the location of the river-water pump house and employee parking. River Drive, which trends north-south, divides the two lots. The Passaic River flows along the western boundary of Block 50.02 Lot 1. A site location map is provided as Figure 1.

HISTORY OF OPERATIONS

The information in this section was researched by Kalama. It is based on a review of historical records and discussions with long-time employees.

The first buildings at the Garfield Plant were constructed in 1891 by Fritzche Brothers to facilitate chemical manufacturing. The plant has operated continuously since that time. Fritzche Brothers sold the plant to Von Heyden Chemical Fabrische around the turn of the century. The company name was changed to Von Heyden Chemicals, then to Heyden Chemicals, then to Heyden-Newport Corporation. Heyden-Newport Corporation was purchased in 1965 by the Tennessee Gas Transmission Company, which later changed its name to Tenneco, Inc. Kalama Chemical, Inc. purchased the facility from Tenneco Chemicals, Inc., a Tenneco, Inc. subsidiary, in December 1982.

The oldest existing buildings on the site were constructed about 1900. The most recent building construction took place in the late 1970s. Existing buildings are referred to by number, as shown on Figure 2. Buildings have been demolished, replaced and modified over the years, as have underground pipes such as chemical and sanitary sewerage lines, and structures such as catch basins and sumps. The plant is served by railroad sidings from the Erie Lackawanna Railroad, in the central and northern section of the facility. Historically, 27 underground storage tanks (USTs) at various locations throughout the site were used for the storage of fuel oil, methanol, toluene and other chemicals. The USTs were removed by Kalama and Tenneco from 1987 to 1990.

Chemicals produced at the Garfield facility are used in pharmaceuticals, cosmetics, food packaging and preservatives, synthetic flavorings, printing inks, dyestuffs and other products. The plant has been the site of salicylic acid production since the turn of the century, and of salicylate salts from the 1930s to the present. Parasepts and methylene disalicylic acid (MDA) have been produced at the plant since the 1940s. (Parasepts, sometimes called Parabens, is a registered trademark for certain methyl, ethyl, propyl and butyl esters of para-hydroxy benzoic acid). During the 1930s until 1982, formaldehyde was produced at the plant. Benzoic acid, benzaldehyde and sodium benzoate were produced in facility buildings and on diked pad in the southeastern section of the facility from 1960 until February 1984.

During the Second World War, the U.S. government installed equipment at the plant for the manufacture of Pentaerythritol, a glycerine substitute. Pentaerythritol production continued until 1962. Other historical products and processes include Resorcinol, Jet Lube, Sodium, Potassium and Methyl Salicylate, Fumaric Acid, Pentamids, DDSA, Nuosperse HOH, Nuvis HS, B-Oxynapththoic Acid and Naphthalene distillation.

Toluene was used at the site as a raw material for the production of benzoic acid and benzaldehyde in the air oxidation process. Phenol and sodium hydroxide are currently used as raw material for the production of salicylic acid in the carboxylation process. Methyl salicylate is manufactured by the esterification of salicylic acid and methanol, with sulfuric acid used as a catalyst. Formaldehyde was formerly produced by the catalytic oxidation of methanol. Benzene was formerly used in the manufacture of Resorcinol.

Manufacturing operations are conducted in approximately one half of the 39 existing buildings at the site (several of which are subdivided into separately numbered structures, for example, Buildings 10-P1 through 10-P4). The other buildings are either vacant, idle, or they are used for storage, shops or offices. Seven buildings have been dismantled (Buildings 2, 3, 37, 38 and three unnumbered buildings). The dates of construction, current use, and, to the extent known, the principal historic use of each separately identified structure are presented in Table 1.

In addition to the numbered buildings, there are and historically have been a variety of other above-ground structures and tanks on the site. Of particular significance is the former benzoic acid/benzaldehyde production facility in the southeastern section of the facility (immediately west of Building 23) which was constructed by Heyden-Newport in 1960 and abandoned and dismantled by Kalama in 1984.

Geraghty & Miller will investigate further the historic operations at the facility as part of the work proposed in the "Sampling Plan Addendum No. 2" which is submitted under separate cover.

HISTORY OF INVESTIGATIONS

Geraghty & Miller conducted a Preliminary Investigation of Soil Quality Conditions in 1986 (Preliminary Investigation or 1986 Investigation). The field work associated with the Preliminary Investigation was conducted in June 1986. The results of that investigation are presented in a report entitled "Preliminary Investigation of Soil Quality Conditions at the Kalama Chemical, Inc. Facility in Garfield, New Jersey" (Geraghty & Miller, Inc., 1986).

Geraghty & Miller prepared a sampling plan as part of the Site Evaluation Submission required under ECRA. The plan was prepared in accordance with the Draft Sampling Plan Guide for ECRA (June 1986), issued by the NJDEP, Bureau of Industrial Site Evaluation (BISE). The plan, entitled "Sampling Plan for Site Evaluation, Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc., 1987) was submitted to the NJDEP in August 1987. The field work was conducted from September 1987 through March 1988. The results of the 1987-1988 Soil and Ground-Water Investigation (ECRA Sampling Plan Investigation or 1987-1988 Investigation) are presented in a report entitled "ECRA Soil and Ground-Water Investigation at the Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc., 1988). That report was submitted to the NJDEP in June 1988.

Based on the results of the ECRA Sampling Plan Investigation, Geraghty & Miller concluded that uncertainties remained regarding the nature and extent of contamination. Therefore, a sampling plan addendum letter, which proposed to address those uncertainties, was submitted to the NJDEP in October 1988.

Kalama received a letter from the NJDEP on March 10, 1989 which required Kalama to submit an expanded sampling plan addendum. In response to that letter, Geraghty & Miller prepared an expanded sampling plan addendum which was submitted to the NJDEP in April 1989 (Geraghty & Miller, Inc., 1989). Due to some deficiencies in the expanded addendum, noted in a letter from NJDEP to Kalama, dated January 8, 1990, Geraghty & Miller prepared a revised sampling plan addendum. The addendum, entitled "Revised Sampling Plan Addendum, Kalama Chemical Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc., 1990), was submitted to the NJDEP in March 1990. The NJDEP approved the Revised Sampling Plan Addendum with certain conditions by letter to Kalama, dated January 3, 1991.

The work detailed in the Revised Sampling Plan Addendum and the work required by the NJDEP conditions began in January 1991 and is completed with the submittal of this report and the proposed "Sampling Plan Addendum No. 2." That work constitutes the Revised Sampling Plan Investigation for the facility.

The scope of work for each of the investigations referred to above is summarized in the following section.

TECHNICAL OVERVIEW

PRELIMINARY INVESTIGATION (1986)

The Preliminary Investigation included the drilling of five soil borings, designated as B-1 through B-5, at the locations depicted on Figure 2. The soil borings were drilled in June 1986 using hollow-stem augering techniques. Samples for laboratory chemical analysis were collected from each soil boring using split-spoon sampling techniques. The soil borings ranged in depth from 8 feet to 12 feet below ground surface (bgs). In addition, a water sample from soil boring B-4 was collected for laboratory analysis. Laboratory chemical analyses were conducted by General Testing Corporation of Hackensack, New Jersey (GTC) and Environmental Testing and Certification of Edison, New Jersey (ETC). Samples from soil borings were analyzed for the following parameters:

- Volatile, base/neutral and acid extractable organic compounds.
- Total petroleum hydrocarbons.
- Total phenolics.
- Benzoic acid.
- Benzaldehyde.
- Formaldehyde.
- Alcohols.

A summary of the sampling and analysis program for the Preliminary Investigation is presented in Table 2.

Additional investigation details are included in the report entitled "Preliminary Investigation of Soil Quality Conditions at the Kalama Chemical, Inc. Facility in Garfield, New Jersey" (Geraghty & Miller, Inc., 1986).

ECRA SAMPLING PLAN INVESTIGATION (1987-1988)

The ECRA Sampling Plan Investigation included the drilling of soil borings, installation of ground-water monitoring wells, sampling of soil and ground water and measuring water levels. Laboratory chemical analyses were conducted by GTC and Envirotech Research Inc. of Edison, New Jersey (ERI).

During the time of the ECRA Sampling Plan Investigation, Kalama and the prior owner, Tenneco jointly initiated the removal of USTs at the facility. Also during that time, Kalama removed a light, non-aqueous phase liquid (LNAPL) from Monitoring Wells MW-5 and MW-7.

The following technical overview summarizes the major tasks conducted during the ECRA Sampling Plan Investigation. Additional investigation details are included in the report entitled "ECRA Soil and Ground-Water Investigation at the Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc., 1988).

Soil Sampling

Thirteen soil borings, designated as S-1 through S-13, were drilled using hollow-stem augering techniques and sampled using split-spoon sampling techniques (one soil sample was collected using a hand auger) in December 1987. Soil boring locations are depicted on Figure 2. The borings ranged in depth from 3.5 feet to 22 feet below ground surface. Samples from soil borings were analyzed for the following parameters:

- Volatile and base/neutral extractable organic compounds including tentatively identified compounds.
- Total petroleum hydrocarbons.
- Total phenolics.
- Benzoic acid.
- Benzaldehyde.

A summary of the soil sampling and analysis program for the ECRA Sampling Plan Investigation is presented in Table 3.

Ground-Water Sampling

Nine monitoring wells were installed in December 1987, including three monitoring wells installed in converted soil borings. The monitoring wells are designated as MW-1, MW-2, MW-3, MW-3D, MW-4, MW-5, MW-6, MW-6D, and MW-7. The monitoring wells locations are depicted on Figure 2. The monitoring wells range in depth from 15 feet to 40 feet bgs. All monitoring wells were constructed of 4-inch diameter PVC with 20-slot screens. Samples from the monitoring wells were analyzed for the following parameters:

- Volatile and base/neutral extractable organic compounds including tentatively identified compounds.
- Total petroleum hydrocarbons.
- Total phenolics.
- Benzoic acid.
- Benzaldehyde.
- Methanol.

One round of ground-water sampling was conducted in January 1988. In addition to the parameters listed above, the sample from Monitoring Well MW-3 was analyzed for selected inorganic constituents (i.e., major ions). Ground water from Monitoring Well MW-

7 was not sampled. Instead, a sample of the LNAPL present in the monitoring well was collected and analyzed for volatile and base/neutral extractable organic compounds, and total petroleum hydrocarbons.

A summary of the ground-water sampling and analysis program for the ECRA Sampling Plan Investigation is presented in Table 4.

Water-Level Measurements

Three rounds of ground-water level measurements were conducted in January, February, and March 1990.

LNAPL Recovery

Kalama removed the LNAPL present in Monitoring Well MW-7 by pumping on seven occasions during the period of May through November 1988. Kalama also removed the LNAPL present in Monitoring Well MW-5.

Underground Storage Tank Removal

Eleven of the 27 USTs were removed during the ECRA Sampling Plan Investigation. The additional 16 USTs were removed in April and May 1988, September and October 1988, January 1989, and February 1990. All USTs were removed under the supervision of Kalama and Tenneco personnel. The locations of the former USTs are shown on Figure 2. Post-excavation soil samples were collected by Geraghty & Miller and submitted to GTC and ERI for laboratory analyses. The soil samples were collected with a hand auger, and/or the backhoe bucket. The analytical parameters were based on the former contents of the USTs and included the following:

o Total petroleum hydrocarbons.

- o Toluene.
- o Hexene.
- o Methanol.
- o Methyl isobutyl ketone.

REVISED ECRA SAMPLING PLAN INVESTIGATION (1991)

The Revised ECRA Sampling Plan Investigation was conducted in accordance with the "Revised Sampling Plan Addendum, Kalama Chemical Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc., 1990), as conditioned and approved by the NJDEP (Revised Plan). The technical overview of the Revised ECRA Sampling Plan Investigation is presented below by task.

Task 1: Aerial Photograph History

Geraghty & Miller obtained historical aerial photographs of the facility from 1947, 1973 and 1982. The photographs were studied to identify changes in the layout of the facility with particular emphasis on the identification of exterior material storage areas and stained areas. Certain information on the photographs was confirmed by site reconnaissance and comparison to a 1973 site plan. The findings of this task are discussed in a subsequent section entitled "Site Conditions."

Task 2: Soil Sampling

Forty-six soil borings, designated as B-1 through B-46, were sampled in January 1991 using split-spoon sampling techniques and hand-auguring drilling techniques (five of the soil samples were collected using hand-augering techniques). The soil boring locations are depicted on Figure 2. The soil borings ranged in depth from 0.5 feet to 12 feet below ground surface. Samples from the soil borings were analyzed by ERI for the following parameters:

- Volatile, and base/neutral and acid extractable organic compounds including tentatively identified compounds.
- Total petroleum hydrocarbons.
- Total phenolics.
- Arsenic, beryllium, cadmium, and vanadium.
- Polychlorinated biphenyls.
- Toluene.
- Methanol.
- Hexene.
- pH.

A summary of the soil sampling and analysis program for the Revised ECRA Sampling Plan Investigation is presented in Table 5. The findings of this task are discussed in subsequent sections entitled "Site Geology and Hydrogeology" and "Soil Quality."

Task 3: Installation of Additional Monitoring Wells

Twelve additional monitoring wells, designated MW-8 through MW-18 and MW-5D, were installed using hollow-stem augering techniques at the locations depicted on Figure 2. The monitoring wells, installed in January 1991 and April 1991, range in depth from 12.5 feet to 35 feet bgs. All monitoring wells are constructed of 4-inch diameter PVC with 20-slot screens. The location and elevation of each monitoring well, including those previously installed, were surveyed by the Geod Corporation of Newfoundland, New Jersey.

To investigate further whether the apparent ground-water mound in the southeastern section of the facility is part of the overburden aquifer or is a perched water body, a pair of clustered piezometers designated as PZ-4S and PZ-4D was installed approximately 6 feet northwest of existing Monitoring Well MW-4 in June 1991. Piezometer PZ-4S is screened from 2 feet to 8 feet bgs; Piezometer PZ-4D is screened from 12 feet to 16 feet bgs. Both piezometers are constructed of 2-inch diameter PVC with 20-slot screens. The installation of piezometers was not required by the Revised Plan. Piezometers PZ-4S and PZ-4D will be surveyed and the water levels will be monitored as part of the additional investigative work proposed for the facility. Details of that work are described in the "Sampling Plan Addendum No. 2" which is submitted under separate cover.

Task 4: Water-Level Measurement Events

Ten rounds of water level measurements were conducted during the Revised ECRA Sampling Plan Investigation in April, May, and June 1991. The presence of LNAPL and dense non-aqueous phase liquid (DNAPL) was monitored concurrently during the first nine rounds of water-level measurements with an oil/water interface probe. The findings of this task are discussed in subsequent sections entitled "Site Geology and Hydrogeology" and "Ground-Water Quality."

Task 5: Monitoring Well Sampling

One round of ground-water sampling was conducted in April 1991. Ground-water samples from monitoring wells, including wells installed during the previous investigation, were analyzed during the Revised ECRA Sampling Plan Investigation for the following parameters:

- Volatile, and base/neutral and acid-extractable organic compounds including tentatively identified compounds.
- Total petroleum hydrocarbons.
- Total phenolics.
- Benzaldehyde.
- Chloride.
- Fecal coliform.

A summary of the ground-water sampling and analysis program for the Revised ECRA Sampling Plan Investigation is presented in Table 6. The findings of this task are discussed in a subsequent section entitled "Ground-Water Quality".

Task 6: Pumping Tests

Two 24-hour pumping tests were conducted in May 1991. The first test was conducted utilizing Monitoring Well MW-3D as the pumping well and Monitoring Wells MW-2, MW-3, MW-13, and MW-18 as observation wells. The second test was conducted utilizing Monitoring Well MW-10 as the pumping well and Monitoring Wells MW-4, MW-5, MW-5D, MW-9, MW-11, and MW-17 as observation wells.

Although not required by the Revised Plan, Geraghty & Miller conducted slug tests in 14 monitoring wells (MW-1, MW-2, MW-3D, MW-5D, MW-6, MW-6D, MW-8, MW-10, MW-11, MW-13, MW-14, MW-15, MW-16, and MW-18) in April 1991. The purpose of slug testing was to obtain soil permeability data. The results of the slug tests and pumping tests are discussed in a subsequent section entitled "Site Geology and Hydrogeology."

Task 7: Underground Storage Tank Removal

As indicated above, all USTs at the facility were removed by February 1990 (i.e., prior to the conduct of the Revised ECRA Sampling Plan Investigation). A summary of the post-excavation soil sampling program, including the sample locations and the analytical data results, is presented in the Revised Plan and is discussed in a subsequent section of this report entitled "Soil Quality."

Task 8: Soil Venting

In June 1991, Geraghty & Miller conducted soil vapor extraction (SVE) pilot tests. The objective of the tests was to determine the feasibility and potential of SVE for removing contaminants from the unsaturated (vadoze) zone. As approved by the NJDEP, Geraghty & Miller will present and discuss the results of the SVE pilot tests at a later date in the cleanup plan.

Well Search

As part of the preparation of the Revised Plan, Geraghty & Miller conducted a well search within a 0.5-mile radius of the Kalama facility. Geraghty & Miller obtained information from the NJDEP Bureau of Water Allocation, Bergen County and the City of Garfield. The findings of the well search are included in Appendix B of the Revised Plan and are summarized and discussed in a subsequent section of this report entitled "Site Conditions."

VARIANCES

Between January and July 1991, Geraghty & Miller executed the tasks presented in the Revised Plan. There were variances to the required scope of work. A discussion of the variances is presented in Appendix A.

LABORATORY DATA ASSESSMENT

Geraghty & Miller assessed the Revised ECRA Sampling Plan Investigation laboratory analytical data generated by ERI. The analytical data include the results of soil and ground-water chemical analyses. The results of the assessment are presented in Appendix B.

FINDINGS AND DISCUSSION

SITE CONDITIONS

Surface Conditions

The Kalama facility is located in the City of Garfield, Bergen County, New Jersey (Figures 1 and 2). The property owned by Kalama consists of two lots. One lot, Block 50.01 Lot 1, is approximately 500 feet by 560 feet (6.4 acres) and is occupied by manufacturing facilities. That lot is referred to as the site, facility, or plant. Most of the investigative work has been conducted within the facility boundary.

The second lot, Block 50.02 Lot 1, is approximately 40 feet by 560 feet (0.5 acres) and is the location of the river-water pump house and employee parking. River water is pumped to the facility and used for non-contact cooling. River Drive, which trends north-south, divides the two lots.

The Passaic River, the primary regional surface-water body, is located 100 feet west of the facility. The Passaic River is tidal, flows by the facility in a north to south direction, and is the receptor for the local ground-water and storm-water discharge. Mixed commercial and residential areas surround the facility on its other three sides.

Most of the facility is covered by buildings and pavement. Buildings occupy approximately 50 percent of the facility; paved areas (primarily asphalt) cover an estimated 25 percent of the facility. The remaining 25 percent of the surface is unpaved. As part of the plant operations, tank trucks, tractor trailers, and rail cars move around the facility regularly.

An asbestos inspection has not been conducted. Therefore, Geraghty & Miller proposes to conduct an asbestos inspection as part of the work presented in the "Sampling

Plan Addendum No. 2." The objective of the inspection will be to identify the location, form and quantity of asbestos containing material.

Subsurface Conditions

An extensive network of pipes and structures (both active and inactive) is present beneath the site surface. Those pipes and structures have not yet been investigated completely. Therefore, Geraghty & Miller proposes to conduct a comprehensive underground utility survey. The objective of the survey will be to evaluate the impact of pipes and structures on ground-water flow and contaminant migration. Details of the proposed underground utility survey are provided in the "Sampling Plan Addendum No. 2", which is submitted under separate cover.

In July 1991, Geraghty & Miller conducted a preliminary underground utility survey. The survey consisted of reviewing maps on file with Kalama and discussing the information on the maps with Kalama personnel. A summary of the preliminary underground utility survey is presented below.

The network of pipes beneath the site surface can be classified into the following categories:

- Intake lines that carry cooling water from the Passaic River to the facility.
- Outfalls that carry cooling water and storm water from the facility to the Passaic River.
- Sewerage lines that connect to the Passaic Valley Sewerage Commissioners (PVSC) system.
- Potable water lines that supply the facility with water from the Passaic Valley Water Company (PVWC) and the City of Garfield.

There are three active 12-inch or 18-inch diameter river intake lines that cross the facility boundaries. River water is pumped (via the pump house) from the Passaic River to the intake lines and is utilized as non-contact cooling water. After use, it is discharged to the river via the two outfalls described below. The active lines cross the northwestern and southern facility boundaries. There is one inactive river intake line which is 8 inches in diameter and crosses the western facility boundary.

There are a total of four outfalls that connect with the Passaic River, two of which are inactive. The two active outfalls are regulated under Kalama's NPDES permit. Those outfalls carry non-contact cooling water and some storm water (via catch basins) from the facility, under River Drive, to the Passaic River. Both active outfalls cross the western facility boundary. One of the active outfalls, designated as 001, is aligned along the northern facility boundary. It is 18 inches in diameter and crosses the facility boundary at its northwest corner. The other active outfall, designated as 002, is 24 inches in diameter and crosses the western facility boundary approximately 20 feet north of Building 34.

There is an inactive 10-inch diameter outfall that crosses the western facility boundary approximately 40 feet north of Outfall 002. That outfall was connected to the boiler room of former Building 2 and was deactivated in 1974. There is also an inactive 15-inch diameter outfall that crosses the facility boundary at its southwestern corner. That outfall has been inactive since 1969.

There is one 12-inch diameter sewerage line that carries sanitary waste, process waste and some storm water (via catch basins). That 12-inch line crosses the western facility boundary adjacent to Outfall 002 described above. The effluent in that sewerage line is monitored in accordance with the PVSC sewer connection permit.

There are seven other sewerage lines that cross the facility boundaries. Those lines are 4-inch or 6-inch in diameter. Five are active lines that carry sanitary waste only. Two active lines cross the eastern facility boundary. Two inactive sewerage lines cross the western facility boundary.

There are five potable water lines that cross the facility boundaries. Two of those lines cross the northern boundary and one line crosses each of the other boundaries. All five lines are active and are either 8 inches or 12 inches in diameter.

The underground structures beneath the site surface can be classified into the following categories:

- Basements.
- Elevator shafts.
- Pipe tunnels.
- Catch basins.
- Sumps.

None of the underground structures extends across the facility boundary.

Buildings 17, 32, 32-A/32-B, 33/33-A/33-B, 34, and 36 have basements. Some of the basements are flooded and may extend below the water-table. The basement of Building 32-A/32-B is intermittently flooded with water which Kalama sampled and analyzed. The analytical results indicate that the water contains concentrations of toluene up to approximately 130,000 micrograms per liter (ug/L).

Buildings 10-B, 12, 30, 31, 32-B, and 36 have elevator shafts. Some elevator shafts extend below the water table. Elevator shafts in Buildings 32-B, 33 and 36 are flooded. Flooded basements and elevator shafts will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

The other underground structures include the following:

- o Pipe tunnel system located in the north-central and eastern sections of the facility.
- o Catch basins connected to both the outfalls and sewerage lines described above.
- o Sumps located in several facility buildings.

The pipe tunnel system, catch basins, and sumps will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

Aerial Photograph Study

Geraghty & Miller evaluated historical aerial photographs from 1947, 1973, and 1982, and confirmed certain information on the photographs by site reconnaissance and comparison to a 1973 site plan. The aerial photographs indicate that the present plant layout differs slightly from that recorded on the 1947 photograph in that three (unnumbered) buildings located along the southern-central facility boundary, adjacent to Monitoring Well MW-10, are no longer present. Buildings 2 and 3, formerly located adjacent to River Drive, were demolished in 1990 and 1988, respectively. Building 37, formerly located in the southeastern section of the facility, was demolished in 1990. Building 38, formerly located in the northwestern section of the facility, was demolished in 1988. The benzoic acid/benzaldehyde production facility was dismantled in 1984.

The aerial photograph taken in 1973 shows a mottled area near Building 12. Soil borings B-10, B-44, and B-46 were drilled during the Revised ECRA Sampling Plan Investigation in or near the mottled area. An area containing approximately 100 drums is evident to the south and west of Building 23. The drums appear to be upright and orderly.

Soil borings B-13, B-14, B-15, B-16, B-17, B-26, B-27 and S-8, and Monitoring Well MW-4 were drilled/installed in that area.

The 1982 aerial photograph, shows an estimated 100 to 150 drums on the ground in the area east of Building 16. Soil borings B-28, B-29, and B-30 were drilled within 50 feet of that area; Monitoring Well MW-1 is located within 15 feet of that area. Approximately 100 drums are evident south of Building 23. A cluster of approximately 25 drums is evident on the ground south of Building 8.

The presence of drums, as documented in the aerial photographs, is consistent with facility operations. Those operations include the storage of raw material and the packaging of finished product in drums. Drums were routinely moved about the facility to accommodate daily activities. The aerial photographs do not indicate any excavation or landfilling activities.

To summarize, our evaluation of historical aerial photographs and current site conditions indicates that, with the exception of seven buildings and the benzoic acid/benzaldehyde production facility that no longer exist, the site surface conditions have changed little over the past 44 years. The information obtained from the aerial-photograph study does not indicate any areas of concern that are not covered by soil borings and/or monitoring wells.

Well Search

Twenty-three wells were identified within a 0.5-mile radius of the site (Table 7). The wells are classified as follows: seven monitoring wells (MW), one test well (TW), five industrial supply wells (ISW), one private well (PW), one product recovery well (PRW), three industrial recharge wells (IRW), one public supply well (PSW), and four wells which have not been type-classified. The locations of the wells are shown on Figure 3.

Of the seven monitoring wells identified, six are owned by E.C. Electroplating and are located at the northeast periphery of the 0.5-mile radius of the site. Those six wells range in depth from 17 feet to 20 feet and are screened in the unconsolidated deposits. The remaining monitoring well, which is 20 feet deep, and three other not type-classified wells, are owned by Dundee Water Power and Land Company and are located west of the Passaic River.

The test well, owned by the Borough of Wallington, is located south of the site near the convergence of the Passaic River and Saddle River. That well is located at the edge of the 0.5-mile radius and is a 400-foot deep bedrock well.

The five industrial supply wells are located outside of the 0.25-mile radius of the site. Two wells are located northeast of the site; the other three wells are west of the Passaic River. All five wells tap the bedrock aquifer and range in depth from 275 feet to 505 feet.

The three industrial recharge wells are located adjacent to the test well owned by the Borough of Wallington. Those wells are bedrock wells that range in depth from 392 feet to 397 feet.

One private well, which is a 130-foot deep bedrock well, is located approximately 0.25-mile east of the site. That well supplies a sprinkling system. The public supply well, which is operated by the City of Garfield, is located approximately 0.3-mile southeast of the site and is a 400-foot deep bedrock well.

The remaining two wells are near each other and are located approximately 0.1 mile from the site in a due north direction. One well, which is 17 feet deep, is a product recovery well owned by the NJDEP. The other well, which has not been type-classified, is a 276-foot deep bedrock well owned by the City of Garfield.

According to Kalama several industrial supply well were formerly operated at the facility. The number, locations, and depths of the wells presently is not known.

To summarize, the well search indicates that there are no private or public supply wells within a 0.25-mile radius from the Kalama site. However, there is uncertainty regarding the type, depth, location, and status of some of the wells identified in the well search, and former on-site industrial supply wells. Additional well search activities are necessary to address this uncertainty and to assess possible off-site sources of contaminants. The additional proposed well search activities are described in the "Sampling Plan Addendum No. 2" which is submitted under separate cover.

REGIONAL GEOLOGY AND HYDROGEOLOGY

Regional Geology

The facility is located in the Piedmont Lowland Physiographic Province. Bedrock within this Province consists of sedimentary and igneous formations of the Triassic and Jurassic Periods. Unconsolidated glacial and fluvial deposits of the Pleistocene and Recent Epochs cover the bedrock in most areas of the Province, especially in lowland areas.

Bedrock underlying the Kalama facility belongs to the sedimentary Brunswick Formation, which is composed primarily of reddish-brown sandstones and shale beds that dip generally 10 degrees to 15 degrees to the northwest. Within the site, approximately 30 feet of unconsolidated deposits overlie the bedrock. The top several feet of the Brunswick Formation are usually weathered and consist of rock fragments embedded in a matrix of clay, silt, and/or sand derived from the bedrock.

Regional Hydrogeology

Regionally, there are two aquifers: the overburden aquifer in the unconsolidated deposits and the bedrock aquifer in the Brunswick Formation. Ground water in the overburden aquifer generally flows to local and regional discharge points, such as the Passaic River. Ground water in the bedrock aquifer occurs in fractures, such as bedding planes, and flows through the fractures to local and regional points of discharge.

SITE GEOLOGY AND HYDROGEOLOGY

Beneath the facility is a complex sequence of unconsolidated deposits, consisting primarily of sand with discontinuous layers of silt and clay, and fill. Fill is present immediately beneath the facility. Generally, the thickness of fill material is approximately 3 feet to 8 feet. Typically, the fill consists of a mixture of sand, gravel, crushed stone, and brick fragments. At some locations, ground water occurs in the fill. The fill is underlain by natural deposits consisting of sand with discontinuous silt and clay layers. The unconsolidated deposits are approximately 25 feet to 35 feet in thickness. Generally, ground water in the unconsolidated deposits occurs about 7 feet to 10 feet bgs. The depth to the water table increases towards the Passaic River.

The silt and clay layers constitute an appreciable component of the unconsolidated deposits. Where saturated, the unconsolidated deposits underlying the facility (including fill) contain one water-bearing zone. However, because of the variation in lithology of the unconsolidated deposits, the water-bearing zone is nonhomogeneous and therefore its hydraulic characteristics will vary significantly both horizontally and vertically across the site.

Evidence of the presence of weathered bedrock was encountered in monitoring-well borehole MW-5D at a depth of about 35 feet bgs, and in monitoring-well boreholes MW-3D and MW-6D at a depth of 36 feet and 30 feet bgs, respectively. The borings logs for several wells identified in the 0.5-mile radius well search indicate a depth to bedrock that ranges from 20 feet to 30 feet. Soil-boring and monitoring-well borehole details are presented in Table 8. Soil-boring and monitoring-well borehole logs are presented in Appendix C. The locations of geologic cross sections are shown on Figure 4. Geologic cross sections are presented on Figures 5, 6 and 7.

Ground-Water Elevations and Shallow Flow Direction

Monitoring well construction details are presented in Table 9 and Appendix C. Monitoring well Forms A and B are included in Appendix D.

Ground-water elevations measured during the ECRA Sampling Plan Investigation are similar to those measured during the Revised ECRA Sampling Plan Investigation. The ground-water levels recorded during the Revised ECRA Sampling Plan Investigation are discussed in this report and summarized in Table 10 and on Figure 8.

The ground-surface elevation at the site is relatively flat and its elevation ranges from approximately 16 feet mean sea level (msl) to 19 feet msl. Ground water occurs under most of the facility from 7 feet to 10 feet bgs. However, in the southeastern section of the facility in the vicinity of Monitoring Well MW-4, anomalously high ground-water levels were observed: the depth to water generally was 3 feet to 4 feet higher than the levels observed in near by monitoring wells. This condition is referred to as an apparent water-table mound.

During the period of record from April 10, 1991 through June 17, 1991, ground-water elevations in the shallow monitoring wells ranged from a high of 14.1 feet msl in Monitoring Well MW-5 to a low of 6.9 feet msl in Monitoring Well MW-6. Elevations observed in Monitoring Well MW-15 located near the Passaic River, ranged from 2.2 feet msl to 4.4 feet msl during the period of record. However, because Monitoring Well MW-15 is affected by tidal fluctuations in the Passaic River, the ground-water elevations in Monitoring Well MW-15 are not discussed further in this section. For the deep monitoring wells, the ground-water elevations ranged from a high of 11.5 feet msl in Monitoring Well MW-5D to a low of 6.4 feet msl in Monitoring Well MW-6D.

For clustered Monitoring Wells MW-3/MW-3D and MW-6/MW-6D, the ground-water elevations in the deeper monitoring well were consistently lower than those in the adjacent shallow monitoring well. The magnitude of the difference for Monitoring Wells MW-3/MW-3D ranged from 3.0 feet to 3.7 feet. The magnitude of the difference for Monitoring Wells MW-6/MW-6D ranged from 0.1 foot to 0.6 foot. These differences indicate the potential for a downward component of the ground-water flow under portions of the facility. The vertical gradient observed at the location of Monitoring Well MW-3/MW-3D probably is due to the presence of a 12-foot thick clay layer between the screens of the two monitoring wells. The borehole log for Monitoring Well MW-6 does not indicate the presence of a clay layer or other low permeability layer that would account for the observed vertical gradients. Tidal fluctuations of up to 0.7 foot were measured in Monitoring Well MW-6D. Those fluctuations may have caused the observed slight downward vertical gradient.

During eight of the ten water-level measurement events, the ground-water elevations in deep Monitoring Well MW-5D were higher than those in the adjacent shallow Monitoring Well MW-5. The magnitude of the differences ranged from 0.3 feet to 0.4 feet. On two occasions, the ground-water elevations in Monitoring Well MW-5 were higher than those in Monitoring Well MW-5D. The magnitude of the difference was 2.6 feet. The apparent change in the magnitude and direction resulted from an anomalous 3-foot rise in the ground-water elevations measured in Monitoring Well MW-5.

The lack of a correlative response in any of the adjacent wells and deep monitoring well MW-5D with the response observed in Monitoring Well MW-5 indicates that the change in ground-water elevation is a localized "point phenomenon".

Geraghty & Miller proposes to investigate further the anomalous ground-water elevations in accordance with the "Sampling Plan Addendum No. 2" which is submitted under separate cover.

Water-table contours are shown on Figures 9 and 10. The contours indicate a general westerly/southwesterly direction of ground-water flow across the site toward the Passaic River. They also indicate a local southwesterly component of ground-water flow in the northern section of the site towards the middle of the site. The inferred direction of ground-water flow may be biased due to the lack of monitoring wells in the northern section of the facility. If such a flow component is accurate, it would indicate a potential ground-water draining effect occurring in the middle of the site area. There are two potential conditions that could cause a ground-water draining effect in that area:

- A higher permeability soil zone that trends east-west.
- High-permeability backfill material around a pipe that extends across the western boundary of the site.

As discussed in a previous section entitled "Site Conditions", there are pipes that extend across the western facility boundary. Their depths relative to the water table and whether they have high-permeability backfill material around them is not presently known. The soil permeability across the site varies significantly, but, Geraghty & Miller's investigations have not identified any zones of consistently higher soil permeability. Therefore, existence of such a zone although possible, is not likely. In the "Sampling Plan Addendum No. 2" which is submitted under separate cover, Geraghty & Miller proposes to investigate further the apparent southwesterly flow component by measuring water levels in existing and proposed monitoring wells and by conducting an underground utility survey.

Anomalously high ground-water elevations measured in the southeastern section of the facility indicate an apparent water-table mound in the vicinity of Monitoring Well MW-4. In June 1991, Geraghty & Miller installed a piezometer cluster: PZ-4S (a shallow piezometer screened above the clay layer occurring at 8.5 to 11 feet bgs) and PZ-4D (a deeper piezometer screened below the clay layer). The piezometers were developed, but not surveyed. The preliminary measurements indicate that the water level in the shallow piezometer is approximately 4 feet higher than that in the deeper piezometer. Based on the preliminary water-level measurements, the apparent water-table mound in the vicinity of Monitoring Well MW-4 could be a water body that is locally perched by the underlying clay layer. In the "Sampling Plan Addendum No. 2," Geraghty & Miller proposes to resolve the water-table mound issue by comparing ground-water levels and ground-water quality in Monitoring Well MW-4, and piezometers PZ-4S and PZ-4D, and other monitoring wells. Anomalously high ground-water elevations were observed in Monitoring Wells MW-7, MW-9, and MW-17. They may also be due to local perched conditions.

The source of the apparent water-table mound in the vicinity of Monitoring Well MW-4 remains unknown. The persistent nature of the observed condition indicates that it may be caused by a leaking pipe or pipes, including exfiltration from catch basins. Precipitation in combination with preferential surface runoff and/or ponding in the vicinity of the monitoring wells may also be responsible for the apparent water-table mound. It is possible that the apparently subdued water-table mounding observed in the vicinity of Monitoring Wells MW-7, MW-9, and MW-17 are independent from MW-4 and each other, and therefore, are caused by different sources.

The extent, if any, to which the anomalous ground-water conditions observed in the southeastern section of the facility impacts contaminant migration will be investigated further as part of the work proposed in the "Sampling Plan Addendum No. 2."

Soil Permeability

The horizontal hydraulic conductivities of the soils underlying the facility were evaluated based on the slug-test results. The hydraulic conductivities data calculated from slug test data are summarized in Table 11. The slug-test data plots are included in Appendix E.

The slug test results indicate that the hydraulic conductivity of the soils varies from 0.3 feet/day (1.2 x 10^{-4} cm/sec) to 13 feet/day (4.6 x 10^{-3} cm/sec) with an average of 3 feet/day (1.1 x 10^{-3} cm/sec). These values are typical for silty and clayey sand, which comprise a significant portion of the soils at the site. Locally more coarse and/or less silty or clayey sand could exhibit higher hydraulic conductivities.

The pumping-test results indicate that the water-bearing zone yields variable and relatively low volumes of water to wells: 0.5 gallon per minute (gpm) at Monitoring Well MW-3D and 3 gpm at Monitoring Well MW-10. Because Monitoring Well MW-10 was pumped at a drawdown of approximately 3 feet out of an available 10 feet, the maximum available yield of Monitoring Well MW-10 can be assumed to be greater than 3 gpm, probably between 5 gpm and 8 gpm.

The results of the pumping tests are inconclusive, primarily because the water-bearing zone was not stressed sufficiently and the distances to the observation wells were too great. Those conditions resulted in very small (less than 0.1 foot) drawdown in most of the observation wells or no observed drawdown. The drawdown values, if used, would result in unrealistically high transmissivity values. Consequently, the pumping tests data were not used to evaluate the transmissivity and storativity of the water-bearing zone. In the "Sampling Plan Addendum No. 2," Geraghty & Miller proposes to conduct a second pumping test in Monitoring Well MW-10 under improved conditions, which would include running a 6-hour test while pumping at a higher rate, and measuring the drawdown in two additional piezometers (observation wells) to be installed 10 feet and 30 feet from Monitoring Well MW-10.

To summarize, based on the presently available data, the horizontal hydraulic conductivity of the soils across the facility is estimated to range from 0.3 feet/day to 13 feet/day. The actual hydraulic conductivities of soils may vary significantly across the site.

Flow Gradient and Ground-Water Velocity

As discussed above, the hydraulic conductivities based on the slug test data ranged from a minimum of 0.3 feet/day (1.2×10^{-4} cm/sec) to a maximum of 13 feet/day (4.6×10^{-3} cm/sec). These hydraulic conductivities are consistent with the grain size and density of the unconsolidated materials underlying facility.

The overall ground-water flow gradient across the site is approximately 0.01. This gradient does not consider the apparent water-table mound observed in the southeastern section of the site. The gradient may vary significantly across the site.

Geraghty & Miller did not estimate the ground-water flow velocity because of high inhomogeneity of the unconsolidated deposits, the potential presence of preferential pathways and tidal influences. Those conditions tend to render the ground-water flow velocities unreliable for predicting time of travel. In addition, ground-water flow velocities often are not indicative of the rate of contaminant migration. Physicochemical interactions among the aquifer matrix, the ground water, and the contaminants tend to retard the rate of contaminant migration.

SOIL QUALITY

The results of the UST post-excavation and soil boring sampling and analysis programs are discussed in this section. The laboratory analytical results for various parameters are evaluated by comparing them to the NJDEP-ECRA guidance levels. Those levels are specified below:

Parameter	Guidance Level milligram per kilogram (mg/kg)
Total Volatile Organic Compounds (VOCs)	1
Total Base Neutral Organic Compounds (BNs)	10
Total Acid Extractable Organic Compounds (AEs)	10
Total Petroleum Hydrocarbons (PHCs)	100
Total Polycyclic Aromatic Hydrocarbons (PAHs)	10
Total Polychlorinated Biphenyls (PCBs)	5
Toluene	1
Methanol	100
Hexene	1
Benzene	1

The guidance levels for toluene, methanol and hexene were provided in the NJDEP approval letter. As part of the evaluation, the presence, concentration, and distribution of individual constituents and groups of constituents are assessed to identify potential source areas and/or patterns, and the extent of contamination. The use of NJDEP-ECRA guidance levels does not imply cleanup criteria for the facility. Instead, the levels are used to help identify and delineate areas and/or conditions of concern.

Post-Excavation Sampling and Analysis Program

A summary of constituents detected in the UST post-excavation soil samples is presented in Table 12. Those constituents that exceed the NJDEP-ECRA guidance levels are plotted on Figure 11. For this discussion, the constituent concentrations have been rounded to the nearest whole number.

Eleven USTs (A-27, A-24, E-13, A-14, A-15, A-16, A-17, A-18, A-21, A-20 and A-19) that formerly contained methanol were removed during the period of October 1987 through

February 1989. Three to five post-excavation soil samples were collected from around each former tank and analyzed for methanol. One of the four soil samples collected from the excavation around former tank E-13 exhibited a concentration of methanol that slightly exceeds the NJDEP-ECRA guidance level of 100 mg/kg. The detected concentration is 116 mg/kg. Similarly, one of the three soil samples collected from the excavation around former Tank A-14 exhibited a concentration of methanol (122 mg/kg) that slightly exceeds the NJDEP-ECRA guidance level (100 mg/kg). None of the other 38 post-excavation soil samples associated with the former methanol tanks exceeded the NJDEP-ECRA guidance level of 100 mg/kg.

Four USTs (A-9, A-10, A-11, and A-12) that formerly contained toluene were removed in October 1987. Three to five post-excavation soil samples were collected and analyzed for toluene. All soil samples collected from the excavations around former tanks A-10, A-11 and A-12 exhibited concentrations of toluene that exceed the NJDEP-ECRA guidance level of 1 mg/kg. The detected concentrations for soil samples associated with former tank A-10 ranged from 261 mg/kg to 342 mg/kg. The detected concentrations for soil samples associated with former tank A-11 ranged from 73 mg/kg to 130 mg/kg. The detected concentrations for soil samples associated with former tank A-12 ranged from 3 mg/kg to 594 mg/kg. Three of the five soil samples associated with tank A-9 exhibited concentrations of toluene that exceed the NJDEP-ECRA guidance level of 1 mg/kg. The concentrations in those three soil samples ranged from 27 mg/kg to 805 mg/kg.

Nine USTs (A-25, C-3, A-4, C-2, E-1, E-5, E-6, A-7, and E-8) that formerly contained fuel oil were removed. Tanks A-25, C-3, A-4, C-2, and E-1 contained No. 2 fuel oil and were removed during the period of September through November 1987. Tanks E-5, E-6, A-7, and E-8 contained No. 6 fuel oil and were removed in February 1990. Four to eight post-excavation soil samples were collected from around each former tank, including the excavated material, and analyzed for total PHCs. With the exception of soil samples associated with former tank A-25, at least two soil samples associated with each of the tanks exhibited concentrations of total PHCs that exceed the NJDEP-ECRA guidance level of 100 mg/kg. The concentrations detected in soil samples associated with the eight tanks that exceed the NJDEP-ECRA guidance level ranged from 116 mg/kg to 24,000 mg/kg. Notable concentrations (i.e., above 10,000 mg/kg) were reported for soil samples associated with former underground storage tanks E-1 and A-7. Soil samples associated with former underground storage tank A-25 did not exhibit concentrations of total PHCs above the NJDEP-ECRA guidance level.

One underground storage tank (A-26) that formerly contained gasoline and one underground storage tank (A-22) that formerly contained methyl isobutyl ketone (MIBK) were removed in October 1987 and January 1989, respectively. Of the four post-excavation soil samples associated with former tank A-26 and analyzed for total PHCs, three soil samples exhibited concentrations that exceed the NJDEP-ECRA guidance level of 100 mg/kg. Those three soil samples exhibited total PHC concentrations of 419 mg/kg, 489 mg/kg, and 1,250 mg/kg. None of the five post-excavation soil samples associated with former tank A-22 exhibited concentrations of MIBK that exceed the NJDEP-ECRA guidance level of 1 mg/kg.

One underground storage tank (A-23) that formerly contained hexene was removed in October 1988. Four post-excavation soil samples were collected and submitted for laboratory analysis of hexene. However, the laboratory misplaced the soil samples and therefore did not perform the analyses. Soil borings were drilled during the Revised ECRA Sampling Plan Investigation to obtain samples from around the former hexene UST. Hexene was not detected in those samples.

The results of the post-excavation soil sampling and analysis program indicate the following:

- For the 11 methanol tanks, 37 out of 39 soil samples exhibited methanol concentrations below the NJDEP-ECRA guidance level. Two samples exhibited methanol concentrations (122 mg/kg and 116 mg/kg) that exceed slightly the NJDEP-ECRA guidance level of 100 mg/kg. The locations of the former methanol USTs are not areas of concern.

- The location of the former toluene USTs is an area of concern. The former toluene USTs appear to have been a source of soil and ground-water contamination.

- With the exception of the location of former UST A-25, and the possible exception of the location of former UST C-3, the locations of the former fuel oil USTs are areas of concern. The former fuel oil USTs appear to have been a source of soil and ground-water contamination.

- The location of the former gasoline UST, A-26, is an area of concern. The former gasoline UST appears to have been a source of soil and ground-water contamination.

- The locations of the former MIBK and hexene USTs are not areas of concern.

- The UST excavations were partially backfilled with the excavated soils. Soil contamination associated with the former toluene, fuel oil and gasoline USTs will be addressed in the cleanup plan.

The UST removal program was completed before the start of the Revised ECRA Sampling Plan Investigation. The results of the UST removal program were used to guide the selection of the soil boring and monitoring well locations proposed for the Revised ECRA Sampling Plan Investigation and the selection of analytical parameters. The results for soil borings drilled during the Preliminary Investigation and ECRA Sampling Plan Investigation were also used for that purpose.

The results of the post-excavation soil sampling were submitted to the NJDEP in the Revised Plan. Based on those results, the NJDEP requested that the UST-related soil contamination be further delineated as part of the soil boring sampling and analysis program.

Soil Boring Sampling and Analysis Program

Summaries of the constituents detected in soil samples from soil borings are presented in Tables 13 through 23. Those tables summarize the soil quality data from the Preliminary Investigation (Tables 13 through 15), the ECRA Sampling Plan Investigation (Tables 16 through 18), and the Revised ECRA Sampling Plan Investigation (Tables 19 through 23). The analytical data reports for the Revised Sampling Plan Investigation (prepared by ERI) are submitted with this report under separate cover. The analytical data reports for the Preliminary Investigation and ECRA Sampling Plan Investigation were submitted previously to the NJDEP.

The soil-quality constituents that exceed the NJDEP-ECRA guidance levels are plotted on Figure 12. The totals of the tentatively identified (TID) compounds for VOCs, BNs and AEs that exceed 1 mg/kg, 10 mg/kg, and 10 mg/kg, respectively, are plotted on Figure 12. Other constituents that were detected but do not have an NJDEP-ECRA guidance level are also plotted on Figure 12.

This discussion is based primarily on the results shown on Figure 12. To facilitate this discussion of the soil boring sampling and analysis program, the following conventions have been adopted:

- o Individual constituents and groups of constituents that exceed NJDEP-ECRA guidance levels are presented and discussed.

- Individual constituents within these groups (e.g., VOCs) that exceed an NJDEP-ECRA guidance level are also presented and selectively discussed.

- PAHs comprised most of the constituents under the BN group. The total PAHs are presented when the total BN group exceeds the NJDEP-ECRA guidance level.

- Phenol comprises all of the AE group when that group exceeds the NJDEP-ECRA guidance level and is presented and discussed.

- Total TID VOCs, total TID BNs, and total TID base/neutral and acid extractable organic compounds (BNAs) are presented only when they exceed 1 mg/kg, 10 mg/kg, and 10 mg/kg, respectively.

- Total phenolics data are presented for each sample that showed detectable concentrations.

- For field duplicate samples, the higher concentration values are presented.

- The "J" qualified concentration values (i.e., estimated values which are less than the detection limit) are included in the sum of a group of compounds and are presented in this text without the qualifier.

- The reported concentrations of chemical constituents are rounded to the nearest 0.1 mg/kg.

Four soil borings, B-18, B-19, B-20, and B-21, were drilled around the location of former soil boring S-7 to further delineate the VOCs and total PHCs detected in the sample collected from that former soil boring during the ECRA Sampling Plan Investigation. A sample was not taken from soil boring B-21 because of poor material recovery and because the nature of the recovered material was not suitable for analysis. One of the two samples collected from soil boring B-20 exhibited concentrations of toluene (230 mg/kg) that exceed the NJDEP-ECRA guidance level of 1 mg/kg. The sample from soil boring B-18 exhibited concentrations of toluene (890 mg/kg) and total PHCs (206 mg/kg) that exceed the NJDEP-ECRA guidance levels of 1 mg/kg and 100 mg/kg, respectively.

Six soil borings, B-6, B-7, B-8, B-9, B-26, and B-27, were drilled in the vicinity of former soil borings S-2 and B-4 (1986) to further delineate the VOCs and total PHCs detected in samples from those former soil borings. Soil borings B-6, B-7, B-8, and B-9 were also drilled to further delineate the total phenolics and BNs detected in the sample from former soil boring S-2. Toluene was detected in each of the samples from soil borings B-6 and B-8 at a concentration of 360 mg/kg and in the samples from soil boring B-7 and B-9 at concentrations of 17 mg/kg and 2.4 mg/kg, respectively. Each of these detected concentrations of toluene exceeds the NJDEP-ECRA guidance level of 1 mg/kg. Total PAHs were detected in the sample from soil boring B-6 at a concentration of 12.5 mg/kg. Total PHCs in samples from soil borings B-6 (547 mg/kg), B-8 (576 mg/kg) and B-9 (153 mg/kg) exceed the NJDEP-ECRA guidance level of 100 mg/kg. Total phenolics were detected in the samples from soil boring B-7 (5.6 mg/kg), B-8 (40 mg/kg), and B-9 (7.4 mg/kg). The total phenolics detected in the sample from former soil boring S-2 was 200 mg/kg.

Toluene and benzene were detected in the sample from soil boring B-26 at concentrations of 20,000 mg/kg and 80 mg/kg, respectively, which exceed the NJDEP-ECRA guidance levels of 1 mg/kg for both constituents. Total PHCs (4,430 mg/kg) and total PAHs (71.3 mg/kg) in the sample from soil boring B-26 exceed the NJDEP-ECRA guidance levels of 100 mg/kg and 10 mg/kg, respectively. Toluene was detected in the sample from soil boring B-27 at a concentration of 160 mg/kg.

Soil borings B-13, B-14, B-15, B-16, B-17, and B-22 were drilled to delineate further the VOCs and total PHCs detected at the location of former soil boring S-8 and to investigate further the soil quality in the vicinity of the former gasoline UST, A-26. Specifically, soil boring B-14 was drilled to "resample" a location formerly sampled (A-26-C) during the post- excavation soil sampling event. Soil sample A-26-C exhibited a total PHC concentration of 1,250 mg/kg. Samples from soil borings B-13, (3,400 mg/kg), B-14 (620 mg/kg) and B-16 (12 mg/kg) exhibited concentrations of toluene that exceed the NJDEP-ECRA guidance level of 1 mg/kg. The sample from soil boring B-16 exhibited concentrations of less than 1 mg/kg for benzene, total xylene, and carbon tetrachloride. Trichlorofluoromethane was detected in the sample from soil boring B-16 at a concentration of 1.6 mg/kg. Total PHCs detected in the samples from soil borings B-13 (1,630 mg/kg) and B-14 (1,410 mg/kg) exceed the NJDEP-ECRA guidance level of 100 mg/kg. Because of poor material recovery during split-spoon sampling, a sample from soil boring B-17 was not collected.

As previously stated, the post-excavation soil samples were misplaced by the laboratory, therefore soil borings B-23, B-24, and B-25 were drilled to sample soils around the former hexene UST. Hexene was not detected in the soil boring samples. However, for one of the three soil boring samples the detection limit (2.5 mg/kg) was above the 1 mg/kg NJDEP-ECRA guidance level.

Soil borings B-28, B-29, and B-30 were drilled to investigate further the soil conditions around former fuel oil UST C-3. Specifically, soil boring B-29 was drilled to "resample" a location (C-3-A) previously sampled during the post-excavation soil sampling event. Soil sample C-3-A exhibited a total PHC concentration of 424 mg/kg. None of the samples from soil borings B-28, B-29 and B-30 exceeds the 100 mg/kg NJDEP-ECRA guidance level.

Soil boring B-42 was drilled to investigate the stained area east of Building 25. Total PAHs were detected at 19.6 mg/kg. The NJDEP-ECRA guidance level for PAHs is 10 mg/kg. Total PHCs were detected (207 mg/kg) above the NJDEP-ECRA guidance level of 100 mg/kg. PCBs were not detected. The PCB detection limit was 0.16 mg/kg.

Soil boring B-41 was drilled to investigate the transformer area south of Building 1. Concentrations of constituents were not detected above NJDEP-ECRA guidance levels. PCBs were not detected. The PCB detection limit was 0.16 mg/kg.

Soil borings B-1, B-2, B-3, B-4, and B-5 were drilled to investigate further the conditions in the vicinity of the former toluene USTs and former soil boring S-1. Toluene was detected in soil borings B-4 and B-3 at concentrations of 17,000 mg/kg and 2.4 mg/kg, respectively, which exceed the NJDEP-ECRA guidance level of 1 mg/kg. Total PHCs were detected in soil borings B-2 (148 mg/kg) and B-4 (4,670 mg/kg) above the NJDEP-ECRA guidance level of 100 mg/kg.

Soil borings B-44 and B-46 were drilled to investigate the area around the transformer located northeast of Building 12. Total PHCs were detected in the samples from B-44 (737 mg/kg) and B-46 (400 mg/kg) above the NJDEP-ECRA guidance level of 100 mg/kg. PCBs were not detected in the sample from soil boring B-46. PCB-1260 was detected in the samples from soil boring B-44 at concentrations of 0.47 mg/kg and 2.2 mg/kg in the original sample and field duplicate sample, respectively.

Soil borings B-10, B-11, B-12, and B-40 were drilled to investigate further the soil quality in the vicinity of former UST A-4. Specifically, soil boring B-40 was drilled to "resample" a location (A-4-A) formerly sampled during the post-excavation sampling event. Soil sample A-4-A exhibited a total PHC concentration of 3,410 mg/kg. Total PHCs detected in samples from soil borings B-10 (193 mg/kg) and B-40 (4,040 mg/kg) exceed the NJDEP-ECRA guidance level of 100 mg/kg.

Soil boring B-43 was drilled to investigate the soil quality adjacent to the steam cleaning pad. Soil boring B-45 was drilled to investigate the stained area adjacent to the loading dock at Building 36. Total PHCs were detected in the sample from soil boring B-43 (320 mg/kg) above the NJDEP-ECRA guidance level of 100 mg/kg. Constituents that exceed NJDEP-ECRA guidance levels were not detected in the samples from soil boring B-45.

Soil borings B-31, B-32, B-33, B-34, B-35, and B-39 were drilled to investigate further the soil quality around former fuel oil USTs E-5, E-6, E-8, and A-7. Total PHCs were detected in the samples from soil borings B-33 (1,820 mg/kg), B-34 (1,770 mg/kg), B-35 (1,550 mg/kg), and B-39 (672 mg/kg) at concentrations of which exceed the NJDEP-ECRA guidance level of 100 mg/kg. Total PAHs were detected in the samples from borings B-33 and B-44 at concentrations of 15.3 mg/kg and 11.1 mg/kg, respectively, which exceed the NJDEP-ECRA guidance level of 10 mg/kg.

Soil borings B-36 through B-39 were drilled to investigate further the soil conditions around the former methanol underground storage tanks. Methanol was not detected above the NJDEP-ECRA guidance level of 100 mg/kg.

Benzoic acid, benzaldehyde and formaldehyde were not detected in the soil samples analyzed for those constituents (Tables 2 and 3). The samples from soil borings B-43 and B-45 scheduled for pH analysis were analyzed 25 days after sample collection during which time the pH may have changed substantially. Therefore, the pH values are not presented. Benzoic acid, benzaldehyde, and formaldehyde in soil, and soil pH will be investigated further as part of the work proposed in the "Sampling Plan Addendum No. 2" which is submitted under separate cover.

TID VOCs were detected in samples from two ECRA Sampling Plan Investigation soil borings, S-9 (1.0 mg/kg) and S-10 (0.8 mg/kg). TID BNs were detected in all soil samples from the ECRA Sampling Plan Investigation at concentrations that ranged from 1,218 mg/kg to 1.4 mg/kg. TID VOCs were not detected in 2 of the 23 soil samples from the Revised ECRA Sampling Plan Investigation that were analyzed for those compounds at concentrations of 2.0 mg/kg and 0.3 mg/kg. TID BNs were detected at concentrations that ranged from 15,150 mg/kg to 0.2 mg/kg in the 16 soil samples from the Revised ECRA

Sampling Plan Investigation that were analyzed for those compounds. A summary of the TID compounds detected in soil samples from both the ECRA Sampling Plan Investigation and the Revised ECRA Sampling Plan Investigation is presented in Appendix F.

Geraghty & Miller proposes to conduct additional soil sampling and analyses, including TID analyses as part of the "Sampling Plan Addendum No. 2." The TID compounds detected during previous investigations will be evaluated together with the TID compounds that will be identified during the proposed sampling and analysis. The evaluation will define the classes of compounds and consider their effect on the potential remedial alternatives for the facility.

The results of the soil boring sampling and analysis program indicate the following:

- Constituents, including toluene, benzene, PAHs, and total PHCs exceed the NJDEP-ECRA guidance levels by a significant margin at several soil sampling locations.
    - Toluene was detected in soil at concentrations up to 20,000 mg/kg
    - Benzene was detected in soil at concentrations up to 80 mg/kg
    - Total PAHs were detected in soil at concentrations up to 71 mg/kg
    - Total PHCs were detected in soil at concentrations up to 4,670 mg/kg
- The southeastern section of the facility, which includes the location of the former toluene USTs and former production facilities that used toluene and benzene, is an area of concern because of the high concentrations of toluene, benzene, and PAHs. The major portion of this area of concern extends 250 feet south of the location of the former toluene USTs. Sources, other than the former USTs, such as spills and leaks, probably contributed to the toluene contamination in soil.

- Total PHCs were detected at high concentrations throughout the facility and are a constituent of concern in soil.

- PCBs and metals are not constituents of concern at the facility.

- Because of the high concentrations of certain constituents, some samples were diluted to facilitate laboratory analysis. Other constituents potentially present at may not have been detected due to sample dilution and associated elevated detection limits.

- Significant levels (up to 15,150 mg/kg) of TID compounds occur in soil.

- Additional soil sampling is proposed in the "Sampling Plan Addendum No. 2." The need for, and extent of, soil remediation will be addressed in the cleanup plan.

GROUND-WATER QUALITY

The results of all ECRA-related ground-water sampling at the facility are discussed in this section.

The laboratory analytical results are evaluated by comparing them to the NJDEP-ECRA guidance levels. Those levels are specified below:

Parameter	Guidance Level micrograms per liter (ug/L)
Total VOCs	10
Total BNs	50
Total AEs	50
Total PHCs	1,000

As part of the evaluation, the presence, concentration, and distribution of individual constituents and groups of constituents are assessed to delineate any potential plumes or other contamination patterns at the facility. The use of NJDEP-ECRA guidance levels does not imply cleanup criteria for the facility. Instead, the levels are used to help identify and delineate areas and/or conditions of concern.

Ground-Water Sampling and Analysis Program

Tables 24 through 30 summarize the ground-water quality data from both the ECRA Sampling Plan Investigation (Tables 24 through 26) and the Revised ECRA Sampling Plan Investigation (Tables 27 through 30). The monitoring well purging and sampling data for the Revised ECRA Sampling Plan Investigation are included in Appendix G. The analytical data reports for the Revised ECRA Sampling Plan Investigation (prepared by ERI) are submitted with this report under separate cover. The analytical data for the Preliminary Investigation and the ECRA Sampling Plan Investigation were submitted previously to the NJDEP.

A summary of the constituents detected in samples from monitoring wells, including total TID compounds, is presented on Figure 13. That figure is designed to facilitate a comparison of the two rounds of ground-water sampling and analysis data. Figures 14 and 15 present the detected concentrations of toluene and phenol in ground water, respectively.

This discussion is based primarily on the results shown on Figure 13. To facilitate this presentation and discussion of the ground-water analytical data, the following conventions have been adopted:

o The reported concentrations of chemical constituents are rounded to the nearest whole unit.

- The "J" qualified concentration values (i.e. estimated values which are less than the detection limit) are included in the sum of a group of compounds and are presented in this text without the qualifier.

- Because the total VOCs reported for each monitoring well sample exceed the NJDEP-ECRA guidance level of 10 ug/L, each VOC is presented and discussed.

- The total BNs for samples from Monitoring Wells MW-2 and MW-4 exceed the NJDEP-ECRA guidance level of 50 ug/L. The PAHs are the primary constituents that contribute to the total BNs when they exceed the guidance level. The BNs are presented and discussed as a group of compounds without reference to individual constituents.

- Phenol is the primary and often the only AE detected. In addition to the total AEs, the analytical results for phenol are presented and discussed.

- For field duplicate samples, the higher concentration values are presented.

The primary constituents of concern in ground water are toluene, phenol and benzene. The highest reported concentration of toluene is 110,000 ug/L detected in the sample from Monitoring Well MW-11. Samples from Monitoring Wells MW-4 and MW-17 contained 100,000 ug/L of toluene. Concentrations of toluene, 64,000 ug/L, 18,000 ug/L, 15,000 ug/L, 12,000 ug/L, and 5,640 ug/L were detected in samples from Monitoring Wells MW-14, MW-6, MW-5, MW-10, and MW-3, respectively.

Toluene was detected at 110 ug/L in one of the samples from Monitoring Well MW-1. Toluene was detected between 100 ug/L and 10 ug/L in the other sample from Monitoring Wells MW-1 and the sample from MW-9, and between 10 ug/L and 1 ug/L (inclusive) in samples from Monitoring Wells MW-2, MW-3D, MW-6D, MW-8, and MW-12.

Toluene was not detected in samples from Monitoring Wells MW-5D, MW-7, MW-15, MW-16, and MW-18.

The highest reported concentration of phenol is 930,000 ug/L, which was detected in the sample from Monitoring Well MW-3D. Samples from Monitoring Wells MW-3 and MW-6 contained 240,000 ug/L and 120,000 ug/L of phenol, respectively, and samples from Monitoring Wells MW-11 and MW-6D contained 54,000 ug/L and 15,000 ug/L, respectively. Phenol was detected at concentrations between 10,000 ug/L and 1,000 ug/L in samples from Monitoring Wells MW-4, MW-12, MW-13, and MW-17, and between 1,000 ug/L and 100 ug/L in Monitoring Wells MW-10 and MW-14. Phenol was detected at concentrations between 100 ug/L and 10 ug/L in samples from Monitoring Wells MW-1, MW-2, MW-5D, and MW-9, and at 10 ug/L or less in samples from Monitoring Wells MW-5 and MW-7. Phenol was not detected in samples from Monitoring Wells MW-8 and MW-16.

The highest reported concentration of benzene is 3,500 ug/L detected in Monitoring Well MW-4. Benzene was detected in the sample from Monitoring Well MW-14 at a concentration of 1,700 ug/L, and in the samples from Monitoring Wells MW-1, MW-9 and MW-10 at concentrations of 1,000 ug/L, 490 ug/L, and 140 ug/L, respectively. Benzene was detected in the samples from Monitoring Wells MW-7 and MW-8 at concentrations of 29 ug/L and 10 ug/L, respectively, and below 10 ug/L in samples from Monitoring Wells MW-2 and MW-6D. Benzene was not detected in samples from Monitoring Wells MW-3, MW-3D, MW-5, MW-5D, MW-6, MW-11, MW-13, MW-15, MW-16, MW-17, and MW-18.

Another constituent of concern is trichloroethene (TCE) which was detected at a maximum concentration of 2,700 ug/L in the sample from Monitoring Well MW-5D. TCE was detected at concentrations of 1,400 ug/L, 900 ug/L, 550 ug/L, and 260 ug/L in samples from Monitoring Wells MW-5, MW-9, MW-18, and MW-16, respectively, and in the sample from Monitoring Well MW-15 at a concentration of 18 ug/L. Trace concentrations, less than 10 ug/L, of trichloroethene were detected in samples from Monitoring Wells MW-3D and MW-6D. Trichloroethene was not detected in samples from Monitoring Wells MW-1,

MW-2, MW-3, MW-4, MW-6, MW-7, MW-8, MW-10, MW-11, MW-13, MW-14, and MW-17.

Trans-1,2-Dichloroethene (DCE) was detected in samples from Monitoring Wells MW-3D (24 ug/L), MW-6D (44 ug/L), MW-9 (32 ug/L), MW-12 (18 ug/L), MW-15 (19 ug/L), and MW-18 (49 ug/L). The reported concentration of DCE in the sample from Monitoring Well MW-16 is 2 ug/L.

Vinyl chloride was detected in samples from Monitoring Wells MW-3D (12 ug/L), MW-9 (20 ug/L), MW-12 (5 ug/L), and MW-18 (24 ug/L). Tetrachloroethene was detected in samples from Monitoring Wells MW-5D (26 ug/L), MW-9 (11 ug/L), MW-12 (9 ug/L), and MW-16 (5 ug/L).

1,1,1-Trichloroethane (TCA) was detected in samples from two monitoring wells MW-5D and MW-16, at concentrations of 80 ug/L and 17 ug/L, respectively. Chloroform was detected in samples from Monitoring Wells MW-8 (1 ug/L) and MW-16 (5 ug/L). 1,1-Dichloroethene was detected in Monitoring Well MW-16, at a concentration of 1 ug/L.

Ethylbenzene was detected in samples from Monitoring Wells MW-1 and MW-9 at concentrations of 15 ug/L and 32 ug/L, respectively. Total xylenes were detected in samples from Monitoring Well MW-1 and MW-9 at concentrations of 26 ug/L and 44 ug/L, respectively. Trace concentrations, less than 10 ug/L, of total xylenes were detected in samples from Monitoring Wells MW-6, MW-8, and MW-12.

Chlorobenzene was detected in samples from Monitoring Wells MW-2, MW-9, MW-12, and MW-18 at concentrations of 29 ug/L, 19 ug/L, 10 ug/L, and 35 ug/L, respectively. Trace concentrations, less than 10 ug/L, of chlorobenzene were reported for Monitoring Wells MW-1, MW-3D, MW-6D, and MW-8.

The water sample collected from soil boring B-4 during the Preliminary Investigation contained 5,400,000 ug/L of toluene, 68,000 ug/L of benzene, and 12,000 ug/L of methylene chloride. The LNAPL collected from Monitoring Well MW-7 contained 541,000 mg/kg (54 percent) of toluene and 408,900,000 ug/L (41 percent) of PHCs.

Chloride was detected in the sample from Monitoring Well MW-5 at a concentration of 130 milligram/liter (mg/L). Fecal coliform was not detected (0 colonies/100 milliliters) in that sample. Major ions detected in the sample from Monitoring Well MW-3 include sulfate (36,000 mg/L), sodium (4,130 mg/L), iron (2,280 mg/L), and chloride (763 mg/L). Total dissolved solids in that sample were detected at a concentration of 37,400 mg/L. Major and minor ions in ground water will be investigated further as part of the work proposed in the "Sampling Plan Addendum No. 2."

TID VOCs were detected in four samples from monitoring wells during the ECRA Sampling Plan Investigation at concentrations that ranged from 71 ug/L to 4.6 ug/L. TID VOCs were detected in samples from 11 monitoring wells during the Revised ECRA Sampling Plan Investigation at concentrations that ranged from 760 ug/L to 11 ug/L.

TID BNAs were detected in samples from all monitoring wells during the ECRA Sampling Plan Investigation at concentrations from 17,324 ug/L to 48 ug/L and in all but one monitoring well during the Revised ECRA Sampling Plan Investigation at concentrations that ranged from 599,785 ug/L to 53 ug/L. A summary of TID compounds detected in ground-water samples is presented in Appendix F.

An evaluation of the TID compounds detected in ground-water samples from previous investigations together with those that will be detected during the proposed sampling and analysis will be conducted as part of the work proposed in the "Sampling Plan Addendum No. 2." The evaluation will define the classes of compounds and consider their effect on the potential remedial alternatives for the facility.

The results of the ground-water sampling and analysis program indicate the following:

- o Toluene, phenol, benzene and TCE are constituents of concern in ground water.

- o Toluene is present in ground water throughout the facility. Toluene concentrations up to 110,000 ug/L were detected in ground-water samples from the southern half of the facility. The toluene area of concern for soil, appears to be a source for toluene in ground water. Other potential sources of toluene will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- o Phenol is present in ground-water throughout the facility. Phenol concentrations up to 930,000 ug/L were detected in samples from monitoring wells along the northern facility boundary. Concentrations of phenol up to 120,000 ug/L were detected in the southern half of the facility. The source(s) of phenol contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- o The areas of toluene and phenol contamination in ground water extend to, and probably cross, the northern, southern and western boundaries of the facility. Additional off-site and downgradient monitoring wells will be installed, as part of the work proposed in the "Sampling Plan Addendum No. 2."

- o Benzene is present in ground water in the southern half of the facility at a maximum concentration of 3,500 ug/L. The area of benzene contamination in groundwater extends to, and probably crosses, the southern and western facility boundaries. The source(s) of benzene contamination is presently not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- TCE and other chlorinated organic compounds are present in ground water at various locations across the facility. The maximum on-site concentration of TCE, 2,700 ug/L, was detected in a sample from a monitoring well located in the southeastern section of the facility. TCE was detected in the sample from an adjacent shallow monitoring well, at a concentration of 1,400 ug/L. TCE was detected in a sample from a monitoring well located in the central section of the facility at a concentration of 550 ug/L. Trace concentrations (less than 10 ug/L) of TCE were detected in ground-water samples from three other monitoring wells across the facility. TCE was detected in an "upgradient" and off-site monitoring well at a concentration of 260 ug/L, and in a downgradient/offsite monitoring well at a concentration of 18 ug/L. The apparent water-table mound in the southeastern section of the facility could be potentially responsible for localized upgradient and off-site contaminant migration. The source(s) of TCE and the chlorinated organic compound contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- Because of the high concentrations of certain constituents, samples were diluted to facilitate laboratory analysis. Other constituents potentially present may not have been detected due to sample dilution and resultant elevated detection limits.

- Significant levels (up to 199,785 ug/L) of TID compounds occur in ground water.

- The need for and extent of ground-water remediation will be addressed in the cleanup plan.

Ground-water quality will be investigated further to define better the presence, concentration, distribution and source of constituents of concern both onsite and offsite. As proposed in the "Sampling Plan Addendum No. 2," two rounds of ground-water sampling will be conducted. Samples will be collected from all existing and proposed monitoring wells.

LNAPL and DNAPL Recovery

According to Kalama, the recovery effort in Monitoring Well MW-7 consisted of pumping the LNAPL out on seven occasions during the period of May through November 1988. The LNAPL thickness was measured before and after each pumping event. Prior to the first event, approximately 1 foot of LNAPL was measured, prior to the second event, approximately 0.6 foot was measured; and prior to the third and fourth event, approximately 0.3 foot was measured. The LNAPL thickness after each of the first four pumping events was not measurable with the oil/water interface probe, but a trace amount of LNAPL was observed. Prior and subsequent to the fifth, sixth and seventh event, the LNAPL thickness was not measurable with the oil-water interface probe, but only a trace amount of LNAPL was observed.

During the ECRA Sampling Plan Investigation, a sample of the LNAPL in Monitoring Well MW-7 was collected and analyzed for VOC and BNs plus TID compounds, and total PHCs. That sample was collected in January 1988, prior to the LNAPL recovery effort. Toluene was detected in the sample at a concentration of 541,000 mg/kg, indicating that 54 percent of the mass of the product phase consists of toluene. TID BNAs were detected at a concentration of 222,700 mg/kg (which included TID toluene at a concentration of 150,000 mg/kg). The total PHC concentration was reported as 408,900,000 ug/L. The PHC concentrations might have been affected by the presence of toluene. Toluene was not detected at a detection limit of 5 ug/L in the sample collected from Monitoring Well MW-7 during the Revised ECRA Sampling Plan Investigation (April 1991), but total PHCs were detected at a concentration of 4,100 ug/L in that sample.

According to Kalama, LNAPL was detected in Monitoring Well MW-5. Kalama recovered the LNAPL which was not analyzed but is similar to the LNAPL recovered from Monitoring Well MW-7.

The presence and thickness of free LNAPL and DNAPL were monitored concurrently during the initial nine rounds of water-level measurements for the Revised ECRA Sampling Plan Investigation with an oil/water interface probe. LNAPL was not detected. Monitoring Well MW-5 was the only well that evidenced the presence of DNAPL. A dark-brown DNAPL was detected at the bottom of Monitoring Well MW-5. The DNAPL was observed initially on April 12, 1991. The measured thickness, based on the coating on the probe, was approximately 0.3 feet. On April 20, 1991, a product thickness of 0.4 feet was measured. On April 22, 1991, the well was purged with a suction pump with the intake at about 4 feet above the bottom of the well. Ground water was sampled as part of the regular sampling event in all monitoring wells, but the DNAPL was not sampled. Based on the concentration of constituents in the sample from Monitoring Well MW-5, which contained 1,400 ug/L of TCE, the DNAPL probably contains TCE. Following the ground-water sampling event, product thicknesses of 0.4 feet, 0.5 feet and 0.2 feet were measured on April 25, May 3, and May 17, 1991, respectively.

The presence of non-aqueous phase liquids (LNAPL and DNAPL) will be monitored in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

CONCLUSIONS

1. The Kalama facility in Garfield, New Jersey is an active chemical manufacturing plant which is approximately 100 years old. Historically, the facility manufactured various chemicals, including formaldehyde, benzoic acid, benzaldehyde and salicylic acid under several ownerships. Kalama purchased the facility from Tenneco in December 1982.

2. Approximately 50 percent of the 6.4 acre facility is occupied by buildings and approximately 25 percent of the facility is covered with pavement, primarily asphalt. An extensive network of pipes and structures is present beneath the site surface. As part of the plant operations, tank trucks, tractor trailers and rail cars move around the facility daily. As such, there are extremely congested surface and underground conditions at the facility. These factors complicate the environmental investigative efforts.

3. With the exception of several buildings and the benzoic acid/benzaldehyde production facility which no longer exist, the site surface conditions have changed little over the past 44 years.

4. There are no private or public supply wells within a 0.25-mile radius from the Kalama site. Additional well search activities are proposed in the "Sampling Plan Addendum No. 2."

5. The geology of the Kalama site is characterized by approximately 25 to 35 feet of unconsolidated deposits which are underlain by the Brunswick Formation shales and sandstones. The unconsolidated deposits generally include approximately 3 feet to 8 feet of fill over natural sand, silt, and clay. The lithology of the unconsolidated deposits varies significantly, both horizontally and vertically, across the site.

6. There is a single water-bearing zone in the unconsolidated deposits. The depth to the water table is generally 7 feet to 10 feet below ground surface and increases toward the Passaic River where the ground water discharges. There are tidal effects on ground water in the unconsolidated deposits within approximately 150 feet of the river. The significance of the tidal fluctuations for off-site contaminant migration and potential remedial alternatives for the facility is not understood at this time. Tidal fluctuations will be monitored further in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

7. There is some evidence that the apparent water-table mound in the southeastern section of the facility is a perched water body. The extent to which the anomalous ground-water conditions observed in the southeastern section of the facility impact off-site contaminant migration will be investigated further in accordance with the "Sampling Plan Addendum No. 2."

8. The general direction of ground-water flow is to the west/southwest, toward the Passaic River.

9. The soil hydraulic conductivity, based on slug tests, ranges from 0.3 feet/day (1.2×10^{-4} centimeters/second) to 13 feet/day (4.6×10^{-3} centimeters/second) with an average of 3 feet/day (1.1×10^{-3} centimeters/second). These values are typical for silty and clayey sands, which comprise a significant portion of the soils on the site. The overall ground-water flow gradient across the site is approximately 0.01. The hydraulic conductivity and ground-water flow gradient may range significantly across the site. Geraghty & Miller did not calculate ground-water flow velocities because of the high inhomogeneity of the unconsolidated deposits, the potential presence of preferential pathways, and tidal influences. Those conditions tend to render ground-water flow velocities unreliable for predicting ground-water time of travel.

10. The pumping tests indicate that the water-bearing zone yields variable and relatively low volumes of water to wells (0.5 gallons per minute and 3 gallons per minute). The results of the pumping tests are inconclusive. An additional pumping test will be conducted in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

11. The results of the post-excavation soil sampling and analysis program indicate the following:

- The locations of the former methanol, methyl isobutyl ketone and hexene USTs are not areas of concern.

- The former toluene, fuel oil and gasoline USTs appear to have been sources of soil contamination. Toluene was detected in post-excavation soil samples at concentrations up to 805 milligrams/kilogram (mg/kg). Total petroleum hydrocarbons (PHCs) were detected in concentrations up to 24,000 mg/kg. The locations of the former toluene, fuel oil and gasoline USTs are areas of concern.

- The UST excavations were partially backfilled with the excavated soils. Soil contamination associated with the former toluene, fuel oil and gasoline USTs will be addressed in the cleanup plan.

12. The results of the soil boring sampling and analysis program indicate the following:

    - Constituents, including toluene, benzene, total polycyclic aromatic hydrocarbons (PAHs), and total PHCs exceed the NJDEP-ECRA guidance levels by a significant margin at several soil sampling locations.

        - Toluene was detected in soil at concentrations up to 20,000 mg/kg.

        - Benzene was detected in soil at concentrations up to 80 mg/kg.

        - Total PAHs were detected in soil at concentrations up to 71 mg/kg.

        - Total PHCs were detected in soil at concentrations up to 4,670 mg/kg.

    - The southeastern section of the facility, which includes the locations of the former toluene USTs and former production facilities that used benzene and toluene, is an area of concern because of the high concentrations of toluene, benzene and PAHs in soil. The major portion of this area of concern extends 250 feet south of the location of the former toluene USTs. Sources other than the former USTs, such as spills and leaks, probably contributed to the toluene contamination in soil.

- Total PHCs were detected at high concentrations throughout the facility and therefore are a constituent of concern in soil.

- Polychlorinated biphenyls (PCBs) and metals are not constituents of concern at the facility.

- Because of the high concentrations of certain constituents, samples were diluted to facilitate laboratory analysis. Other constituents potentially present may not have been detected due to sample dilution and associated elevated detection limits.

- Significant levels (up to 15,150 mg/kg) of tentatively identified (TID) compounds occur in soil.

- Additional soil sampling is proposed in the "Sampling Plan Addendum No. 2."

- The need for, and extent of, soil remediation will be addressed in the cleanup plan.

13. The results of the ground-water sampling and analysis program indicate the following:

- Toluene, phenol, benzene, and trichloroethane (TCE) are constituents of concern in ground water.

- Toluene is present in ground water throughout the facility. Toluene concentrations up to 110,000 micrograms/liter were detected in ground-water samples from the southern half of the facility. The toluene area of concern for soil appears to be one of the source areas for toluene in ground water. Other potential sources of toluene contamination will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- Phenol is present in ground water throughout the facility. Phenol concentrations up to 930,000 ug/L were detected in samples from monitoring wells along the northern facility boundary. Concentrations of phenol up to 120,000 ug/L were detected in the southern half of the facility. The source(s) of phenol contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- The areas of toluene and phenol contamination in ground water extend to, and probably cross, the northern, southern and western boundaries of the facility. Additional off-site and downgradient monitoring wells will be installed as part of the work proposed in the "Sampling Plan Addendum No. 2."

- Benzene is present in ground water in the southern half of the facility at a maximum concentration of 3,500 ug/L. The area of benzene contamination in ground water extends to, and probably crosses, the southern and western facility boundaries. The source(s) of benzene contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

- TCE and other chlorinated organic compounds are present in ground water at various locations across the facility. TCE was detected onsite in ground water at concentrations up to 2,700 ug/L in the southeastern section of the facility. TCE was detected "upgradient" in an off-site monitoring well at a concentration of 260 ug/L. The apparent water-table mound in the southeastern section of the facility could be responsible for this apparent upgradient and off-site contaminant migration. TCE was detected downgradients/offsite at a concentration of 18 ug/L. The source(s) of TCE and the chlorinated organic compound contamination presently is not known but will be investigated as part of the work proposed in the "Sampling Plan Addendum No. 2."

o Because of the high concentrations of certain constituents, samples were diluted to facilitate laboratory analysis. Other constituents potentially present may not have been detected due to sample dilution and associated elevated detection limits.

o Significant levels (up to 599,785 ug/L) of TID compounds occur in ground water.

o The need for, and extent of, ground-water remediation will be addressed in the cleanup plan.

14. The presence of non-aqueous phase liquids will continue to be monitored in accordance with the work proposed in the "Sampling Plan Addendum No. 2."

15. A dense, non-aqueous phase liquid, which probably contains TCE, was detected at the bottom of one monitoring well located in the southeastern corner of the facility. The presence, nature, extent, and source of this non-aqueous phase liquid will be investigated further in accordance with work proposed in the "Sampling Plan Addendum No. 2."

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Geraghty & Miller, Inc., 1988. ECRA Soil and Ground-Water Investigation at the Kalama Chemical, Inc. Facility, Garfield, New Jersey.

Geraghty & Miller, Inc., 1989. Sampling Plan Addendum, Kalama Chemical, Inc. Facility, Garfield, New Jersey.

Geraghty & Miller, Inc., 1990. Revised Sampling Plan Addendum, Kalama Chemical, Inc. Facility, Garfield, New Jersey.

16. A feasible and effective cleanup plan can only be developed after completion of additional investigative work. Geraghty & Miller recommends that the work proposed in the "Sampling Plan Addendum No. 2" be implemented.

RECOMMENDATIONS

Based on the data presented and evaluated in this report, Geraghty & Miller recommends that an additional investigation be conducted in accordance with the "Sampling Plan Addendum No. 2" prior to submitting a cleanup plan to the NJDEP. The additional investigation proposed includes the following:

- Inspection of building interiors.
- Asbestos inspection.
- Installation of additional monitoring wells including off-site wells.
- Sampling and analysis of soil and ground-water.
- Survey of underground utilities.
- Pumping test.
- Investigation of the apparent water-table mound.
- Evaluation of LNAPL, DNAPL and TID compounds.

Geraghty & Miller anticipates that a cleanup plan will be submitted with the report on the additional investigative work.

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NJ03602/report.kal

ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN KALAMA CHEMICAL INC. FACILITY GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

VOLUME I OF VI

December 1993

Prepared for

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VOLUME I

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ECRA INVESTIGATION REPORT
AND PROPOSED
REMEDIAL ACTION PLAN
KALAMA CHEMICAL INC. FACILITY
GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

December 13, 1993

Geraghty & Miller, Inc. is submitting this document to Kalama Chemical Inc. for the Garfield, New Jersey facility. The document was prepared in conformance with Geraghty & Miller's strict quality assurance/quality control procedures to ensure that it meets industry standards in terms of the methods used and the information presented. If you have any questions or comments concerning this document, please contact Chris Motta or Greg Shkuda.

Respectfully submitted,

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APPENDICES

ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN KALAMA CHEMICAL INC. FACILITY GARFIELD, NEW JERSEY

ECRA CASE NO. 86B73

1.0 INTRODUCTION

In June 1986, Geraghty & Miller, Inc. was retained by Kalama Chemical Inc. of Seattle, Washington (Kalama) to conduct an environmental sampling and analysis program at its chemical manufacturing facility in Garfield, New Jersey. The purpose of the program was to evaluate the environmental conditions of the facility in accordance with the requirements of the New Jersey Environmental Cleanup Responsibility Act (ECRA). As required by ECRA, Kalama submitted the General Information Submission (GIS) to the New Jersey Department of Environmental Protection (NJDEP, now the New Jersey Department of Environmental Protection and Energy [NJDEPE]) in 1986. Kalama also submitted the Site Evaluation Submission (SES) and the Request for Hydrogeologic Assessment to the NJDEPE in January 1987 and August 1987, respectively. An Administrative Consent Order (ACO) was executed between Kalama and the NJDEPE in December 1988.

From June 1986 through June 1993, five phases of ECRA-related investigations were conducted at the facility. A preliminary investigation of soil quality (Preliminary Investigation or 1986 Investigation) was conducted in 1986. The field work associated with the Preliminary Investigation was conducted in June 1986. The results of that investigation are presented in a report entitled "Preliminary Investigation of Soil Quality Conditions at the Kalama Chemical, Inc. Facility in Garfield, New Jersey" (Geraghty & Miller, Inc. 1986).

Geraghty & Miller subsequently prepared a sampling plan as part of the Site Evaluation Submission, as required by ECRA. The plan was prepared in accordance with the Draft Sampling Plan Guide for ECRA (June 1986), issued by the NJDEPE, Bureau of Industrial Site Evaluation (BISE). The plan, entitled "Sampling Plan for Site Evaluation, Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1987) was submitted to the NJDEPE in August 1987. The field work for this phase of the investigation was conducted from September 1987 through March 1988. The results of the 1987-1988 Soil and Groundwater Investigation (ECRA Sampling Plan Investigation or 1987-1988 Investigation) are presented in a report entitled "ECRA Soil and Ground-Water Investigation at the Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1988). That report was submitted to the NJDEPE in June 1988.

The ECRA Sampling Plan Investigation did not completely delineate the nature and extent of contamination at the Kalama Garfield facility. Therefore, a sampling plan addendum letter, which proposed additional investigative work, was required by the NJDEPE and was submitted in October 1988.

On March 10, 1989, Kalama received a letter from the NJDEPE that required Kalama to submit an expanded sampling plan addendum. In response to that letter, an expanded sampling plan addendum was prepared and submitted to the NJDEPE in April 1989 (Geraghty & Miller, Inc., 1989). In response to a letter from the NJDEPE to Kalama, dated January 8, 1990, a revised sampling plan addendum was prepared. The addendum, entitled "Revised Sampling Plan Addendum, Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1990) was submitted to the NJDEPE in March 1990. The NJDEPE approved the Revised Sampling Plan Addendum with conditions by letter to Kalama, dated January 3, 1991.

The work detailed in the Revised Sampling Plan Addendum and the work required by the NJDEPE conditions began in January 1991 and was completed in September 1991 with the submittal of the report entitled "Revised ECRA Sampling Plan Investigation Report, Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1991a). To comply with the NJDEPE requirements set forth in the ACO, a sampling plan entitled "Sampling Plan Addendum No. 2, Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1991b) also was submitted to the NJDEPE in September 1991.

The NJDEPE provided a draft copy of the sampling plan conditional approval letter (facsimile transmission, dated December 19, 1991) for the Sampling Plan Addendum No. 2. Geraghty & Miller, on behalf of Kalama, prepared a response letter dated February 3, 1992 that addressed the draft conditional approval letter. The NJDEPE approved the Sampling Plan Addendum No. 2 with conditions in a letter to Kalama, dated February 6, 1992.

The Sampling Plan Addendum No. 2 Investigation was conducted in accordance with the sampling plan, the Geraghty & Miller response letter, and the NJDEPE conditional approval letter. Field work was conducted from November 1991 through June 1992. The "Sampling Plan Addendum No. 2 Investigation Report, Kalama Chemical Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1992a) was submitted to the NJDEPE in August 1992. To comply with the NJDEPE requirements as set forth in the ACO, a sampling plan entitled "Sampling Plan Addendum No. 3, Kalama Chemical Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1992b) also was submitted to the NJDEPE in August 1992.

The NJDEPE provided a draft copy of the sampling plan conditional approval letter (facsimile transmission, dated April 4, 1993) for the Sampling Plan Addendum No. 3. The letter included numeric soil cleanup criteria and other guidance on site remediation, including the groundwater quality standards. Kalama responded by letter, dated April 19, 1993, and the NJDEPE approved the Sampling Plan Addendum No. 3 with conditions in a letter to Kalama dated June 1, 1993.

The scope of work for each of the investigations identified above is summarized in Section 2.3 (History of ECRA-Related Investigations).

1.1 PURPOSE

This ECRA Investigation Report and Proposed Remedial Action Plan document was prepared for the following purposes:

- To summarize the significant findings of the Sampling Plan Addendum No. 3 Investigation and previous investigations, and to present a conceptual site model.

- To identify areas and conditions of concern that require remediation.

- To identify goals for site remediation.

- To evaluate applicable remedial technologies and process options, and to propose a cost-effective remedial system that will achieve the remediation goals.

2.0 BACKGROUND

This section describes the facility, its operational history, and the history of the ECRA investigation. Information on the history of operations (Section 2.2 [History of Operations]) was researched and provided by Kalama.

2.1 FACILITY DESCRIPTION

The facility, including its location, surface features, and subsurface pipes and structures, is described in this section.

2.1.1 Location

The facility is located in the City of Garfield, Bergen County, New Jersey. The property is owned by Kalama Chemical Inc. and is designated as Block 50.01 Lot 1 and Block 50.02 Lot 1 on the assessment map for the City of Garfield. River Drive, which trends north-south, separates the two lots. Block 50.01 Lot 1 is east of River Drive and is approximately 500 feet by 560 feet (6.4 acres). This part of the site is occupied by manufacturing, warehousing, maintenance, and office facilities and is referred to as the facility, site, or plant. Block 50.02 Lot 1 is west of River Drive and is approximately 40 feet by 560 feet (0.5 acre). This part of the site is the location of the river water pump house and employee parking. The Passaic River flows along the western boundary of Block 50.02 Lot 1. A site location map is provided on Figure 2-1.

2.1.2 Surface Features

Buildings occupy approximately 50 percent of the facility. Paved areas (primarily asphalt) cover an estimated 25 percent of the facility. The remaining 25 percent of the surface is unpaved. As part of the plant operations, tank trucks, tractor trailers, and rail cars move within the facility regularly.

The Passaic River, a primary regional surface-water body, is located approximately 100 feet west of the manufacturing facilities. The Passaic River is tidal (the tidal amplitude is approximately 4 to 5 feet adjacent to the site). The river flows by the facility in a north to south direction and is a receptor for local groundwater and storm-water discharge. Mixed commercial and residential areas surround the facility on its other three sides.

The oldest existing buildings on the site were constructed about 1900. The most recent building construction took place in the late 1970s. Existing buildings are referred to by number as shown on Figures 2-2 and 2-3. Buildings have been demolished, replaced, and modified over the years, as have underground pipes, such as process wastewater and sewer lines, and structures such as catch basins and sumps. The plant is served by railroad sidings from Conrail.

2.1.3 Subsurface Pipes and Structures

An extensive network of pipes and structures (both active and inactive) is present beneath the facility and bordering public roads. Those pipes and structures include the following:

- Intake lines that carry non-contact cooling water from the Passaic River to the facility.
- River-water lines that discharge non-contact cooling water and storm water to the Passaic River.
- Process wastewater lines that connect to the Passaic Valley Sewerage Commissioners (PVSC) trunk line beneath River Drive.
- Sanitary sewer lines that connect either to a City of Garfield line or directly to the PVSC line.
- Potable water lines.
- Steam lines.
- Floor canals and drains.
- Sumps, catch basins, and manholes.
- Basements and elevator shafts.

- Pipe trenches and a pipe tunnel.
- Abandoned and inactive lines.

2.2 HISTORY OF OPERATIONS

The property ownership and manufacturing history of the facility is described in this section.

2.2.1 Property Ownership

The first buildings at the site were constructed in 1891 by Fritzche Brothers to facilitate chemical manufacturing. Chemical manufacturing has operated continuously at the site since that time. Fritzche Brothers sold the site to Von Heyden Chemical Fabrische around the turn of the century. The company was incorporated in New Jersey as Heyden Chemical Works in 1900. This company was seized by the Alien Property Custodian during World War I and sold at public auction in 1919. In 1919, the site was purchased by a newly formed New York corporation called Heyden Chemical Company of America Inc. The company was consolidated into the Heyden Chemical Corporation in 1925, and in 1956 changed its name to the Heyden Newport Chemical Corporation. Heyden Newport Chemical Corporation was purchased in 1963 by Tenneco. Kalama Chemical Inc. purchased the site from Tenneco in December 1982.

2.2.2 Manufacturing History

Chemicals produced at the site are used in pharmaceuticals, cosmetics, food packaging and preservatives, synthetic flavorings, printing inks, dyestuffs, and other products. The site has been the location of salicylic acid and sodium, potassium, and methyl salicylate production since the turn of the century. Parasepts and methylene disalicylic acid have been produced at the site since the 1940s. (Parasepts, sometimes called Parabens, is a registered trademark for certain methyl, ethyl, propyl and butyl esters of para-hydroxy benzoic acid.) From the 1930s until 1982, formaldehyde was produced at the site.

During World War II, the U.S. Government installed equipment at the site for the manufacture of pentaerythritol, a glycerine substitute. Pentaerythritol production continued until 1962. Benzoic acid, benzaldehyde, and sodium benzoate were produced in buildings and on a diked pad in the southeastern section of the site from 1961 until February 1984. Other historical products and processes include Resorcinol, jet lube, fumaric acid, pentamids, DDSA, Nuosperse HOH, Nuvis HS, B-Oxynapththoic Acid, and naphthalene distillation.

Toluene was used at the site in large quantities between 1961 and 1984 as a raw material for the production of benzoic acid and benzaldehyde in the air oxidation process. Benzene was formerly used in the manufacture of resorcinol (in the 1940s and early 1950s) and was a waste byproduct of the benzoic acid/benzaldehyde manufacturing process (1961-1984). Phenol and sodium hydroxide have been used as raw materials for the production of salicylic acid in the carboxylation process since early in the site's history. Methyl salicylate is manufactured by the esterification of salicylic acid and methanol, using sulfuric acid as a catalyst. Methanol was used also in the catalytic oxidation production of formaldehyde.

Manufacturing operations currently are conducted in approximately one-half of the 38 existing buildings at the site (several of these buildings are subdivided into separately numbered structures, for example, Buildings 10-P1 through 10-P4). The other buildings are either vacant, idle, or are used for storage, shops, or offices. Eight buildings have been dismantled over the years (Buildings 2, 3, 8, 10-A, 10-M, 10-N, 37, and 38). The dates of construction, current use, and, to the extent known, the principal historic use of each separately identified structure are presented in Table 2-1.

During the past three years, Kalama has conducted an in-depth investigation into the history of manufacturing operations, surface and subsurface conditions and environmental incidents at the site. This investigation, which is ongoing, is a part of discovery in a lawsuit entitled _Kalama Chemical, Inc. v. Tenneco Polymers, Inc. et al_. (U.S. District Court for the Western District of Washington, Cause No. C90-1229(WD)Z) which Kalama has brought against the former owner and operator of the site (Tenneco) for indemnification of liabilities arising from environmental problems caused by Tenneco.

Kalama's investigation has involved the review of hundreds of thousands of historical documents obtained from Tenneco and from site archives, as well as interviews and/or depositions of dozens of long-time Tenneco/Kalama and former Tenneco employees. As a result, Kalama and Geraghty & Miller have been made aware of a number of conditions and incidents that predate Kalama's purchase of the facility (December 1982) and that appear to provide specific sources for much of the soil and groundwater contamination that has been identified during the ECRA investigation, particularly in those parts of the site that have been largely inactive during Kalama's ownership.

Tenneco operated a benzoic acid/benzaldehyde manufacturing plant in Building 10-T and on a diked pad in the southeastern section of the plant for twenty years (1963-1982). The benzoic acid plant was originally constructed by Heyden in 1961. Tenneco substantially expanded benzoic acid production and added benzaldehyde production. Kalama operated this plant during 1983 and for the first two months of 1984 before shutting it down and dismantling much of the production equipment. Toluene was the principal raw material for the benzoic acid/benzaldehyde manufacturing process and was regularly delivered to the site in large quantities (up to 6,500 gallons per day) while the process was in operation. Toluene consumption and benzoic acid/benzaldehyde production peaked in the late 1970s.

Raw toluene was unloaded to, and stored in, underground storage tanks (USTs) adjacent to Building 18, near the benzoic acid/benzaldehyde operation. Recently obtained information indicates that tank overflows during loading occurred during Tenneco's operation of the plant. Also, at some time in the late 1970s, one of these USTs (A-9) was discovered to be a "leaker." Nonetheless, Tenneco continued to store contaminated toluene, and, on one occasion, an inadvertent shipment of several thousand gallons of benzene, in that tank.

Historic spills of both raw toluene and partially reacted product (containing both toluene and benzene) have been described recently by former Tenneco employees. In one instance in the late 1970s, it is reported that a large quantity of partially reacted benzoic acid containing toluene was released through operator error. The material that did not soak into the ground solidified over the entire southeastern section of the site, forming a 4-inch to 6-inch thick crust that blocked sewer grates and catch basins and required a several-day cleanup operation. On another occasion during the same time period, raw toluene was released accidentally from a reactor vessel and formed what was reported to be a 3-inch deep "lake" of toluene in the southeastern corner of the site, north of building 22. Another reported incident from the 1970s involved release of an estimated 5,000 gallons of toluene from an aboveground feed tank to the underground sewer system in the southeastern corner of the plant. Historic site documents and former Tenneco employees indicate that valve and line leaks from the benzoic acid/benzaldehyde process and associated DowTherm heat transfer boiler and plumbing were common during Tenneco's operation of the facility and often resulted in chemically saturated soil conditions in unpaved areas in the southeastern section of the site.

Between 1984 and 1990, small quantities of toluene (roughly 1/30th the prior consumption) were stored on-site by Kalama in aboveground, diked tanks for use in other product manufacturing in Buildings 32 and 10, far removed from the benzoic acid/benzaldehyde operations. No significant leaks or spills of toluene have been reported during Kalama's ownership. Kalama curtailed use of toluene completely in 1990.

Plant production records indicate that Kalama's use of toluene was approximately 6 percent of the overall historic toluene use at the facility. Tenneco's use was approximately 93 percent. Toluene use in benzoic acid production prior to Tenneco's operation of the facility is estimated at less than 1 percent. Kalama is not aware of any toluene usage for manufacturing at the facility prior to 1961.

Former Tenneco employees have disclosed in recent interviews and depositions that the physical condition of the complex chemical and storm-water sewer systems beneath the site has been poor since at least the 1960s. These lines have been historically broken, plugged, cross-connected and abandoned in order to reroute and divert flows to and from the chemical and/or river return (storm water) portions of the system. These modifications, along with the natural degradation of the underground pipe materials, appear to have resulted in a piping network of generally compromised integrity that offered a multitude of sources for contaminated fluids to enter the soil and groundwater, particularly where process fluids were collected or carried above the water table. In addition, plugged lines in the southeastern section of the site at times offered no drainage for spilled feedstock, washdown, and product, which would pool and soak into cracked or unpaved areas. Underground lines in this area have been mostly inactive since Kalama terminated the benzoic acid/benzaldehyde process in February 1984.

Degraded subsurface conditions in the northeastern section of the site have been identified as the source of operational releases of process washdown and wastewater containing phenol, methanol, and formaldehyde from the production of salicylic acid, MDA, and related products. In these areas, Kalama has undertaken extensive repairs in an effort to eliminate these operational releases.

2.3 HISTORY OF ECRA-RELATED INVESTIGATIONS

This section summarizes the scope of work for each of the five phases of ECRA-related investigations conducted by Geraghty & Miller at the facility. The scope of work for the UST removal program, conducted by Kalama and Tenneco, also is summarized in this section. Soil boring and former UST locations are shown on Figure 2-2. Monitoring well locations are shown on Figure 2-3.

2.3.1 Preliminary Investigation (1986)

A preliminary investigation, which was performed as part of the ECRA filing process, included the drilling of five soil borings and sampling of soil. A summary of the sampling and analysis program for the Preliminary Investigation is presented in Table 2-2. The results of the investigation were reported to the NJDEPE in the document entitled "Preliminary Investigation of Soil Quality Conditions at the Kalama Chemical, Inc. Facility in Garfield, New Jersey" (Geraghty & Miller, Inc. 1986).

2.3.2 ECRA Sampling Plan Investigation (1987-1988)

The ECRA Sampling Plan Investigation (ESPI) included the drilling of soil borings, installation of groundwater monitoring wells, sampling of soil and groundwater, and measuring water levels. Summaries of the soil and groundwater sampling and analysis programs for the ESPI are presented in Tables 2-3 and 2-4, respectively. The results of the investigation were reported to the NJDEPE in the document entitled "ECRA Soil and Ground-Water Investigation at the Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1988).

2.3.3 UST Removal Program (1987-1990)

Under the supervision of Kalama and Tenneco personnel, 27 USTs were removed from September 1987 through February 1990. A summary of the post-excavation sampling and analysis program, including tank numbers and contents, is presented in Table 2-5.

Results for the post-excavation sampling and analysis program were presented in several of the ECRA submittals, including sampling plans and reports. The results of the post-excavation sampling and analysis program are summarized in the Revised ECRA Sampling Plan Investigation Report (Section 2.3.4 [Revised ECRA Sampling Plan Investigation (1991)]).

2.3.3.1 Non-Aqueous Phase Liquid Removal (1988 - Present)

Kalama and Geraghty & Miller have, on several occasions from 1988 to the present, removed non-aqueous phase liquid (NAPL) present in monitoring wells located in the southeastern section of the facility and in a monitoring well located south of, and adjacent to, the southeastern section. NAPL monitoring and removal activities are described in Appendix A. NAPL monitoring and removal activities are ongoing.

2.3.4 Revised ECRA Sampling Plan Investigation (1991)

The Revised ECRA Sampling Plan Investigation (RESPI) included the following:

- Aerial photograph study.
- Soil sampling and analysis.
- Monitoring well installation and groundwater sampling and analysis.
- Water-level measurements.
- Aquifer pumping tests.
- Soil-vapor extraction (SVE) pilot tests.
- Well search.

Summaries of the soil and groundwater sampling and analysis programs for the RESPI are presented in Tables 2-6 and 2-7, respectively. The results of the investigation were reported to the NJDEPE in the document entitled "Revised ECRA Sampling Plan Investigation Report, Kalama Chemical, Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1991a).

2.3.5 Sampling Plan Addendum No. 2 Investigation (1991-1992)

The Sampling Plan Addendum No. 2 (SPAN-2) Investigation included the following:

- Soil sampling and analysis.
- Monitoring well installation (on-site and off-site) and groundwater sampling and analysis.
- Water-level measurements.
- NAPL monitoring and removal.
- Aquifer pumping test.

- Tentatively identified compound (TIC) evaluation.
- Laboratory data assessment.
- Well search (updated).
- Process wastewater sampling and analysis.
- Asbestos inspection (Kalama will submit the asbestos inspection report to the NJDEPE as an amendment to the SES).

Summaries of the soil, groundwater, and process wastewater sampling and analysis programs for the SPAN-2 Investigation are presented in Tables 2-8, 2-9, and 2-10, respectively. The results of the investigation were reported to the NJDEPE in the document entitled "Sampling Plan Addendum No. 2 Investigation Report, Kalama Chemical Inc. Facility, Garfield, New Jersey" (Geraghty & Miller, Inc. 1992b).

2.3.6 Sampling Plan Addendum No. 3 Investigation (1992-1993)

The Sampling Plan Addendum No. 3 (SPAN-3) Investigation included the following:

- Monitoring well installation (on-site and off-site, overburden and bedrock, and one till/bedrock well) and groundwater sampling and analysis.
- Floor canal soil sampling (one sample) from the basement of Building 36.
- Water-level measurements.
- Laboratory data assessment.
- Ongoing NAPL monitoring and removal because of the persistence of NAPL (see Appendix A).
- Off-site soil-vapor survey (see Appendix B).
- Bench-scale biodegradation treatability study (see Appendix C).
- Soil-vapor extraction pilot tests (see Appendices D, E, and F).
    - Low vacuum soil-vapor extraction.
    - Low vacuum soil-vapor and groundwater extraction.
    - High vacuum soil-vapor and groundwater extraction.

- Search for the locations of the former on-site supply wells (see Appendix G).

A summary of the overburden and till/bedrock groundwater sampling and analysis program for the SPAN-3 Investigation is presented in Table 2-11. A summary of the SPAN-3 Investigation groundwater sampling and analysis program for the bedrock, till/bedrock, and associated clustered wells is presented in Table 2-12. Monitoring well borehole logs, construction details, and Forms A and B for the SPAN-3 Investigation are presented in Appendix H. Groundwater sampling forms for the SPAN-3 Investigation are presented in Appendix I.

Certain SPAN-2 tasks were completed during the SPAN-3 Investigation. Those tasks, and the appendices in which they are reported, are as follows:

- Underground utility survey and inspection (see Appendix J).
- Water purveyor survey (see Appendix K).
- Removal of water from basements and elevator shafts, and inspection of building interiors (see Appendix L).
- Bench-scale biodegradation treatability study (see Appendix C).
- Evaluation of SVE pilot test data (see Appendix D).

In summary, the ECRA-related investigations of the Kalama Chemical Inc., Garfield, New Jersey facility conducted by Geraghty & Miller included the following components:

- 111 soil borings.
- 115 UST post-excavation soil sampling locations.
- 39 on-site monitoring wells.
- 31 off-site monitoring wells.
- 7 wellpoints.
- 4 piezometers.
- 35 soil-vapor sampling locations.

3.0 GEOLOGY AND HYDROGEOLOGY

This section provides a description of the geology and hydrogeology of the region and the site area. The description of the regional geology and hydrogeology is presented in Section 3.1 (Regional Geology and Hydrogeology) and the description of the site area geology and hydrogeology is presented in Section 3.2 (Site Area Geology and Hydrogeology).

3.1 REGIONAL GEOLOGY AND HYDROGEOLOGY

This section provides a summary of generally accepted interpretations of the regional geology and hydrogeology.

3.1.1 Regional Geology

The facility is located in the Piedmont Lowland Physiographic Province. Bedrock within this province consists of sedimentary and igneous formations of the Triassic and Jurassic Periods. Unconsolidated glacial (ice) and fluvial (river) deposits of the Pleistocene and Recent Epochs cover the bedrock in most areas of the Province, especially in lowland areas.

The bedrock underlying the site area belongs to the sedimentary Brunswick Formation, which is composed primarily of reddish-brown sandstone and shale beds that strike to the northeast and dip generally 10 degrees to 15 degrees to the northwest. The top of the Brunswick Formation usually is weathered and consists of rock fragments embedded in a matrix of clay, silt, and sand derived from the bedrock. Unconsolidated deposits overlie either till, where present, or bedrock. Till is a heterogeneous compacted mixture of clay, silt, sand, and gravel deposited by ice.

3.1.2 Regional Hydrogeology

Regionally, there are two aquifers: the overburden aquifer in the unconsolidated deposits and the bedrock aquifer in the Brunswick Formation. Groundwater in the overburden aquifer concentrations. Concentrations of phenol in the soil ranged from 0.0941 mg/kg in Sample B-2 to an estimated 310 mg/kg in Sample SB-8-B. Detections of phenol above the impact-to-groundwater soil remediation criterion of 50 mg/kg were limited to the northeastern section of the facility, which is consistent with the use of phenol as a raw material in the manufacturing of salicylic acid in this section of the facility.

PAHs were detected in 50 of 69 soil samples analyzed for PAHs. The total PAH concentrations (sum of the individual PAH concentrations) ranged from an estimated 0.018 mg/kg in Sample B-43-A to approximately 101 mg/kg in Sample B-52-A. Sample B-52-A, which was collected just south of former fuel oil UST A-4, was the only sample that contained total PAHs above the impact-to-groundwater soil remediation criterion of 100 mg/kg.

5.1.3 Petroleum Hydrocarbons

A summary of TPHC concentrations detected in soil samples is provided in Tables 5-4 and 5-7. TPHCs were detected in 48 of 146 soil samples, at concentrations ranging from 76 mg/kg in Sample B-55-D to 24,000 mg/kg in Sample A-7. Detections above the soil remediation criterion of 10,000 mg/kg were limited to two areas, which correspond to the locations of former fuel oil USTs A-7 and E-1.

5.2 OTHER FACILITY RELATED CONSTITUENTS

A summary of methanol and formaldehyde concentrations detected in soil samples is provided in Tables 5-3 and 5-7. Methanol was detected in nine of 71 soil samples, and formaldehyde was detected in 15 of 27 soil samples. Formaldehyde concentrations were uniformly low (0.65 to 4.5 mg/kg) and were distributed across the facility. The highest formaldehyde concentrations were observed in the northeastern section of the facility. Methanol concentrations ranged from an estimated 0.22 mg/kg to 122 mg/kg. The highest methanol concentrations were detected in post-excavation soil samples collected at the locations of former methanol USTs E-13 and A-14 (116 mg/kg and 122 mg/kg, respectively) and in a sample collected below Building 10-E (Sample SB-8-B at 34 mg/kg) located in the northeastern section of the facility. The NJDEPE has not established numeric soil remediation criteria for either methanol or formaldehyde.

Benzoic acid was detected in ten of 60 soil samples at concentrations ranging from an estimated 0.071 mg/kg in Sample B-70-B to an estimated 19 mg/kg in Sample B-80-A (Table 5-2). Benzaldehyde was detected in nine of 60 soil samples at concentrations ranging from an estimated 0.28 mg/kg in Sample SB-11-A to an estimated 14 mg/kg in Sample B-81-A (Table 5-2). The highest benzoic acid and benzaldehyde concentrations were observed in the southeastern section of the facility. The NJDEPE has not established numeric soil remediation criteria for either benzoic acid or benzaldehyde.

5.3 OTHER CONSTITUENTS

Soil samples were also analyzed for metals and polychlorinated biphenyls (PCBs). Analysis for these constituents was required by the NJDEPE in its conditions for approval of the SPAN-2 (Geraghty & Miller, Inc. 1992b) and the Revised Sampling Plan Addendum (Geraghty & Miller, Inc. 1990).

A summary of metal concentrations detected in soil samples is provided in Table 5-5. All of the samples were collected from fill, so it is likely that the metals data reflect the variable content of the fill material. Sample B-47-Fill, which was collected adjacent to the railroad tracks near Monroe Street, exhibited the highest metals content, presumably because the sample was comprised mainly of the ash and cinder used to grade the railroad tracks. No clear distribution of metals was evident with respect to sample location. The metals content of the soils appears to be unrelated to facility operations.

A summary of PCB concentrations detected in soil samples is presented in Table 5-6. PCBs (Aroclor 1260) were detected in one soil sample and its duplicate (Samples B-44-01 and generally flows to local and regional discharge points, such as the Passaic River. Groundwater in the bedrock aquifer occurs in fractures, such as partings between bedding planes, and flows to local and regional points of groundwater discharge. The bedrock aquifer is tapped for domestic water supply in the area, but not within a minimum of 1.5 miles of the site.

3.2 SITE AREA GEOLOGY AND HYDROGEOLOGY

This section presents a description of the site area geology and hydrogeology.

3.2.1 Site Area Geology

This section presents Geraghty & Miller's understanding of the site area geology based on the ECRA-related investigations. Because of the considerable heterogeneity of the geologic strata at the site, variation from the described conditions should be expected.

3.2.1.1 Fill and Natural Deposits

The on-site ground surface is relatively flat and ranges approximately from an elevation of 16 feet mean sea level (msl) to 18 feet msl. Below the site is a complex sequence of unconsolidated deposits, the upper 30 to 35 feet of which consist primarily of fill and natural deposits. Fill is present immediately below ground surface to a depth of approximately 3 to 8 feet below ground surface (bgs). Typically, the fill consists of a mixture of sand, gravel, silt, clay, crushed stone, and brick and sandstone fragments. Where man-made materials are not encountered, it is difficult to distinguish between fill and natural deposits. The fill is underlain by natural deposits consisting of sand, with varying silt content, and silt and clay layers. The estimated proportion by volume of sand to silt and clay is approximately 2 to 1. Figure 3-1 shows the areal extent and thickness of clay layers at the facility. The clay layers were found predominantly in the eastern half of the site.

3.2.1.2 Till and Bedrock

Till was encountered in most of the borings advanced to refusal (blow counts of 50 to 100 blows per 3 to 5 inches of penetration). The till was encountered at depths of approximately 30 to 39 feet bgs on-site and approximately 32 to 66 feet bgs off-site. In the other borings advanced to refusal, either there was no recovery from the refusal level, or there was fragments of sandstone with silt and clay in the tip of the sampler.

Information obtained from the boreholes for till/bedrock Monitoring Well MW-5D2 (on-site) and bedrock Monitoring Well MW-4D2 (on-site) indicate that the top of competent bedrock is approximately 44 feet bgs. This information also indicates that competent bedrock is separated from the unconsolidated deposits by approximately 5 to 12 feet of till in the area of those boreholes. Till was recovered in the final split spoons from most of the deep overburden monitoring well boreholes. The top of the till surface is shown on Figure 3-2. Information obtained from the boreholes for off-site bedrock wells MW-20D2 and MW-35D2 indicates that the top of competent bedrock ranges from approximately 54 to 75 feet bgs east of the site. The bedrock in that area is separated from the unconsolidated deposits by approximately 16 to 27 feet of till.

The boring logs for several wells identified in the 0.5-mile radius well search indicate a depth to bedrock from 20 to 30 feet bgs. Those wells are located approximately 2,500 feet east of the facility an elevation of 50 feet msl. This indicates that the top of competent bedrock may slope toward the Passaic River from an elevation of approximately +25 feet msl 0.5 mile east of the facility to approximately elevation -30 feet msl at the facility.

Soil boring and monitoring well borehole details are presented in Table 3-1. Monitoring well construction details are presented in Table 3-2. Soil boring and monitoring well borehole logs for the SPAN-3 Investigation are presented in Appendix H. Monitoring Well Forms A and B are also presented in Appendix H. The locations of geologic cross sections are shown on Figure 3-3. Geologic cross sections are presented on Figures 3-4 through 3-8. The soil units on the boring logs and cross sections were identified based on field observations and sieve analyses of selected soil samples. Groundwater sampling forms are presented in Appendix I.

3.2.2 Site Area Hydrogeology

This section presents Geraghty & Miller's understanding of the site area hydrogeology based on the ECRA-related investigations.

3.2.2.1 Groundwater Elevation and Levels

Groundwater elevations are summarized on Figure 3-9. Water-table contours for April 1992, October 1992, and April 1993 are shown on Figures 3-10, 3-11, and 3-12, respectively. Deep groundwater contours for October 1992 and April 1993 are shown on Figures 3-13 and 3-14, respectively. Although the unconsolidated deposits (fill and natural deposits) contain one aquifer, the configurations of the groundwater table contour maps are different for the shallow and deep portions of this aquifer. Groundwater contours for the bedrock are shown on Figure 3-15.

The groundwater levels and river-stage measurements indicate the following:

- Generally, depth to the groundwater table on-site and outside the mounded areas is approximately 7 to 10 feet bgs, with depths increasing toward the Passaic River. Depth to groundwater south and east of the southeastern section of the site increases with ground surface elevation. The minimum depth to groundwater in those areas is approximately 13 feet. The maximum depth to groundwater in those areas is approximately 18 feet.

- Anomalously high groundwater levels measured in the northeastern section of the facility indicate the presence of a groundwater mound in the unconsolidated deposits. The mound, which is approximately 500 feet by 250 feet in area and up to 4 feet higher than surrounding water levels, is referred to as the northern mound. The northern mound appears to be supported by the underlying silt/clay layer.

- Anomalously high groundwater elevations were also measured in the southeastern section of the facility and indicate the presence of a groundwater mound in the unconsolidated deposits. Continuous water-level monitoring indicates that the water level in shallow Piezometer PZ-1, which is screened above the silt/clay layer, is approximately 4 feet higher than in deep Piezometer PZ-2, which is screened below the silt/clay layer. The southern mound is supported by the underlying silt/clay layer and appears to be hydraulically connected to the northern mound.

- The general direction of groundwater flow in the unconsolidated deposits is to the west and southwest, toward the Passaic River. Groundwater mounding appears to be responsible for local components of flow towards the north, east, and south. The general direction of groundwater flow in the bedrock (based on the three bedrock wells) is to the west.

- The Passaic River is tidal. The tidal fluctuations adjacent to the site in the river reach approximately 4 to 5 feet, and cause tidal fluctuations of the groundwater table up to 0.6 foot at approximately 170 feet east of the river (in Monitoring Well MW-6).

- For clustered Monitoring Wells MW-2/2D, MW-3/3D, MW-10/10D, MW-17/17D, MW-19/19D, MW-25/25D, MW-27/27D, MW-28/28D, and MW-32/32D, the groundwater elevations in the deep wells were lower than the water levels in the shallow wells. Maximum differences in water levels were as follows:

MW-2/2D	2.2 feet
MW-3/3D	4.4 feet
MW-10/10D	1.1 feet
MW-17/17D	3.0 feet
MW-19/19D	1.8 feet
MW-25/25D	0.7 foot
MW-27/27D	0.9 foot
MW-28/28D	5.9 feet
MW-32/32D	5.0 feet

These measurements show a downward gradient within the unconsolidated deposits that could result in a downward component of groundwater flow. With the exception of Monitoring Wells MW-10/10D, the monitoring well clusters are within the area(s) of shallow clay, which appears to be supporting the water levels in the shallow wells The water level in Monitoring Well MW-10 may be influenced by the adjacent limited area of anomalously elevated groundwater, as evidenced in nearby Piezometer PZ-3.

- For clustered Monitoring Wells MW-5/5D, MW-16/16D, MW-20/20D, MW-33/33D, MW-34/34D, MW-35/35D, MW-37/37D, and MW-39/39D, the groundwater levels in the deep wells were higher than the water levels in the shallow wells. Maximum differences in water levels were as follows:

MW-5/5D	1.3 feet
MW-16/16D	1.9 feet
MW-20/20D	0.1 foot
MW-33/33D	1.3 feet
MW-34/34D	1.8 feet
MW-35/35D	0.2 foot
MW-37/37D	2.0 feet
MW-39/39D	0.3 foot

The consistently higher water levels in these clustered monitoring wells indicate an upward component of the groundwater flow within the unconsolidated deposits in those areas, which includes the southeastern section of the site and the off-site vicinity to the south.

- In clustered wells MW-20D/MW-20D2, MW-35D/MW-35D2, PZ-2/MW-4D2, and MW-5D/MW-5D2 the groundwater levels in the bedrock were higher than the water levels in the unconsolidated deposits. Maximum differences in water levels were as follows:

MW-20D/20D2	0.3 foot
MW-35D/35D2	2.1 feet
PZ-2/MW-4D2	0.3 foot
MW-5D/MW-5D2 (till/bedrock well)	0.5 foot

The higher water levels in bedrock monitoring wells indicate an upward groundwater gradient between the bedrock and the unconsolidated deposits.

3.2.2.2 Soil Permeability

The permeability (hydraulic conductivity) of the soils underlying the facility was evaluated based on the pumping test and slug test results, the soil sieve analyses, and the inspection of approximately 450 split-spoon soil samples.

The slug test results indicate that the hydraulic conductivity of the unconsolidated deposits ranges from 0.3 to 13 feet per day (feet/day) with an average of 3 feet/day. The 3 feet/day value is typical for silty fine sand, which comprises a significant portion of the unconsolidated deposits at the site. Inspection of split-spoon soil samples and the results of the soil sieve analyses indicate that fine to coarse sands also exist in the unconsolidated deposits. Hydraulic conductivities in these materials would be greater than 3 feet/day. Hydraulic conductivities would be less than 3 feet/day in the silts and clays that occur in the unconsolidated deposits.

The aquifer pumping test conducted in Monitoring Well MW-10 during the SPAN-2 Investigation indicates the following local hydraulic characteristics of the overburden aquifer:

• Transmissivity:	3,500 gallons per day per foot (gpd/ft)
• Storativity:	0.001
• Hydraulic Conductivity:	13 feet/day (based on a 35-foot saturated thickness)

Those results are based on an analysis of the calculated recovery versus distance plots, residual drawdown plots, time versus drawdown plots, and calculated recovery versus time plots.

3.2.2.3 Flow Gradient and Velocity

The groundwater flow gradient in the unconsolidated deposits varies significantly across the site. The overall groundwater flow gradient across the site from the top of the northern mound toward the Passaic River is approximately 0.02. The gradients are significantly lower outside of the mound areas and average approximately 0.01. The calculated average linear flow velocities range between 0.3 feet/day and 1.5 feet/day.

Groundwater flow velocities are generally not indicative of the rate of contaminant migration. Physicochemical interactions between soils and contaminants generally retard the rate of contaminant migration.

3.2.2.4 Groundwater Discharge

Based on the hydraulic conductivity of 13 feet/day calculated from the aquifer pumping test data, a gradient of 0.01, and a cross-sectional area of 21,000 square feet, the groundwater discharge from the on-site unconsolidated deposits to the Passaic River was calculated to be

20,000 gallons per day. The Passaic Valley Sewerage Commissioners (PVSC) trunk line beneath River Drive may be intercepting groundwater (see Section 7.0 [Conceptual Site Model]).

4.0 NON-AQUEOUS PHASE LIQUID

This section presents a discussion of non-aqueous phase liquid (NAPL) observations. Both light non-aqueous phase liquid (LNAPL) and dense non-aqueous phase liquid (DNAPL) were found during the ECRA-related investigations. LNAPL was observed in the southeastern section of the facility with measurable thicknesses (0.01 foot or greater) of LNAPL detected on-site in Monitoring Wells MW-4, MW-5, MW-7, and MW-9, and Wellpoint WP-7, and off-site in Monitoring Well MW-33 (Figure 4-1). NAPL in each well was sampled. A summary of the constituents of concern and tentatively identified compounds (TICs) detected in NAPL samples is presented in Table 4-1.

The LNAPL samples collected from Monitoring Wells MW-4, MW-7, and MW-33 and Wellpoint WP-7 contained approximately 35 percent, 54 percent, 40 percent, and 29 percent toluene, respectively, and a total of 7 percent, 2 percent, 3 percent, and 8 percent of tentatively identified substituted 1,1'-biphenyl isomers, respectively. The concentration of total petroleum hydrocarbons (TPHCs) was 408,900 milligrams per liter (approximately 41 percent) in the LNAPL sample from Monitoring Well MW-7 (other NAPL samples were not tested for TPHCs). The LNAPL sample collected from Monitoring Well MW-9 contained approximately 0.3 percent toluene, 0.02 percent benzene, and 1 percent total polynuclear aromatic hydrocarbons (PAHs). PAHs were detected at total concentrations of 0.5 percent, 0.2 percent, 0.05 percent, and 0.09 percent in the NAPL samples collected from Monitoring Wells MW-4, MW-7, and MW-33 and Wellpoint WP-7, respectively.

DNAPL was detected in Monitoring Well MW-5. A sample of this DNAPL contained approximately 11 percent toluene, 0.01 percent trichloroethene (TCE), and several tentatively identified substituted 1,1'-biphenyl isomers, which were a total of 16 percent of the sample.

Kalama monitored LNAPL in Monitoring Well MW-7 on eight occasions from May 1988 through June 1989. LNAPL was first observed in January 1988 during a water-level measurement event conducted by Geraghty & Miller. The initial LNAPL-measured thickness was approximately 2 feet. A total of approximately 5 gallons of LNAPL was removed by

Kalama on four occasions from May through June 1988. Since June 1988, LNAPL has been monitored in MW-7 using an oil/water interface tape but it has not been detected. However, a sheen and "product" (as described by the field geologist) were observed in January 1992 on the probe used to monitor MW-7 (see Appendix A). Kalama personnel also removed LNAPL from Monitoring Well MW-5. However, the quantity of LNAPL removed and its recovery were not documented. Appendix A provides additional data on NAPL monitoring and removal.

NAPL removal has been conducted by Geraghty & Miller since April 1992 and is ongoing because of the persistence of LNAPL in certain monitoring wells. The approximate volumes of NAPL removed as of July 1993 from each monitoring well and wellpoint are as follows:

- 30 gallons of LNAPL from Monitoring Well MW-9 during ten events.
- 18 gallons of LNAPL from Wellpoint WP-7 during ten events.
- 8 gallons of LNAPL from Monitoring Well MW-33 during ten events.
- 1 gallon of LNAPL from Monitoring Well MW-4 during two events.
- 0.4 gallon of DNAPL from Monitoring Well MW-5 during one event.

LNAPL persists in Monitoring Wells MW-9 and MW-33, and in Wellpoint WP-7. The original measured thickness of LNAPL in Monitoring Well MW-9 (8.1 feet) has decreased significantly since removal efforts began. Recently, the measured thickness has been less than 1 foot in Monitoring Well MW-9. The original measured thickness of LNAPL in Monitoring Well MW-33 (0.3 foot), has decreased slightly since removal efforts began and currently measured thicknesses range from 0.01 foot to approximately 0.2 foot. Pre- and post-removal NAPL thicknesses measured in Wellpoint WP-7 generally have ranged from approximately 0.1 foot to 0.2 foot.

LNAPL, at a measured thickness of 1.4 feet, was first observed in Monitoring Well MW-4 in October 1992 and a sample was collected at that time. LNAPL has not reappeared in Monitoring Well MW-4 since the second removal event conducted in December 1992.

DNAPL in Monitoring Well MW-5 was removed during sampling in December 1991. The DNAPL thickness measured prior to sampling was 0.5 foot. DNAPL has not been detected in Monitoring Well MW-5 since the December 1991 sampling event.

NAPL was observed in split-spoon samples from 24 soil borings either as globules in the interstices of the soil sample, or smearing on the outside of the split-spoon, or sheens. Locations where such observations were made are shown on Figure 4-1.

Approximately 0.01 foot of LNAPL was detected by Ebasco Environmental of Bellevue, Washington (Ebasco) in a temporary wellpoint installed adjacent to (within 10 feet of) Monitoring Well MW-25. A sheen was detected in a temporary wellpoint installed along Hudson Street approximately 250 feet west of Monitoring Well MW-25. The wellpoints were installed by Ebasco as part of the second phase of the soil-vapor survey (see Appendix M).

5.0 SOIL QUALITY

This section presents a discussion of the soil quality data from all investigations. The discussion is focused on the constituents of concern in the soil (toluene, benzene, phenol, PAHs, and TPHCs) at the facility. The constituents of concern were identified based on an evaluation of the following:

- Their concentrations, frequency of occurrence, distribution, and relationship to site activities.
- The NJDEPE remediation criteria.

Other facility related constituents detected in the soil include methanol, formaldehyde, benzoic acid, and benzaldehyde. These constituents were considered as potential constituents of concern during development of the remedial system because of their concentrations, frequency of occurrence, and distribution. However, the NJDEPE has not established numeric remediation criteria for these constituents. For this reason and because they will be treated incidentally by the proposed remedial system, they have not been retained as individual constituents of concern. Analytical data for the constituents of concern and other facility related constituents are summarized on Figures 5-1a and 5-1b.

5.1 CONSTITUENTS OF CONCERN

The constituents of concern in the soil include volatile organic compounds (VOCs), base/neutral and acid extractable compounds (BNAs), and TPHCs. The concentration, frequency of occurrence, distribution, and the NJDEPE numeric remediation criterion for each constituent of concern are summarized below. Summaries of the constituents detected in soil samples are presented in Tables 5-1 through 5-7.

5.1.1 Volatile Organic Compounds

The VOCs of concern in the soil are toluene and benzene. Analytical data for these compounds and other VOCs detected in the soil are presented in Tables 5-1 and 5-7. A total of 144 soil samples was collected and analyzed during all investigations.

Toluene, the most prevalent VOC in the soil, was detected in 69 of 97 soil samples analyzed for toluene. Concentrations ranged from an estimated 0.001 milligrams per kilogram (mg/kg) in Sample SB-7-B to 20,000 mg/kg in Sample B-26-01. Detections of toluene above the impact-to-groundwater soil remediation criterion of 500 mg/kg were limited to the southeastern section of the facility, which is consistent with the use of toluene as a raw material in the historical manufacturing of benzoic acid and benzaldehyde in this section of the facility.

Benzene was detected in 12 of 82 soil samples analyzed for benzene. Concentrations ranged from 0.066 mg/kg in Sample B-5 to 80 mg/kg in Sample B-26-01. Detections of benzene above the impact-to-groundwater soil remediation criterion of 1 mg/kg were limited to the southeastern section of the facility, which is consistent with the historical manufacturing of benzoic acid and benzaldehyde in this section of the facility.

Trichloroethene was not detected in any of the soil samples.

5.1.2 Base/Neutral and Acid Extractable Compounds

The BNAs of concern in the soil are phenol and PAHs. Analytical data for these compounds and other BNAs detected in the soil are presented in Table 5-2.

Phenol was detected in 17 of 62 soil samples analyzed for phenol. In addition, 22 of 47 soil samples tested positive for total phenolics (Table 5-3). Because of the probable presence of compounds, notably biphenyls, that would produce false-positive results for the total phenolics test, the reported total phenolic concentrations are not considered indicative of phenol

B-44-02) at concentrations of 0.47 mg/kg and 2.2 mg/kg, respectively. Metals and PCBs are not considered constituents of concern.

5.4 TENTATIVELY IDENTIFIED COMPOUNDS

Non-target compounds were tentatively identified in the VOC and BNA fractions obtained from each soil sample. These compounds were identified by a comparison of the mass spectra recorded during the sample analysis to a library of mass spectra. The non-target compounds, commonly referred to as TICs, are summarized in Table 5-7. The TICs presented in this table have been grouped into general categories by functional group. The most frequently identified compounds are substituted biphenyls, biphenylethers, and hydrocarbons. Substituted biphenyls and biphenylethers were detected most frequently in the southeastern section of the facility. Hydrocarbons were detected most frequently in the eastern section of the facility. There are no established soil remediation criteria for the TICs identified in the soil at the facility. The TICs are not considered constituents of concern.

6.0 GROUNDWATER QUALITY

This section presents an evaluation of the groundwater quality data from all investigations. The discussion of groundwater quality focuses on current conditions, as evidenced by the most recent groundwater samples, with respect to the constituents of concern (toluene, benzene, phenol, PAHs, and TPHCs). The constituents of concern were identified based on an evaluation of the following:

- Their concentrations, frequency of occurrence, distribution, and relationship to site activities.
- The NJDEPE remediation criteria.

Other facility related constituents detected in the groundwater include methanol, formaldehyde, benzoic acid, and benzaldehyde. These constituents were considered as potential constituents of concern during development of the remedial system because of their concentrations, frequency of occurrence, and distribution. However, the NJDEPE has not established numeric remediation criteria for these constituents. For this reason and because they will be treated incidently by the proposed remedial system, they have not been retained as individual constituents of concern. Analytical data for the constituents of concern and other facility related constituents are presented on Figure 6-1. The analytical data for the bedrock groundwater are presented in Section 6.6 (Bedrock Groundwater Quality).

6.1 CONSTITUENTS OF CONCERN

The constituents of concern in the groundwater include VOCs, BNAs, and TPHCs. The concentration, frequency of occurrence, distribution, and the NJDEPE numeric remediation criterion for each constituent of concern are summarized below.

6.1.1 Volatile Organic Compounds

The VOCs of concern in the overburden groundwater are toluene and benzene. Analytical data for these compounds and other VOCs detected in the groundwater, from all phases of the investigation, are provided in Table 6-1. A total of 74 on-site and off-site groundwater sampling points (monitoring wells, wellpoints, and piezometers; collectively referred to as wells) was employed to collect groundwater samples.

Toluene was detected in 48 of the 75 wells at concentrations ranging from 0.001 to 370 mg/L. Detections of toluene in the groundwater above the remediation criterion of 1 mg/L are observed only in the southern part of the facility, particularly in the southeastern section, and off-site to the south across Hudson Street (Figure 6-1). A comparison of the data from shallow and deep monitoring wells indicates that toluene concentrations generally decrease with depth. The only deep wells that have exhibited toluene concentrations above the remediation criterion of 1 mg/L are Monitoring Wells MW-10D, MW-17D, and MW-33D, which are located in the southeastern section of the facility.

Benzene was detected in 36 of the 75 wells at concentrations ranging from 0.001 to 7.3 mg/L. Detections of benzene in the groundwater above the remediation criterion of 0.001 mg/L are observed in the southern part of the facility, particularly in the southeastern section, and off-site to the south across Hudson Street to Riverside Avenue (Figure 6-1). Benzene was detected slightly above the remediation criterion in one recent groundwater sample (MW-2D) from the northwestern section of the facility. The concentration reported in that sample was estimated at 0.002 mg/L.

6.1.2 Base/Neutral and Acid Extractable Compounds

The BNAs of concern in the overburden groundwater are phenol and PAHs. Analytical data for these compounds and other BNAs detected in the groundwater are provided in Table 6-2.

Phenol was detected in 53 of the 75 wells at concentrations ranging from 0.001 to 5,600 mg/L. Detections of phenol in the groundwater above the remediation criterion of 4 mg/L are primarily observed in the northeastern and southwestern sections of the facility (Figure 6-1).

PAHs were detected in 33 of the 75 wells at total concentrations ranging from 0.0007 to 16 mg/L. Detections of total PAHs in groundwater samples above the remediation criterion of 0.01 mg/L are observed in the southeastern section of the facility (Figure 6-1). Total PAHs were detected slightly above the remediation criterion of 0.01 mg/L in a recent groundwater sample (MW-2) from the northwestern section of the facility. The concentration reported in that sample was estimated at 0.016 mg/L.

6.1.3 Petroleum Hydrocarbons

TPHCs were detected in 32 of 75 wells at concentrations ranging from 0.5 to 290 mg/L (Table 6-3). Although the NJDEPE has not established a numeric groundwater remediation criterion for TPHCs, the department has established a general organic contaminant criterion of 1 mg/L. Detections of TPHCs in overburden groundwater above 1 mg/L are observed only in the southern part of the facility, particularly in the southeastern section, and off-site to the south across Hudson Street (Figure 6-1).

6.2 OTHER FACILITY RELATED CONSTITUENTS

A summary of methanol and formaldehyde concentrations detected in overburden groundwater samples is provided in Table 6-4. The distribution of methanol in the groundwater is similar to the distribution of phenol in the groundwater.

Formaldehyde was detected in 53 of 75 wells at concentrations ranging from 0.1 to 952 mg/L (Table 6-4). The highest formaldehyde concentrations in the groundwater were observed in the northeastern section of the facility.

Benzoic acid was detected in 45 of 75 wells at concentrations ranging from 0.001 to 170 mg/L (Table 6-2). The highest benzoic acid concentrations in the groundwater were observed in the southeastern section of the facility.

Benzaldehyde was detected in 31 of 75 monitoring wells at concentrations ranging from 0.001 to 0.99 mg/L (Table 6-2). The highest benzaldehyde concentrations in the groundwater were observed in the southeastern section of the facility and off-site to the south across Hudson Street.

6.3 BACKGROUND CONSTITUENTS

TCE was detected in 39 of the 75 wells at concentrations ranging from 0.001 to 13 mg/L (see Section 7.4 [Regional Background Contamination]). TCE has been detected above the remediation criterion of 0.001 mg/L at all off-site well locations. Concentrations increase with depth, with the highest levels occurring in off-site Monitoring Wells MW-16D (13 mg/L) and MW-34D (8.1 mg/L) located on Cambridge Avenue, adjacent to the southeastern section of the facility. The highest on-site concentration of TCE detected in the groundwater is 4.2 mg/L, which was detected in the groundwater sample from Monitoring Well MW-5D (in the southeastern section of the facility). TCE was detected in MW-5D2 (the only monitoring well completed in the till/bedrock) at a concentration of 1.0 mg/L, and was also detected in the two off-site bedrock monitoring wells (see Section 6.6 [Bedrock Groundwater Quality]).

6.4 OTHER CONSTITUENTS

Other constituents tested for in overburden groundwater samples include major and minor ions, total organic carbon (TOC), total suspended solids (TSS), total dissolved solids (TDS), biological oxygen demand (BOD), chemical oxygen demand (COD), and nutrients. These constituents were analyzed in order to evaluate the treatability of groundwater. A summary of these constituents is presented in Tables 6-4 and 6-5.

6.5 TENTATIVELY IDENTIFIED COMPOUNDS

Non-target compounds were identified in the VOC and BNA fractions from each overburden groundwater sample. These compounds were identified by comparison of the mass spectrum recorded during the analysis to a library of mass spectra. A qualitative summary of the non-target compounds, commonly referred to as TICs, is provided in Table 6-6. The TICs presented in this table have been grouped into general categories by functional group. The most frequently identified compounds are substituted biphenyls, biphenylethers, and 2-hydroxybenzoic acid. Substituted biphenyls and biphenylethers were detected most frequently in the southeastern section of the facility. 2-Hydroxybenzoic acid was detected most frequently in the northeastern section of the facility. There are no established groundwater remediation criteria for the TICs identified in the groundwater at the facility. The TICs are not considered constituents of concern.

6.6 BEDROCK GROUNDWATER QUALITY

The analytical data for the bedrock groundwater are provided in Tables 6-7, 6-8, and 6-9. These tables also provide the analytical data for the till/bedrock well and clustered overburden wells, which were sampled along with the bedrock wells.

Toluene was detected in one of the three bedrock wells (MW-20D2) at an estimated concentration of 0.002 mg/L. Monitoring Well MW-20D2 is located off-site and east of the facility. Toluene also was detected in the groundwater sample from the on-site till/bedrock well (MW-5D2) at a concentration of 0.97 mg/L. The NJDEPE remediation criterion for toluene is 1 mg/L. Benzene was not detected in the bedrock groundwater, but was detected in the groundwater sample from the till/bedrock well at an estimated concentration of 0.044 mg/L, which is above the NJDEPE remediation criterion of 0.001 mg/L.

TCE was detected above the NJDEPE remediation criterion of 0.001 mg/L in all the groundwater samples from the bedrock wells. The TCE concentrations in upgradient, off-site monitoring wells of 0.059 mg/L (MW-35D2) and 0.19 mg/L (MW-20D2) are greater than the on-site concentration of 0.058 mg/L (MW-4D2). TCE also was detected in the groundwater sample from the till/bedrock well (MW-5D2) at a concentration of 0.79 mg/L.

Phenol was not detected in the bedrock groundwater but was detected at an estimated concentration of 0.008 mg/L in the groundwater sample from the till/bedrock well (MW-5D2). The NJDEPE remediation criterion for phenol is 4 mg/L. PAHs, TPHCs, methanol, benzoic acid, and benzaldehyde were not detected in the groundwater samples from the three bedrock wells or the till/bedrock well. Formaldehyde was detected in the groundwater samples from the off-site bedrock wells at concentrations of 0.17 mg/L (MW-20D2) and 0.13 mg/L (MW-35D2) but was not detected in the groundwater samples from the on-site bedrock well and till/bedrock well.

7.0 CONCEPTUAL SITE MODEL

This section describes the sources of soil, NAPL, and groundwater contamination at the site, presents a conceptual site model of subsurface contaminant transport, and identifies the remedial goals for the cleanup of the constituents of concern at the site.

7.1 CONSTITUENTS OF CONCERN

The following constituents of concern have been identified (see Sections 5.0 [Soil Quality] and 6.0. [Groundwater Quality]).

Constituent	Impacted Media
Benzene	Soil, NAPL, and groundwater
Toluene	Soil, NAPL, and groundwater
Phenol	Soil, NAPL, and groundwater
TPHCs	Soil, NAPL, and groundwater
PAHs	Soil, NAPL, and groundwater

7.1.1 Benzene and Toluene

Benzene and toluene are aromatic hydrocarbons that are used commercially as feedstocks for chemical syntheses and as solvents for chemical reactions. They are also components of gasoline and fuel oil. Both are lighter than water and therefore form LNAPL if released into the subsurface in sufficient quantity. Benzene and toluene interact with (adsorb to) the soil matrix due to their chemical structure. The adsorption affinity of benzene and toluene, as measured by K_{OC}, is 78 for benzene and 132 for toluene. Benzene and toluene also have appreciable aqueous solubilities, 1,700 mg/L and 580 mg/L respectively. Therefore, infiltrating precipitation will dissolve a fraction of the adsorbed material as it percolates through the unsaturated zone, and benzene and toluene adsorbed on soil will be a continuing source of groundwater contamination. Benzene and toluene in LNAPL will also be a continuing long-term source of groundwater contamination because of their dissolution by groundwater.

The southeastern section of the site is the source area for benzene and toluene, which have been detected in both the soil and LNAPL. Approximately 40 percent of the soil samples collected in the southeastern section were above the NJDEPE remediation criteria for benzene and toluene of 1 mg/kg and 500 mg/kg, respectively (Figures 7-1 and 7-2). All of the LNAPL on- and off-site is in, or downgradient of, the southeastern section of the facility.

Groundwater has also been impacted by the benzene and toluene sources in the southeastern section of the site. The impacted groundwater extends off-site to the south. The benzene and toluene areas of concern, as defined by the NJDEPE remediation criteria of 0.001 mg/L for benzene and 1 mg/L for toluene, are shown on Figures 7-3 and 7-4, respectively.

Toluene and benzene contamination sources in the southeastern section of the site are consistent with the historic usage of these chemicals in this area of the facility. Toluene was used as a feedstock in the benzoic acid/benzaldehyde manufacturing process, which was carried out in the southeastern section of the site from 1962 to 1984. The toluene for this process was stored in nearby USTs located north of Building 18. A number of spills and releases of toluene and benzene in the southeastern section of the site have been documented (see Section 2.2.2 [Manufacturing History]).

Benzene was a contaminant in the toluene used for the production of benzoic acid/benzaldehyde and was produced as a by-product of this manufacturing process. It is reported that on one occasion in 1978, instead of feedstock toluene, benzene was shipped to the site and put into a reactor vessel. When this error was discovered, the benzene was removed from the reactor vessel and placed in UST that was known to leak, located north of Building 18.

Other potential benzene and toluene sources include the gasoline UST formerly located north of Building 22 and the fuel oil USTs formerly located south of Buildings 20 and 25.

Another potential source of benzene was the production of Resorcinol, from 1940 to the mid-1950s, in Building 10-T, which used benzene as a feedstock. There was a fire and explosion in this building in February 1951.

The Passaic River is a receptor for the dissolved benzene and toluene plumes. However, benzene and toluene concentrations detected in monitoring wells located on the east side of River Drive (MW-14, MW-23, and MW-31) and within the dissolved toluene and benzene plumes are significantly higher than the concentrations in the wells on the west side of the street (MW-15, MW-21, and MW-22). This concentration gradient suggests that the PVSC line below River Drive, which is below the water table, is intercepting groundwater.

Based on the average concentrations observed in the monitoring wells adjacent to the Passaic River (MW-15, MW-21, and MW-22) benzene exceeds the NJDEPE allowable monthly average and daily maximum effluent limits for FW-2 surface waters. Toluene concentrations in those wells are below both the daily maximum and monthly average effluent limits.

The water purveyor survey indicates that groundwater is not withdrawn from the benzene or toluene plume area (see Appendix K). The purveyor survey and associated well search indicates that no private potable (drinking) water supply wells are located within 0.5 mile of the site, east of the Passaic River. Therefore, there is no groundwater exposure pathway for benzene and toluene.

The observed Henry's law (K_H) constants for benzene and toluene are 5.48×10^{-3} atmospheres cubic meters/mole (atm m^3/mol) and 6.7×10^{-3} atm m^3/mol, respectively. As such, volatilization from the soil, LNAPL, or the shallow groundwater can be a transfer mechanism. Volatilization is a significant transfer mechanism when K_H is in the range from 10^{-5} to 10^{-3} atm m^3/mol. Values of K_H greater than 10^{-3} atm m^3/mol indicate volatilization will proceed rapidly (Lyman, et al. 1982). Therefore, a soil-vapor survey was conducted off-site to evaluate this pathway (see Appendices B and M). Benzene was detected in soil-vapor samples collected from north and south of the site. The samples collected from the north are a considerable distance from the benzene area of concern for the soil and the groundwater (Figures 7-1 and 7-3) which suggests an off-site source. The samples collected to the south are within the benzene and toluene plume emanating from the southeastern section of the site. Benzene and toluene could potentially impact residences located above the plume by volatilizing from the groundwater and diffusing into basements. Potential impacts from soil-vapor to off-site receptors via the air pathway were investigated as part of the second phase of the soil-vapor survey (see Appendix M).

7.1.2 Petroleum Hydrocarbons and Polynuclear Aromatic Hydrocarbons

TPHCs and PAHs are components of fuels (gasoline and fuel oil). Historically, fuel oil at the site was stored in the following areas of the site: the northwestern section, north of Building 7 (No. 6 fuel oil) and east of Building 33-B (No. 2 fuel oil); the northeastern section, east of Building 12 (No. 2 fuel oil); the southeastern section, south of Building 20 (No. 2 fuel oil) and north of Building 22 (gasoline); and the southwestern section, south of Building 25 (No. 2 fuel oil). All USTs were removed from the facility by Kalama and Tenneco from September 1987 through February 1990. Soil samples collected after removal indicated the presence of TPHCs in some of the soils from the tank pits (see Table 5-7). The contaminated soils apparently are a source of groundwater contamination. Additionally, several of the tank excavations filled with water after tank removal, which suggests that any leaks or spills from the tank may have also directly contaminated the groundwater.

There are two soil areas of concern for TPHCs above the NJDEPE remediation criterion of 10,000 mg/kg (Figure 7-5). Area 1 is located south of Building 20 in the area of former UST E-1. Former UST E-1 was used to store No. 2 fuel oil. Area 2 is located north of Building 7 and is in the area of former USTs E-5, E-6, A-7, and E-8. Those tanks were used to store No. 6 fuel oil.

The compounds that make up No. 6 fuel oil are strongly adsorbed to soil and, therefore, less of this fuel will be leached into the groundwater by infiltrating precipitation. This observation is supported by the general absence of TPHC groundwater contamination in the northwestern section of the site.

The LNAPL observed in MW-7, located in the southeastern section of the site, contained approximately 41 percent TPHCs. Since the components of an LNAPL are dissolved by groundwater and infiltrating precipitation, this LNAPL was a continuing source of groundwater contamination until it was removed by Kalama in 1988.

The TPHC area of concern in groundwater, defined by the NJDEPE remediation criterion of 1 mg/L, is shown on Figure 7-6. The figure shows a plume of TPHC-contaminated groundwater extending from TPHC Area 1 in the southeastern section of the site, westward towards the Passaic River. The plume includes the locations of Monitoring Wells MW-4 and MW-7, in which LNAPL containing TPHCs was detected and removed during the ECRA investigation. No TPHC contamination above the NJDEPE remediation criterion of 1 mg/L was detected in groundwater downgradient of TPHC Area 2.

The FW-2 standard for TPHCs is "non-noticeable"; therefore, Geraghty & Miller used the surface-water remediation goal of 1 mg/L (the typical detection limit for TPHC analysis) to evaluate TPHC impacts to the Passaic River. Concentrations observed in Monitoring Wells MW-15, MW-21, and MW-22 are less than 1 mg/L and, accordingly, there are no impacts to the river above the FW-2 remediation goal. However, as discussed above for benzene and toluene, concentrations of TPHCs detected in the monitoring wells located on the east side of River Drive are higher than those on the west side of the street, suggesting that the PVSC line located below River Drive is intercepting groundwater.

Because a portion of the TPHC plume extends off-site to the south of the site, TPHCs could potentially impact the residences located above the plume by volatilizing from the groundwater and diffusing into the basement. This potential was investigated as part of the second phase of the soil-vapor survey (see Appendix M).

Tank pit soil samples were not tested for PAHs during the removal of the former USTs. However, PAHs were tested for in soil samples collected from borings installed adjacent to the tank pits during the ECRA-related investigations to define the extent of soil contamination. Samples in which PAHs were detected include the following: S-1, B-2, B-3, and B-4, installed adjacent to USTs A-9 through A-12; B-6, B-9, and B-53 installed adjacent to USTs C-2 and E-1; and B-40, B-50, and S-12 installed adjacent to UST A-4. PAHs are leached into the groundwater by precipitation, albeit at a somewhat lower rate than benzene and toluene. Infiltration of precipitation, into the groundwater will create a dissolved plume since most PAHs are soluble in water. The LNAPLs observed in Monitoring Wells MW-4, MW-7, MW-9, and MW-33, and in Wellpoint WP-7 contained PAHs ranging in concentration from 0.05 to 1 percent. As indicated previously, these wells are all located in the southeastern section of the site. The PAHs in the LNAPLs are also a source of groundwater contamination because the groundwater flowing under the LNAPL will dissolve soluble components from it.

The PAH areas of concern in soil, defined by the NJDEPE remediation criterion of 100 mg/kg, are shown on Figure 7-7. The PAH area of concern in groundwater, as defined by the NJDEPE remediation criterion of 0.01 mg/L, is shown on Figure 7-8. Groundwater samples collected in the expected path of the PAH plume (i.e., from monitoring wells in the southwestern section of the site) were analyzed for PAHs, but some of the PAH detection limits exceeded the remediation criterion of 0.01 mg/L.

7.1.3 Phenol

Phenol is used in the production of salicylic acid, which is carried out in the northeastern section of the plant in Buildings 10 and 36. Salicylic acid has been produced at the site since the early 1900s. Phenol above the NJDEPE remediation criterion of 50 mg/kg was detected in soil samples collected in the northeastern section of the site, west of Building 36, and in soil samples collected below Buildings 36 and 10-E. The phenol areas of concern in the soil are shown on Figure 7-9. The source of the phenol is apparently the chemical manufacturing operations conducted in Buildings 10 and 36. Phenol has been detected in process wastewater samples collected from the floor canals in Buildings 36 and 10-Q, and from the floor of Building 10-E.

The K_{OC} for phenol is 22 and its aqueous solubility is 93,000 mg/L. Therefore, phenol entering the subsurface is transported rapidly into the groundwater and forms a dissolved plume in the direction of groundwater flow. The phenol area of concern in groundwater above the NJDEPE criterion of 4 mg/L is shown on Figure 7-10. The phenol plume extends from the source area in the northeastern section of the site downgradient toward the Passaic River. There is no substantial off-site component to the phenol plume (Figure 7-10). The water purveyor survey (see Appendix K) indicates that groundwater from the unconsolidated aquifer is not used in this part of Garfield. No potential impact to receptors exists because phenol has a low K_H and therefore would not be expected to create a soil-vapor problem. The average phenol concentrations in the monitoring wells adjacent to the Passaic River (MW-15, MW-21, and MW-22) are below both the NJDEPE daily maximum and monthly average discharge limits to FW-2 class waters. Phenol concentrations are higher in groundwater samples collected from monitoring wells located to the east of River Drive than in those located to the west of the street, suggesting that the PVSC line is intercepting groundwater. The pattern of soil and groundwater contamination observed at the site is consistent with phenol usage at the facility.

7.2 REMEDIATION GOALS

Based on the distribution of the constituents of concern in environmental media at the site, soil, NAPL, and groundwater were identified as media of concern. Media-specific remediation goals, for each of the constituents of concern, were then identified. The remedial goals are based on the conceptual site model as presented above and applicable NJDEPE remediation criteria. A summary of the range of detected concentrations for each of the constituents of concern, by medium, is provided in Table 7-1.

7.2.1 NJDEPE Remediation Criteria

The remediation criteria for each media of concern are identified in the following sections.

7.2.1.1 Soil Remediation Criteria

Soil remediation criteria, for surface and subsurface soil, consist of the following:

- "Soil Cleanup Criteria," NJDEPE, March 8, 1993 (derived from Tables 3-1 and 7-1 of Proposed New Rule NJAC 7:26D, New Jersey Register, February 3, 1992, and subsequently revised).
- Criteria provided by the NJDEPE in the June 1, 1993 conditional approval letter addressed to Kalama.

Surface soil cleanup criteria are based on the assumed contact between a human receptor and the contaminated soil, and are established for residential and non-residential settings. Surface soil cleanup criteria were developed to reduce risk associated with chronic ingestion of relatively small amounts of soil. Because the facility is used for industrial operations, non-residential direct contact surface soil cleanup criteria are applicable to the facility.

Subsurface soil cleanup criteria were developed to protect groundwater, surface water, and structures potentially affected by contaminants in subsurface soil. Subsurface or impact-to-groundwater soil cleanup criteria are based on leaching of contaminants to groundwater and were developed by the NJDEPE to protect groundwater quality in areas where groundwater is an actual or potential potable drinking water source. Subsurface cleanup criteria for VOCs are based on a model that predicts the percentage of contaminants that may leach to groundwater over 70 years, while criteria developed for semivolatile organic compounds (SVOCs) were developed using a ranking system that considered solubility, biodegradability, and toxicity.

Non-residential direct contact soil cleanup criteria and impact-to-groundwater soil cleanup criteria for the constituents of concern were compared (Table 7-2). Impact-to-groundwater soil cleanup criteria were found to be more stringent for the constituents of concern. As required in the NJDEPE conditional approval letter to Kalama, dated June 1, 1993, the more stringent criteria (i.e., impact-to-groundwater soil cleanup criteria) are required to be used in remedial action activities at the facility.

Additional criteria utilized by the NJDEPE in evaluating soil cleanups were also provided in the conditional approval letter. The additional guidance specifies that total organic contaminants in soil must be remediated to a level below 10,000 parts per million (ppm). Total organic contaminants include a wide range of contaminants including TPHCs and other carbon-based compounds. The additional NJDEPE criterion has also been incorporated into the proposed remediation criteria for the facility (Table 7-2).

7.2.1.2 Groundwater Remediation Criteria

The guidance identified by the NJDEPE for groundwater remediation is the Groundwater Quality Standards (NJAC 7:9-6) which were developed based on the primary receptors for each class of groundwater. The standards are protective of the primary designated groundwater use for each class. Geraghty & Miller has assumed that the groundwater beneath the facility is classified as Class II-A. The groundwater quality standards for Class II-A groundwater are presented in Table 7-3.

7.2.1.3 Additional Remediation Criteria

As required by the NJDEPE, additional remediation criteria to be considered at the facility are as follows:

- Source removal/control.
- NAPL removal.

- Effluent criteria for surface water.

A summary of the additional remediation criteria is presented in Table 7-4.

7.2.1.4 Site-Specific Risk Based Remediation Goals

The remediation goals for the site are to achieve the NJDEPE remediation criteria discussed above. However, consideration of site-specific risk based remediation goals may be appropriate based on an evaluation of the remedial system's performance.

7.3 SPECIFIC REMEDIATION GOALS FOR THE CONSTITUENTS OF CONCERN

The remediation goals for each constituent of concern are presented in the following sections.

7.3.1 Benzene and Toluene

The remediation goals for the benzene and toluene contamination are as follows:

- Remediate/remove the soil sources of benzene and toluene so that concentrations remaining in soil are below 1 mg/kg and 500 mg/kg, respectively.
- Remove NAPL to eliminate these sources of benzene- and toluene-contamination.
- Hydraulically contain the benzene and toluene contaminated groundwater at the facility boundary.

- Reduce benzene and toluene concentrations in the groundwater so that concentrations in groundwater are below 0.001 mg/L and 1 mg/L, respectively.

7.3.2 Petroleum Hydrocarbons and Polynuclear Aromatic Hydrocarbons

The remediation goals for TPHC and PAH contamination are as follows:

- Remediate/remove the soil sources of TPHCs and PAHs so that concentrations remaining in soil are below 10,000 mg/kg and 100 mg/kg, respectively. Total organic contaminant concentrations also cannot exceed 10,000 mg/kg.

- Remove NAPL to eliminate these sources of TPHC and PAH contamination.

- Hydraulically contain the TPHC and PAH contaminated groundwater at the facility boundary.

- Reduce TPHC concentrations in the groundwater so that concentrations are below 1 mg/L.

7.3.3 Phenol

The remediation goals for phenol contamination are as follows:

- Eliminate operational sources of phenol to the groundwater.

- Reduce phenol concentrations in the groundwater to below 4 mg/L.

7.4 REGIONAL BACKGROUND CONTAMINATION

Trichloroethene is a common solvent used for degreasing and drying metals; as a solvent for oils, waxes and fats; as a refrigerant and heat exchange medium; as a dry cleaning agent; and as a solvent in organic syntheses. Trichloroethene was not detected in any of the soil samples collected at the Garfield site; however, documents indicate that Tenneco used chlorinated organic compounds during the 1960s. Those compounds included TCE, TCA, and carbon tetrachloride, which were used in pilot and research projects, and PCE, which was used in connection with maintenance of the DowTherm heat transfer boiler formerly located in the southeastern section of the facility. There is no known TCE usage by Kalama. TCE was detected in the DNAPL removed from Monitoring Well MW-5, and in groundwater collected from 38 of the 72 overburden monitoring wells (Figure 7-11). Nine of these wells are either upgradient of, or otherwise outside, the area of groundwater impacted by site operations. Statistical evaluation using probability plots indicates that the background concentration of TCE in the study area is approximately 0.45 mg/L. Therefore, in addition to any sources that may have been present at the Garfield site, Geraghty & Miller has concluded that there is regional TCE contamination in the overburden aquifer.

Trichloroethene was also detected in the till/bedrock Monitoring Well MW-5D2 and in all three of the bedrock monitoring wells (MW-4D2, MW-20D2 and MW-35D2). These wells are located off-site to the east (MW-20D2), to the southeast (MW-35D2), and in the southeastern section of the site (MW-4D2 and MW-5D2). Groundwater flow in the bedrock aquifer is from east to west, similar to that of the overburden aquifer (see Section 3.0 [Geology and Hydrogeology]). The concentrations of TCE in monitoring wells MW-4D2, MW-20D2, and MW-35D2 are within the estimated regional background TCE concentration of 0.45 mg/L, suggesting that there is also regional TCE contamination of the bedrock aquifer.

DNAPL containing TCE was observed in Monitoring Well MW-5 (see Section 4.0 [Non-Aqueous Phase Liquid]). The dynamics of DNAPL movement suggest that the TCE detected in Monitoring Well MW-5D2 above background concentrations likely results from the vertical migration of a DNAPL containing TCE to the till-bedrock interface. The only detected on-site source of TCE was the DNAPL formerly observed in Monitoring Well MW-5. NAPL will be removed as a component of the proposed remedial plan, which will incidently remove any TCE contamination that may exist.

8.0 REMEDIAL ALTERNATIVES ANALYSIS FOR THE DEVELOPMENT OF THE PROPOSED REMEDIAL ACTION PLAN

This section presents a remedial alternatives analysis, based upon the results of the ECRA investigation, for development of the proposed remedial action plan. The remedial alternatives analysis for a site-wide remedial system included the following steps:

- Develop general response actions.
- Identify and screen remedial technologies and identify process options applicable to the response actions.
- Screen process options for the remedial technologies.
- Evaluate remaining process options based on effectiveness, implementability and relative cost.
- Assemble selected process options into a proposed remedial system for the facility.

8.1 OVERVIEW OF PROPOSED REMEDIAL SYSTEM

The proposed remedial system will provide a cost-effective program to meet site remedial goals. It includes the following:

- On-site source control and treatment of on-site contamination, including the following:

- Institutional controls (deed notices and physical restrictions).
- Asphalt capping to reduce leaching of soil contaminants.
- Development of a hydraulic barrier to restrict off-site migration of groundwater.
- Physical removal (bailing) and off-site incineration of NAPL.
- Treatment of contaminated soils by engineered soil piles and off-site disposal.
- Collection, on-site treatment and biosparging of contaminated groundwater.

- Treatment of off-site contaminated groundwater on the south side of the plant, including the following:

  - Physical removal (bailing) and off-site incineration of NAPL.
  - Collection and on-site treatment of contaminated groundwater.

- Groundwater monitoring to demonstrate compliance and to assess remedial system performance.

8.2 OBJECTIVES OF THE PROPOSED REMEDIAL SYSTEM

The objectives of the proposed remedial system are as follows:

- On-site source control and treatment of on-site contamination.
- Treatment of off-site contaminated groundwater on the south side of the plant.
- Groundwater monitoring to demonstrate compliance and to assess remedial system performance.

8.3 GENERAL RESPONSE ACTIONS

General response actions are site-specific remedial actions that will address the conditions of concern for each specific medium (NAPL, soil, and groundwater) at the site. The general response actions for the conditions of concern at the Kalama facility are as follows:

- NAPL
  - No further action
  - NAPL recovery
  - NAPL treatment/disposal

- Soil
  - No action
  - Institutional controls
  - Containment
  - Source control: in-situ treatment
  - Source control: on-site ex-situ treatment
  - Source control: removal and disposal

- Groundwater
  - No action
  - Institutional controls
  - Containment and management of migration
  - Source control
  - Collection
  - In-situ treatment
  - On-site ex-situ treatment
  - Discharge

8.4 IDENTIFICATION AND SCREENING OF REMEDIAL TECHNOLOGIES

The term remedial technologies refers to general categories of remedial action, such as capping or biological treatment. Process options, which are identified in this section and screened in Section 8.5, refer to specific processes within each technology category, such as an asphalt cap or engineered soil piles. The purpose of this section is to identify and screen remedial technologies associated with the general response actions presented in Section 8.3. The remedial technologies screening process is based on technical implementability and potential effectiveness in addressing conditions of concern at the site. If these two threshold conditions are met, a remedial technology will be retained for further evaluation.

NAPL, soil, and groundwater remedial technologies are presented below. For each technology, the justification for either retention for further evaluation or elimination from further consideration is discussed.

8.4.1 NAPL Remedial Technologies

Remedial technologies for the removal, treatment, and disposal of NAPL are identified and screened in this section. The NAPL remedial technologies screening process is summarized in Table 8-1.

8.4.1.1 No Further Action

The no further action alternative would result in discontinuance of the existing NAPL removal program (see Section 4.0 [Non-Aqueous Phase Liquid]) and thus would allow this medium to continue to act as a source of soil and groundwater contamination. Evaluation of the no further action alternative provides a baseline against which other remedial alternatives are evaluated and, therefore, is retained.

8.4.1.2 NAPL Removal

Physical removal is the only applicable remedial technology for NAPL. Physical removal is implementable and potentially effective and, therefore, is retained. The physical removal process options to be screened (see Section 8.5) are as follows:

- Automated NAPL/water pumping and separation.
- Automated NAPL pumping.
- Manual NAPL bailing and pumping.

8.4.1.3 NAPL Treatment/Disposal

There are two applicable remedial technologies associated with NAPL treatment and disposal: thermal treatment and off-site disposal. Thermal treatment of NAPL is implementable and potentially effective and, therefore, is retained. Thermal treatment process options to be screened (see Section 8.5) are as follows:

- On-site incineration.
- Off-site incineration

Off-site disposal would involve the disposal of recovered NAPL at a Resource Conservation and Recovery Act (RCRA) landfill. This remedial technology is not implementable because of the Land Disposal Restrictions (LDRs) and, therefore, is not retained.

8.4.2 Soil Remedial Technologies

The soil remedial technologies identified and screened in this section are technologies designed to reduce or eliminate potential direct contact with contaminants and eliminate contaminant leaching to the groundwater. The soil remedial technologies screening process is summarized in Table 8-2.

8.4.2.1 No Action

Under no action, soil remediation would not be conducted, and thus contaminated soils would continue to act as a source of groundwater contamination and a risk of exposure by direct contact. The no action alternative provides a baseline against which other remedial alternatives are evaluated and, therefore, is retained.

8.4.2.2 Institutional Controls

Institutional controls restrict access to impacted soil areas. Remedial technologies associated with institutional controls include access restrictions. Access restrictions are implementable and potentially effective, and may be applicable in conjunction with other, engineered remedial technologies; therefore, they are retained. Access restrictions process options to be screened (see Section 8.5) are as follows:

- Deed notices and restrictions
- Physical restrictions

8.4.2.3 Containment

Containment for soils reduces the migration of contaminants by isolating the soils, reducing the leaching of soil contamination to surface water and groundwater, and preventing migration by wind.

Capping is the only applicable remedial technology for soil containment. Capping involves the placement of an engineered cover over the contaminated soil. Capping is implementable and potentially effective and is retained. The capping process options to be screened (see Section 8.5) are as follows:

- Clay cap.
- Concrete cap.
- Asphalt cap.

8.4.2.4 Source Control

Soil source control measures have been partially implemented at the site by the elimination of operational sources of VOC contamination, associated with the benzoic acid/benzaldehyde manufacturing process in the southeast portion of the facility. This process was terminated by Kalama in February 1984. Associated USTs that contributed to soil contamination were removed between 1987 and 1990; however, contaminated soils remain on site.

8.4.2.4.1 Source Control: In-Situ Treatment

In-situ soil treatment degrades, removes, or detoxifies hazardous components in place. There are three applicable remedial technologies for in-situ soil treatment: physical/chemical, biological, and thermal. Physical/chemical technologies are implementable and potentially effective for treatment of certain soil contaminants of concern and, therefore, are retained. The physical/chemical process options to be screened (see Section 8.5) are as follows:

- Soil vapor extraction.
- Soil flushing.
- Soil solidification/stabilization.

Biological treatment technology is also implementable and potentially effective for treatment of certain soil contaminants of concern and, therefore, is retained. The biological process option to be screened (see Section 8.5) is as follows:

- Soil bioventing.

Thermal treatment technology process options are in-situ vitrification (ISV) and radio frequency heating. ISV involves placing an array of electrodes in the soil to be vitrified and applying electric power to heat and vitrify the soil. A high current is passed through these electrodes, heating the adjacent soil to approximately 2,900 to 3,600 degrees Fahrenheit (°F) and causing the soil to melt. As the melting soil spreads downward and outward, it thermally destroys organic contaminants by pyrolysis. Off-gases migrate to the surface where they are treated prior to atmospheric release. Inorganic soil contaminants are dissolved into, or encapsulated within, the vitrified mass. When the electric current ceases, the mass cools and solidifies into a glassy, solid matrix similar in form and durability to the igneous rock obsidian. The ISV process option is not implementable at the site due to the complex underground utility network and the nearby foundations; therefore, this process option will not be retained.

Radio frequency heating is a technique for rapid and uniform in-situ heating of large volumes of soil. It heats the soil to the point where volatile and semivolatile contaminants are vaporized into the soil matrix. Vented electrodes recover the gases formed in the soil matrix. The concentrated extracted gas stream can be incinerated or subjected to other treatment methods. This process option is applicable to predominantly sandy soils (Dev et al. 1988). The overburden soil at the site has a high content of clay and silts and, therefore, radio frequency heating is not implementable and will not be retained.

8.4.2.4.2 Source Control: On-Site Ex-Situ Treatment

On-site ex-situ soil treatment is a process by which excavated contaminated soil is treated on-site and the treated soil is used to backfill the excavated area. Treatment of the excavated soil involves utilizing technologies that degrade, remove, or immobilize contaminants of concern. There are three applicable remedial technologies for ex-situ soil treatment: physical/chemical, biological, and thermal. Physical/chemical remedial technology is implementable and potentially effective and, therefore, is retained. The physical/chemical process option to be screened (see Section 18.5) is as follows:

- Soil washing.

Ex-situ biological treatment is also implementable and potentially effective and is, therefore, retained. Biological process options to be screened (see Section 8.5) are as follows:

- Landfarming.
- Engineered soil piles.

Thermal treatment technology is implementable and potentially effective and, therefore, is retained. Thermal treatment options to be screened (see Section 8.5) are as follows:

- Thermal destruction
- Thermal desorption

8.4.2.4.3 Source Control: Removal and Disposal

There are two applicable remedial technologies for soil removal and disposal: off-site disposal and on-site disposal. Off-site disposal remedial technologies are implementable and potentially effective and, therefore, are retained. Off-site disposal process options to be screened (see Section 8.5) are as follows:

- Off-site treatment and disposal.
- RCRA disposal facility.

On-site landfill is a process option associated with on-site disposal remedial technology. Due to the spatial limitations and physical characteristics of the site, on-site disposal remedial technology is not considered implementable and, therefore, will not be retained.

8.4.3 Groundwater Remedial Technologies

The groundwater remedial technologies identified and screened in this section are technologies designed to reduce or eliminate migration of contaminated groundwater off-site, prevent further degradation of groundwater quality, and eliminate exposure of potential receptors to contaminated groundwater. The groundwater remedial technologies screening process is summarized in Table 8-3.

8.4.3.1 No Action

The no action alternative would allow contaminated groundwater to migrate off-site. The no action alternative provides a baseline for comparison with other groundwater remedial alternatives and, therefore, is retained.

8.4.3.2 Access Restrictions

Access restrictions is a remedial technology associated with institutional controls. Access restrictions are implementable and potentially effective and, therefore, are retained. Access restrictions process options to be screened (see Section 8.5) are as follows:

- Deed notices and restrictions
- Groundwater monitoring

8.4.3.3 Containment and Management of Migration

Containment and management of migration technologies reduce the mobility of contaminants and the exposure to affected media. Containment consists of minimizing the infiltration of precipitation through the use of a cap and/or controlling groundwater movement through the use of low permeability physical or hydraulic barriers. Applicable remedial technologies for containment and management of groundwater migration are capping, vertical physical barriers, and hydraulic barriers.

Capping technology is implementable and potentially effective and, therefore, is retained. Capping technology process options to be screened (see Section 8.5) are as follows:

- Clay cap
- Concrete cap
- Asphalt cap

Vertical physical barriers involve the use of mechanisms to block or divert groundwater flow to prevent upgradient waters from mixing with downgradient groundwater or to prevent migration of affected water from the source. To be effective, barriers must be anchored or sealed into a relatively impervious unit such as bedrock or clay. A cut-off wall is a process option associated with vertical physical barriers. Due to the complex subsurface utility network at the site, vertical barriers are considered not implementable and, therefore, will not be retained.

Control of the migration of pollutants can also be achieved by implementing hydraulic barriers. Hydraulic barrier technology is implementable and potentially effective and, therefore, is retained. Hydraulic barrier process options to be screened (see Section 8.5) are as follows:

- Groundwater withdrawal
- Groundwater injection

8.4.3.4 Source Control

Source control for groundwater has been partially implemented at the site through the elimination of operational sources of volatile organic contamination in the southeast portion of the facility associated with the benzoic acid/benzaldehyde manufacturing process. This process was terminated by Kalama in February 1984; associated USTs which may have contributed to groundwater contamination were removed between 1987 and 1990.

Contaminated NAPL and soils remaining on the site are a source of groundwater contamination. NAPL and soil process options will provide source control for groundwater. These process options were identified in Section 8.4.2.4 (source control) as implementable and potentially effective and have been retained for screening (see Section 8.5). Those options and their respective technologies are as follows:

- NAPL Remedial Technologies:
  - No Further Action
  - Physical Removal
    - Automated NAPL/water pumping and separation
    - Automated NAPL pumping only
    - Manual NAPL bailing and pumping
  - Thermal Treatment
    - On-site incineration
    - Off-site incineration
- Soil Remedial Technologies:
  - No Action
  - Access Restrictions
    - Deed notices and restrictions
    - Physical restriction
  - Capping
    - Clay cap
    - Asphalt cap
    - Concrete cap
  - In-Situ: Physical/Chemical Treatment
    - Soil vapor extraction
    - Soil flushing
    - Soil solidification/stabilization
  - In-Situ: Biological Treatment
    - Soil bioventing
  - Ex-Situ: Physical/Chemical Treatment
    - Soil washing
  - Ex-Situ: Biological Treatment
    - Landfarming
    - Engineered soil piles

- Ex-Situ: Thermal Treatment
  - Thermal destruction
  - Thermal desorption
- Off-Site Disposal
  - Off-site treatment and disposal
  - RCRA disposal facility

8.4.3.4.1 Operational Source Control

Plant operations are also a source of groundwater contamination due to discharges from underground utilities. The applicable remedial technology for such contamination is operational control. Operational control is implementable and potentially effective and, therefore, has been retained. Operational source control process options to be screened (see Section 8.5) are as follows:

- Replacement
- Rectification
- Abandonment

8.4.3.5 In-Situ Treatment

In-situ treatment for groundwater consists of those remedial technologies that can be applied without the extraction of groundwater. There are two applicable remedial technologies for in-situ treatment: physical treatment and biological treatment. Both are implementable and potentially effective for certain contaminants of concern (i.e., semivolatiles in the northeast portion of the site); therefore, both are retained. The physical treatment process option is adsorption trenches. Adsorption trenches are permeable groundwater treatment beds that are located downgradient of contaminant sources and filled with activated carbon to adsorb contaminants from passively collected groundwater. The installation of adsorption trenches at the site is considered not implementable due to the complexity of the underground utility network. Therefore, this process option will not be retained.

The biological treatment process option to be screened (see Section 8.5) is as follows:

- Biosparging.

8.4.3.6 Collection

There are two applicable remedial technologies for groundwater collection: recovery wells and subsurface trenches/drains. Recovery well technology is implementable and potentially effective and, therefore, is retained. Recovery well process options are vertical and horizontal wells. The recovery well process options to be screened (see Section 8.5) are as follows:

- Vertical wells
- Horizontal Wells

Subsurface trenches/drains technology consists of an excavated trench filled with highly permeable materials, such as gravel, that incorporates perforated piping as the collection medium; the trench bottom typically is anchored into a relatively impermeable layer, such as bedrock, or a silt or clay layer and is generally limited to shallow depths. The permeable material then serves as a conduit to induce flow from the subsurface to a collection point for treatment or discharge. The trench serves as a continuous barrier that maximizes constituent removal and may, cost-effectively, use gravity flow. Due to the technical difficulty of excavating a drain/trench at the site, with its complex underground utility network, this option is considered not implementable and, therefore, will not be retained.

8.4.3.7 On-Site Ex-Situ Treatment

There are three applicable remedial technologies for groundwater ex-situ treatment: physical, chemical, and biological. Physical remedial technology is implementable and potentially effective and, therefore, is retained. Physical process options to be screened (see Section 8.5) are as follows:

- Air stripping.
- Filtration.
- Activated carbon adsorption.
- Gravity separation.

Chemical treatment is implementable and potentially effective and, therefore, is retained. Chemical process options to be screened (see Section 8.5) are as follows:

- Chemical precipitation.
- Ultraviolet (UV) oxidation.

Biological treatment is implementable and potentially effective and, therefore, is retained. Biological process options to be screened (see Section 8.5) are as follows:

- Activated sludge.
- Fixed-film bioreactors.
- Fluidized-bed bioreactors.

8.4.3.8 Discharge

Applicable remedial technologies for groundwater discharge are off-site discharge and on-site discharge. Off-site discharge technology is implementable and potentially effective and, therefore, is retained. Off-site discharge process options to be screened (see Section 8.5) are as follows:

- Discharge to PVSC.
- Discharge to Passaic River.

The applicable process option for on-site discharge would require construction of recharge basins and on-site shallow or deep injection wells. The use of recharge basins and shallow or deep wells for the injection of treated groundwater at the site is considered not implementable due to spatial constraints and geologic site characteristics. Therefore, on-site discharge will not be retained.

8.5 SCREENING OF PROCESS OPTIONS

In the preceding section, remedial technologies were identified and screened, and process options were identified, for the remediation of each medium of concern at the site. In this section, process options are screened to select appropriate site-specific processes for each remedial technology retained.

8.5.1 Screening of NAPL Process Options

The following section presents a screening of NAPL process options (see Table 8-4).

8.5.1.1 No Further Action

The no further action general response action provides a baseline for comparison only and is retained for further evaluation.

8.5.1.2 Physical Removal

Process options associated with physical removal remedial technology are as follows: automated NAPL/water pumping and separation, automated NAPL pumping only, and manual NAPL bailing and pumping.

8.5.1.2.1 Automated NAPL/Water Pumping and Separation

This method involves withdrawing fluids containing groundwater and NAPL from the subsurface by means of extraction wells or a collection trench followed by treatment using a gravity (oil/water) separator to remove the NAPL. The thickness of NAPL observed at the site would generally not allow the use of a total fluids pump; therefore, the process option will not be retained for further evaluation.

8.5.1.2.2 Automated NAPL Pumping Only

A recovery pump may be used to pump the floating NAPL only. However, the thickness and rate of NAPL recovery at the site would make the operation of a recovery pump inefficient. Therefore, this process option will not be retained for further evaluation.

8.5.1.2.3 Manual NAPL Bailing and Pumping

NAPL may be recovered by manual bailing and pumping on a regular basis. The recovered NAPL may be separated and stored for disposal. Manual bailing and pumping is demonstrably implementable, as it has been accomplished in the past. Therefore, manual bailing and pumping will be retained for further evaluation.

8.5.1.3 Thermal Treatment

There are two process options associated with thermal tratment: on-site incineration and off-site incineration.

8.5.1.3.1 On-Site Incineration

This method involves destruction of recovered NAPL by an on-site incinerator. Permitting, construction and operation of an on-site incinerator would not be appropriate for the site due to the small amounts of NAPL expected to be recovered. Therefore, on-site incineration will not be retained for further evaluation.

8.5.1.3.2 Off-Site Incineration

This method is similar to on-site incineration, but the incineration would be performed off-site at an approved facility. Off-site incineration will be retained for further evaluation.

8.5.2 Evaluation of Soil Process Options

The following section presents an evaluation of soil process options for the site (see Table 8-5).

8.5.2.1 No Action

Under no action, no additional cleanup would be undertaken, and the contaminated surface and subsurface soil would be left as it now exists. The no action general response action provides a baseline for comparison only and is retained for further evaluation.

8.5.2.2 Access Restrictions

Process options associated with access restrictions are described in the following sections.

8.5.2.2.1 Deed Notices and Restrictions

Deed notices and restrictions would limit future site use to non-residential (i.e., commercial) uses. Deed notices and restrictions are acknowledged by the NJDEPE as potentially effective controls on use of contaminated property. Deed notices and restrictions will be retained for further evaluation.

8.5.2.2.2 Physical Restrictions

Physical restrictions would limit access to the site via fencing, with regular inspections and maintenance. The site is currently fenced, and maintenance of this fence will be appropriate during both continued operations and remedial activities. Physical restrictions will be retained for further evaluation.

8.5.2.3 Capping

The process options for capping are described in the following sections.

8.5.2.3.1 Clay Cap

A clay cap is effective in preventing the infiltration of precipitation and exposure to contaminated soils, but it is susceptible to cracking. Long-term inspection and maintenance of the cap would be needed. Clay cap construction is relatively simple although clay becomes more difficult to install in congested areas or where facility operations are in progress. Installation of a clay cap presents restrictions on future land use. Degradation of the cap over time may require maintenance or repair. A clay cap will not be evaluated further since it is susceptible to cracking, requires maintenance and repair, and is incompatible with site operations; in addition, more effective capping materials are available for use at the site.

8.5.2.3.2 Concrete Cap

A concrete cap involves the installation of a concrete slab over areas of concern. A concrete cap is effective in preventing the infiltration of precipitation and exposure to contaminated soils, but it is susceptible to weathering and cracking. Long-term inspection and maintenance of the cap would be needed. Because a concrete cap is susceptible to cracking and chemical deterioration, special handling and application procedures are required. The installation of a concrete cap presents restrictions on future land use. Since concrete caps are susceptible to cracking and chemical deterioration, and since more effective capping materials are available, the installation of a concrete cap at the site will not be further evaluated.

8.5.2.3.3 Asphalt Cap

An asphalt cap involves the application of a layer of asphalt pavement over areas of concern. An asphalt cap is effective in preventing the infiltration of precipitation and exposure to contaminated soils, but could be susceptible to weathering and cracking if proper maintenance is not provided. Asphalt pavement is more flexible and would be somewhat more feasible than clay or concrete. Any cracks that develop can be exposed, cleaned, and sealed with tar with relative ease, compared to the repair procedures required for concrete caps. As with all caps, periodic inspection and maintenance are necessary. Asphalt caps present fewer restrictions on future land use than do clay caps. Asphalt capping will be retained for further evaluation, in combination with soil remediation process options.

8.5.2.4 Physical/Chemical Treatment

Process options associated with physical/chemical treatment are described in the following sections.

8.5.2.4.1 Soil Vapor Extraction

SVE is designed to remove volatile compounds physically from the unsaturated zone. It employs vapor extraction wells alone or in combination with air injection wells. Vacuum blowers create negative pressure to induce air flow through the soil matrix. The forced air movement carries the volatilized compounds to an extraction well. SVE can be used alone or in conjunction with other process options to treat soil contamination.

Pilot studies conducted at the site (see Appendices D, E, and F) to determine the applicability and performance of SVE indicate that SVE would not be an effective remedial process option for source control, due to the heterogeneous character of subsurface soils and air flow impediments presented by the extensive underground utility network. Therefore, SVE will not be retained for further evaluation.

8.5.2.4.2 Soil Flushing

In-situ soil flushing involves the extraction of contaminants from soil with water or other suitable aqueous solutions. Soil flushing is accomplished by passing the extraction fluid through in-place soils using injection wells, trenches, or infiltration processes. An effective collection system is required to prevent further migration of the flushed contaminants. Soil flushing is only effective in permeable soils. The addition of surfactants, as part of the soil flushing process, would increase the concentrations of the constituents of concern in the groundwater at the site. The low permeability of soils at locations at the site also preclude the use of soil flushing. Therefore, soil flushing will not be retained for further evaluation.

8.5.2.4.3 Soil Solidification/Stabilization

In-situ solidification/stabilization involves the direct injection of reagents and additives into the subsurface soil using specialized machinery with injection augers and rotary-type mixers for blending. This process option has the potential to reduce the mobility of inorganic contaminants.

For organics, however, the effectiveness of this process is questionable. Due to the nature of the constituents of concern and the complex underground utilities network, solidification/stabilization does not have potential for use at the site. Therefore, solidification/stabilization will not be retained for further evaluation.

8.5.2.5 Biological Treatment

Process options associated with biological treatment are described in the following sections.

8.5.2.5.1 Bioventing

Bioventing is a term that has been used to describe the in-situ microbial degradation of contaminants enhanced by introduction of oxygen into the soil. The bioventing application consists of a combination of volatilization and biodegradation. Generally speaking, the contaminants present at the site are subject to degradation by naturally occurring organisms. The rate at which degradation proceeds, however, is related to soil, contaminant, and other site characteristics and is controlled by oxygen, moisture-content, and nutrient availability.

The heterogenous nature of the subsurface soils at the site coupled with the extensive underground utility network, preclude the application of bioventing as a remedial option for the site. Therefore, bioventing will not be retained for further evaluation.

8.5.2.6 Physical Treatment

Soil washing is a process option associated with physical treatment technology.

8.5.2.6.1 Soil Washing

Soil washing is a water-based process for mechanically scrubbing soils ex-situ to remove undesirable contaminants. The process removes contaminants from soils in one of two ways:

by dissolving or suspending them in the wash solution (which is later treated by conventional wastewater treatment methods) or by concentrating them into a smaller volume of soil through simple particle size separation techniques (similar to those used in sand and gravel operations). Soil washing systems incorporating both removal techniques offer the greatest promise for application to soils contaminated with a wide variety of heavy metal and organic contaminants. Soil washing is not implementable at the site due to spatial constraints. Therefore, soil washing will not be retained for further evaluation.

8.5.2.7 Biological Treatment

Ex-situ biological treatment of contaminated soils involves the degradation of organic contaminants by micro-organisms in an aboveground controlled environment. Microorganisms may be either indigenous or externally introduced. The process options of landfarming and engineered soil piles are discussed below.

8.5.2.7.1 Landfarming

This method relies upon the microbial, chemical, and physical properties of surficial soils. The excavated soils are spread on the ground surface along with nutrient supplements where appropriate, and are tilled several times during the treatment period. Landfarming applications are limited by factors such as the amount of land surface available, length and warmth of growing season, amount of rainfall, site slope and soil conditions, waste content and concentrations, and nature of the indigenous microbial consortia. Due to the limited available space and the availability of more suitable process options for the site, this process option will not be considered for further evaluation.

8.5.2.7.2 Engineered Soil Piles

Engineered soil piles refers to a batch process in which excavated soil is biologically treated under controlled conditions. It is a more intensive process than landfarming and maximizes microbial activity by the indigenous microorganisms while controlling air emissions and leachate. The excavated soil is placed in piles up to 6 feet high. Oxygen supply is provided by enhanced air circulation through the piles by air injection/extraction systems. Vacuum systems pull air into the pile through perforated pipes placed through the pile. Moisture and nutrients are provided by an irrigation system at the top of the piles. The top of the pile is often covered by a synthetic liner for moisture and air emissions control. The pile base is similarly lined for leachate interception.

Engineered soil piles are well suited to remediate soils contaminated with VOCs (e.g., toluene and benzene), as well as highly biodegradable compounds such as phenol. The method requires substantially less time and area than landfarming. The amount of vacuum applied and the reinjection of the extraction air can be adjusted to vary and control the volatilization/bioventing ratios. This process option is applicable for the site and therefore will be retained for further evaluation.

8.5.2.8 Thermal Treatment

The process options for thermal treatment are thermal destruction and thermal desorption.

8.5.2.8.1 Thermal Destruction

Thermal destruction or incineration of soil is a treatment method that uses high temperature oxidation under controlled conditions to degrade a waste material into by-products that include carbon dioxide, water vapor, inert ash, nitrous oxides, sulfur dioxide, and hydrogen chloride gas. The last three types of by-products are considered hazardous materials and must be removed via air pollution control devices if they are found in the gases at concentrations exceeding regulatory limits. The thermal destruction process can be controlled to provide the optimum temperature, residence time, turbulence, and oxygen supply required for adequate destruction of organics. Inert inorganic constituents in the waste including metals, are released from the operation in two ways: solids and relatively nonvolatile materials are discharged as ash; volatile constituents and some carryover solids (e.g., fly ash) are vented to the atmosphere with the exhaust gases. Ash disposal from incineration depends on the nature of the ash constituents and could include direct disposal of nonhazardous materials or treatment and disposal of hazardous ash. Exhaust gases from an incinerator may require treatment prior to release.

Ex-situ thermal destruction would require complete excavation and removal of contaminated soils. Subsequently, excavated soils would have to be transported to a permitted incineration facility, and clean backfill would be required to restore existing surface elevation. This process option is applicable for the site and therefore will be retained for further evaluation.

8.5.2.8.2 Thermal Desorption

Thermal desorption is a soil remediation process option whereby relatively low heat is applied to the excavated soil to slowly drive VOCs from the soil matrix by elevating the vapor pressure of the contaminants to enable diffusion through, and volatilization from, the solid in a reasonable time. This method may achieve high levels of soil remediation in a short period of time, but it generally requires the capture and treatment of emissions. This process option is applicable for the site and therefore will be retained for further evaluation.

8.5.2.9 Off-Site Disposal

The process options for off-site disposal are off-site treatment and disposal and RCRA disposal facility.

8.5.2.9.1 Off-Site Treatment and Disposal

This option would require off-site treatment of the excavated soils, which could include off-site incineration, to reduce the contaminant levels to an acceptable level for landfilling or recycling. This option may be applicable in conjunction with other soil treatment options (when where certain soil contaminants are not amenable to other process options) and will, therefore, also be retained for further evaluation.

8.5.2.9.2 RCRA Disposal Facility

This option involves the excavation of some or all contaminated soils and transportation to a RCRA landfill for disposal. Use of this option would be dependent on the landfill's acceptance of the excavated soils. This option may be applicable in conjunction with other soil treatment options (when certain soil contaminants are not amenable to other process options) and will, therefore, be retained for further evaluation.

8.5.3 Evaluation of Groundwater Process Options

The following section presents an evaluation of groundwater process options for the site (see Table 8-6).

8.5.3.1 No Action

The no action general response action provides a baseline for comparison only and is retained for further evaluation.

8.5.3.2 Access Restrictions

Process options associated with access restrictions are discussed in the following sections.

8.5.3.2.1 Deed Notices and Restrictions

Access restrictions involve deed notices and restrictions prohibiting access to, and use of, the groundwater beneath the site. Deed notices and restrictions do not, however, apply to groundwater beneath adjacent properties controlled by other parties and are therefore limited to a source control strategy. Well restrictions may be implemented at the site to place restrictions on future well construction and to prevent future groundwater use. Deed and well restrictions would effectively prohibit access and use of groundwater at the site. This process option will be retained for further evaluation.

8.5.3.2.2 Groundwater Monitoring

Monitoring wells have already been constructed on- and off-site and the bounds of the plume have been determined. The constituents and characteristics of the site would dictate the parameters to be analyzed and the wells to be sampled. Monitoring activities would involve scheduled, periodic sampling and analysis of groundwater underlying the site. Groundwater monitoring at the site will be retained for further evaluation.

8.5.3.3 Capping

Process options associated with capping are discussed in the following sections.

Based on the analysis presented in Section 8.5.2.3 (Capping), clay and concrete caps will not be retained for further evaluation.

8.5.3.3.1 Asphalt Capping

Asphalt capping is implementable and effective at the site. An asphalt cap would be constructed following remediation of the soils to cover the northeast corner of the facility primarily and also the south portion of the facility. Asphalt capping will be retained for further evaluation.

8.5.3.4 Hydraulic Barriers

Process options for hydraulic barriers are discussed in the following sections.

8.5.3.4.1 Groundwater Withdrawal

Control of the migration of pollutants can be achieved by implementing hydraulic barriers created by groundwater withdrawal. A hydraulic barrier created by groundwater withdrawal is a potential option because it would be flexible and adoptive in response to plume migration; would be reliable when properly designed and operated; and would not necessarily cause a permanent change in groundwater flow patterns.

Implementation of groundwater withdrawal at the site may be an effective hydraulic barrier to control further migration of groundwater contaminants. Therefore this process option will be considered for further evaluation.

8.5.3.4.2 Groundwater Injection

The migration of pollutants in groundwater may also be controlled by implementing a hydraulic barrier created through groundwater injection. Injection wells can be arranged so that impacted groundwater is diverted toward extraction wells or towards predetermined discharge points. The direction of a plume and the speed of the plume migration can be changed or controlled by creating groundwater barriers using injection wells.

A problem frequently encountered with the arrangement of injection wells acting as hydraulic barriers is that dead spots (i.e., areas where water movement is very slow or nonexistent) can occur when these configurations are used. In addition, injection wells are often associated with operational problems that require frequent maintenance and ~~well~~ rehabilitation. The implementability and effectiveness of injection wells at the site may be hindered by the complex and heterogeneous soils and the extensive underground utility network. Therefore, this process option will not be retained for further evaluation.

8.5.3.5 Source Control

Process options for the control of NAPL and contaminated soils that act as a source of groundwater contamination at the site were evaluated in Section 8.5.2.4 above. Those options retained for further evaluation are listed below:

- NAPL Process Options
  - No Further Action
  - Manual Bailing
  - Off-Site Incineration

- Soil Process Options:
  - No action
  - Institutional controls
    - Deed notices and restrictions
    - Physical restrictions
  - Ex-Situ Treatment
    - Engineered soil piles
  - Removal and Disposal
    - RCRA disposal facility
    - Off-Site treatment and disposal

8.5.3.6 Operational Source Control

The only existing operational source of a constituent of concern (phenol) is the salicylic acid production area in the northeast section of the site. The following source control process options are applicable for phenol in the northeast section of the site.

8.5.3.6.1 Replacement

This process option includes replacement of surface and underground utilities that carry chemically contaminated process, cooling, or wash-down water, with the purpose of eliminating surface and subsurface discharges, thereby eliminating the source of contaminants to the soil and groundwater from current operations in Buildings 10 and 36. This option is implementable at the site, would provide effective contaminant source control for phenol, and would allow continued operations of the facility. This option will be retained for further evaluation.

8.5.3.6.2 Rectification

This option consists of an extensive inspection to identify leaks in the surface and underground process wastewater system, and to repair any leaks found. This option has already been undertaken as an interim measure. The implementation and effectiveness of this process option are uncertain because they are dependent on the identification of all leaks and the feasibility of repair. This option will be retained for further evaluation.

8.5.3.6.3 Abandonment

Abandonment would be accomplished by sealing underground utilities that currently carry contaminated water and by discontinuing chemical manufacturing operations that produce contaminated process, cooling, or wash-down water. This process option is retained for further evaluation.

8.5.3.7 Biological Treatment

Process options associated with biological treatment are discussed in the following sections.

8.5.3.7.1 Biosparging

Biosparging consists of introducing air at very low rates into the subsurface with the sole purpose of increasing the dissolved oxygen levels in the groundwater, thereby enhancing the natural aerobic biodegradation of organic contaminants. By providing an oxygen and nutrient source, the rate of degradation of the constituents is accelerated, thus reducing the concentration of contaminants. In-situ biosparging uses the existing indigenous microbial population to degrade contaminants present in the groundwater. Indigenous microorganisms can generally be relied upon to degrade a wide range of compounds if they are given proper nutrients and sufficient oxygen. Considering the biodegradation characteristics of the constituents of concern, particularly phenol in the northeast portion of the site, biosparging will be retained for further evaluation.

8.5.3.8 Recovery Wells

The process options associated with recovery wells are discussed in the following sections.

8.5.3.8.1 Vertical Wells

The extraction of affected groundwater may be accomplished by locating vertical recovery wells so that the contaminated groundwater plume is captured effectively. Groundwater modeling would be used to determine the number, location, and pumping rates of the recovery wells required to capture the southern (benzene and toluene) plume without pumping overly large volumes of clean water. The recovery wells would prevent the further migration of the constituents of concern off-site and also capture and contain the groundwater plume that has migrated beyond the site boundaries south and west into the residential neighborhood. This option will be retained for further evaluation.

8.5.3.8.2 Horizontal Wells

Horizontal wells consist of screen pipes or laterals that are projected horizontally to induce flow from the subsurface and ultimately convey the flow from the horizontal screens into a collection point for treatment and discharge. Horizontal wells at the site are considered not implementable due to the complexity of the underground utility network, and, therefore, will not be retained.

8.5.3.9 Physical Treatment

Process options associated with physical treatment are discussed in the following sections.

8.5.3.9.1 Air Stripping

Air stripping involves the transfer of VOCs from the liquid to the gaseous phase by means of a countercurrent air/water scrubber. The process is effective for many VOCs. Complete water treatment may require pretreatment or polishing to remove constituents other than VOCs. Therefore, air stripping may be a stand-alone process only for certain constituents. Depending on constituent loadings and local regulations, off-gas treatment may also be required to capture stripped constituents for recovery or for further treatment to prevent air emissions. Constituents of concern at the site include SVOCs, such as phenol, for which this process option will not be effective. Therefore, this process will not be retained for further evaluation.

8.5.3.9.2 Filtration

Filtration is a physical process whereby suspended solids are removed freoma liquid by passing the liquid thorugha bed of filter media. Filtration is frequently installed ahead of bioloigcal or activated carbon treatment units to reduce the suspended solids load and/or to prevent clogging. Filtration can also be used as part of a polishing unit to remove residual floc from the effluent of a precipitation, flocculation, and sedimentation process. Filtration will be retained for further evaluation, as it has the potential to be used in combination with other process options.

8.5.3.9.3 Carbon Adsorption

The use of activated carbon to purify water is well established. Activated carbon has the ability to remove relatively non-polar organic compounds. Water is contacted with the carbon in a series of downflow-packed bed columns. When the carbon becomes saturated with chemicals, it can either be thermally regenerated for reuse or discarded. Activated carbon can adsorb a wide range of organic compounds, but is more effective in the removal of less soluble compounds of moderate molecular weight. For effective and economical operation of an adsorption unit, the influent may require pretreatment. Pretreatment may include chemical precipitation/coagulation to remove heavy metal contaminants and filtration to remove suspended solids. Activated carbon adsorption will be retained for further evaluation because of its potential to remove dissolved organics or (as a secondary treatment) to polish the treated water before disposal, to remove TCE to comply with discharge standards.

8.5.3.9.4 Gravity Separation

Gravity separation is a physical process whereby free-phase products and water are separated from each other on the basis of density. In a separator, water containing free-phase product is passed through a quiescent zone, consisting of coalescer plates and filter material where the oily material is concentrated into a second phase. The non-aqueous layer, either lighter or heavier is than mechanically drawn off. Oil/water separators are frequently installed ahead of other treatment units to prevent fouling of the treatment process by non-aqueous material. Oil/water separators will be retained for further evaluation since NAPL has been observed both on- and off-site.

8.5.3.10 Chemical Treatment

Process options associated with chemical treatment are discussed in the following sections.

8.5.3.10.1 Chemical Precipitation

Chemical precipitation is a process in which soluble metallic ions and certain anions are removed from water through chemical conversion to an insoluble form by means of a reaction with other chemicals or a change in pH. Chemical precipitation has been demonstrated to be an effective means by which to remediate inorganic-affected groundwater with minimal detriment to human health and the environment. Although it is dependent on chemical additives and requires regular sludge removal and disposal, the procedure is readily implemented and expandable. Because the groundwater at the site contains iron at high concentrations, chemical precipitation will be retained for further evaluation, in conjunction with other technologies.

8.5.3.10.2 UV/Oxidation

The UV/oxidation process destroys dissolved organic constituents in groundwater by means of chemical oxidation. UV light catalyzes the chemical oxidation of organic constituents in groundwater by its combined effect on the organic constituents and its reaction with hydrogen peroxide. UV/oxidation has been demonstrated to destroy organic constituents with minimal emissions to the environment. A UV/oxidation system can handle variable flow rates and loadings, but may require pretreatment for metals to prevent fouling. The system has a high energy consumption rate and complex operation and maintenance (O&M). Because high iron concentrations are expected in the extracted groundwater at the site, filtration before and after the UV/oxidation system would likely be required, and, therefore, capital and O&M costs would be very high. Therefore, this process option will not be retained for further evaluation.

8.5.3.11 Biological Treatment

Process options for biological treatment are discussed in the following sections.

8.5.3.11.1 Activated Sludge

In the conventional activated sludge process, aqueous waste flows into an aeration basin where it is aerated for several hours. During this time, a suspended active microbial population (maintained by recycling sludge) aerobically degrades organic matter in the waste stream and produces new cells. The new cells produced during aeration form a sludge that is settled out in a clarifier. A portion of the settled sludge is recycled to the aeration basin to maintain the microbial population while the remaining sludge undergoes volume reduction and disposal. Clarified water is either disposed or receives further polishing/processing.

In the pure oxygen activated sludge process, oxygen or oxygen-enriched air is used instead of air to increase the transfer of oxygen. Extended aeration involves longer detention times than conventional activated sludge and relies on a higher population of microorganisms to degrade wastes. Odor control for activated sludge processes can become troublesome. The activated sludge process generally requires a large area for the aeration basins and clarifiers and has labor-intensive operational requirements. Constraints imposed by site operations and space limitations preclude the use of activated sludge process at the site. Therefore, this process option will not be retained for further evaluation.

8.5.3.11.2 Fixed-Film Bioreactors

Fixed-film systems involve contact of the aqueous waste stream with microorganisms attached to some inert medium such as rock or specially designed material. The inert support media are placed in a reactor to provide a large surface area onto which bacteria will naturally grow. As contaminated groundwater is passed through the reactor over the fixed-film bacteria, organic contaminants in the groundwater are biologically degraded before exiting the reactor.

Biological treatment using fixed-film bioreactors require more space than fluidized-bed bioreactors (see below) to achieve the same degradation rate and residence time. Due to spatial limitations at the site, fixed-film bioreactors will not be retained for further evaluation.

8.5.3.11.3 Fluidized-Bed Bioreactors

Fluidized-bed bioreactors have inert material, such as sand or activated carbon, that has extremely high surface areas covered with biological growth. These reactors are operated with hydraulic velocities sufficient to maintain an expanded bed, but low enough to avoid solids washout. Recycling of some of the effluent stream is usually required to maintain the design velocities, and the reactor can be operated with high efficiency. Buildup of particulate solids on the media surfaces is not a concern, nor are problems with hydraulic channeling and plugging. Fluidized-bed bioreactors require less space and provide a higher rate of degradation and lower residence time than fixed-film bioreactors. Based on the biodegradation characteristics of the constituents of concern, the quality of groundwater anticipated, and the spatial constraints present at the site, this process option will be retained for further evaluation.

8.5.3.12 Discharge

Process options associated with discharge are discussed in the following sections.

8.5.3.12.1 PVSC

Contaminated groundwater from the site may be pretreated on-site and then discharged to the PVSC via existing sanitary sewer lines for final disposal and treatment at its off-site treatment facility. The discharge of extracted groundwater to the PVSC facility is a feasible alternative only if the PVSC facility has the capacity to accept the additional hydraulic and constituent loadings. Compliance with pretreatment standards will be required. Further investigation is warranted regarding the level of pretreatment required and the volume of flow acceptable by the facility. This option may be implementable and will be retained for further evaluation.

8.5.3.12.2 Discharge to Passaic River

Contaminated groundwater from the site may be pretreated on site and than discharged to the Passaic River. A New Jersey State Pollutant Discharge Elimination System - Discharge to Surface Water (NJPDES-DSW) permit would be required for the discharge. This option may be implementable and will be retained for further evaluation.

8.6 EVALUATION OF IDENTIFIED PROCESS OPTIONS

The following process options are potentially applicable to the site (see Table 8-7):

- NAPL
  - No further action
  - NAPL Removal
    - Manual bailing and pumping
  - NAPL treatment
    - Off-site incineration
- Soil
  - No action
  - Institutional controls
    - Deed notices and restrictions
    - Physical restrictions
  - Containment
    - Asphalt cap
  - Source control: on-site treatment
    - Engineered soil piles

- Thermal Treatment
    - Thermal destruction
    - Thermal desorption
- Source control: removal and disposal
    - Off-site treatment/disposal

- Groundwater
    - No action
    - Institutional controls
        - Access restrictions
        - Monitoring
    - Containment and management of migration
        - Asphalt cap
        - Groundwater withdrawal
    - Source control
        - NAPL source control:
        - No further action
            - Manual bailing
            - Off-site incineration
        - Soil source control:
            - On-site ex-situ treatment
            - Removal and disposal
        - Operational Source Control:
            - Replacement
            - Rectification
            - Abandonment
    - In-Situ treatment
        - Biosparging
    - Collection
        - Vertical wells

- On-site ex-situ treatment
  - Gravity separation
  - Activated carbon adsorption
  - Filtration
  - Chemical precipitation
  - Fluidized bed bioreactors
- Discharge
  - Discharge to PVSC
  - Discharge to Passaic River

In this section, process options identified and screened in Sections 8.4 (Identification and Screening of Remedial Technologies) and 8.5 (Screening of Process Options) are evaluated based on their effectiveness, implementability and cost.

The effectiveness of each process option has been evaluated in terms of its short- and long-term ability to reduce the toxicity, mobility, and volume of contaminants of concern and its consistency with site remedial goals. Implementability measures both the technical and administrative feasibility of construction, operation, and maintenance of the remedial technology or process option, and the likelihood of community acceptance. The cost of each remedial technology and process option was assigned a relative value of low, medium, or high, and a cost estimate was developed for the proposed remedial action plan.

8.6.1 NAPL

Process options for NAPL are discussed in the following sections.

8.6.1.1 No Further Action

No further action for NAPL at the site would not reduce the toxicity, mobility, and volume of the contaminants of concern in either the short- or long-term, and it is unlikely that the local community would respond favorably to no further action. This option would not meet the remedial goals for the site and is, therefore, not incorporated into the proposed remedial action plan.

8.6.1.2 NAPL Removal: Manual NAPL Bailing

This process option for NAPL would reduce the toxicity, mobility, and volume of contaminants of concern in the on-site NAPL in both the short- and long-term, and would eliminate it as a continuing source of groundwater contamination. Relative costs for this technology are low, and it has been proven to be implementable. Community acceptance is likely. This process option would meet the remedial goals for the site, and has retained for incorporation into the proposed remedial action plan.

8.6.1.3 NAPL Treatment: Off-Site Incineration

This process option for NAPL would reduce the toxicity, mobility, and volume of contaminants of concern in recovered NAPL in both the short- and the long-term. Relative costs for this technology are moderate to high. Community acceptance is likely. This process option would meet the remedial goals for the site and has been retained for incorporation into the proposed remedial action plan.

8.6.2 <u>Soil</u>

The process options for soil are discussed in the following sections.

8.6.2.1 No Action

No action for contaminated soils at the site would not reduce the toxicity, mobility and volume of the contaminants of concern in either the short- or the long-term, and it is unlikely that the local community would respond favorable to no further action. This process option would not meet the remedial goals for the site and is, therefore, not incorporated into the proposed remedial action plan.

8.6.2.2 Deed Notices and Restrictions

Deed notices to restrict future use of the property to non-residential (industrial/commercial) purposes and continued fencing of the site, would not reduce the toxicity or volume of the contaminants of concern in either the short- or the long-term. They would, however, restrict the mobility of contaminants, by eliminating potential exposure to soils, which is consistent with site remedial goals. It is likely that the community would respond favorably to institutional controls. This process option is incorporated into the proposed remedial action plan, along with the other process options for soils.

8.6.2.3 Asphalt Cap

Asphalt capping to reduce the migration of contaminants by isolating the soils, thereby reducing soil contaminant leaching to groundwater and preventing migration by wind, would not reduce the toxicity or volume of the contaminants of concern in either the short- or long-term. It would, however, reduce the mobility of contaminants by reducing the potential of the soils to act as a source for groundwater contamination and by eliminating the exposure pathway of wind-borne soil contaminants; therefore, this option is consistent with site remedial goals. It is likely that the local community would respond favorably to capping as a means of contaminant containment in some areas of the site. Specifically, an asphalt cap would be implemented in the southern part of the site after soil remediation activities have been completed, and in the northeast part of the site to address phenol-impacted soils. A total of 138,000 square feet of the site would be covered with an asphalt cap. Costs associated with capping are low. This process option is retained for incorporation into the proposed remedial action plan both for soil containment and as a groundwater containment and management of migration option (see below) after soil remediation has been accomplished.

8.6.2.4 Engineered Soil Piles

Excavation of VOC and TPHC/PAH-contaminated soils and treatment on-site by engineered soil piles would reduce the toxicity, mobility, and volume of contaminants of concern in both the short- and the long-term, which is consistent with site remedial goals. Engineered soil piles would be constructed aboveground with soil excavated by conventional methods (backhoes, loaders, etc.). The piles would be placed on impermeable liners with high density polyethylene to prevent leachate percolation and to control runoff. Leachate collected would be recycled into the soil piles, thereby adding moisture. Odors and off-gases would be controlled by synthetic liners. During excavation and backfilling activities, temporary odors and dust would also be controlled by implementing a health and safety program during construction activities.

The contaminants present at the site are subject to degradation by naturally occurring organisms. The rate at which degradation proceeds is related to soil/waste characteristics and is controlled by adequate oxygen, moisture content, and nutrient availability. Engineered soil piles provide a means of introducing additional oxygen to enhance the aerobic degradation of organic contaminants. In other words, the natural anaerobic biodegradation process (usually evidenced by high methane concentration as is present in site soil) is converted to aerobic degradation with time. The process of completely converting from anaerobic to aerobic usually takes about 2 to 3 months. The mass removal in a engineered soil pile may be adjusted for a combination of volatilization and biodegradation.

Approximately 7,600 cubic yards (yd^3) of toluene and benzene contaminated soil and about 2,500 yd^3 of soil contaminated with TPHC and PAH would be excavated and treated in soil piles. The approximately 10,000 yd^3 of soil estimated for removal may represent the lower limit of soil requiring remediation since during the installation of soil borings in the southern section of the facility, traces of NAPL were observed in some of the split-spoon samples. Additionally, since benzene, toluene, TPHCs, and PAHs have been detected in LNAPL, fluctuation of the water table may have smeared these contaminants through the capillary fringe. Based on these observations, an upper limit estimate of approximately 20,000 yd^3 of soil to be potentially excavated may be calculated. The exact quantity of soil to be excavated will be determined in the field and from samples collected from the excavations. Clean and contaminated soils will be segregated during excavation, based on visual observation of NAPL or field VOC measurements, to minimize the amount of soil that will be treated in the soil piles.

Based on Geraghty & Miller's experience, it is estimated that reduction of contaminant levels to applicable NJDEPE standards for toluene and benzene will be achieved in an average period of 6 months; TPHCs and PAHs are estimated to be reduced to NJDEPE standards in approximately 2 years. A remediation period of 1 year for cleanup to NJDEPE standards has been estimated for the additional soil that may be excavated from the southern section of the facility. This estimate is based upon the presence of benzene/toluene and TPHC in the southeastern section of the site. These biodegradation rates have been estimated based primarily on empirical data derived from applications of this technology at sites that exhibit similarities to the Garfield site regarding soil characteristics, type of contaminant, and contaminant concentrations. Based on the need for balancing the rate of treatment and excavation volumes, and the spatial constraints imposed by the site conditions, Geraghty & Miller has determined that the most efficient and manageable size for engineered soil piles at the site is about 1,000 yd^3 (100 ft long, 50 ft wide, and 5 ft high). It is estimated that two-1,000 yd^3 soil piles will be concurrently used for remediation of TPHC and PAH. Excavation/backfill activities will be scheduled so that minimal disturbance to plant activities is incurred and that transport and off-site disposal of soils unsuitable for engineered soil piles are kept to a minimum. Capital and O&M costs associated with ex-situ engineered soil piles are moderate to high. Community acceptance is likely. This process option has been retained for inclusion in the proposed remedial action plan.

8.6.2.5 Thermal Destruction

This process option would reduce the toxicity, mobility, and volume of contaminants in the soils in both the short- and the long-term. However, the site is located in a densely populated residential and commercial area; therefore, there could be significant opposition to the implementation of this process option. Massive transportation of contaminated soil through this already highly congested area would generate additional traffic jams and will likely pose an unacceptable health exposure risk to the local community. In addition, implementation of this process option will significantly interfere with the operations at the site. Capital and O&M costs would also be high. Based on the above and the fact that more suitable soil treatment process options applicable to the site exist, thermal destruction will not be retained for inclusion in the proposed remedial action plan.

8.6.2.6 Thermal Desorption

The process option would reduce the toxicity, mobility, and volume of contaminants in the soils in both the short- and the long-term; however, it also exhibits high energy demands and, therefore, is very costly. Permits for the portable thermal desorption unit, required for this process option, would be difficult to obtain. This option will also interfere with the operations of the facility. Therefore, this option will not be retained for inclusion in the proposed remedial action plan.

8.6.2.7 Off-Site Treatment and Disposal

This process option would reduce the toxicity, mobility, and volume of contaminants in the soils in both the short- and the long-term and is consistent with site remedial goals. Community acceptance of off-site disposal is likely. Off-site disposal would likely involve treatment (such as incineration) to reduce contamination levels to acceptable levels for landfilling or recycling. Costs associated with this technology are high. Due to the high cost and to the preference of the State of New Jersey for on-site, as opposed to off-site, treatment, this technology has not been retained as a remedial option for contaminated soils; it is, however, retained for incorporation in the proposed remedial action plan for soils that are not amenable to other technologies.

Geraghty & Miller anticipates that the last batch (1,000 yd^3) of treated soil from the engineered soil piles will be disposed off-site. In addition, during remedial activities, a currently unknown volume of excavated soil may be determined unsuitable for construction of the engineered soil piles. Such material may include boulders, rubble, and large-diameter debris. It is estimated that about 10 percent of the total excavated soil for treatment by engineered soil piles may be considered unsuitable for treatment and may be disposed off-site. High pressure washing of some of these materials may be possible, thereby reducing the quantity of material to be disposed of.

8.6.3 Groundwater

Process options for groundwater are discussed in the following sections.

8.6.3.1 No Action

No action for groundwater at the site would not reduce the toxicity, mobility, and volume of contaminants of concern in either the short- or long-term, and it is unlikely that the local community would respond favorably to no further action. This option would not meet the remedial goals for the site and is, therefore, not incorporated into the proposed remedial action plan.

8.6.3.2 Access Restrictions and Groundwater Monitoring

Deed and well restrictions and groundwater monitoring would not reduce the toxicity or volume of contaminants of concern in the groundwater, but would reduce mobility in both the short- and the long-term by eliminating a potential pathway to human ingestion through drinking water wells, which is consistent with site remedial goals. Community acceptance of access restrictions and groundwater monitoring is likely, provided that effective groundwater remedial technologies are implemented. Capital costs associated with these process options are low, but O&M costs may be high as extensive monitoring would likely be necessary to provide information on groundwater quality at and in the vicinity of the site. Access restrictions and groundwater monitoring have been incorporated into the proposed remedial action plan, along with other process options.

8.6.3.3 Asphalt Cap

The installation of an asphalt cap following soil remediation, to control storm water and reduce the potential for contaminant leaching from soils, would reduce the toxicity, mobility, and volume of contaminants of concern in groundwater in both the short- and the long-term, and is consistent with site remedial objectives. Community acceptance is likely. Costs associated with installation and maintenance of an asphalt cap are low to moderate. This process option has been retained for incorporation into the proposed remedial action plan, along with other groundwater process options.

8.6.3.4 Groundwater Withdrawal

Groundwater withdrawal would control migration of contaminants in the groundwater to the south and west of the site, through emplacement of vertical wells. Groundwater collected via these wells would be pumped to a water treatment system that would remove contaminants of concern (principally VOCs) from the water before discharge. (see Section 8.6.3.11 [Discharge to PVSC and Passaic River]). Groundwater withdrawal would effectively contain within the site boundaries contaminants of concern originating in the southeast section of the site, so that any off-site remediation could be confined to reduction of contaminants in groundwater that has already left the site. Groundwater withdrawal would reduce the mobility of constituents of concern at the site in both the short- and the long-term. In addition, the volume and toxicity of the constituents of concern would be reduced as contaminated water would be treated before discharge. Groundwater withdrawal would, therefore, be consistent with site remedial goals. Community acceptance to groundwater withdrawal is likely. Capital costs are moderate, and O&M costs are expected to be moderate to high, depending on the length of time these wells are required to operate and on the effectiveness of other means of source control. Groundwater monitoring has been retained for incorporation into the proposed remedial action plan, along with other process options for groundwater.

8.6.3.5 Source Control: NAPL

Control of NAPL as a source of contaminants to groundwater is described in Section 8.6.1. This technology has been retained for incorporation into the proposed remedial action plan.

8.6.3.6 Source Control: Soil

Source control for soils, which is designed to reduce the potential for contaminated soils to act as a source of groundwater contamination, is described in Section 8.6.2. It has been retained for incorporation into the proposed remedial action plan.

8.6.3.7 Replacement, Rectification, or Abandonment

Operational source control would be focused on potential sources of groundwater contamination from ongoing operations, specifically salicylic acid manufacturing in the northeast portion of the site. This control would involve either replacement, rectification, or abandonment (in conjunction with process shutdown) of underground utilities and structures that may act as a continuing source of groundwater contamination. Operational source control would reduce the mobility and volume of constituents of concern in both the short- and the long-term, but not their toxicity, and is consistent with site remedial goals. Community acceptance of operational source control is likely. Capital costs are expected to be high under any of the operational source control alternatives, while O&M costs are expected to be low. This process option has been retained for incorporation into the proposed remedial action plan, along with other source control technologies for groundwater.

8.6.3.8 Biosparging

Biosparging would be employed to increase dissolved oxygen levels in the northeast section of the plant, thereby enhancing the natural aerobic degradation of organic contaminants (principally phenol) in that area. Biosparging would not be considered an effective technology for VOC contamination in the southeast portion of the site, given the biodegradation characteristics of these VOCs and the anaerobic conditions that prevail in this area. Biosparging, combined with operational source control, would reduce the toxicity, volume, and mobility of contaminants in the northeast, in both the short- and the long-term, which is consistent with the site remedial goals. Community acceptance to biosparging is likely. Both capital and O&M costs associated with biosparging are considered to be moderate. Biosparging has been retained for incorporation into the proposed remedial action plan, along with other process options for groundwater.

8.6.3.9 Vertical Wells

Groundwater recovery wells would remove contaminated groundwater, both within the site boundaries and in the VOC plume that has been detected to the south of the site. The groundwater recovery system would create hydraulic barriers to provide effective contaminant migration control and treatment of recovered groundwater, and would reduce the toxicity, mobility, and volume of constituents of concern in both the short- and the long-term, which is consistent with site remedial goals. Groundwater recovery would be cost-effective in addressing the benzene and toluene contamination in the southeastern section of the facility. However, biosparging is more cost-effective for the remediation of the phenol contamination detected in the northeastern section of the site because of the high rate of degradation of phenol and the greater distance phenol has to travel before it leaves the site; therefore, the groundwater recovery system will be focused on the benzene and toluene plumes. Groundwater modeling has been performed to determine the optimum number, location, and pumping rates of recovery wells (see Appendix M) required to capture the southern (VOC) plume. Community acceptance of groundwater recovery is likely. Both capital and O&M costs associated with the groundwater recovery well network are moderate to high. Recovery wells have been retained for incorporation into the proposed remedial action plan, along with other process options for groundwater.

8.6.3.10 Ex-Situ Groundwater Treatment by Filtration, Fluidized Bed Reactors, and Chemical Precipitation

Groundwater treatment, in a treatment plant that would be constructed within the site boundaries, would involve a treatment train of gravity separation, activated carbon adsorption, filtration, chemical precipitation, and biological treatment via fluidized-bed bioreactors. The majority of specific treatment technologies for the groundwater are designed to remove VOC and TPHC contamination originating in the southeast portion of the site. Carbon adsorption is included in the treatment technologies principally to remove TCE, which is present in both regional and on-site groundwater. Ex-situ groundwater treatment would reduce the toxicity, mobility, and volume of constituents of concern in groundwater in both the short- and the long-term, which is consistent with site remedial goals. Community acceptance of groundwater treatment is likely. Both capital and O&M costs associated with ex-situ groundwater treatment and discharge are considered to be moderate to high. Ex-situ on-site groundwater treatment has been retained for incorporation into the proposed remedial action plan, along with other remedial technologies for groundwater.

8.6.3.11 Discharge to PVSC and Passaic River

Discharge of treated groundwater would be to either the PVSC or the Passaic River, depending on pretreatment requirements. Discharge following treatment would reduce the toxicity, volume, and mobility of constituents of concern, which would be consistent with site remedial goals. Community acceptance of discharge of treated groundwater is likely. Both capital and O&M costs associated with discharge are considered to be low to moderate. Discharge of treated groundwater has been retained for incorporation into the proposed remedial plan, along with other process options for groundwater.

8.7 PROPOSED REMEDIAL ACTION PLAN

The NAPL, soil, and groundwater process options and remedial technologies assembled for the site have been combined into a proposed site-wide remedial action plan. A description of this proposed plan is presented in this section and includes general unit processes with approximate order of magnitude volumes and capacities. The details provided in this section are intended to facilitate the understanding of the elements included in the remedial action proposed for each medium of concern. Actual dimensions, quantities, and equipment types will be identified and selected during the remedial design phase.

8.7.1 Proposed Remedial Action Plan

The proposed remedial action plan was assembled by combining the following medium-specific remedial technologies and process options:

- Manual bailing and off-site disposal of NAPL.
- Excavation of soils, engineered soil piles, and limited off-site soil disposal.
- Hydraulic barriers; groundwater collection, treatment, and discharge; in-situ bio sparging; groundwater source control; and asphalt capping.
- Performance monitoring and institutional controls.

The proposed remedial action plan includes the following:

- The continuation of current remedial activities with respect to NAPL on a systematic, periodic basis.

- Implementation of engineered soil piles in conjunction with limited off-site disposal to address VOC and TPHC/PAH soil contamination.

- Construction of a hydraulic barrier via groundwater withdrawal to contain on-site contamination.

- A groundwater collection and treatment system, with off-site discharge, to address benzene and toluene groundwater contamination localized in the southeast corner of the property and off-site to the south.

- An in-situ biosparging system to address phenol contamination in the northeast corner of the site.

- Elimination of any remaining operational sources of phenol contamination for soils and groundwater.

- An asphalt cap to be constructed over the areas where soil remediation was achieved, with storm-water control included with the cap.

- A system performance and long-term remediation monitoring program to be developed to monitor the performance of the various remedial systems established for the site and also to monitor on a long-term basis the attenuation, fate and transport, and biodegradation of the constituents of concern. Treatment system performance will be optimized either by varying flow rates or pumping wells intermittently. Pumping rates may be adjusted in response to seasonal water-table fluctuating.

This proposed remedial action plan is consistent with the remedial goals established for the site, is implementable, provides short- and long-term effectiveness, will reduce the toxicity, mobility, and volume of contaminants in each medium identified, is cost-effective, and is likely to be accepted by the community and the state. The costs associated with this alternative are presented in Section 8.6.2.

Geraghty & Miller recommends this remedial action plan to address NAPL, soil, and groundwater at the site.

Figure 8-1 illustrates an engineered soil pile. A preliminary layout of proposed engineered soil piles at the site is shown on Figure 8-2, and a biosparging injection well detail is presented on Figure 8-3. Figure 8-4 shows a preliminary injection point layout for biosparging at the site, the extraction system layout is shown on Figure 8-5, and a process flow diagram for the proposed remedial system is shown on Figure 8-6.

8.7.2 Cost Analysis

A detailed cost estimate was developed for the recommended alternative and is presented in Table 8-8. The cost estimate includes capital costs and annual O&M costs as follows:

- Capital Costs. Capital costs include costs for equipment, buildings, construction, land and site development, engineering design, contingency and purchased services, such as transportation and disposal.

- O&M Costs. O&M costs, including operating labor; maintenance costs, including materials and labor; auxiliary materials and energy; and purchased services such as transportation and disposal.

A present worth value was calculated based on a discount rate of 5 percent, which takes into account estimates of long-term interest and inflation rates.

Performance monitoring, operational costs, and disposal costs will decrease with time as the site is being remediated. This is based on the fact that constituent concentrations will decrease as remediation progresses. Accordingly, annual O&M costs have been assumed to remain the same during the first 5 years. Subsequently, costs are assumed to decrease from years 5 to 10 and further decrease from years 10 to 30. For cost estimating purposes a 30-year duration was assumed.

Major and minor equipment replacement costs have been included, as well as site closure, which includes soil, surface-water, groundwater, and air sampling, and preparation of a closure report.

9.0 PERMITS

The following permits/approvals have been identified as being potentially applicable to the implementation of remedial action at the Kalama Garfield facility:

- County Site Plan Review (Bergen County).
- Soil Erosion and Sediment Control Plan Certification (Bergen County)
- Municipal Land Use/Zone Approval (City of Garfield).
- Local Construction Permits (City of Garfield).
- Building Permit (City of Garfield).
- Sewer Extension Approval (Passaic Valley Sewerage Commissioners [PVSC]).
- Treatment Works Approval (NJDEPE).
- New Jersey Pollution Discharge Elimination System (NJDEPE).
- Air Quality Control Apparatus/Equipment (NJDEPE).
- Well Drilling Permits (NJDEPE).
- Well Abandonment Permit (NJDEPE).
- Water Quality Management Plan Consistency Determination (NJDEPE).
- Utility Opening Permit (New Jersey Department of Transportation [NJDOT]).

The identified permits/approval is based on the pre-design, design, and construction activities associated with the proposed remedial action (see Section 8.0 [Remedial Alternatives Analysis for the Development of the Proposed Remedial Action Plan]). The respective agencies will be contacted to verify the applicability of the permits/approvals and to expedite processing and approval.

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SOVEREIGN CONSULTING INC.

Remedial Action Progress Report

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

24 January 2005

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APPENDICES

ATTACHMENTS (under separate cover)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this *Remedial Action Progress Report* (RAPR) for investigation and remediation activities conducted at the Kalama Chemical Inc. facility in Garfield, New Jersey (Figure 1). During a telephone conversation with Sovereign in January 2003, the New Jersey Department of Environmental Protection (NJDEP) requested that EPI reduce the number of submissions to the Department by attempting to combine the results of field activities and/or responses to NJDEP letters into each quarterly RAPR. Therefore, this RAPR contains the results of the following activities:

- Quarterly groundwater sampling conducted in April 2004 and July 2004;
- Routine operation and maintenance of the existing remediation systems;
- A review of potential background sources for the chlorinated compounds present in groundwater; and,
- Proposed revisions to the current groundwater monitoring program.

No vapor phase hydrocarbons were recovered by the on-site soil vapor extraction (SVE) system during the first three weeks of April 2003, which was consistent with the previous seven weeks of operation of the system. Due to the low mass removal rates being achieved (and due to the expense of operating the thermal oxidizer under these conditions), EPI requested and received verbal approval from the NJDEP on 17 April 2003 to shut down the on-site SVE system; the system was subsequently shut down the same day. EPI will periodically re-evaluate site conditions to determine if re-starting the SVE system is warranted.

Starting with the July 2003 monitoring event, the air curtain system and the off-site SVE system are now shut down prior to each sampling event to allow static groundwater conditions to be monitored. EPI had requested (and received) approval for this shut down from the NJDEP in order to evaluate dissolved concentrations in wells that are strongly influenced by the operation of the air curtain (i.e., OW-2, OW-4, and OW-5). Both systems are re-started following the completion of each monitoring event.

2.0 GROUNDWATER MONITORING PROGRAM

A groundwater monitoring program was originally proposed to the NJDEP in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan had not been approved by the NJDEP, a monitoring program was implemented in June 1997 to establish a base-line against which remediation progress could be compared. The monitoring program started in June 1997 and has subsequently been modified to include additional wells and compounds of concern.

The January 1995 groundwater sampling event identified three areas of the site requiring remediation and/or monitoring: 1) the Northeast Phenol Hot Spot (Former Building 10/36); 2) the Northwest Phenol Hot Spot (Former Building 33-B); and, 3) the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14). In addition, benzene, toluene, phenol, benzoic acid, methanol, and formaldehyde were identified as the six primary compounds of concern in groundwater, although the distribution of these compounds varied across the site. The Northeast and Northwest Phenol Hot Spot areas were subsequently combined, and are now collectively referred to as the Northern Phenol Area.

Based on the results of grab groundwater samples collected following the demolition of the Building 10/36 complex, salicylic acid (or 2-hydroxybenzoic acid) was added to the list of analytical parameters for the monitoring wells in the Northeast Phenol Hot Spot area. Based on the quarterly sampling results from June 1997 through October 1998, phenol and benzoic acid are no longer considered to be compounds of concern in the Toluene Spill Area and have been eliminated from the monitoring program for the wells addressing this AEC.

In response to comments in the NJDEP's letter dated 26 June 2000, 1,1'-biphenyl and diphenyl ether were added to the monitoring program for wells addressing the Toluene Spill Area during the July 2000 sampling event. In response to the NJDEP's letter dated 26 June 2000, a groundwater monitoring program for AEC-14 was submitted as part of the 3 August 2001 *Remedial Investigation Report Addendum* (RIRA). The NJDEP approved the monitoring program for AEC-14 in their letter dated 15 October 2001. A groundwater monitoring program for the Northeast and Northwest Phenol Hot Spot areas was included in Section 7.0 of the 1 May 2002 *Remedial Investigation Report Addendum No. 2* (RIRA-2). The NJDEP approved this monitoring program in their letter dated 30 July 2002.

On 9 August 2001, all of the remediation systems at the site were shut down in response to the NJDEP's 6 August 2001 letter. Due to low groundwater levels, EPI requested permission to re-start the soil vapor extraction (SVE) system in the southeast corner of the site in November 2001. The NJDEP verbally approved EPI's request, and the SVE system was re-started on 15 November 2001. The off-site SVE system and the vertical and horizontal components of the air curtain were re-started on 5 March 2002, following the construction of a new equipment compound to replace the one that had been located in Building 32-B[1].

2.1 Groundwater Quality Standards

The groundwater quality standards (GWQS) for the six original compounds of concern identified at the Kalama site are summarized below.

Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Benzene	1.0
Toluene	1,000
Phenol	4,000
Benzoic Acid	30,000
Methanol	50,000
Formaldehyde	100

The benzene, toluene, and phenol standards are from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The standards for benzoic acid, methanol, and formaldehyde are from the "Interim Specific & Generic Groundwater Quality Criteria" posted on the NJDEP's Water Monitoring & Standards (WM&S) web page.

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[1] The Building 32/32-A/32-B complex had been demolished by Goodrich Corporation as part of their site restoration plans.

Groundwater at the site has been found to also contain salicylic acid, 1,1'-biphenyl, and diphenyl ether. However, since the NJDEP does not have any established groundwater quality standards for these compounds, a generic value of 100 parts per billion (ppb) would be applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believes the generic 100 ppb criterion is too conservative, since it does not incorporate toxicological data specific to each compound. Since none of these compounds of concern are volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the NJDEP's 100 ppb criterion is based, acceptable groundwater concentrations at the site should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request to establish alternate groundwater quality standards for methyl salicylate[2], salicylic acid, 1,1'-biphenyl, and diphenyl ether. In their letter dated 24 June 2002, the NJDEP responded to EPI's 17 April 2001 correspondence, and listed Interim Groundwater Standards for these compounds that had been posted on the NJDEP-WM&S web page:

Interim Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Methyl Salicylate	4,000
Salicylic Acid	80.0
1,1'-Biphenyl	400
Diphenyl Ether	100

Given the disparity between the alternate groundwater standards proposed by EPI for salicylic acid and diphenyl ether (5,600 ppb and 21,000 ppb, respectively), and the Interim Groundwater Quality Standards (IGWQS) established by the NJDEP, EPI believes further discussions are required before these values are formally adopted for the Kalama Chemical site. A more detailed discussion on the proposed groundwater quality standards for salicylic acid, 1,1'-biphenyl, and diphenyl ether can be found in the 13

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[2] Although methyl salicylate (oil of wintergreen) had not previously been detected in groundwater, an alternate standard had been requested since this compound had been detected in the soil of AEC-30 at concentrations requiring remediation (i.e., excavation and off-site disposal).

February 2004 RIR/RAW. Until these issues are resolved, however, the results of the April 2004 and July 2004 groundwater sampling events have been evaluated using both sets of groundwater quality standards.

2.2 Groundwater Sampling Procedures

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". However, in accordance with the NJDEP's letter dated 6 August 2001, and as discussed during the 6 December 2001 conference call, wells that exhibit poor recharge or excessive drawdown were purged and sampled using low flow methodology.

2.2.1 *Standard Purging & Sampling Methodology*

Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rates did not exceed approximately two gallons per minute (gpm). In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

Before Purging

- Date, time, and weather conditions
- Well number
- Head space reading immediately after well cap is removed
- Product thickness, if any

- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

Well purging information for the April 2004 and July 2004 sampling events is summarized on the tables included in Appendix A.

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for volatile organic compound (VOC) analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling. At the end of each day, all samples (except for the ones to be analyzed for formaldehyde) were either delivered to the analytical laboratory (Accutest in Dayton, New Jersey; Certification No. 12129) or returned to the office where they were picked up by an Accutest courier the following morning. The formaldehyde samples were shipped via overnight courier to Accutest's laboratory in Marlborough, Massachusetts. Copies of the analytical data packages for the April 2004 and July 2004 groundwater samples (including the electronic data disk deliverables) are included under separate cover as Attachments I and II, respectively.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

2.2.2 *Low Flow Purging & Sampling Methodology*

As discussed above, the NJDEP has approved the use of low flow purging and sampling for collecting samples from wells that exhibit poor recharge or excessive drawdown during purging. After reviewing the historical well purging data, EPI has identified the following 14 wells on which the low flow methodology is to be used:

Wells Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-1	Poor Recharge
MW-4	Poor Recharge
MW-22	Very Poor Recharge
MW-25	Very Poor Recharge
MW-28D	Excessive Drawdown (>10 feet)
MW-31	Very Poor Recharge
MW-32D	Excessive Drawdown (>10 feet)
MW-40	Poor Recharge
MW-47D	Poor Recharge
MW-47D2	Excessive Drawdown (>10 feet)
MW-48D	Excessive Drawdown (>10 feet)

Wells Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-51D	Excessive Drawdown (>10 feet)
MW-53D	Poor Recharge
MW-57D	Excessive Drawdown (>10 feet)

The low flow purging and sampling procedures used were taken from the USEPA Region II's *Groundwater Sampling Procedure - Low Stress (Low Flow) Purging and Sampling* document that was provided by the NJDEP following the 6 December 2001 conference call. A description of the methodology used and the completed data forms for each well are included in Appendix B.

3.0 APRIL 2004 GROUNDWATER SAMPLING RESULTS

Groundwater samples were collected from 67 wells between 13 and 16 April 2004. None of the monitoring wells gauged during the April 2004 monitoring event contained detectable amounts of LNAPL or DNAPL. Monitoring well MW-1 contained excessive amounts of sediment (due to the operation of the air curtain) and could not be purged by either low flow or standard techniques. MW-17 was covered by debris associated with the demolition of Buildings 18, 29, and 30. Therefore, samples were not collected from these wells. The off-site SVE system and the vertical and horizontal components of the air curtain were on shut down on 8 April 2004, and were re-started on 22 April 2004.

As stated in EPI's letter to the NJDEP dated 18 July 2002, the Northeast and Northwest Phenol Hot Spot Areas have been combined. Starting with the 4 September 2002 RAPR, these two areas are now referred to as the Northern Phenol Area. As per the approved monitoring programs for the Toluene Spill and Northern Phenol Areas, all of the groundwater samples collected during the April 2004 monitoring event were analyzed for volatile organic compounds (VOCs) by USEPA Method 8260 and base neutral/acid extractable compounds (BNAs) by USEPA Method 8270. For the samples from the Northern Phenol Area wells, the BNA analyses included calibrations for salicylic acid (and methyl salicylate for samples from MW-21D and MW-51D). The BNA analyses for the wells addressing the Toluene Spill Area included calibrations for 1,1'-biphenyl and diphenyl ether.

3.1 Groundwater Elevations

Prior to sampling, each well was gauged to determine the presence/absence of LNAPL and DNAPL and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 1 and were used to prepare the groundwater elevation contour maps shown on Figure 2 and Figure 3.

Figure 2 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. Consistent with historical site conditions, a water table mound was present in the northeast corner of the site. A water table mound was also observed around MW-4 in the southeast corner of the site.

Groundwater elevation contours for the deep overburden zone are shown on Figure 3. Consistent with previous gauging events, the direction of groundwater flow in the deep overburden zone continues to be to the west.

3.2 Northern Phenol Area

Although at one time the Northeast and Northwest Phenol Hot Spots appeared to be distinct areas, current groundwater sampling results suggest that they completely overlap and cannot be differentiated. Therefore, both areas are now referred to as the combined Northern Phenol Area.

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

In addition to VOCs and BNAs, each groundwater sample was analyzed for methanol by USEPA Method 8015 - Direct Aqueous Injection (DAI) and formaldehyde by USEPA Method 8315. The results of these analyses are summarized on Table 2 and are presented on Figure 4 (shallow overburden zone) and Figure 5 (deep overburden zone). Concentration vs. Time graphs summarizing historical data for each well are included in Appendix C.

3.2.1 *Shallow Overburden Zone*

The shallow overburden zone wells within the source area include WP-2R and MW-58. As shown on Figure 4, phenol was detected at 20,500 ppb in WP-2R. Salicylic acid was detected at 3,580 ppb and 843 ppb in WP-2R and MW-62, respectively. WP-2R also contained 122 ppb of formaldehyde. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-58, MW-59, and WP-1R. No VOCs were detected in the shallow overburden zone monitoring wells at concentrations exceeding their respective GWQS or IGWQS.

Vertical delineation well WP-2D contained 4.7 ppb of phenol, but no detectable concentrations of salicylic acid, methanol or formaldehyde.

3.2.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R (Figure 5). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (9,260 ppb), MW-47D (59,000 ppb), MW-48D (70,500 ppb), MW-50D (8,590 ppb), and ORC-4D (27,700 ppb). Methanol only exceeded its IGWQS of 50,000 ppb in MW-47D (183,000 ppb). Salicylic acid was detected in three source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in six source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-47D (132,000 ppb), MW-48D (240,000 ppb), MW-49D (2,010 ppb), MW-50D (178 ppb), MW-55D (864 ppb), and ORC-4D (54,500 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb in MW-47D (390 ppb) and MW-55D (111 ppb). Methyl salicylate was not detected in MW-51D, which is consistent with previous results from this well.

Benzene was detected at 1.5 ppb in MW-47D and 1.4 ppb in ORC-4D. No other site-related VOCs were detected in the deep overburden zone source area wells at concentrations exceeding their respective GWQS or IGWQS.

The concentrations of the phenol, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-2DR, MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, and MW-59D) except MW-57D, which contained 6,580 ppb of phenol, and MW-

58D, which contained 164 ppb of formaldehyde. Salicylic acid exceeded the NJDEP's IGWQS of 80.0 ppb in MW-2DR (108 ppb) and MW-57D (17,900 ppb). Benzene was detected in MW-2DR at 1.2 ppb and MW-57D at 2.3 ppb. No other site related VOCs were detected in the deep overburden zone monitoring points at concentrations exceeding their respective GWQS or IGWQS.

Vertical delineation well MW-47D2 contained 1.9 ppb of phenol, but no detectable concentrations of salicylic acid, formaldehyde or methanol during this sampling event.

3.3 Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14)

In order to monitor the effectiveness of the air curtain and the off-site SVE systems, groundwater samples were to be collected from 34 wells. As per the NJDEP's letters dated 15 October 2001 and 20 June 2002, the monitoring wells addressing this AEC have been re-characterized as "source area", "fringe", "sentinel", or "background" wells as follows:

Source Area Wells: MW-4, MW-5, MW-D5, MW-E5, MW-9, MW-17, MW-33, MW-45, and OW-3

Fringe Wells: MW-1, MW-10, MW-11, MW-14R, MW-23, MW-25, MW-31, MW-36, MW-40, MW-41, MW-42, MW-46, MW-56, OW-1, OW-2, OW-4, and OW-5

Sentinel Wells: MW-6, MW-22, MW-30, MW-37, MW-38, and MW-61

Background Well: MW-16 and MW-60

As indicated at the start of this Section, MW-1 contained excessive amounts of sediment and could not be purged, and MW-17 was covered by demolition debris; neither of these wells were sampled during this monitoring event. MW-9 was abandoned in October 2003 prior to the excavation of soil from around the well; a replacement for MW-9 has not yet been installed. Finally, upon reviewing the well depths recorded during this sampling event, it was determined that MW-10D was accidentally sampled instead of MW-10. The analytical results for these samples are summarized on Table 3 and are presented on Figure 6. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix D.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in nine of the 31 wells sampled. In the source area wells, benzene was detected in four of the seven wells sampled, including MW-D5 (272 ppb), MW-33 (53.4 ppb), MW-45 (177 ppb), and OW-3 (29.6 ppb). In the fringe area wells, benzene was detected at concentrations exceeding the GWQS in four of the 16 wells sampled, including MW-25 (4.8 ppb), MW-41 (6.4 ppb), OW-1 (1.1 ppb), and OW-2 (87.0 ppb). Benzene was not detected in the six sentinel and two background monitoring wells except MW-37 (9.9 ppb).

Benzene concentrations decreased in MW-D5, MW-14R, OW-2, and OW-3 from 2.47 ppb (MW-14R) to 595 ppb (OW-2), relative to the January 2004 sampling event. Benzene concentrations increased in MW-25 (4.8 ppb), MW-33 (44.6 ppb), and MW-45 (171 ppb) relative to January 2004, and in MW-37 (8.8 ppb) relative to October 2003[3]. Benzene concentrations were below the GWQS of 1.0 ppb in MW-4, MW-5, MW-E5, MW-6, MW-10D, MW-11, MW-14R, MW-16, MW-22, MW-23, MW-30, MW-31, MW-36, MW-38, MW-40, MW-42, MW-46, MW-56, MW-60, MW-61, OW-4, and OW-5.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in four of the 31 wells sampled. In the source area, toluene exceeded the GWQS in three of the seven wells sampled, including MW-D5 (35,200 ppb), MW-33 (12,500 ppb), and MW-45 (5,680 ppb). Toluene concentrations were below the GWQS of 1,000 ppb in all of the fringe area, sentinel, and background wells during the April 2004 sampling event except OW-2 (23,000 ppb).

1,1'-Biphenyl concentrations exceeded the NJDEP's proposed IGWQS of 400 ppb, and EPI's proposed alternate GWQS of 1,800 ppb, only in source area well MW-D5 (3,670 ppb). 1,1'-Biphenyl concentrations were below the NJDEP's proposed IGWQS in all of the remaining source area, fringe, sentinel, and background wells. Diphenyl ether was detected at concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb, but below EPI's proposed alternate GWQS of 21,000 ppb, in four of the 31 wells sampled, including MW-D5 (9,220 ppb), MW-33 (1,460 ppb), MW-41 (454 ppb), and OW-3 (471 ppb).

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[3] MW-37 was covered by snow and ice in January 2004 and could not be sampled.

3.4 Other Compounds Detected in Groundwater

In addition to the primary compounds of concern (i.e., benzene, toluene, 1,1'-biphenyl, diphenyl ether, phenol, salicylic acid, methyl salicylate, methanol, and formaldehyde), the results of the April 2004 sampling event indicated that other VOCs and BNAs were present in groundwater at concentrations exceeding their respective groundwater quality standards (see Tables 2 & 3). As shown on Figure 7 (shallow overburden) and Figure 8 (deep overburden), groundwater at and around the site also contains elevated concentrations of chloroform, cis-1,2-dichloroethene (1,2-DCE), tetrachloroethene (PCE), trichloroethene (TCE), vinyl chloride, 2-methylphenol, and 3&4-methylphenol.

Chloroform was detected at a concentration exceeding its GWQS of 6.0 ppb in shallow overburden background well MW-16 (17.2 ppb). 1,2-DCE was detected in OW-1 at 96.4 ppb, which exceeds the NJDEP's GWQS of 70.0 ppb for this compound. PCE exceeded its GWQS of 1.0 ppb in three shallow overburden wells, including MW-E5 (1.8 ppb), MW-16 (1.2 ppb), and MW-46 (2.3 ppb), and one deep overburden well (4.8 ppb in MW-52D). TCE exceeded its GWQS of 1.0 ppb in shallow overburden wells MW-5 (18.2 ppb), MW-E5 (17.2 ppb), MW-16 (23.9 ppb), MW-37 (8.9 ppb), MW-38 (80.5 ppb), MW-41 (6.5 ppb), MW-46 (171 ppb), MW-60 (41.4 ppb), MW-61 (44.2 ppb), OW-1 (44.3 ppb), and OW-5 (7.7 ppb). In addition, TCE exceeded its GWQS in deep overburden wells MW-2DR (1.1 ppb), MW-12D (60.0 ppb), MW-48D (28.8 ppb), MW-50D (4.5 ppb), MW-52D (129 ppb), MW-53D (98.9 ppb), and MW-54D (11.6 ppb). Vinyl chloride exceeded its GWQS of 5.0 ppb in shallow overburden well OW-1 (22.2 ppb), and deep overburden wells MW-2DR (9.8 ppb), MW-3D (20.1 ppb), MW-32D (10.8 ppb), MW-49D (37.5 ppb), and MW-50D (15.7 ppb).

2-Methylphenol was detected in MW-33 (146 ppb) and OW-2 (229 ppb) at concentrations exceeding the NJDEP's IGWQS of 100 ppb. 3&4-Methylphenol concentrations exceeded the IGWQS of 100 ppb only in MW-47D (592 ppb).

3.5 Background Wells

Groundwater samples were collected from background wells MW-8, MW-19, MW-19D, MW-20, MW-20D, MW-35, and MW-35D during the April 2004 monitoring event. As shown on Figure 1, MW-8 is located off-site, immediately to the east of the Toluene Spill Area. MW-19 and MW-19D are located 55.0 feet east of the northeast corner of the site, near the corner of Cambridge Avenue and Monroe Street. MW-20 and MW-20D are located in Commerce Street, approximately 190 feet east of the central portion of the site. MW-35 and MW-35D are located in Hudson Street, approximately 210 feet east of the southeast corner of the site.

Each background well was sampled for VOCs, BNAs (including 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate), methanol, and formaldehyde. The analytical results for these samples are summarized on Table 4, and are presented on Figures 7 and 8. Concentration vs. Time graphs summarizing historical data for each background well are included in Appendix E.

No detectable concentrations of benzene, toluene, 1,1'-biphenyl, diphenyl ether, salicylic acid, methyl salicylate, methanol or formaldehyde were found in the background wells, although phenol was detected at 1.3 ppb in MW-20. However, the corresponding field blank for MW-20 also contained 6.6 ppb of phenol, suggesting possible cross-contamination in the field. Chlorinated VOCs were detected at concentrations exceeding their respective GWQS in four of the seven background wells. Chloroform exceeded its GWQS of 6.0 ppb in MW-20 (32.0 ppb) and MW-20D (30.1 ppb). PCE exceeded 1.0 ppb in MW-35D (8.0 ppb), while TCE also exceeded 1.0 ppb in MW-20D (3.8 ppb), MW-35 (19.5 ppb), and MW-35D (876 ppb).

3.6 Distribution of Compounds of Concern

The distributions of toluene and benzene in the shallow overburden zone using the April 2004 groundwater sampling results are shown on Figure 9 and Figure 10, respectively. The highest concentrations of toluene (greater than 10,000 ppb) are limited to the areas around MW-D5 and MW-33 in the southeast corner of the site, and in OW-2 to the south of the site. No toluene concentrations over 100,000 ppb were detected during this monitoring event. Concentrations of toluene exceeding the GWQS of 1,000 ppb are also limited to the areas around MW-D5/MW-33 and OW-2.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 100 ppb) being found around MW-D5 and MW-33. Benzene concentrations exceeding 10.0 ppb were also found to the south of the site (OW-2).

The distributions of 1,1'-biphenyl and diphenyl ether in the shallow overburden zone are shown on Figures 11 and 12, respectively. Concentrations of 1,1'-biphenyl only exceeded the NJDEP's proposed IGWQS of 400 ppb in MW-D5 in the southeast corner of the site. Diphenyl ether concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb were also limited to the southeast (MW-D5, MW-33, MW-41, OW-3) portion of the site.

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 13 and 14, respectively. The area with the highest concentration of phenol in the shallow overburden zone is limited to beneath former Building 33-B (20,500 ppb in WP-2R). The wells containing salicylic acid at concentrations exceeding the NJDEP's proposed IGWQS of 80.0 ppb include WP-2R (3,580 ppb) and MW-62 (843 ppb).

The distribution of formaldehyde in the shallow overburden zone is shown on Figure 15. The area of the formaldehyde plume mirrors that of the salicylic acid plume, with concentrations exceeding the IGWQS of 100 ppb being limited to WP-2R (122 ppb).

The concentrations of methanol in the shallow overburden zone did not exceed the IGWQS of 50,000 ppb during the April 2004 sampling event.

The distribution of phenol in the deep overburden zone is depicted on Figure 16. Phenol concentrations over 10,000 ppb were found around MW-47D, MW-48D, and ORC-4D, with concentrations exceeding 4,000 ppb also encompassing MW-28D, MW-50D, and MW-57D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-49D, MW-51D, MW-53D, MW-54D, and MW-55D.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 17. The areal extent of salicylic acid in the deep overburden zone is larger than that of phenol, with the highest concentrations (exceeding 100,000 ppb) being found in MW-47D and MW-48D. A smaller area of salicylic acid concentrations above 10,000 ppb is centered around MW-57D. The area of the salicylic acid plume as defined by the NJDEP's proposed IGWQS of 80.0 ppb encompasses MW-55D in the north-central portion of the site.

The distribution of formaldehyde in the deep overburden zone is shown on Figure 18. Formaldehyde concentrations above 100 ppb were found in an area encompassing MW-47D, MW-55D, and MW-58D.

The distribution of methanol in the deep overburden zone is shown on Figure 19. Methanol concentrations only exceeded the NJDEP's IGWQS of 50,000 ppb in MW-47D.

4.0 JULY 2004 GROUNDWATER SAMPLING RESULTS

Groundwater samples were collected from 56 wells between 20 and 23 July 2004. None of the monitoring wells gauged during this monitoring event contained detectable amounts of LNAPL or DNAPL. Monitoring wells MW-1 and MW-11 contained excessive amounts of sediment (due to the operation of the air curtain) and could not be purged by either low flow or standard techniques. Therefore, samples were not collected from these wells. MW-25 was covered by standing water and could not be accessed for sampling. MW-30 began collecting storm water run-off during purging, so sampling of this well was abandoned. Finally, OW-2 and OW-5 contained an insufficient volume of water for purging or sampling. The off-site SVE system and the vertical and horizontal components of the air curtain were shut down on 20 July 2004, and were re-started on 29 July 2004.

4.1 Groundwater Elevations

Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 5 and were used to prepare the groundwater elevation contour maps shown on Figure 20 and Figure 21.

Figure 20 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. None of the remediation systems in the southern half of the site were in operation at the time of sampling. Consistent with historical site conditions, a water table mound was present in the northeast corner of the site. The smaller water table mound typically observed around MW-4 and MW-17 in the southeast corner of the site was present during this gauging event, along with a slight water table depression around MW-D5.

Groundwater elevation contours for the deep overburden zone are shown on Figure 21. The direction of groundwater flow in the deep overburden zone continues to be to the west.

4.2 Northern Phenol Area

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected and analyzed for phenol, salicylic acid, methanol, and formaldehyde. In addition, the groundwater samples from MW-21D and MW-51D were analyzed for methyl salicylate. The results of these analyses are summarized on Table 6 and are presented on Figure 22 (shallow overburden zone) and Figure 23 (deep overburden zone). Concentration vs. Time graphs summarizing historical data for each well are included in Appendix C.

Formaldehyde was detected at concentrations of 10.6 ppb to 11.7 ppb in all of the method blanks associated with the July 2004 groundwater samples. As a result, there was a widespread distribution of low concentrations of formaldehyde seen during this monitoring event. Using a typical "three times rule" to correct for method blank contamination, only the formaldehyde concentrations seen in MW-47D, MW-48D, MW-51D, MW-55D, MW-58, MW-58D, MW-59, and WP-2R appear to be representative of groundwater quality.

4.2.1 *Shallow Overburden Zone*

The shallow overburden zone wells within the source area include WP-2R and MW-58. As shown on Figure 22, phenol was detected at 41,200 ppb in WP-2R. Salicylic acid was not detected at concentrations above the NJDEP's IGWQS of 80.0 ppb in the shallow overburden zone. WP-2R also contained 705 ppb of formaldehyde, while MW-58 contained 264 ppb of formaldehyde. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-59, MW-62, and WP-1R.

Vertical delineation well WP-2D contained 29.5 ppb of phenol and 14.1 ppb of formaldehyde, but no detectable concentrations of salicylic acid or methanol during the July 2004 monitoring event. As discussed above, the formaldehyde detected in WP-2D is most likely related to method blank contamination and is not representative of groundwater quality in this well.

4.2.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R (Figure 23). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (401,000 ppb), MW-48D (89,600 ppb), MW-50D (4,720 ppb), and ORC-4D (18,300 ppb). Methanol did not exceed its IGWQS of 50,000 ppb during this sampling event. Salicylic acid was detected in one source area well at a concentration exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in two source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-55D (564 ppb), and ORC-4D (54,400 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb in MW-47D (2,570 ppb) and MW-55D (607 ppb). Methyl salicylate was not detected in MW-51D during this sampling event.

The concentrations of the phenol, salicylic acid, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-2DR, MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, and MW-59D) except MW-57D, which contained 283 ppb of salicylic acid, and MW-58D, which contained 146 ppb of formaldehyde.

Vertical delineation well MW-47D2 contained no detectable concentrations of phenol, salicylic acid, or methanol, and 12.6 ppb of formaldehyde during this sampling event. As discussed above, the formaldehyde detected in MW-47D2 is most likely related to method blank contamination and is not representative of groundwater quality in this well.

4.3 Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14)

As indicated at the start of this Section, MW-1 and MW-11 contained excessive amounts of sediment and could not be purged, MW-25 was covered by standing water, MW-30 began to collect storm water run-off during purging, and OW-2 and OW-5 contained an insufficient volume of water to be purged. Therefore, none of these wells were sampled during this monitoring event. Analytical results for the 27 samples collected are summarized on Table 7 and are presented on Figure 24. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix D.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 12 of the 27 wells sampled. In the source area wells, benzene was detected in six of the eight wells sampled, including MW-4 (1.1 ppb), MW-D5 (692 ppb), MW-17 (69.5 ppb), MW-33 (2,420 ppb), MW-45 (270 ppb), and OW-3 (7.7 ppb). In the fringe area wells, benzene was detected at concentrations exceeding the GWQS in five of the 12 wells sampled, including MW-40 (7.0 ppb), MW-41 (1.8 ppb), MW-56 (1.5 ppb), OW-1 (1.7 ppb), and OW-4 (7.3 ppb). In the background and sentinel wells, benzene was only detected in MW-37 (3.5 ppb).

Benzene concentrations decreased in MW-14R, MW-37, MW-41, and OW-3 from 0.33 ppb (MW-14R) to 21.9 ppb (OW-3), relative to the April 2004 sampling event. Benzene concentrations increased in MW-D5 (420 ppb), MW-33 (2,367 ppb), MW-40 (6.61 ppb), MW-45 (93.0 ppb), and OW-4 (6.57 ppb) relative to April 2004, and in MW-17 (19.2 ppb) relative to January 2004. Benzene concentrations were below the GWQS of 1.0 ppb in MW-5, MW-E5, MW-6, MW-10, MW-14R, MW-16, MW-22, MW-23, MW-31, MW-36, MW-38, MW-42, MW-46, MW-60, and MW-61.

Table 8 presents a comparison of the July 2004 benzene concentrations to i) the maximum concentration ever detected in a well; ii) the last four quarters of data for each well before the remediation systems were shut down for the first time in August 2001; iii) the October 2001 groundwater results (the first time no remediation systems were running); and, iv) the July 2003, October 2003, January 2004, and April 2004 groundwater results. The summary on Table 8 shows that there has been an average reduction of 88.1% in the levels of benzene in the monitoring wells that address the Toluene Spill Area of the site (excluding MW-E5 and MW-46 which have never contained more than 1.0 ppb of benzene). Average benzene concentrations are approximately 5.0% higher in July 2004 than in January 2004.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in four of the 27 wells sampled. In the source area, toluene exceeded the GWQS in MW-D5 (33,300 ppb), MW-33 (158,000 ppb), and MW-45 (4,490 ppb). With the exception of 1,620 ppb in OW-4, toluene concentrations were below the GWQS of 1,000 ppb in all of the fringe area, sentinel, and background wells during the July 2004 sampling event.

Table 9 shows that as of July 2004, the number of wells that contain over 1,000 ppb of toluene has been reduced from 22 to four, and that there has been an average reduction in toluene concentrations of 97.7% in the wells addressing the Toluene Spill Area (excluding those wells that have never contained toluene at a concentration exceeding the GWQS of 1,000 ppb). Average toluene concentrations are approximately 3.0% lower than in January 2004.

1,1'-Biphenyl concentrations exceeded the NJDEP's proposed IGWQS of 400 ppb, and EPI's proposed alternate GWQS of 1,800 ppb, only in source area well MW-D5 (3,100 ppb). 1,1'-Biphenyl concentrations were below the proposed IGWQS in all of the remaining source area, fringe, sentinel, and background wells. Diphenyl ether was detected at concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb, but below EPI's proposed alternate GWQS of 21,000 ppb, in six of the 27 wells sampled, including MW-D5 (6,240 ppb), MW-17 (1,920 ppb), MW-23 (177 ppb), MW-33 (317 ppb), MW-56 (175 ppb), and OW-3 (700 ppb).

4.4 Distribution of Compounds of Concern

The distributions of toluene and benzene in the shallow overburden zone using the July 2004 groundwater sampling results are shown on Figure 25 and Figure 26, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to the area around MW-33 in the southeast corner of the site. The highest concentrations on-site (greater than 10,000 ppb) are limited to the southeast corner of the site around MW-D5. Concentrations of toluene exceeding the GWQS of 1,000 ppb are also limited to the areas around MW-D5, MW-33, and OW-4. As shown on Table 10, the areal extent of the portions of the toluene plume in July 2004 that contained greater than 10,000 ppb and 1,000 ppb increased to 9,003 ft^2 and 2,538 ft^2, respectively (relative to January 2004). The overall size of the toluene plume (as defined by the 1,000 ppb isoconcentration line) has been reduced approximately 93% relative to the baseline conditions of June 1997.

Although larger, the benzene affected area has a similar pattern to that of the toluene affected area, with the highest concentrations (greater than 100 ppb) being found around MW-D5, MW-33, and MW-45. Benzene concentrations exceeding 1.0 ppb were also found to the south of the site (MW-40, OW-1, and OW-4), and in isolated wells MW-37 and MW-56. As shown on Table 11, the portions of the benzene plume in July 2004 that contained greater than 1,000 ppb increase in areal extent (relative to January 2004) to approximately 582 ft^2, while the 100 ppb, 10.0 ppb and 1.0 ppb portions of the plume also increased to 7,788 ft^2, 25,716 ft^2, and 130,454 ft^2, respectively. The overall size of the benzene plume (as defined by the 1.0 ppb isoconcentration line) is still approximately 71% smaller relative to the baseline conditions of June 1997.

The distributions of 1,1'-biphenyl and diphenyl ether in the shallow overburden zone are shown on Figures 27 and 28, respectively. Concentrations of 1,1'-biphenyl only exceeded the NJDEP's proposed IGWQS of 400 ppb in MW-D5 in the southeast corner of the site. Diphenyl ether concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb were found in the southeast (MW-D5 and MW-17) and southwest (MW-23 and MW-56) portions of the site.

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 29 and 30, respectively. The area with the highest concentration of phenol in the shallow overburden zone is limited to beneath former Buildings 33-A and 33-B (41,200 ppb in WP-2R). Salicylic acid concentrations did not exceed the NJDEP's proposed IGWQS of 80.0 ppb in the shallow overburden zone in July 2004.

The distribution of formaldehyde in the shallow overburden zone is shown on Figure 31. The area of the plume containing greater than 100 ppb of formaldehyde encompasses MW-58 (264 ppb) and WP-2R (705 ppb). The concentrations of methanol in the shallow overburden zone did not exceed the IGWQS of 50,000 ppb during the July 2004 sampling event.

The distribution of phenol in the deep overburden zone is depicted on Figure 32. Phenol concentrations over 100,000 ppb were limited to MW-47D, with concentrations exceeding 10,000 ppb also encompassing MW-48D and ORC-4D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-28D, MW-49D, MW-53D, and MW-54D.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 33. The areal extent of salicylic acid in the deep overburden zone is the smallest seen since sampling for this compound began in July 1998. The highest concentrations (exceeding 10,000 ppb) were limited to the area around ORC-4D.

An area of salicylic acid exceeding the NJDEP's proposed IGWQS of 80.0 ppb was also found around MW-55D and MW-57D.

The distribution of formaldehyde in the deep overburden zone is shown on Figure 34. Formaldehyde concentrations above 1,000 ppb were found in MW-47D, with concentrations exceeding the IGWQS of 100 ppb also being found in MW-55D and MW-58D.

The distribution of methanol in the deep overburden zone is shown on Figure 35. Methanol concentrations did not exceed the NJDEP's IGWQS of 50,000 ppb during the July 2004 monitoring event.

5.0 BACKGROUND SOURCE OF CHLORINATED VOCS

Item 6 of the NJDEP's letter dated 15 January 2003 required EPI to conduct a background study to address the potential off-site source of the chlorinated solvents (primarily TCE) present in groundwater at and around the site. As was discussed in Section 3.4 above, groundwater at the site in April 2004 contained chloroform, 1,2-DCE, PCE, TCE, and vinyl chloride at concentrations exceeding their respective GWQS. As discussed in Section 3.5, the highest concentrations of chloroform, TCE, and PCE in groundwater were found in the background monitoring wells (i.e., MW-8, MW-19, MW-19D, MW-20, MW-20D, MW-35, and MW-35D).

Based on 35 years of experience, and a review of the available historical records, former Kalama personnel have determined that chlorinated VOCs would never have been used as raw materials in the facility's manufacturing operations. Although chlorinated solvents may have been used in the machine shops, they would only have been present in small quantities. It would therefore be expected that the only way these compounds could result in an impact to groundwater would be through surface spills. However, the soil data collected at the site does not support this.

Over the course of the investigation of the Kalama facility, close to 300 soil samples have been collected for either priority pollutant or target compound list VOC analyses. Trace amounts (less than 0.10 ppm) of chlorinated VOCs were only detected in 13 samples from across the site. Only two soil samples have ever contained chlorinated VOCs at concentrations exceeding their respective Impact to Groundwater cleanup criterion of 1.0.part per million (ppm). Sample B-4 (collected in 1986 in the southeast corner of the site) contained 4.4 ppm of 1,1,2,2-tetrachloroethane (1,1,2,2-TCA). It should be noted that 1,1,2,2-TCA has only been detected once, and has never been detected in any of the hundreds of groundwater samples which have been collected at the site. Sample SL-17-2 (collected in 2002 in the southwest corner of the site) contained 1.05 ppm of chloroform and 4.68 ppm of 1,2-dichloroethane (1,2-DCA). The post-excavation sample collected above the water table at 6.0 - 6.5 feet below grade at this location did not contain detectable concentrations of any chlorinated compounds.

Given the absence of all but trace amounts of chlorinated VOCs in soil, EPI maintains that a source of these compounds does not exist at the site.

5.1 Migration Potential

In Item 6 of their 15 January 2003 letter, the NJDEP required EPI to evaluate the potential for downward and radial migration of the chlorinated compounds due to the water table mounding present in the southeast corner of the site.

5.1.1 *Water Table Mounding*

As had been discussed in Section 3.3.2 of the 29 February 1996 *Revised Remedial Action Work Plan Addendum*, the slight groundwater mound present in the southeast corner of the facility has not contributed to the spread of chlorinated compounds in a direction up-gradient to the site (i.e., to the east). The source of this mound has been demonstrated to be water perched atop a lens of silty clay and fine sand in the vicinity of MW-4 and piezometers PZ-1 and PZ-2. After reviewing groundwater contour maps from 40 rounds of well gauging between April 1991 and July 2004, it has been determined that the average height of the water table mound observed around MW-4 was approximately 1.7 feet, with the largest mound being observed in April 2004 (see Figure 2). At that time, the mound was approximately 3.87 feet high at MW-4 and extended approximately 80.0 feet in an up-gradient direction to the property line near MW-5. However, even a mound of this magnitude did not reverse the overall direction of groundwater flow (to the west-southwest), considering that the groundwater gradient from the east (i.e., from MW-35 towards MW-5) was 0.012 ft/ft. It should also be noted that elevated concentrations of TCE have also been found in the deep monitoring wells up-gradient from the site (MW-16D, MW-19D, MW-20D, MW-34D, MW-35D), although a groundwater mound has never been seen in the deep overburden zone.

5.1.2 *Vertical Migration*

Section 6.0 of the 4 September 2002 RAPR presented a "diving plume" evaluation that discussed the groundwater elevation differences noted between the shallow and deep overburden zone wells. This evaluation is summarized below, and was performed using the April 2002 well gauging data.

The most important factor to be evaluated to determine the presence of a diving plume is the vertical gradient between shallow and deep monitoring wells. Table 12 presents a comparison of the groundwater elevations in 18 nested well pairs at the site. The data from monitoring wells MW-1/1D, MW-12/12D, MW-17/17D, and MW-25/25D were not used in this evaluation due to influences from the air curtain or due to anomalous well gauging data. The construction of MW-4 and MW-4D2 preclude their use in this evaluation. MW-4 is a shallow overburden well located within the center of the southeastern water table mound, while MW-4D2 is bedrock well. For a valid evaluation to be made at this location, a deep overburden monitoring well would need to be constructed with a screened interval near the top of bedrock.

For the following overburden monitoring wells, the groundwater elevations in the deep wells were lower than in the shallow wells (i.e., exhibited a downward gradient): MW-2/2DR, MW-3/3D, MW-6/6D, MW-27/27D, MW-28/28D, and MW-32/32D. With the exception of MW-6/6D, all of these wells are located in the northeastern corner of the site, and are influenced by the clay layer that separates the shallow and deep overburden zones and produces the northern water table mound. In this portion of the site, the deep overburden zone has been impacted by site related compounds of concern. The elevation differences between the shallow and deep overburden wells observed during the April 2002 gauging event are consistent with the data from historical gauging events. Although a downward gradient exists between MW-6 and MW-6D, historical gauging data from these wells indicate that this condition can change to an upward gradient. These changes in vertical gradient may be related to the fact that MW-6 has been shown to be tidally influenced by the Passaic River.

Groundwater elevations in the deep wells were higher than in the shallow wells for the following overburden monitoring wells (i.e., exhibited an upward gradient): MW-5/5D, MW-16/16D, MW-35/35D, and MW-37/37D. MW-16/16D and MW-35/35D are located to the east (upgradient) of the toluene spill area in the southeast corner of the site, while MW-5/5D are located within the spill area. MW-37/37D are located to the south of the site and represent the most downgradient monitoring points. These results are consistent with the historical gauging data for each well pair.

The groundwater elevation differences between the following shallow and deep overburden wells were considered to be inconclusive, in that the differences were less than 0.10 feet: MW-19/19D, MW-20/20D, MW-33/33D, MW-36/36D, and MW-38/38D. MW-19/19D and MW-20/20D are located upgradient from the site, MW-33/33D are located within the toluene spill source area, and MW-36/36D and MW-38/38D are located downgradient from the site. Although the data are considered to be inconclusive, groundwater elevations in the deep wells were always higher than in the shallow wells, suggesting a slight upward gradient. These results would be consistent with the historical gauging data for well pairs MW-20/20D and MW-33/33D.

With the exception of the northeastern corner of the site, the vertical gradient between shallow and deep zone overburden wells is upward. This observed upward gradient is expected given the proximity of the site to the Passaic River, a gaining surface water body (i.e., overburden groundwater discharges to the river).

5.2 Background Property Survey

In the Fall of 2003, the area surrounding the Kalama site was researched to determine the presence and location of commercial and industrial properties on which TCE (or other chlorinated solvents) may currently or historically have been stored or used. A review of available literature indicates that TCE has a number of commercial and industrial uses, including:

- Vapor degreasing of metal parts (automotive and metals industry).
- Extraction solvent for grease, oils, fats, waxes, and tars.
- General solvent or component of solvent blends used with adhesives, lubricants, paints, varnishes, paint strippers and pesticides.
- Solvent for waterless dyeing and finishing operations (textiles.)
- Scouring medium for cotton, wool, and other fabrics (textiles).
- Degreaser (tanning industry)
- Cold metal cleaner (automotive repair shops)

The background property use review was conducted through canvassing the neighborhood surrounding the site, reviewing Sanborn Fire Insurance Maps from 1910, 1917, 1951, and 1968 to document past operators on commercial and industrial properties surrounding the site, and reviewing the City Directory to document (where possible) historic commercial and industrial operators not indicated on the Sanborn Maps. The information on the Sanborn Maps and City Directory indicate that industrial operations have been conducted in the area surrounding the Kalama site since at least 1910.

The background property use review identified 38 properties upgradient from the Kalama site on which current or historic use/storage of chlorinated solvents is possible (see Figure 36). Table 13 lists the properties, current and historic operators, and the source(s) of data accessed to compile this information.

EPI believes that 1) the absence of any on-site sources of chlorinated solvents; 2) the site specific hydrogeologic conditions; and 3) the numerous other potential sources of chlorinated solvents identified upgradient from the site all conclusively demonstrate that the Kalama site is not the source for the chlorinated solvents present in groundwater. Therefore, EPI requests that No Further Actions be required relative to this matter.

6.0 REMEDIAL ACTIONS

The following Sections discuss the performance of the off-site SVE and air curtain remediation systems for the period of February 2004 through July 2004. Due to the low mass removal rates being achieved by the on-site SVE system (and due to the expense of operating the thermal oxidizer under these conditions), EPI requested and received verbal approval from the NJDEP on 17 April 2003 to shut down the SVE component of the AS/SVE system[4]; the system was subsequently shut down the same day. EPI will periodically re-evaluate site conditions to determine if re-starting the SVE system is warranted.

6.1 AS/SVE System

Monthly observation well monitoring was conducted in February, March, April, May, and July 2004. SPH was not detected during any of these gauging events. As shown on Table F-1 in Appendix F, monthly precipitation totals ranged from 2.63 inches in June 2004 to 10.05 inches in July 2004. However, average groundwater levels fell approximately 1.0 foot across the remediation area. Since groundwater levels were still slightly above normal across the area, the SVE component of the remediation system was not re-started. Precipitation data and graphs comparing monthly precipitation to changes in groundwater elevation for the wells within the remediation area (i.e., MW-4, MW-5, MW-5D, MW-D5, MW-E5, MW-F5, MW-9, MW-17, MW-17D, MW-33, and MW-33D) are included in Appendix F.

6.2 Offsite SVE System

The off-site SVE system was operational approximately 91% of the time during the February through July 2004 reporting period. The only periods of down-time were associated with two possible power outages, and the April 2004 and July 2004 groundwater sampling events. The extraction blower for the system operated at an average inlet vacuum of approximately 27 inches of water (i.w.) and a maximum

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[4] The AS component of the system was shut down in August 2001 at the direction of the NJDEP, and has not been re-started due to the discovery of DNAPL in the area.

extraction rate of approximately 360 cubic feet per minute (cfm). No vapor phase hydrocarbons were recovered by the off-site SVE system during this reporting period. A total of 4,296 pounds of non-methane hydrocarbons have been recovered by the off-site SVE system (see Appendix G).

6.3 Air Curtain System

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the February through July 2004 reporting period. Flow rates on the horizontal well system were balanced at an average of 41 to 42 cfm on each of the two lines; the total flow into the formation via the vertical injection wells averaged approximately 26 cfm (see Appendix H). All injection flow rates were in proportion to the hydrostatic pressures yielded by the groundwater table. The air curtain equipment was operated at maximum obtainable pressure (20 pounds per square inch [psi]).

Monthly observation well monitoring was conducted in February, March, April, May, and July 2004. Churning/bubbling conditions were observed in monitoring wells MW-1D, MW-10D, MW-11, MW-14R, MW-25, MW-25D, OW-2, OW-4, and/or OW-5 during this reporting period. No VOCs were detected in the on-site vapor monitoring points (VMPs 1 through 10) during this reporting period.

6.4 DNAPL Recovery

Between July and August 2002, DNAPL was discovered in the southeast and northwest corners of the site. The DNAPL in the southeast corner of the site has been identified by laboratory analysis to be Dowtherm, a heat transfer oil that was used in this area of the facility. Based on its distinctive smell, the DNAPL in the northwest corner of the site is believed to be methyl salicylate (i.e., synthetic oil of wintergreen), which used to be manufactured and handled in former Buildings 3 and 4.

6.4.1 *Dowtherm*

EPI implemented a manual recovery program for the DNAPL in AS-12 following its discovery in August 2002. During each operation & maintenance (O&M) visit for the SVE system and thermal oxidizer, AS-12 was gauged to determine the presence of DNAPL, and a surface mounted double-diaphragm pump was used to remove any accumulated product. Approximately 30.1 gallons of DNAPL were recovered from AS-12; the results of the recovery program are summarized on Table 14.

The last DNAPL recovery event from AS-12 was conducted on 30 January 2003. While sealing the borings associated with the DNAPL investigation that was conducted during the first week of February 2003, grout from one or more of the boreholes migrated into AS-12, and effectively sealed the well to a depth of 18.0 feet below grade. Attempts to remove the grout were unsuccessful, since it was not discovered until several days after it had entered the sparge well.

On 17 October 2003, monitoring well MW-63 was installed adjacent to former air sparge well AS-12. MW-63 has a total depth of approximately 37.0 feet (the top of the glacial till), and is constructed with 25.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 12.0 feet of PVC casing. The screened portion of the well overlaps the intervals where staining was observed on the Ribbon NAPL Sample (RNS) liners (i.e., those intervals where DNAPL is suspected to be present in the soil) used during the February 2003 DNAPL investigation. Since MW-63 was installed, it has been gauged eight times, and no measurable amounts of DNAPL have been detected in the well (see Table 15). MW-63 will continue to be included in the monthly monitoring program for the site.

6.4.2 *Methyl Salicylate*

Monitoring well MW-51D was installed at the same location as the temporary well point (TWP-2) in which DNAPL appeared to be present in July 2002. As shown on Table 16, MW-51D has been gauged 21 times since it was installed on 17 October 2002, and no measurable amounts of DNAPL have been detected. MW-51D will continue to be included in the monthly monitoring program for the site.

7.0 REVISED GROUNDWATER MONITORING PROGRAM

The primary objective of the proposed groundwater monitoring plan (GWMP) is to: (i) comprehensively assess the groundwater quality at the site on a frequent basis; and (ii) determine whether the compounds of concern (COCs) are moving from specific source areas at rates that would increase the areal extent of the impacted groundwater and result in an unacceptable risk to human health and the environment. The groundwater monitoring plan documents the success of the various remediation efforts that have been made by EPI to reduce the contaminant concentrations in soil and groundwater. It also monitors the effectiveness of the natural attenuation processes.

The proposed groundwater monitoring plan is based on the review of the extensive groundwater data collected at the Kalama site since 1997 and the identification of the distinct areas of primary impact (i.e. source areas). It builds on the reduction in concentrations and/or non-increasing trends of the various COCs noted in the groundwater monitoring wells that have been sampled on a frequent basis.

Review of the existing data in conjunction with the identified areas of primary impact has helped identify monitoring wells that could be added or removed from the current groundwater monitoring plan. Inclusion of some of the groundwater monitoring wells into the GWMP will help monitor the extent of impact from specific source areas. Removal of monitoring wells from the current GWMP was based on reduced and/or non-increasing trend of COC concentrations.

Groundwater monitoring will continue as before, ensuring contaminants are not moving at rates that would result in an increase of the impacted plume area. Associating portions of the impacted groundwater to distinct source areas will also allow for a more focused approach to remediation, performance evaluation and closure. The proposed GWMP divides the Toluene Spill Area plume into three distinct source areas and associated monitoring points. In the short term, the proposed program would serve to reduce project costs, as well as reduce the number of wells that need to be accessed on a regular basis. In the long term, the proposed program may allow for elimination of groups of monitoring wells as source areas are remediated.

7.1 Toluene Spill Area

The Toluene Spill Area is located in the southeast corner of the site and represents the source area for the benzene and toluene in groundwater. Soil and groundwater in the area have been actively treated over the years. Based on the review of the groundwater data collected in the area, three distinct areas of high groundwater impact have been identified. Tables 3 and 7, and Figures 9 - 12 and Figures 25 - 28 in this report show the current distribution of the primary COCs in these areas. It is anticipated that segregating this large area of impact into three distinct impact areas will allow a more focused approach to remediation, performance evaluation and closure. Accordingly, the following monitoring plan has been developed to monitor each of these three areas of high impact:

1. Plant/Spill Area

- Source Area Wells: MW-D5, MW-9 (when it is re-installed), MW-17 and MW-33
- Monitoring Points: MW-5, MW-E5, MW-18, MW-10, MW-11, MW-16, MW-41, MW-45, MW-60, and OW-3

Groundwater samples in this area should be collected quarterly from all wells that do not contain separate phase hydrocarbons and should be analyzed for benzene, toluene, 1,1'-biphenyl and diphenyl ether.

2. Hot Spot Area in Bloomingdale Avenue

- Hot Spot Area Well: OW-2
- Monitoring Points: MW-40, MW-56, and OW-1

Groundwater samples in this area should be collected quarterly from all wells that do not contain separate phase hydrocarbons and should be analyzed for benzene, toluene and 1,1'-biphenyl, and diphenyl ether.

3. Hot Spot Area Near Bldg 17

- Hot Spot Area Well: MW-14R
- Monitoring Points: MW-22, MW-23, MW-31, MW-36, and MW-56

Groundwater samples in this area should be collected quarterly from all wells that do not contain separate phase hydrocarbons and should be analyzed for benzene, toluene, 1,1'-biphenyl, and diphenyl ether.

7.2 Northern Phenol Area

The Northern Phenol Area is comprised of the Northeast Phenol Hot Spot Area (Former Building 10/36) and the Northwest Phenol Hot Spot Area (Former Building 33-B). Based on the review of the groundwater data collected in this area, two zones of groundwater impact have been identified: (i) Shallow Overburden Zone and (ii) Deep Overburden Zone. Tables 2 and 6, and Figures 13 - 19 and Figures 29 - 35 in this report show the current distribution of the primary COCs in these zones. In an effort to monitor the natural degradation of phenol, salicylic acid, methanol, and formaldehyde present in the overburden zones, the following source area wells and monitoring points are proposed for the two impacted zones:

1. Shallow Groundwater

1. Source Area Wells: MW-51, MW-58, WP-1R, and WP-2R
1. Monitoring Points: MW-2, MW-21, MW-24, MW-30, MW-59, MW-62

Groundwater samples in this zone should be collected quarterly from all wells that do not contain separate phase hydrocarbons and should be analyzed for phenol, salicylic acid, and formaldehyde. Based on available information it is determined that sufficient data exists to document that methanol is not a compound of concern in the shallow overburden zone groundwater.

2. Deep Groundwater

- Source Area Wells: MW-47D, MW-48D, and MW-55D
- Monitoring Points: MW-2DR, MW-3D, MW-32D, MW-52D, MW-53D, MW-54D, MW-58D, and MW-59D

Groundwater samples in this zone should be collected quarterly from all wells that do not contain separate phase hydrocarbons and should be analyzed for phenol, salicylic acid, methanol, and formaldehyde

The following summarizes the proposed changes in the over-all groundwater monitoring program:

- The number of groundwater samples to be collected on a quarterly basis has been reduced from 62 to 44. MW-1, MW-4, MW-6, MW-25, MW-37, MW-38, MW-42, MW-46, MW-61, OW-4, and OW-5 in the Toluene Spill Area, and MW-21D, MW-47D2, MW-49D, MW-50D, MW-51D, MW-57D, ORC-4D, WP-2D, and WP-3R in the Northern Phenol Area have been eliminated from the monitoring program. The samples collected during each event would only be analyzed for site specific compounds (i.e., benzene, toluene, 1,1'-biphenyl, diphenyl ether in the Toluene Spill Area, and phenol, salicylic acid, methanol, and/or formaldehyde in the Northern Phenol Area). The annual sampling event in which all samples are analyzed for full VOC and BNA target compound lists has been eliminated. It is EPI's position that the three rounds of samples that have been analyzed for full VOCs and BNAs has demonstrated that no additional site related compounds are present in groundwater.

- The annual sampling of seven background wells (MW-8, MW-19, MW-19D, MW-20, MW-20D, MW-35, and MW-35D) has been eliminated. It is EPI's position that additional sampling of these wells is not warranted since no site related compounds of concern have been detected in these wells since the groundwater monitoring program began in 1997.

7.2.1 *Natural Attenuation Monitoring*

In addition to the monitoring program outlined above for the Northen Phenol Area, EPI proposes to collect samples to document whether natural attenuation is occurring in the deep and shallow overburden zones. The primary line of evidence for remediation by natural attenuation would be provided by observed reductions in plume geometry and observed reductions in concentrations of COCs (ASTM, 1998). A shrinking plume would be indicative of a rate of natural attenuation that is greater than the rate at which COCs are entering the plume from the source area.

Secondary lines of evidence for remediation by natural attenuation would be changes in geochemical indicators specific to the biodegradation process. Hydrocarbons are metabolized by bacteria through a series of enzyme-catalyzed, oxidative-reductive reactions. These reactions yield electrons which, through a series of enzyme-catalyzed electron transport steps, produce the energy the cell needs for maintenance and growth. In order for the electrons to pass through the energy generating steps, an electron acceptor is required. In the case of aerobic respiration, molecular oxygen (O_2) would be the electron acceptor. In the absence or near absence of molecular oxygen (i.e., anaerobic respiration), the following geochemical parameters (in the order listed) may serve as electron acceptors: nitrate (NO_3^-); manganese (Mn^{+4}); ferric iron (Fe^{+3}); sulfate (SO_4^{-2}); and carbon dioxide (ASTM, 1998; NJDEP, 1996).

EPI proposes to collect groundwater samples from the following wells to determine if the geochemical parameters indicate that biodegradation is occurring:

Proposed Natural Attenuation Monitoring Wells
Northern Phenol Area

Shallow Overburden Zone		**Deep Overburden Zone**	
Wells	Plume Area Monitored	Wells	Plume Area Monitored
MW-2, MW-24	Background	MW-32D, MW-52D	Background
MW-58, WP-2R	Within Plume	MW-47D, MW-48D, MW-55D	Within Plume
MW-59, MW-62, WP-1R	Plume Fringe	MW-2DR, MW-53D, MW-59D	Plume Fringe

Each sample would be analyzed for the following inorganic parameters: alkalinity (as $CaCO_3$); ferrous (Fe^{+2}) and total iron; nitrate; total phosphorous; sulfate; dissolved oxygen; redox potential (Eh); pH; specific conductivity; and temperature. In addition, the samples would be analyzed for biological parameters, including: total viable and non-viable cells, and total viable organisms. The following table summarizes the uses of each inorganic and biologic parameter (ASTM, 1998).

Parameter	Use of Data
pH*	Difference in pH between contaminated and uncontaminated groundwater may indicate biological activity is occurring.
Temperature*	Biodegradation rates may depend on temperature. An increase in temperature may be seen within the contaminant plume.
Dissolved Oxygen (D.O.)*	An inverse correlation between D.O. and benzene/toluene concentrations indicates aerobic biodegradation is occurring. D.O. concentrations should be lower within the plume relative to background wells.
Redox Potential*	Evaluate potential for biologically mediated redox reactions to occur.
Ferrous Iron	Increased concentrations may indicate that ferric iron is being used as an electron acceptor during anaerobic biodegradation.
Total Iron	Increased dissolved iron may indicate that ferric iron is being used as an electron acceptor during anaerobic biodegradation.
Nitrate	Decreased concentrations may indicate use of nitrate as a nutrient in aerobic biodegradation or as an electron acceptor during anaerobic biodegradation.
Sulfate	Decreased concentrations may indicate use of sulfate as an electron acceptor during anaerobic biodegradation.
Alkalinity	A zone of increased alkalinity indicates biodegradation is either producing organic acids which lower the pH and solubilize carbonates, or that CO_2 is being produced.
Total Viable & Non-Viable Cells	A direct measurement of all bacteria, including active, dormant, or dead organisms.
Total Viable Organisms	A measurement of all viable bacteria. These results are an indicator of the ability of the sample to support bacterial growth.

Notes:
* - To be measured in the field while purging the well.

Due to the need to measure pH, temperature, dissolved oxygen, and redox potential in the field, EPI proposes to utilize the low flow sampling and purging methodology currently used at the site (and described in Appendix B) when collecting the groundwater samples form all of the natural attenuation parameters listed above. In accordance with ASTM 1998, at least four quarters of sampling would be conducted to define seasonal fluctuations in the data. After the first year of monitoring, EPI may propose to modify the frequency of sampling for natural attenuation parameters in the shallow and deep overburden zones of the Northern Phenol Area.

7.3 Methyl Salicylate Area (AEC-30)

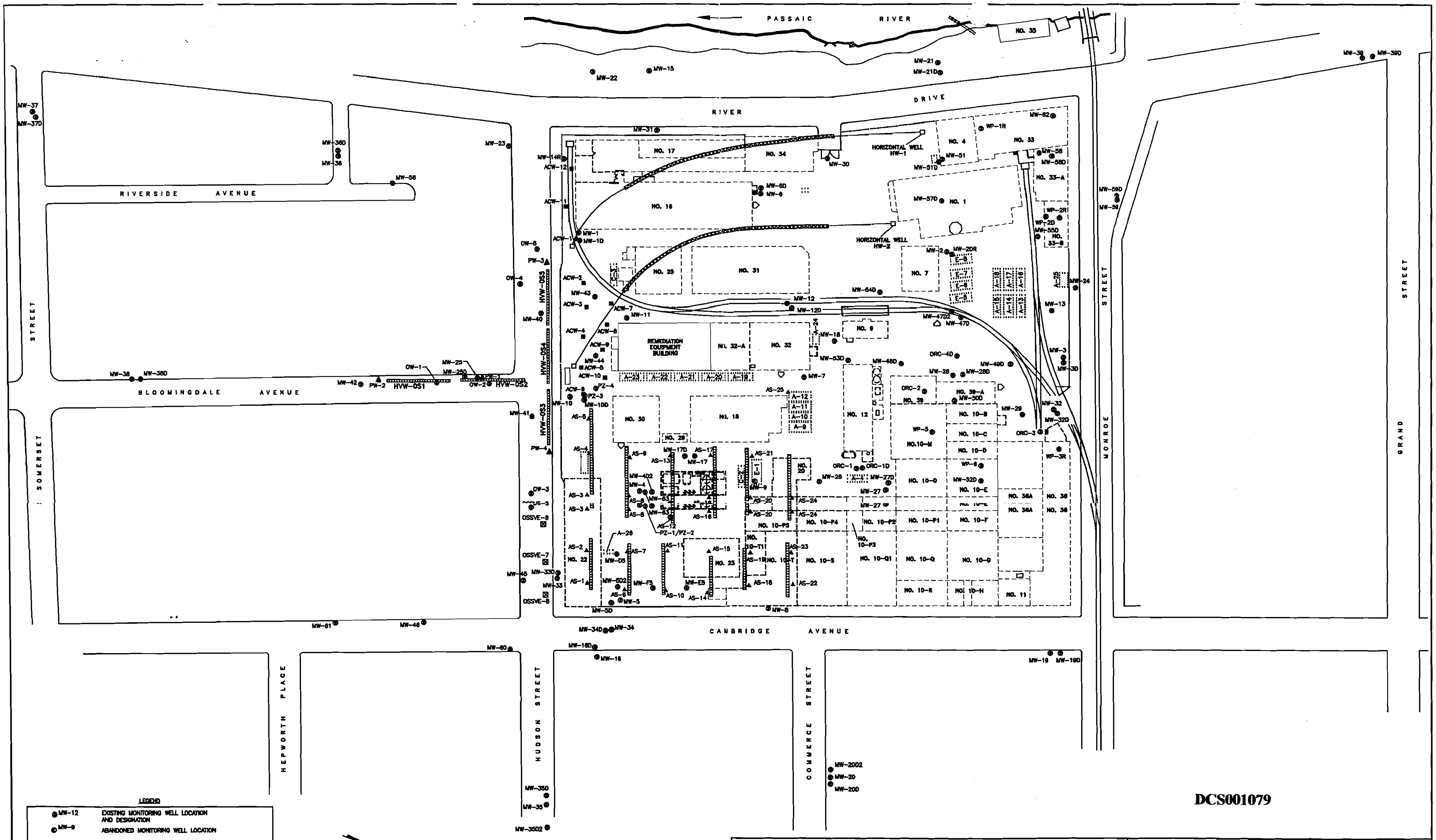
Groundwater monitoring for the methyl salicylate area (AEC-30) is not included in this proposed sampling program. A groundwater monitoring program for the methyl salicylate area will be developed once the delineation of the area has been completed.

8.0 REFERENCES

American Society for Testing and Materials. August, 1998. *Standard Guide for Remediation of Ground Water by Natural Attenuation at Petroleum Release Sites*, ASTM E1943-98. Conshohocken, Pennsylvania.

New Jersey Department of Environmental Protection. March, 1996. *Evaluating Sites for Natural Remediation of Contaminated Aquifers*, Site Remediation News. Trenton, New Jersey.

Figures



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK

NOTE: OSSVE-6, 7, & 8 ARE CONNECTED TO THE ON-SITE AS/SVE SYSTEM.

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.
REVISED DECEMBER 2002.

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FIGURE 1
SITE PLAN

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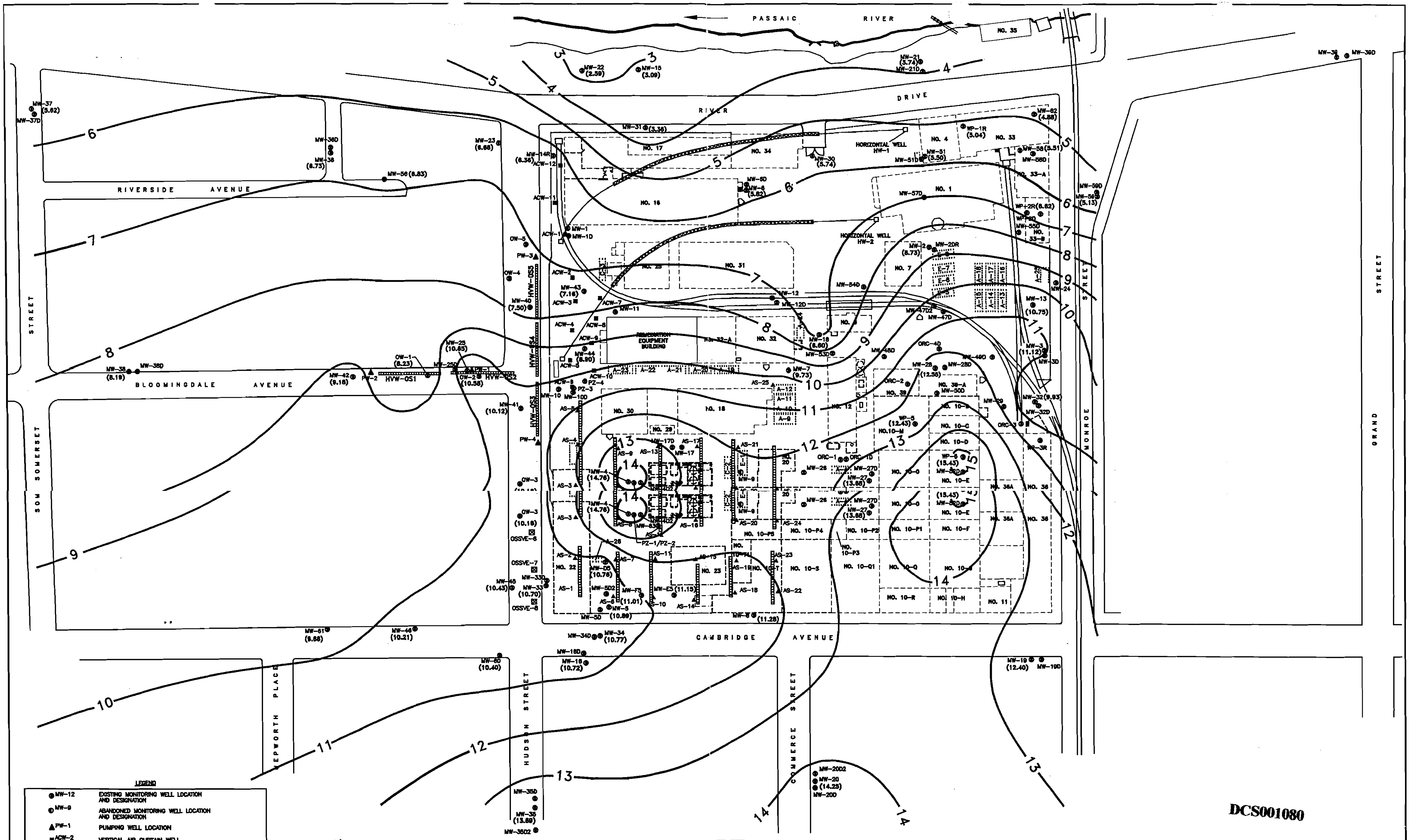
Date: 11/29/04



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(13.69)	GROUNDWATER ELEVATION
10 ——	GROUNDWATER CONTOUR LINE CONTOUR INTERVAL = 1 FOOT

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3. REVISED DECEMBER 2002.

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FIGURE 2
GROUNDWATER ELEVATION CONTOURS
SHALLOW OVERBURDEN ZONE
13 APRIL 2004

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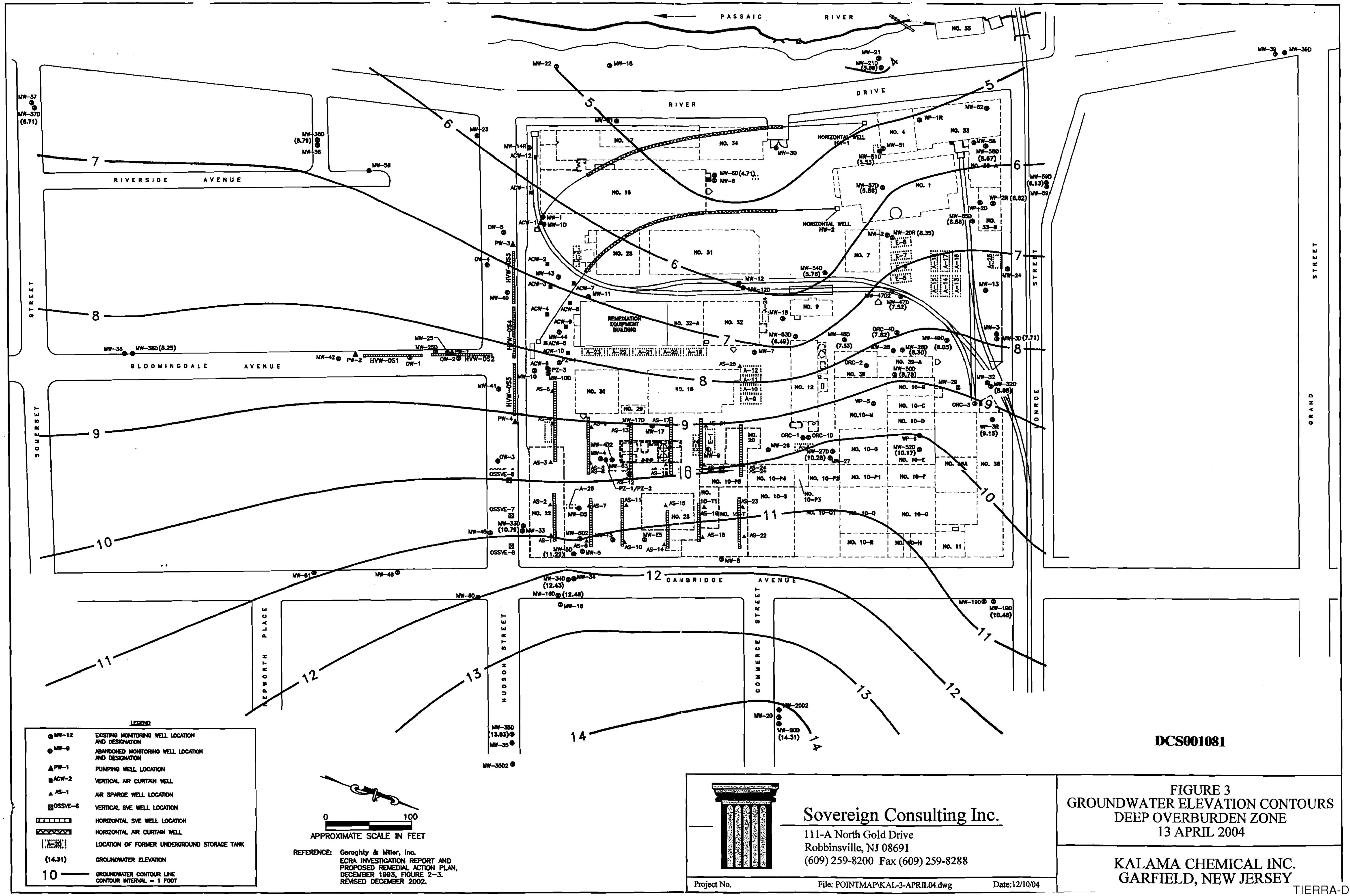

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.
REVISED DECEMBER 2002.

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Date:12/10/04

FIGURE 3
GROUNDWATER ELEVATION CONTOURS
DEEP OVERBURDEN ZONE
13 APRIL 2004

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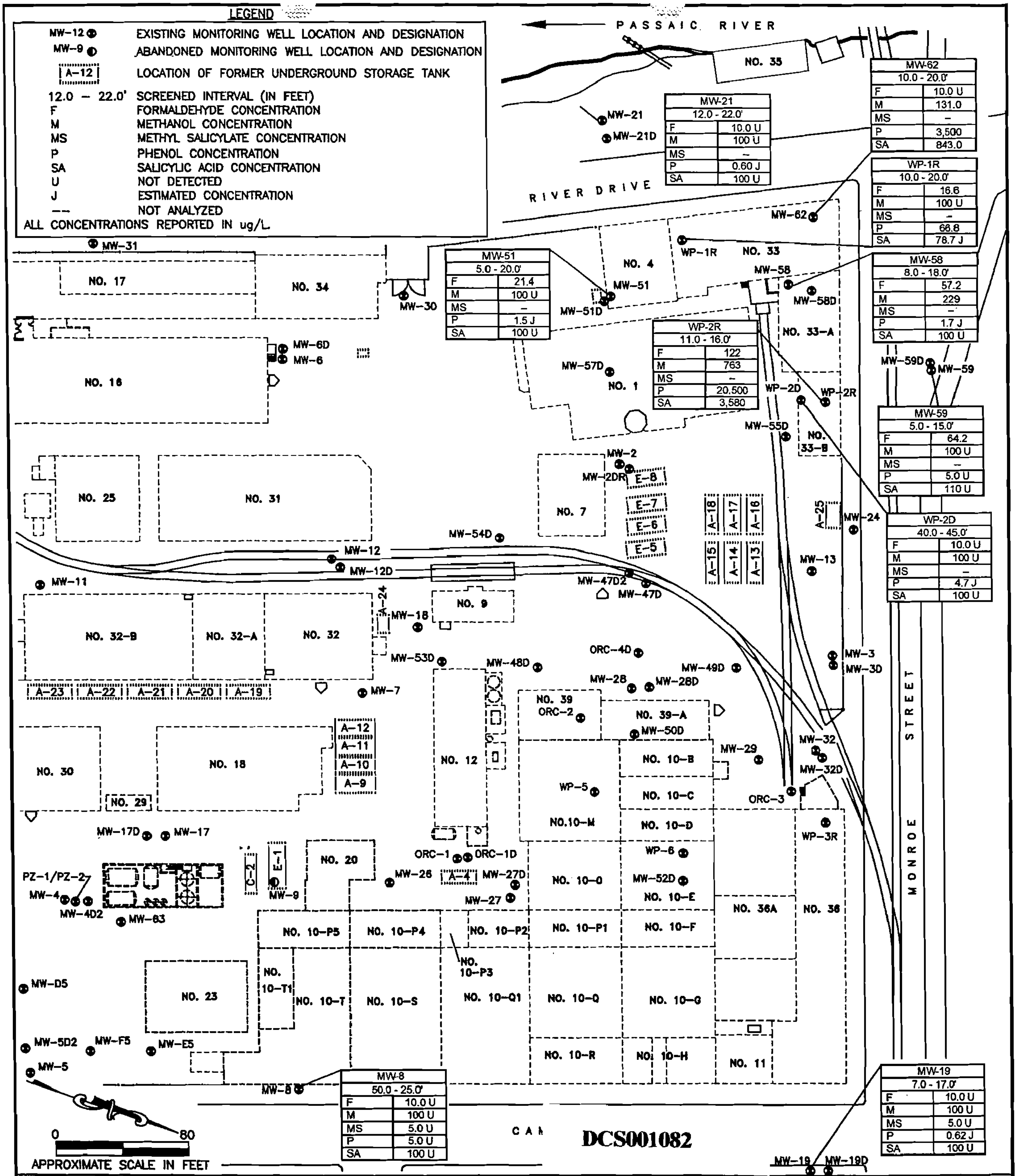

LEGEND

MW-12 ⊗	EXISTING MONITORING WELL LOCATION AND DESIGNATION
MW-9 ◐	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-12	LOCATION OF FORMER UNDERGROUND STORAGE TANK
12.0 – 22.0'	SCREENED INTERVAL (IN FEET)
F	FORMALDEHYDE CONCENTRATION
M	METHANOL CONCENTRATION
MS	METHYL SALICYLATE CONCENTRATION
P	PHENOL CONCENTRATION
SA	SALICYLIC ACID CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
––	NOT ANALYZED

ALL CONCENTRATIONS REPORTED IN ug/L

MW-21	
12.0 - 22.0'	
F	10.0 U
M	100 U
MS	–
P	0.60 J
SA	100 U

MW-62	
10.0 - 20.0'	
F	10.0 U
M	131.0
MS	–
P	3,500
SA	843.0

WP-1R	
10.0 - 20.0'	
F	16.6
M	100 U
MS	–
P	66.8
SA	78.7 J

MW-51	
5.0 - 20.0'	
F	21.4
M	100 U
MS	–
P	1.5 J
SA	100 U

MW-58	
8.0 - 18.0'	
F	57.2
M	229
MS	–
P	1.7 J
SA	100 U

WP-2R	
11.0 - 16.0'	
F	122
M	763
MS	–
P	20,500
SA	3,580

MW-59	
5.0 - 15.0'	
F	64.2
M	100 U
MS	–
P	5.0 U
SA	110 U

WP-2D	
40.0 - 45.0'	
F	10.0 U
M	100 U
MS	–
P	4.7 J
SA	100 U

MW-8	
50.0 - 25.0'	
F	10.0 U
M	100 U
MS	5.0 U
P	5.0 U
SA	100 U

MW-19	
7.0 - 17.0'	
F	10.0 U
M	100 U
MS	5.0 U
P	0.62 J
SA	100 U

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FIGURE 4
NORTHERN PHENOL AREA
PHENOL, METHANOL, FORMALDEHYDE,
& SALICYLIC ACID IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

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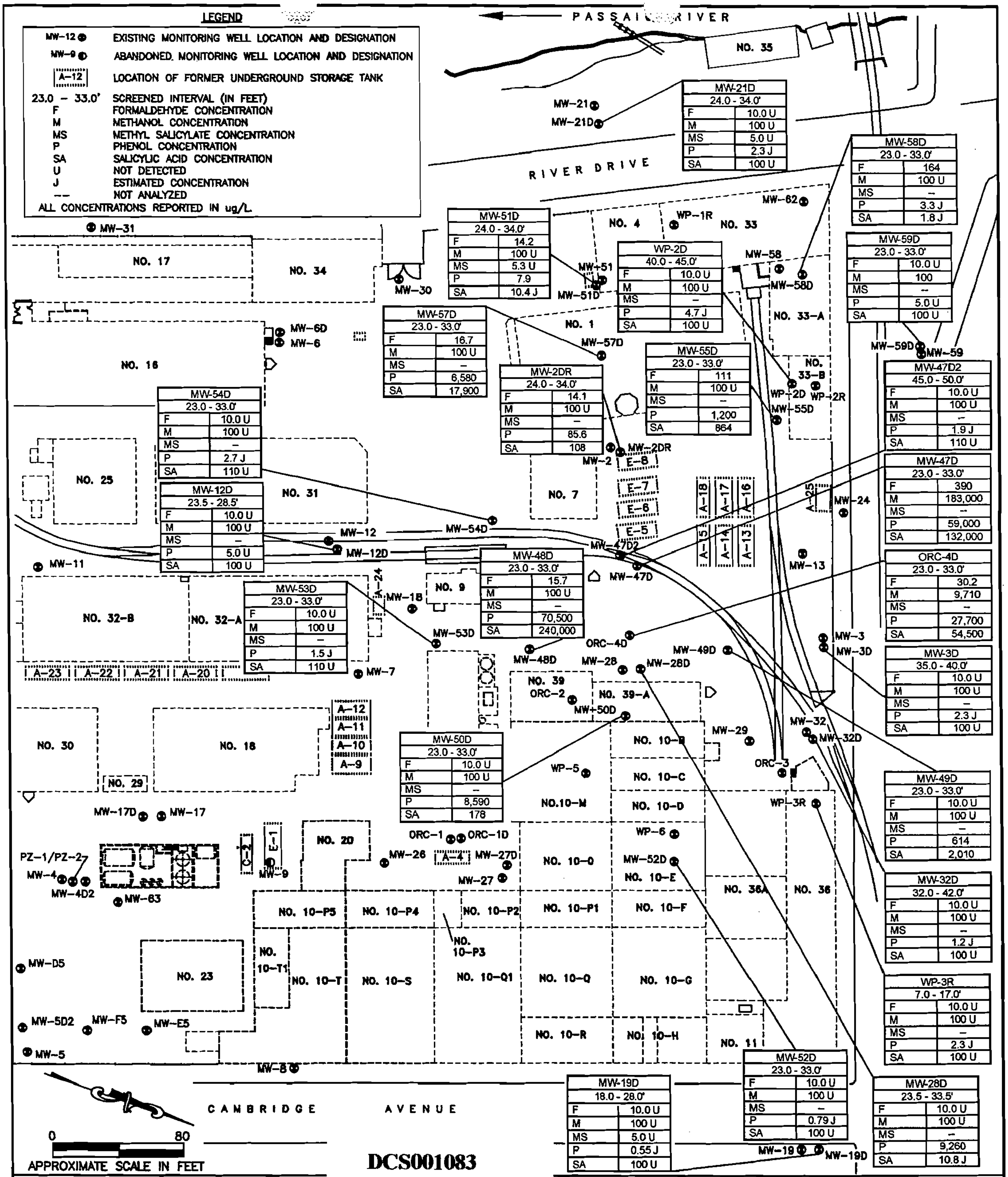

LEGEND

MW-12 ⊗	EXISTING MONITORING WELL LOCATION AND DESIGNATION
MW-9 ⊗	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-12	LOCATION OF FORMER UNDERGROUND STORAGE TANK
23.0 – 33.0'	SCREENED INTERVAL (IN FEET)
F	FORMALDEHYDE CONCENTRATION
M	METHANOL CONCENTRATION
MS	METHYL SALICYLATE CONCENTRATION
P	PHENOL CONCENTRATION
SA	SALICYLIC ACID CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
—	NOT ANALYZED

ALL CONCENTRATIONS REPORTED IN ug/L

MW-21D	
24.0 - 34.0'	
F	10.0 U
M	100 U
MS	5.0 U
P	2.3 J
SA	100 U

MW-58D	
23.0 - 33.0'	
F	164
M	100 U
MS	–
P	3.3 J
SA	1.8 J

MW-51D	
24.0 - 34.0'	
F	14.2
M	100 U
MS	5.3 U
P	7.9
SA	10.4 J

WP-2D	
40.0 - 45.0'	
F	10.0 U
M	100 U
MS	–
P	4.7 J
SA	100 U

MW-59D	
23.0 - 33.0'	
F	10.0 U
M	100
MS	–
P	5.0 U
SA	100 U

MW-57D	
23.0 - 33.0'	
F	16.7
M	100 U
MS	–
P	6,580
SA	17,900

MW-55D	
23.0 - 33.0'	
F	111
M	100 U
MS	–
P	1,200
SA	864

MW-2DR	
24.0 - 34.0'	
F	14.1
M	100 U
MS	–
P	85.6
SA	108

MW-47D2	
45.0 - 50.0'	
F	10.0 U
M	100 U
MS	–
P	1.9 J
SA	110 U

MW-54D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	–
P	2.7 J
SA	110 U

MW-12D	
23.5 - 28.5'	
F	10.0 U
M	100 U
MS	–
P	5.0 U
SA	100 U

MW-47D	
23.0 - 33.0'	
F	390
M	183,000
MS	–
P	59,000
SA	132,000

MW-48D	
23.0 - 33.0'	
F	15.7
M	100 U
MS	–
P	70,500
SA	240,000

ORC-4D	
23.0 - 33.0'	
F	30.2
M	9,710
MS	–
P	27,700
SA	54,500

MW-53D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	–
P	1.5 J
SA	110 U

MW-3D	
35.0 - 40.0'	
F	10.0 U
M	100 U
MS	–
P	2.3 J
SA	100 U

MW-50D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	–
P	8,590
SA	178

MW-49D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	–
P	614
SA	2,010

MW-32D	
32.0 - 42.0'	
F	10.0 U
M	100 U
MS	–
P	1.2 J
SA	100 U

WP-3R	
7.0 - 17.0'	
F	10.0 U
M	100 U
MS	–
P	2.3 J
SA	100 U

MW-19D	
18.0 - 28.0'	
F	10.0 U
M	100 U
MS	5.0 U
P	0.55 J
SA	100 U

MW-52D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	–
P	0.79 J
SA	100 U

MW-28D	
23.5 - 33.5'	
F	10.0 U
M	100 U
MS	–
P	9,260
SA	10.8 J

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FIGURE 5
NORTHERN PHENOL AREA
PHENOL, METHANOL, FORMALDEHYDE,
SALICYLIC ACID & METHYL SALICYLATE
IN GROUNDWATER
DEEP OVERBURDEN ZONE
APRIL 2004

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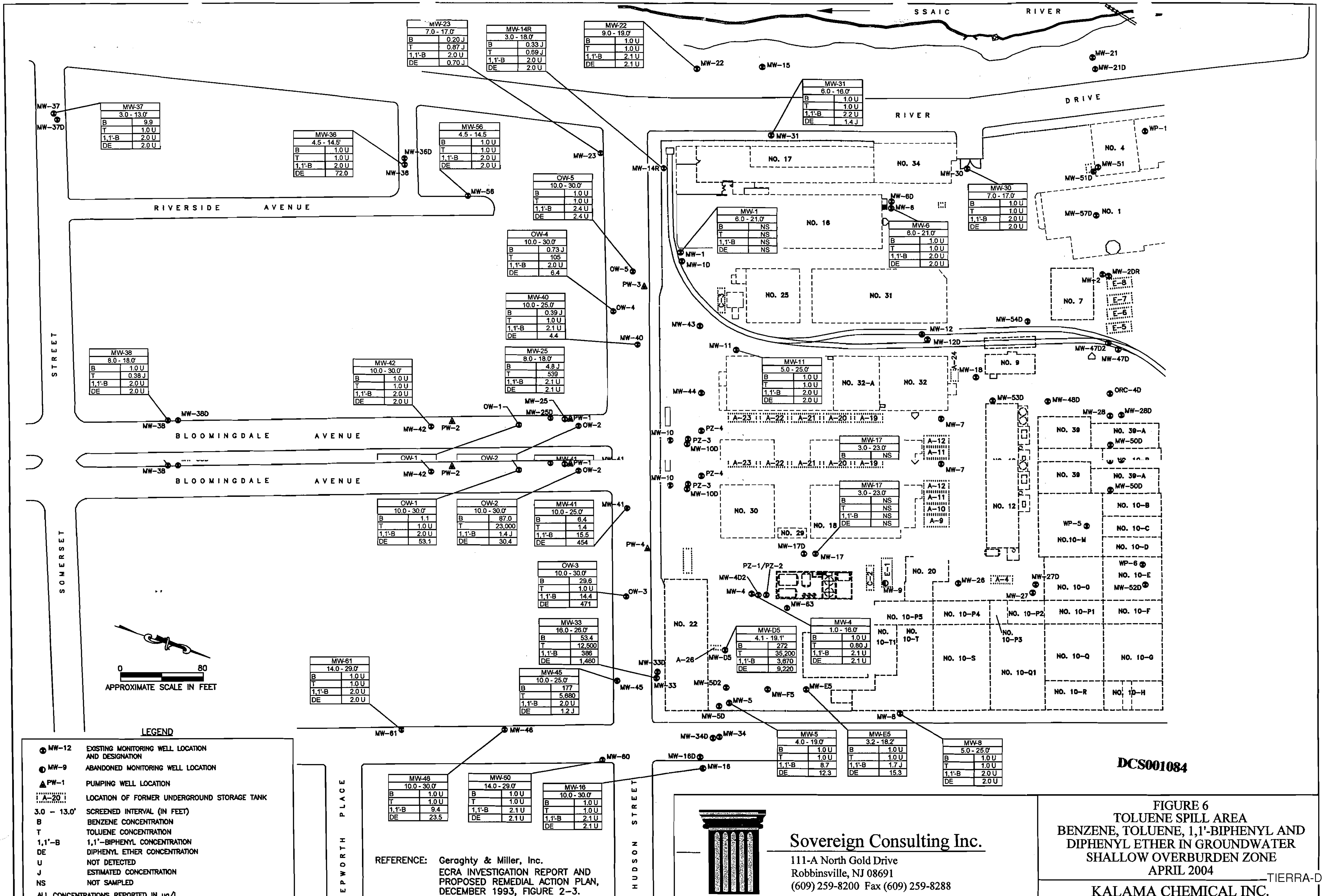

MW-23	
7.0 - 17.0'	
B	0.20 J
T	0.87 J
1,1'-B	2.0 U
DE	0.70 J

MW-14R	
3.0 - 18.0'	
B	0.33 J
T	0.69 J
1,1'-B	2.0 U
DE	2.0 U

MW-22	
9.0 - 19.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.1 U
DE	2.1 U

MW-31	
6.0 - 16.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.2 U
DE	1.4 J

MW-37	
3.0 - 13.0'	
B	9.9
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-36	
4.5 - 14.5'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	72.0

MW-56	
4.5 - 14.5	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

OW-5	
10.0 - 30.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.4 U
DE	2.4 U

OW-4	
10.0 - 30.0'	
B	0.73 J
T	105
1,1'-B	2.0 U
DE	6.4

MW-40	
10.0 - 25.0'	
B	0.39 J
T	1.0 U
1,1'-B	2.1 U
DE	4.4

MW-25	
8.0 - 18.0'	
B	4.8 J
T	539
1,1'-B	2.1 U
DE	2.1 U

MW-38	
8.0 - 18.0'	
B	1.0 U
T	0.38 J
1,1'-B	2.0 U
DE	2.0 U

MW-42	
10.0 - 30.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-1	
6.0 - 21.0'	
B	NS
T	NS
1,1'-B	NS
DE	NS

MW-6	
6.0 - 21.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-30	
7.0 - 17.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-11	
5.0 - 25.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-17	
3.0 - 23.0'	
B	NS

MW-17	
3.0 - 23.0'	
B	NS
T	NS
1,1'-B	NS
DE	NS

OW-1	
10.0 - 30.0'	
B	1.1
T	1.0 U
1,1'-B	2.0 U
DE	53.1

OW-2	
10.0 - 30.0'	
B	87.0
T	23,000
1,1'-B	1.4 J
DE	30.4

MW-41	
10.0 - 25.0'	
B	6.4
T	1.4
1,1'-B	15.5
DE	454

OW-3	
10.0 - 30.0'	
B	29.6
T	1.0 U
1,1'-B	14.4
DE	471

MW-33	
16.0 - 26.0'	
B	53.4
T	12,500
1,1'-B	386
DE	1,460

MW-45	
10.0 - 25.0'	
B	177
T	5,680
1,1'-B	2.0 U
DE	1.2 J

MW-61	
14.0 - 29.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-D5	
4.1 - 19.1'	
B	272
T	35,200
1,1'-B	3,670
DE	9,220

MW-4	
1.0 - 16.0'	
B	1.0 U
T	0.80 J
1,1'-B	2.1 U
DE	2.1 U

MW-5	
4.0 - 19.0'	
B	1.0 U
T	1.0 U
1,1'-B	8.7
DE	12.3

MW-E5	
3.2 - 18.2'	
B	1.0 U
T	1.0 U
1,1'-B	1.7 J
DE	15.3

MW-8	
5.0 - 25.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.0 U
DE	2.0 U

MW-46	
10.0 - 30.0'	
B	1.0 U
T	1.0 U
1,1'-B	9.4
DE	23.5

MW-60	
14.0 - 29.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.1 U
DE	2.1 U

MW-16	
10.0 - 30.0'	
B	1.0 U
T	1.0 U
1,1'-B	2.1 U
DE	2.1 U

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION
▲ PW-1	PUMPING WELL LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
3.0 - 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION
T	TOLUENE CONCENTRATION
1,1'-B	1,1'-BIPHENYL CONCENTRATION
DE	DIPHENYL ETHER CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
NS	NOT SAMPLED

ALL CONCENTRATIONS REPORTED IN ug/l

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.

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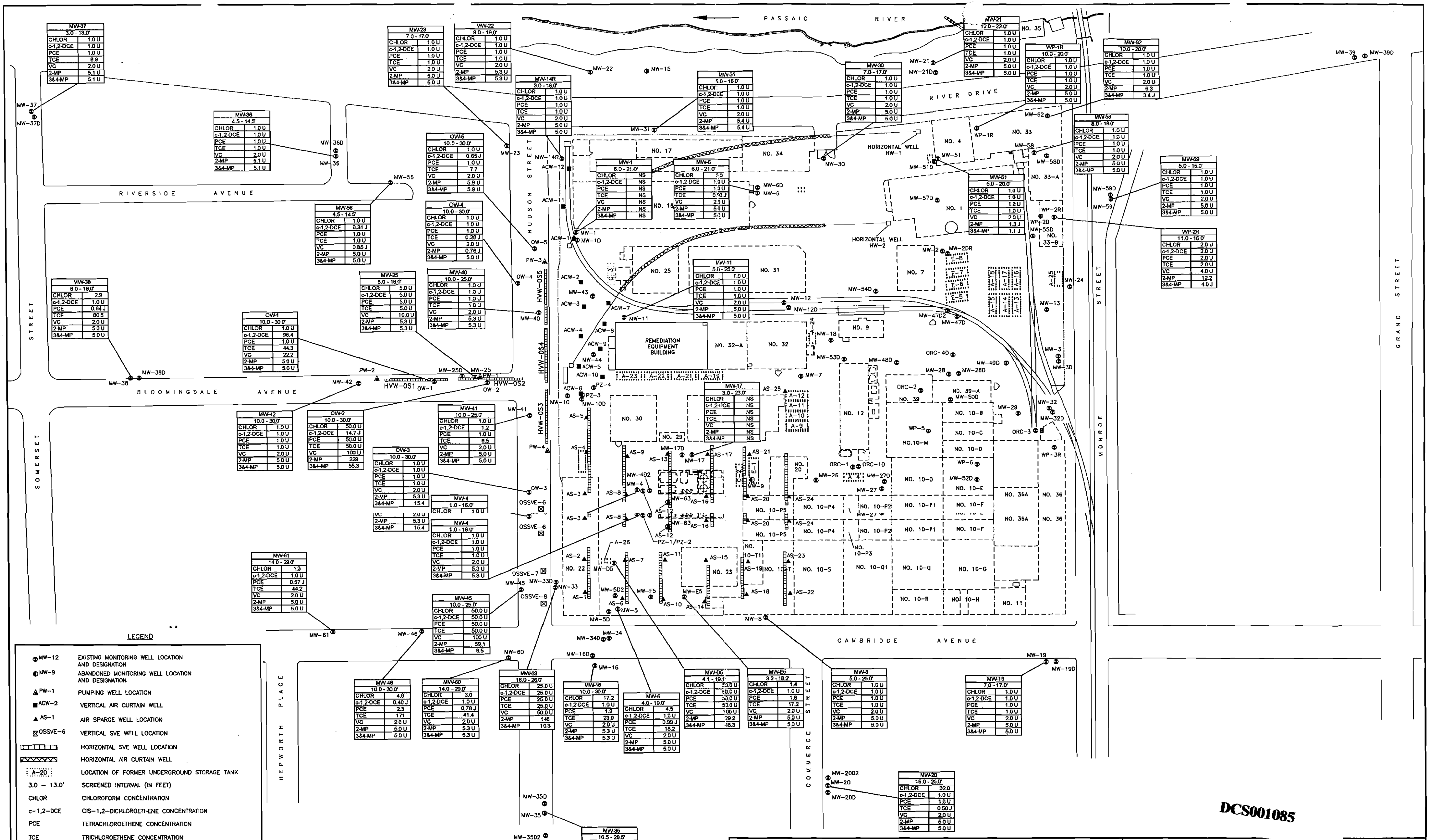
FIGURE 6
TOLUENE SPILL AREA
BENZENE, TOLUENE, 1,1'-BIPHENYL AND
DIPHENYL ETHER IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.



MW-37	
3.0 - 13.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	8.9
VC	2.0 U
2-MP	5.1 U
3&4-MP	5.1 U

MW-36	
4.5 - 14.5'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.1 U
3&4-MP	5.1 U

MW-23	
7.0 - 17.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-22	
9.0 - 19.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-14R	
3.0 - 18.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-31	
6.0 - 16.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.4 U
3&4-MP	5.4 U

MW-30	
7.0 - 17.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-21	
12.0 - 22.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

WP-1R	
10.0 - 20.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-62	
10.0 - 20.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	6.3
3&4-MP	3.4 J

OW-5	
10.0 - 30.0'	
CHLOR	1.0 U
c-1,2-DCE	0.65 J
PCE	1.0 U
TCE	7.7
VC	2.0 U
2-MP	5.9 U
3&4-MP	5.9 U

MW-1	
6.0 - 21.0'	
CHLOR	NS
c-1,2-DCE	NS
PCE	NS
TCE	NS
VC	NS
2-MP	NS
3&4-MP	NS

MW-6	
6.0 - 21.0'	
CHLOR	3.0
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	0.90 J
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-58	
8.0 - 18.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-59	
5.0 - 15.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-51	
5.0 - 20.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	1.3 J
3&4-MP	1.1 J

WP-2R	
11.0 - 16.0'	
CHLOR	2.0 U
c-1,2-DCE	2.0 U
PCE	2.0 U
TCE	2.0 U
VC	4.0 U
2-MP	12.2
3&4-MP	4.0 J

MW-56	
4.5 - 14.5'	
CHLOR	1.0 U
c-1,2-DCE	0.31 J
PCE	1.0 U
TCE	1.0 U
VC	0.85 J
2-MP	5.0 U
3&4-MP	5.0 U

OW-4	
10.0 - 30.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	0.28 J
VC	2.0 U
2-MP	0.76 J
3&4-MP	5.0 U

MW-11	
5.0 - 25.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-38	
8.0 - 18.0'	
CHLOR	2.9
c-1,2-DCE	1.0 U
PCE	0.64 J
TCE	80.5
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

OW-1	
10.0 - 30.0'	
CHLOR	1.0 U
c-1,2-DCE	96.4
PCE	1.0 U
TCE	44.3
VC	22.2
2-MP	5.0 U
3&4-MP	5.0 U

MW-25	
8.0 - 18.0'	
CHLOR	5.0 U
c-1,2-DCE	5.0 U
PCE	5.0 U
TCE	5.0 U
VC	10.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-40	
10.0 - 25.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-17	
3.0 - 23.0'	
CHLOR	NS
c-1,2-DCE	NS
PCE	NS
TCE	NS
VC	NS
2-MP	NS
3&4-MP	NS

MW-42	
10.0 - 30.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

OW-2	
10.0 - 30.0'	
CHLOR	50.0 U
c-1,2-DCE	14.7 J
PCE	50.0 U
TCE	50.0 U
VC	100 U
2-MP	229
3&4-MP	55.3

MW-41	
10.0 - 25.0'	
CHLOR	1.0 U
c-1,2-DCE	1.2
PCE	1.0 U
TCE	6.5
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

OW-3	
10.0 - 30.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.3 U
3&4-MP	15.4

MW-4	
1.0 - 16.0'	
CHLOR	1.0 U

VC	2.0 U
2-MP	5.3 U
3&4-MP	15.4

MW-4	
1.0 - 16.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-61	
14.0 - 29.0'	
CHLOR	1.3
c-1,2-DCE	1.0 U
PCE	0.57 J
TCE	44.2
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-45	
10.0 - 25.0'	
CHLOR	50.0 U
c-1,2-DCE	50.0 U
PCE	50.0 U
TCE	50.0 U
VC	100 U
2-MP	59.1
3&4-MP	9.5

MW-46	
10.0 - 30.0'	
CHLOR	4.9
c-1,2-DCE	0.40 J
PCE	2.3
TCE	171
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-60	
14.0 - 29.0'	
CHLOR	3.0
c-1,2-DCE	1.0 U
PCE	0.78 J
TCE	41.4
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-33	
16.0 - 26.0'	
CHLOR	25.0 U
c-1,2-DCE	25.0 U
PCE	25.0 U
TCE	25.0 U
VC	50.0 U
2-MP	146
3&4-MP	10.3

MW-16	
10.0 - 30.0'	
CHLOR	17.2
c-1,2-DCE	1.0 U
PCE	1.2
TCE	23.9
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-5	
4.0 - 19.0'	
CHLOR	4.5
c-1,2-DCE	1.0 U
PCE	0.99 J
TCE	18.2
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-D5	
4.1 - 19.1'	
CHLOR	50.0 U
c-1,2-DCE	50.0 U
PCE	50.0 U
TCE	50.0 U
VC	100 U
2-MP	29.2
3&4-MP	18.3

MW-E5	
3.2 - 18.2'	
CHLOR	1.4
c-1,2-DCE	1.0 U
PCE	1.8
TCE	17.2
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-8	
5.0 - 25.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-19	
7.0 - 17.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-20	
15.0 - 25.0'	
CHLOR	32.0
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	0.50 J
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-35	
16.5 - 26.5'	
CHLOR	0.64 J
c-1,2-DCE	1.0 U
PCE	0.35 J
TCE	19.5
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
CHLOR	CHLOROFORM CONCENTRATION
c–1,2–DCE	CIS–1,2–DICHLOROETHENE CONCENTRATION
PCE	TETRACHLOROETHENE CONCENTRATION
TCE	TRICHLOROETHENE CONCENTRATION
VC	VINYL CHLORIDE CONCENTRATION
2–MP	2–METHYLPHENOL CONCENTRATION
3&4–MP	3&4–METHYLPHENOL CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
NS	NOT SAMPLED
SPH	THICKNESS OF SEPARATE PHASE HYDROCARBONS (IN FEET)

ALL CONCENTRATIONS REPORTED IN ug/L.

0 100
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.
REVISED DECEMBER 2002.

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Project No.
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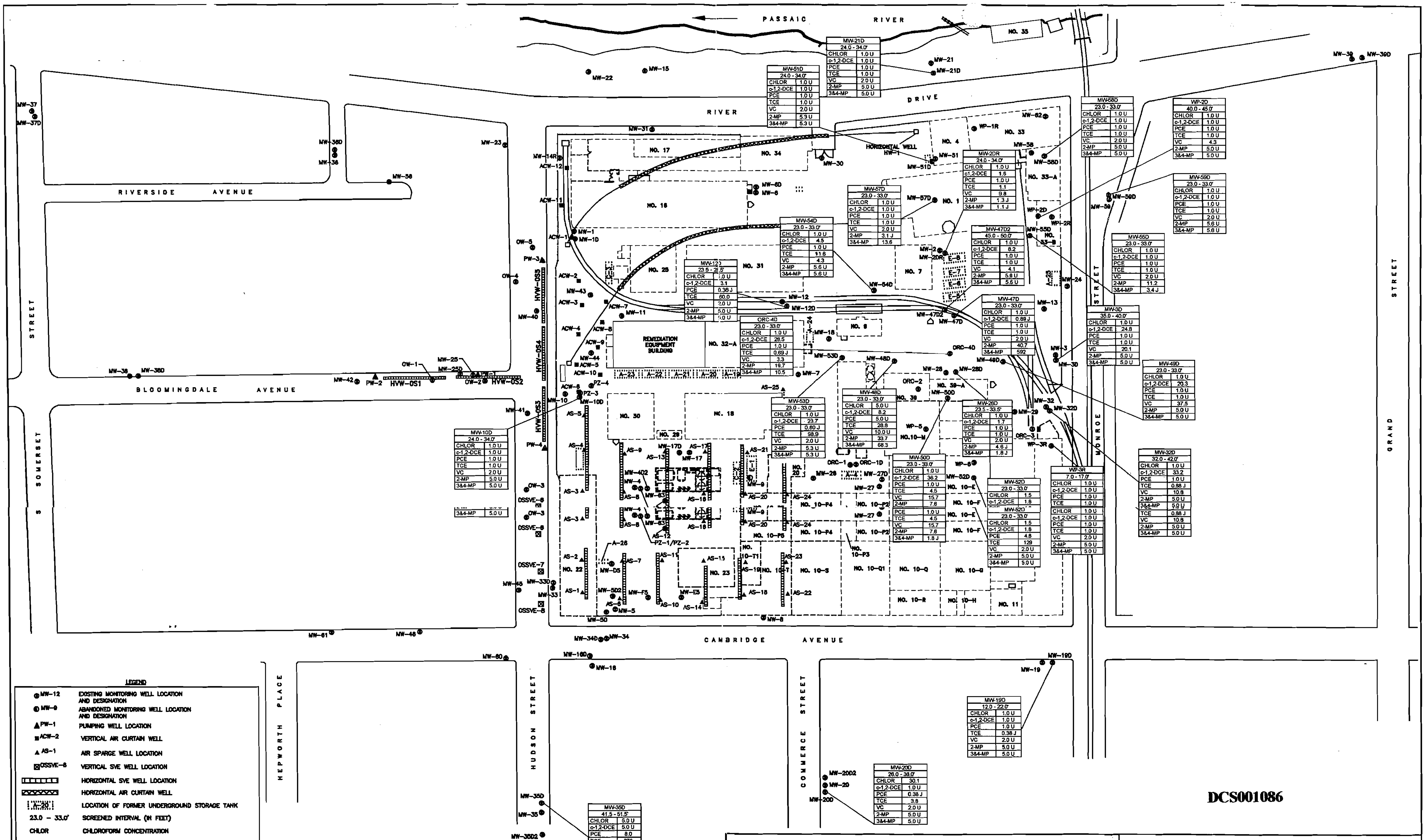
Date: 11/30/04

FIGURE 7
CHLORINATED VOCs AND METHYL PHENOL IN GROUNDWATER SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



MW-21D	
24.0 - 34.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-51D	
24.0 - 34.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-58D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

WP-2D	
40.0 - 45.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	4.3
2-MP	5.0 U
3&4-MP	5.0 U

MW-2DR	
24.0 - 34.0'	
CHLOR	1.0 U
c1,2-DCE	1.6
PCE	1.0 U
TCE	1.1
VC	9.8
2-MP	1.3 J
3&4-MP	1.1 J

MW-57D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	3.1 J
3&4-MP	13.6

MW-59D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.6 U
3&4-MP	5.6 U

MW-54D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	4.5
PCE	1.0 U
TCE	11.6
VC	4.3
2-MP	5.6 U
3&4-MP	5.6 U

MW-47D2	
45.0 - 50.0'	
CHLOR	1.0 U
c-1,2-DCE	8.2
PCE	1.0 U
TCE	1.0 U
VC	4.1
2-MP	5.6 U
3&4-MP	5.6 U

MW-55D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	11.2
3&4-MP	3.4 J

MW-12D	
23.5 - 28.5'	
CHLOR	1.0 U
c-1,2-DCE	3.1
PCE	0.38 J
TCE	60.0
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-47D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	0.89 J
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	40.7
3&4-MP	592

MW-3D	
35.0 - 40.0'	
CHLOR	1.0 U
c-1,2-DCE	24.8
PCE	1.0 U
TCE	1.0 U
VC	20.1
2-MP	5.0 U
3&4-MP	5.0 U

ORC-4D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	28.5
PCE	1.0 U
TCE	0.69 J
VC	3.3
2-MP	19.7
3&4-MP	10.5

MW-49D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	20.3
PCE	1.0 U
TCE	1.0 U
VC	37.5
2-MP	5.0 U
3&4-MP	5.0 U

MW-48D	
23.0 - 33.0'	
CHLOR	5.0 U
c-1,2-DCE	8.2
PCE	5.0 U
TCE	28.8
VC	10.0 U
2-MP	33.7
3&4-MP	68.3

MW-10D	
24.0 - 34.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

3&4-MP	5.0 U

MW-53D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	23.7
PCE	0.80 J
TCE	98.9
VC	2.0 U
2-MP	5.3 U
3&4-MP	5.3 U

MW-28D	
23.5 - 33.5'	
CHLOR	1.0 U
c-1,2-DCE	1.7
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	4.6 J
3&4-MP	1.8 J

MW-50D	
23.0 - 33.0'	
CHLOR	1.0 U
c-1,2-DCE	36.2
PCE	1.0 U
TCE	4.5
VC	15.7
2-MP	7.6
PCE	1.0 U
TCE	4.5
VC	15.7
2-MP	7.6
3&4-MP	1.8 J

MW-52D	
23.0 - 33.0'	
CHLOR	1.5
c-1,2-DCE	1.8

MW-52D	
23.0 - 33.0'	
CHLOR	1.5
c-1,2-DCE	1.8
PCE	4.8
TCE	129
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

WP-3R	
7.0 - 17.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	1.0 U
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-32D	
32.0 - 42.0'	
CHLOR	1.0 U
c-1,2-DCE	33.2
PCE	1.0 U
TCE	0.88 J
VC	10.8
2-MP	5.0 U
3&4-MP	5.0 U
TCE	0.88 J
VC	10.8
2-MP	5.0 U
3&4-MP	5.0 U

MW-19D	
12.0 - 22.0'	
CHLOR	1.0 U
c-1,2-DCE	1.0 U
PCE	1.0 U
TCE	0.38 J
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-20D	
26.0 - 36.0'	
CHLOR	30.1
c-1,2-DCE	1.0 U
PCE	0.38 J
TCE	3.8
VC	2.0 U
2-MP	5.0 U
3&4-MP	5.0 U

MW-35D	
41.5 - 51.5'	
CHLOR	5.0 U
c-1,2-DCE	5.0 U
PCE	8.0
TCE	876
VC	10.0 U
2-MP	5.0 U
3&4-MP	5.0 U

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
⦶ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
⊠ OSSVE-6	VERTICAL SVE WELL LOCATION
▭▭▭▭	HORIZONTAL SVE WELL LOCATION
▨▨▨▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
23.0 - 33.0'	SCREENED INTERVAL (IN FEET)
CHLOR	CHLOROFORM CONCENTRATION
c-1,2-DCE	c-1,2-DICHLOROETHENE CONCENTRATION
PCE	TETRACHLOROETHENE CONCENTRATION
TCE	TRICHLOROETHENE CONCENTRATION
VC	VINYL CHLORIDE CONCENTRATION
2-MP	2-METHYLPHENOL CONCENTRATION
3&4-MP	3&4-METHYLPHENOL CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION

ALL CONCENTRATIONS REPORTED IN ug/L.

0 100
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.
REVISED DECEMBER 2002.

DCS001086

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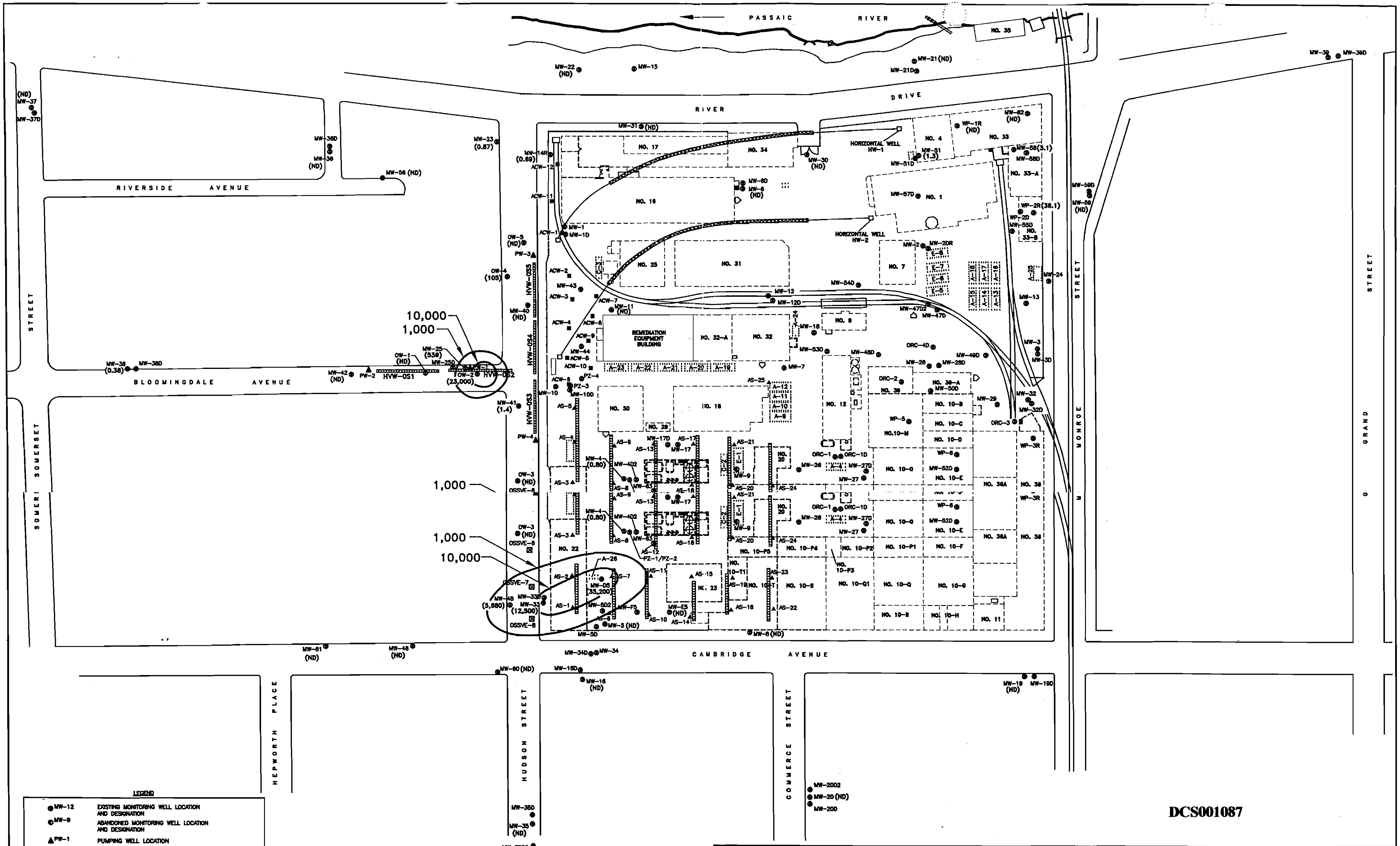
FIGURE 8
CHLORINATED VOCs, CHLOROPHENOL, AND METHYL PHENOL
IN GROUNDWATER
DEEP OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-8-APRIL04.dwg Date: 12/10/04



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
⊠ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(105)	TOLUENE CONCENTRATION IN (μg/l)
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

0 100
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.

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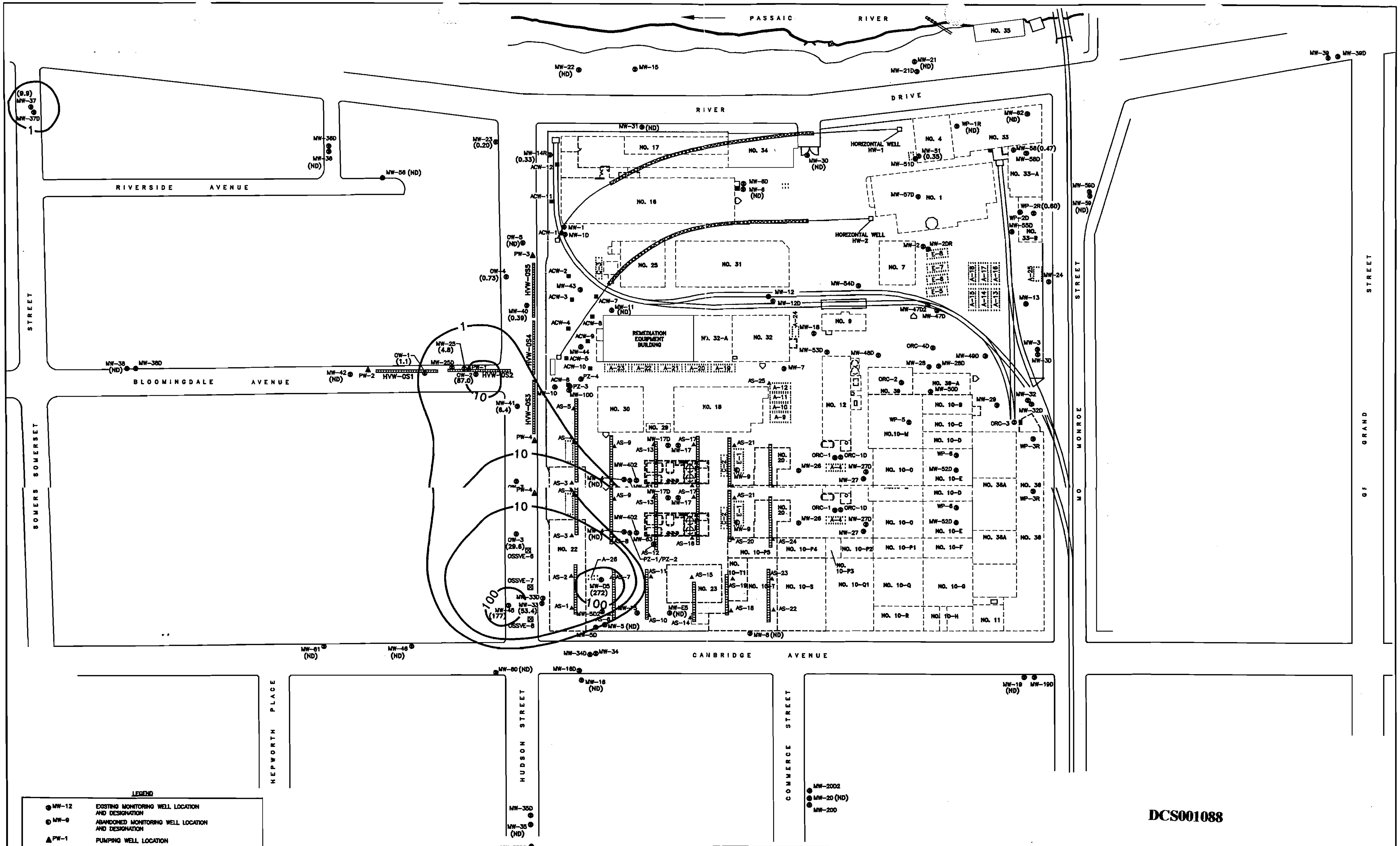
FIGURE 9
DISTRIBUTION OF TOLUENE
IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
⊠ OSSVE-8	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(87.0)	BENZENE CONCENTRATION IN (μg/l)
(ND)	NOT DETECTED

0 100
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND
PROPOSED REMEDIAL ACTION PLAN,

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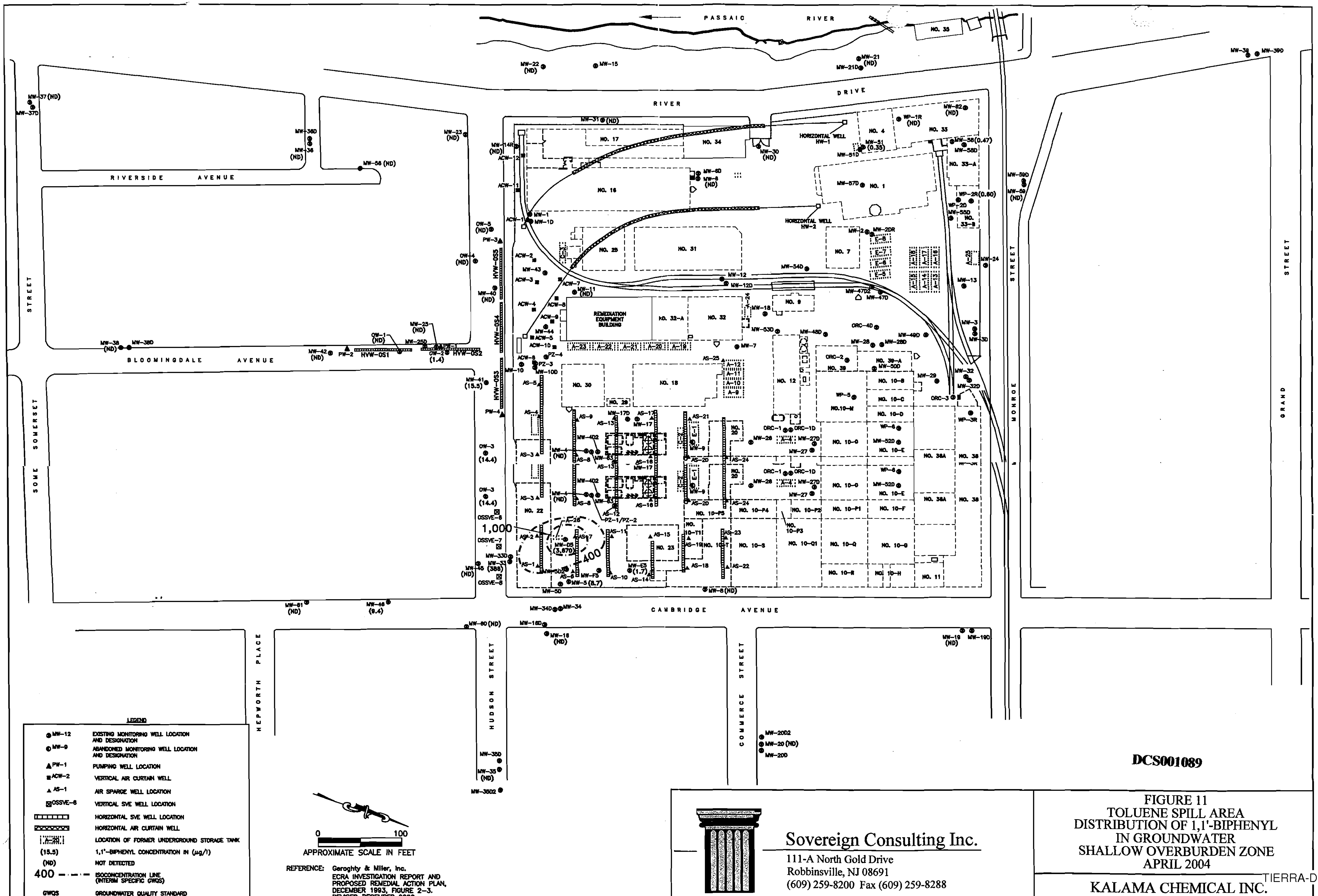
FIGURE 10
DISTRIBUTION OF BENZENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE
APRIL 2004



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
● MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(15.5)	1,1'-BIPHENYL CONCENTRATION IN (µg/l)
(ND)	NOT DETECTED
400 — · — · —	ISOCONCENTRATION LINE (INTERIM SPECIFIC GWQS)
GWQS	GROUNDWATER QUALITY STANDARD

REFERENCE: Geroghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.

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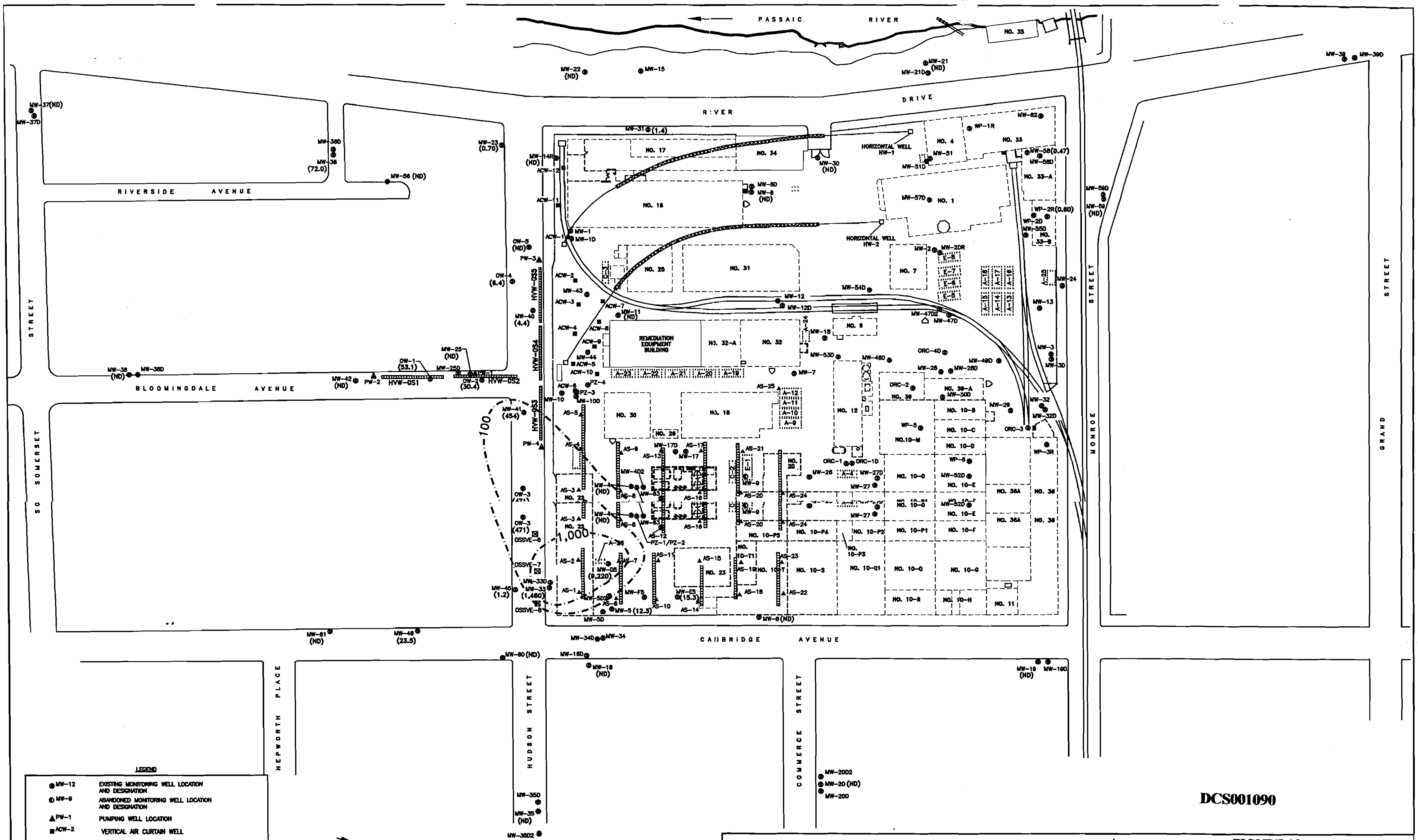
FIGURE 11
TOLUENE SPILL AREA
DISTRIBUTION OF 1,1'-BIPHENYL
IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(1,460)	DIPHENYL ETHER CONCENTRATION IN (μg/l)
(ND)	NOT DETECTED
100 — · — · —	ISOCONCENTRATION LINE (INTERIM SPECIFIC GWQS)
GWQS	GROUNDWATER QUALITY STANDARD

0 100
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3. REVISED DECEMBER 2002.

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FIGURE 12
TOLUENE SPILL AREA
DISTRIBUTION OF DIPHENYL ETHER
IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
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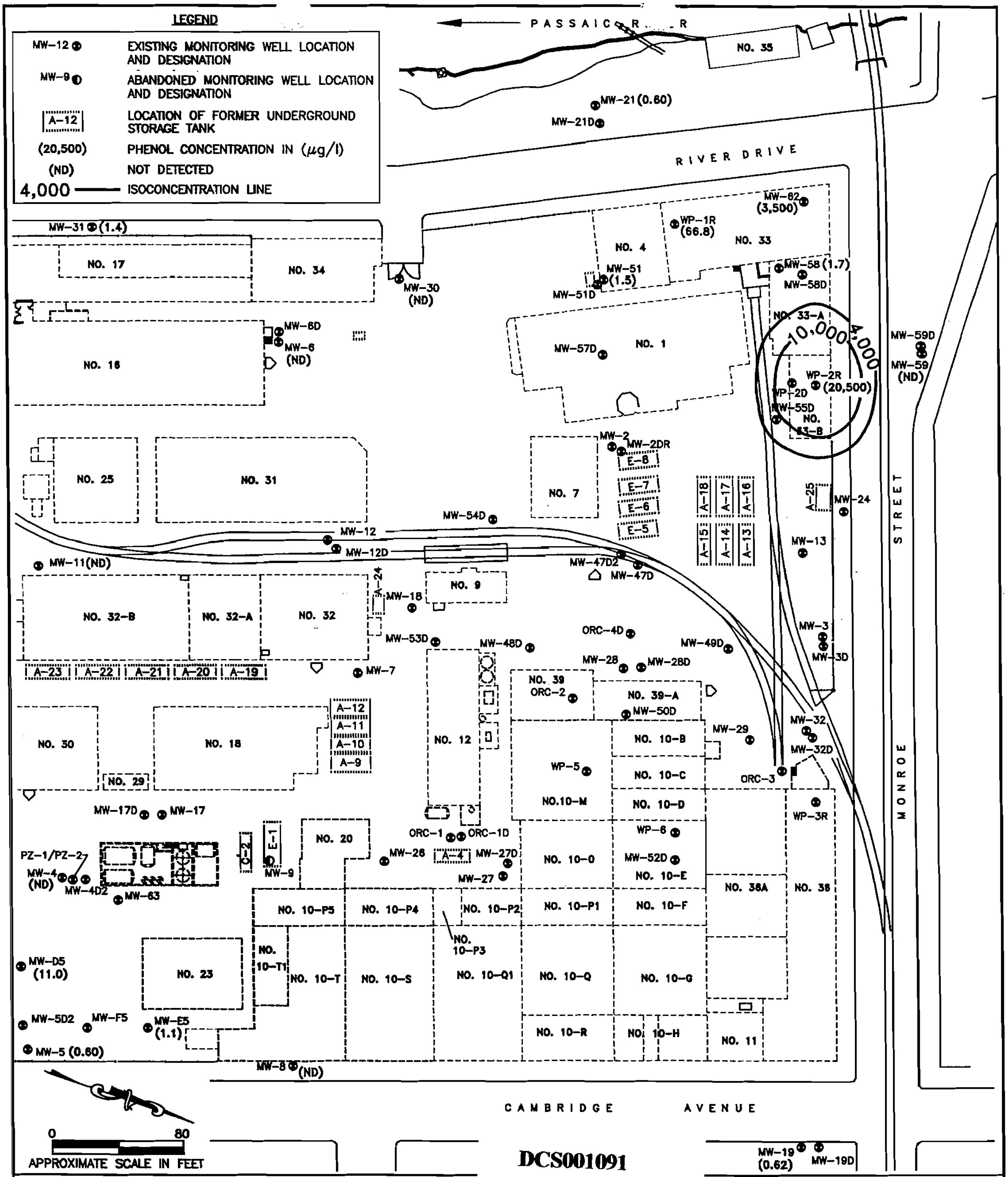
Project No. File: POINTMAP\KAL-12-APRIL04.dwg Date: 12/10/04



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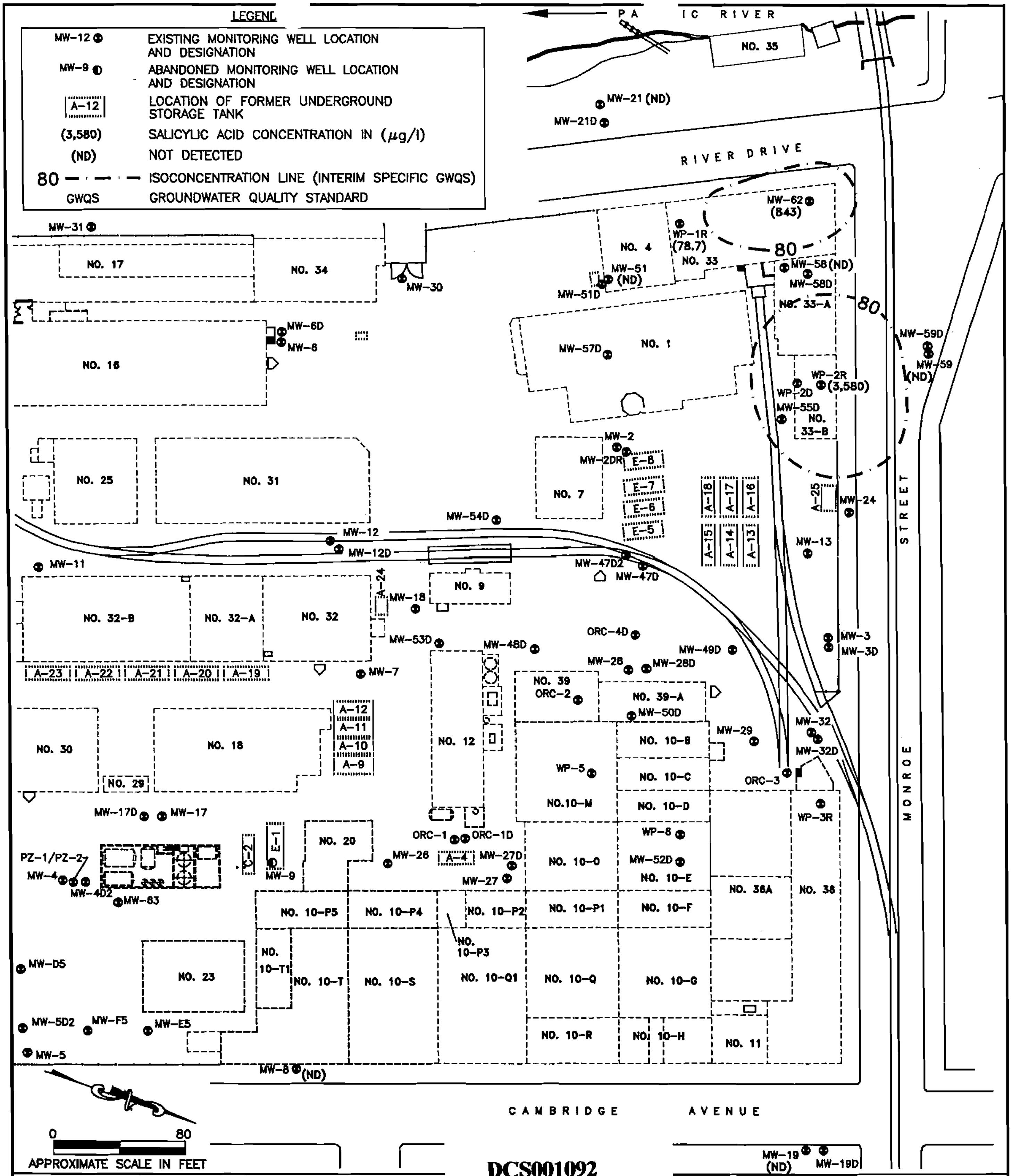
Project No.
File: POINTMAP\KAL-13-APRIL04.dwg
Date: 12/10/04

FIGURE 13
NORTHERN PHENOL AREA
DISTRIBUTION OF PHENOL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



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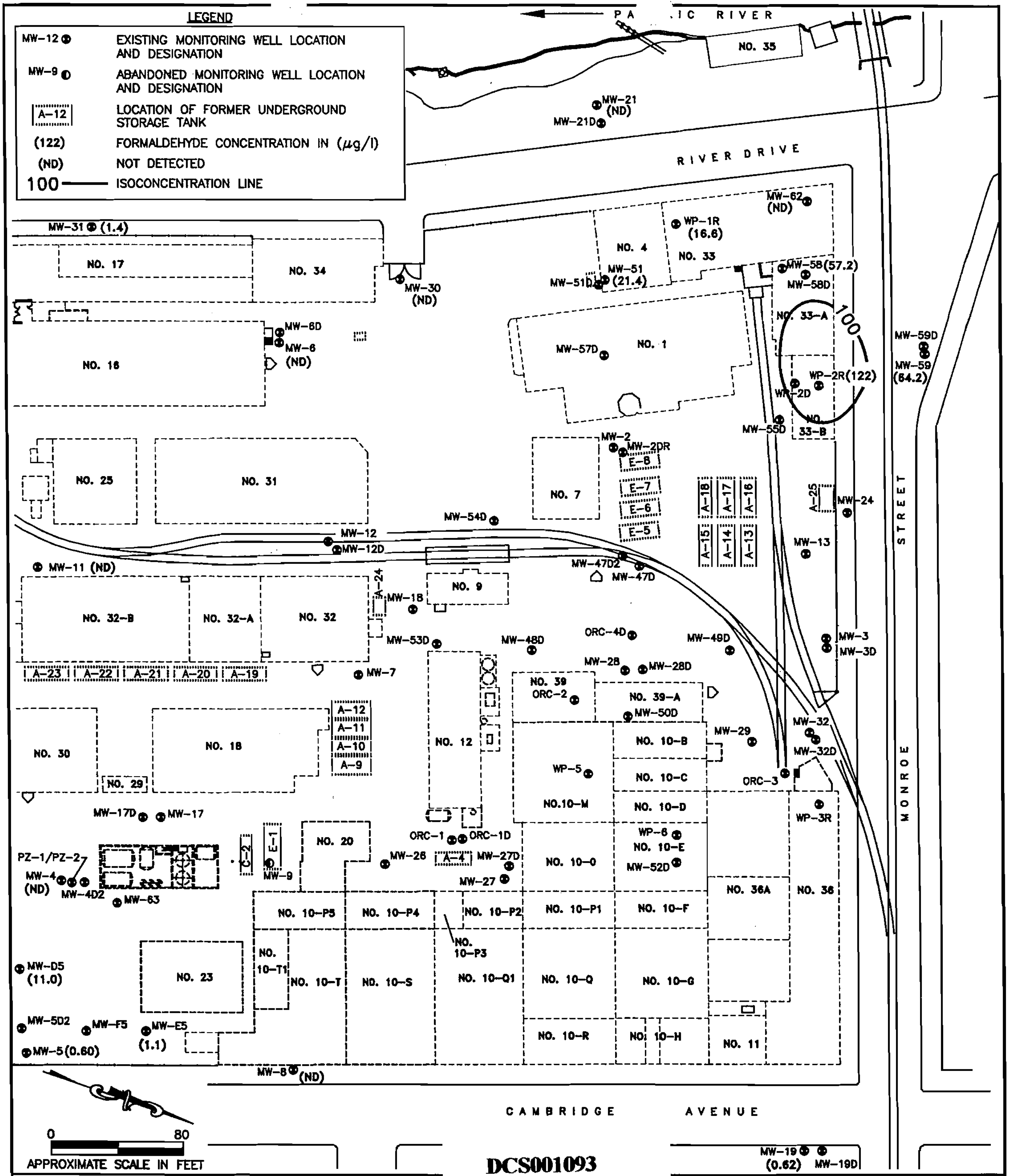
Project No. File: POINTMAP\KAL-14-APRIL04.dwg Date: 12/10/04

FIGURE 14
NORTHERN PHENOL AREA
DISTRIBUTION OF SALICYLIC ACID
IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



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Project No.

File: POINTMAP\KAL-15-APRIL04.dwg

Date: 12/10/04

FIGURE 15
NORTHERN PHENOL AREA
DISTRIBUTION OF FORMALDEHYDE
IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

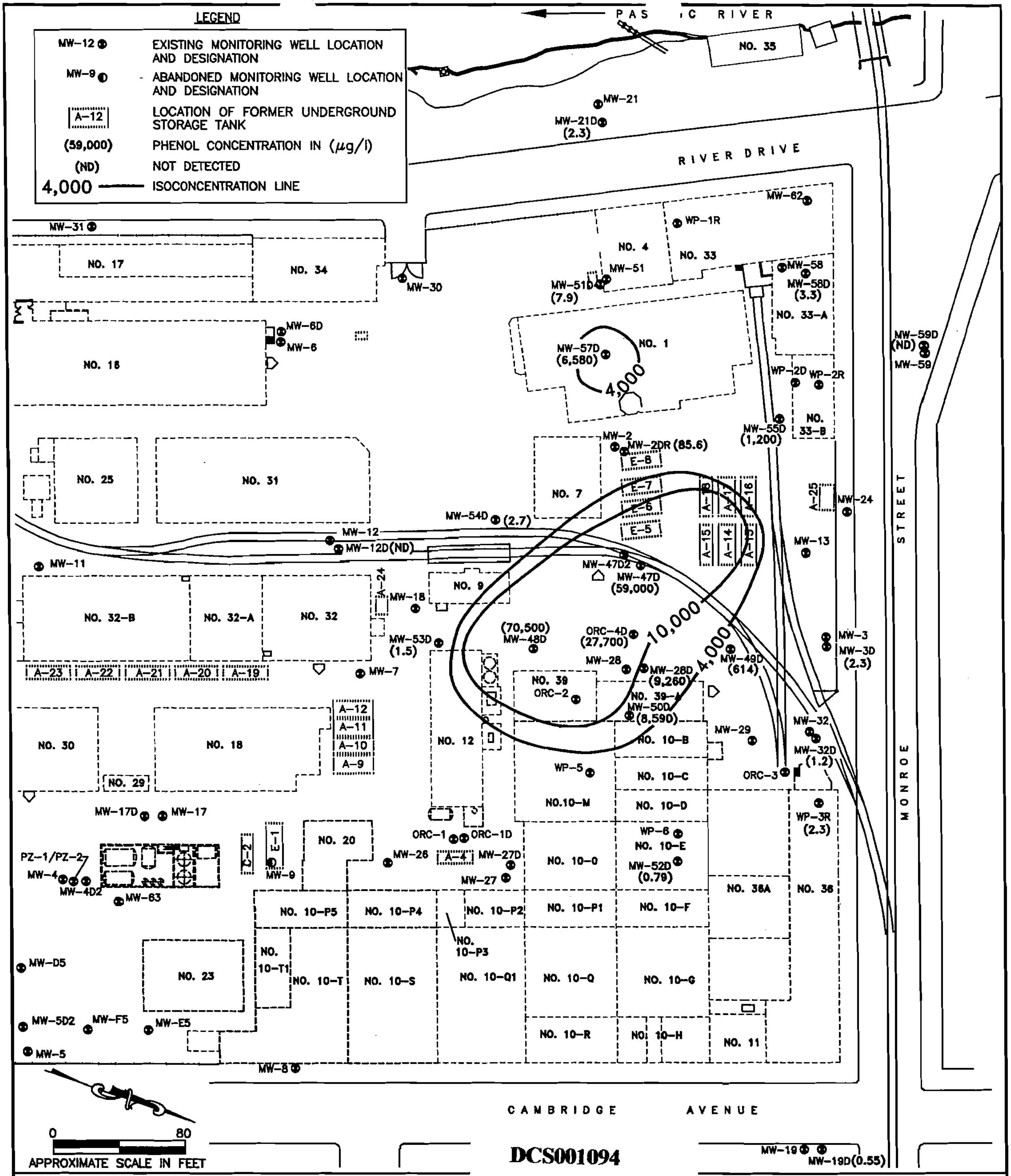

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FIGURE 16
NORTHERN PHENOL AREA
DISTRIBUTION OF PHENOL IN GROUNDWATER
DEEP OVERBURDEN ZONE
APRIL 2004

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Project No. File: POINTMAP\KAL-16-APRIL04.dwg Date: 11/29/04

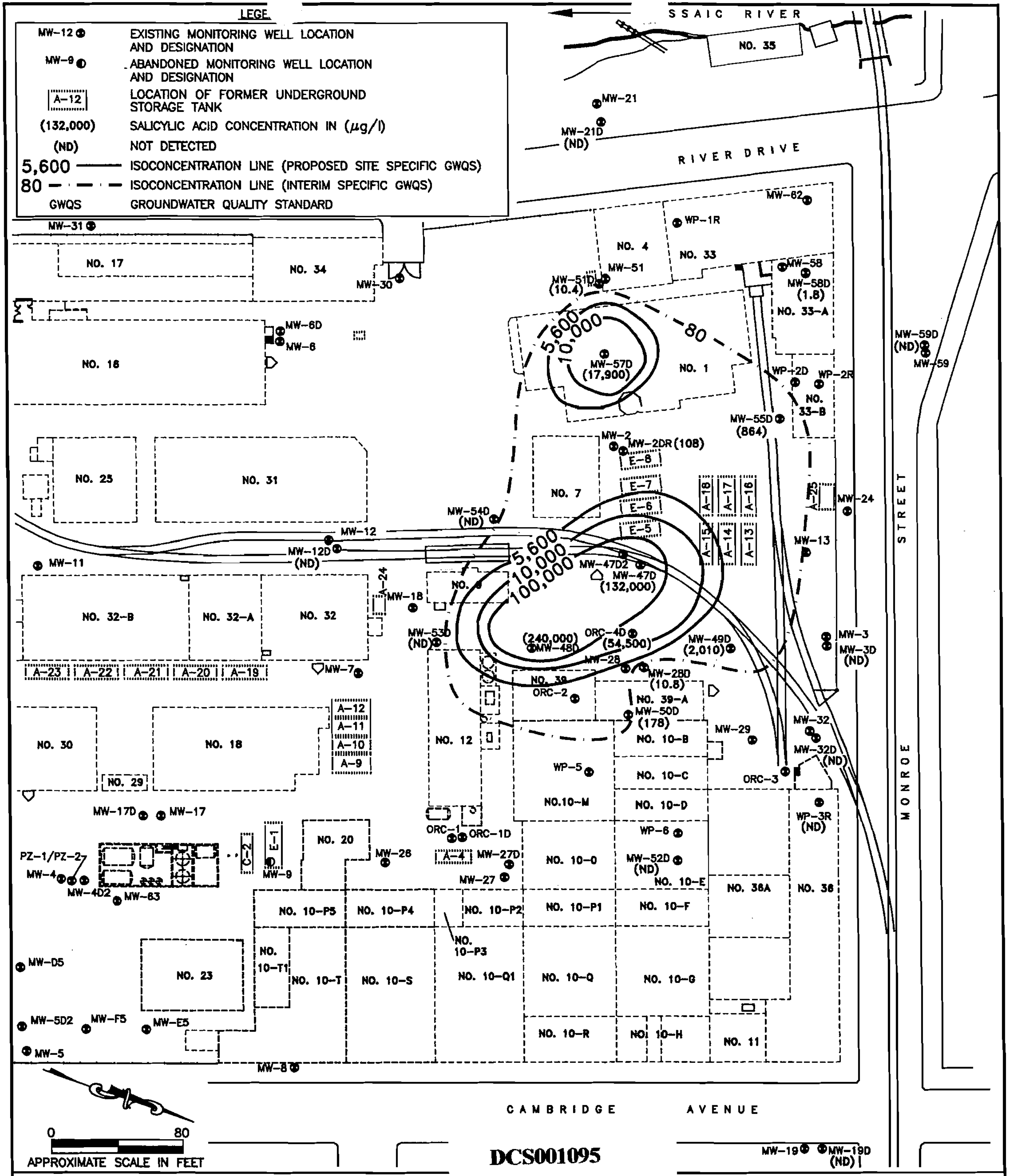

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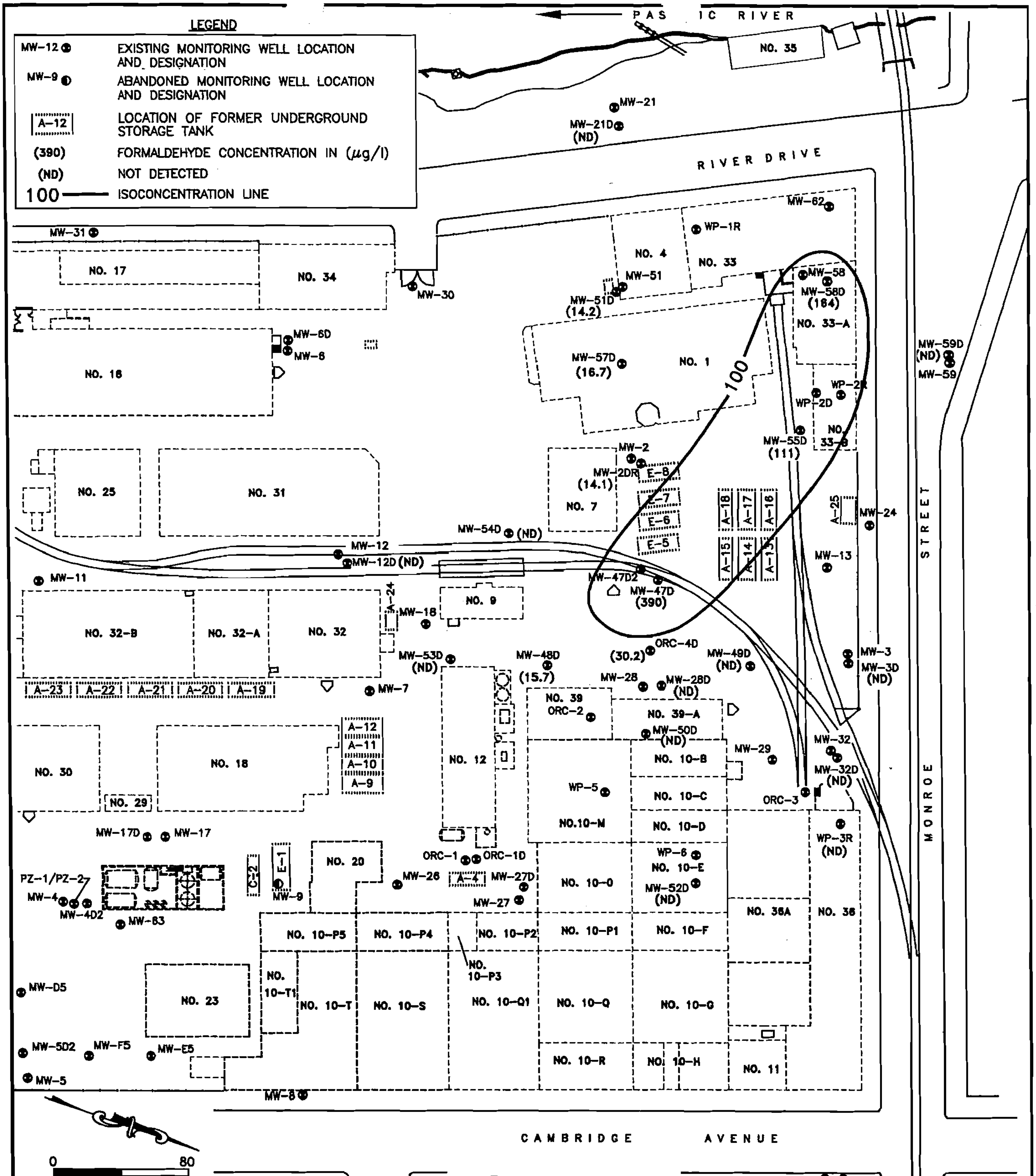
FIGURE 17
NORTHERN PHENOL AREA
DISTRIBUTION OF SALICYLIC ACID
IN GROUNDWATER
DEEP OVERBURDEN ZONE
APRIL 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-17-APRIL04.dwg Date: 12/10/04



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Project No. File: POINTMAP\KAL-18-APRIL04.dwg Date: 11/29/04

FIGURE 18
NORTHERN PHENOL AREA
DISTRIBUTION OF FORMALDEHYDE
IN GROUNDWATER
DEEP OVERBURDEN ZONE
APRIL 2004

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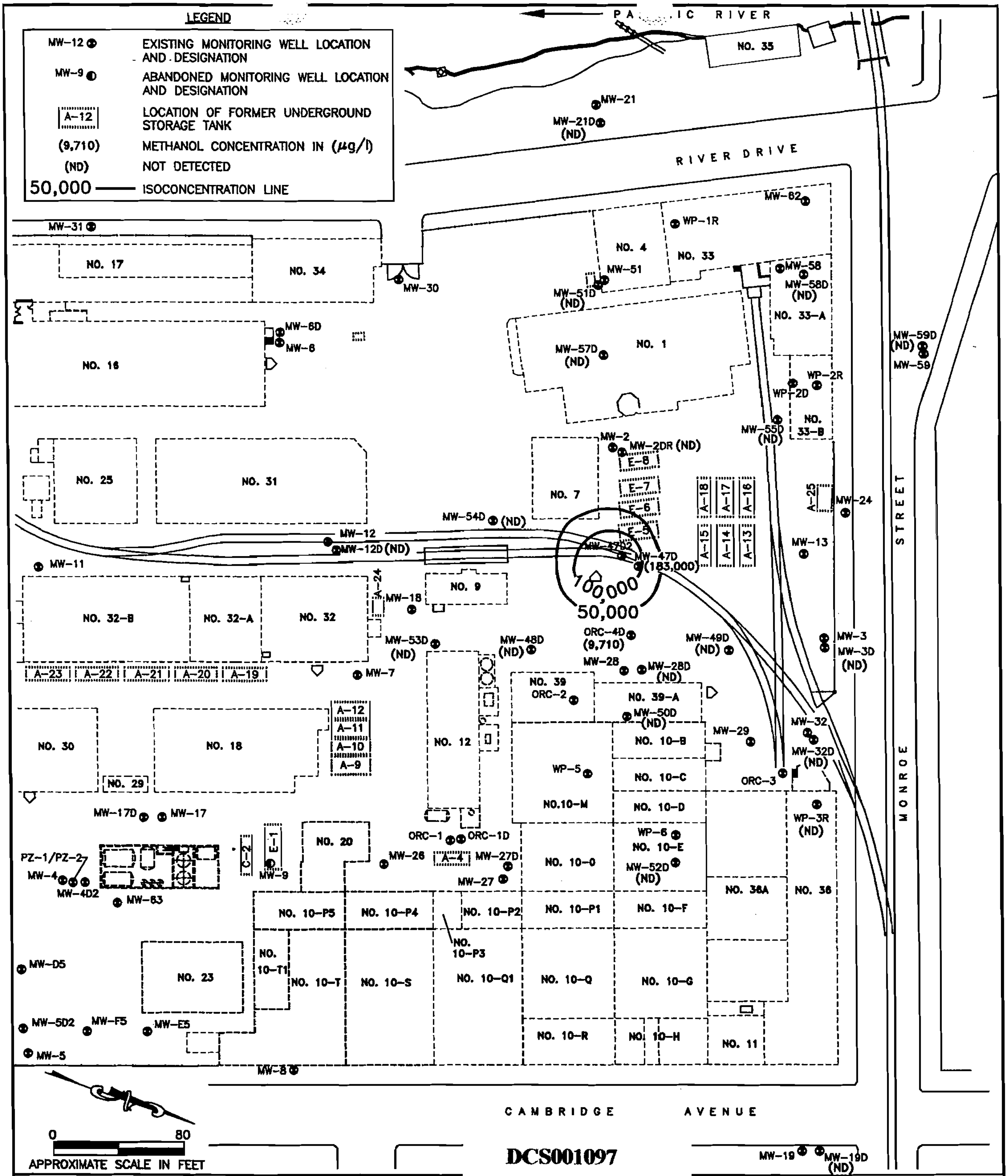

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FIGURE 19
NORTHERN PHENOL AREA
DISTRIBUTION OF METHANOL IN GROUNDWATER
DEEP OVERBURDEN ZONE
APRIL 2004

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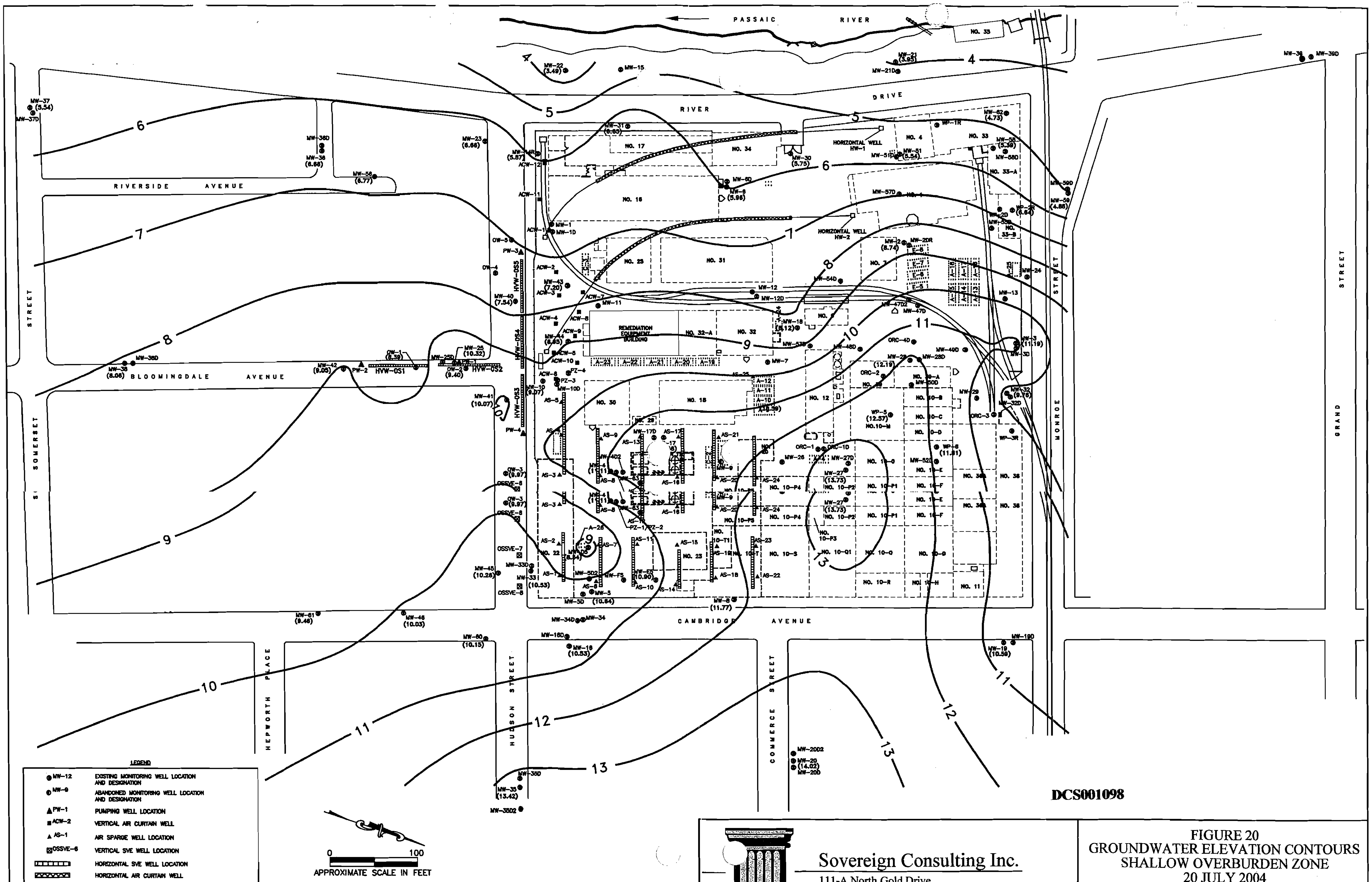
Project No. File: POINTMAP\KAL-19-APRIL04.dwg Date: 12/10/04



REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND
PROPOSED REMEDIAL ACTION PLAN,
DECEMBER 1993, FIGURE 2-3.
REVISED DECEMBER 2002.

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
● MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-1	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(10.59)	GROUNDWATER ELEVATION
10 ——	GROUNDWATER CONTOUR LINE CONTOUR INTERVAL = 1 FOOT

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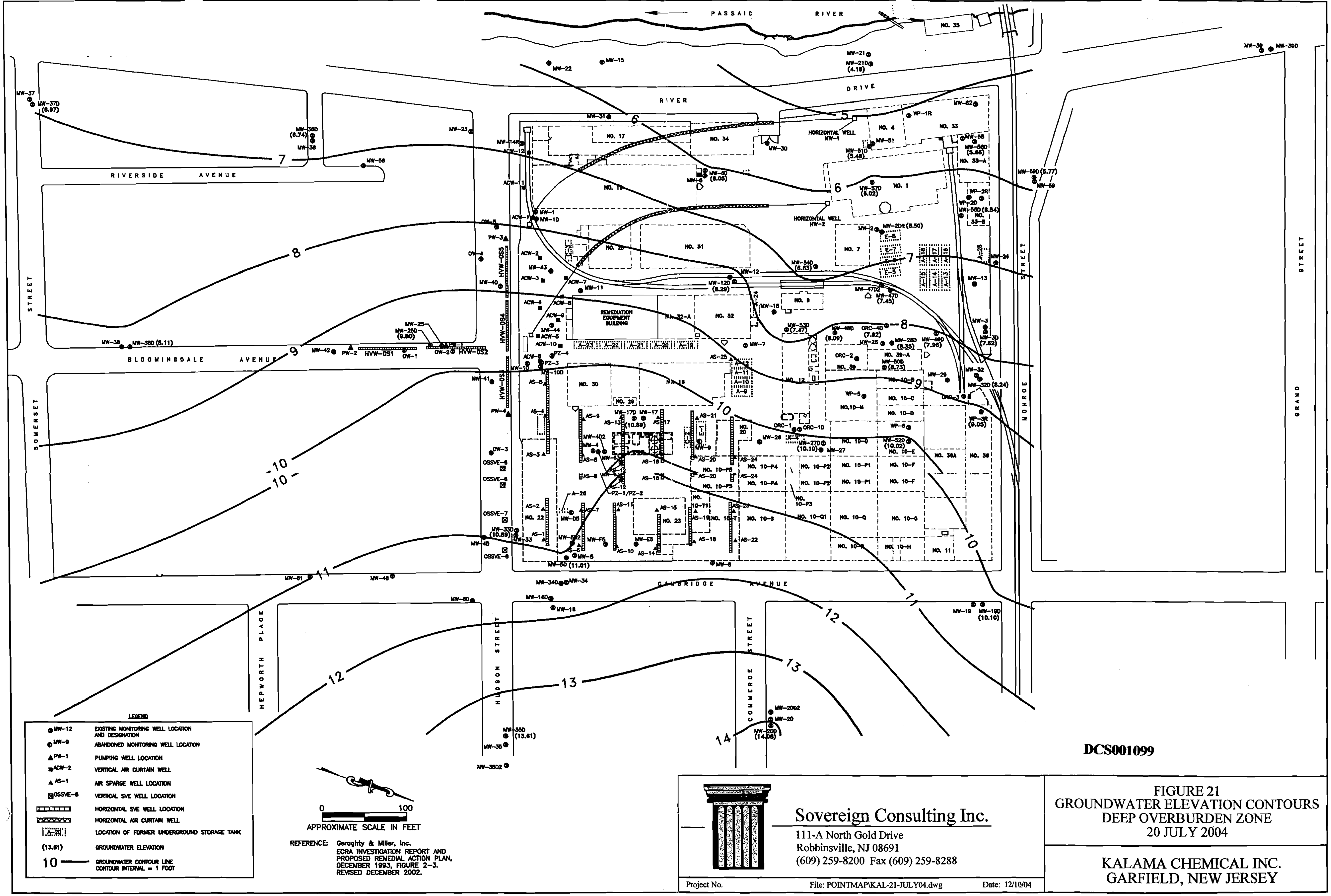
Project No. File: POINTMAP\KAL-20-JULY04.dwg Date: 12/10/04

FIGURE 20
GROUNDWATER ELEVATION CONTOURS
SHALLOW OVERBURDEN ZONE
20 JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



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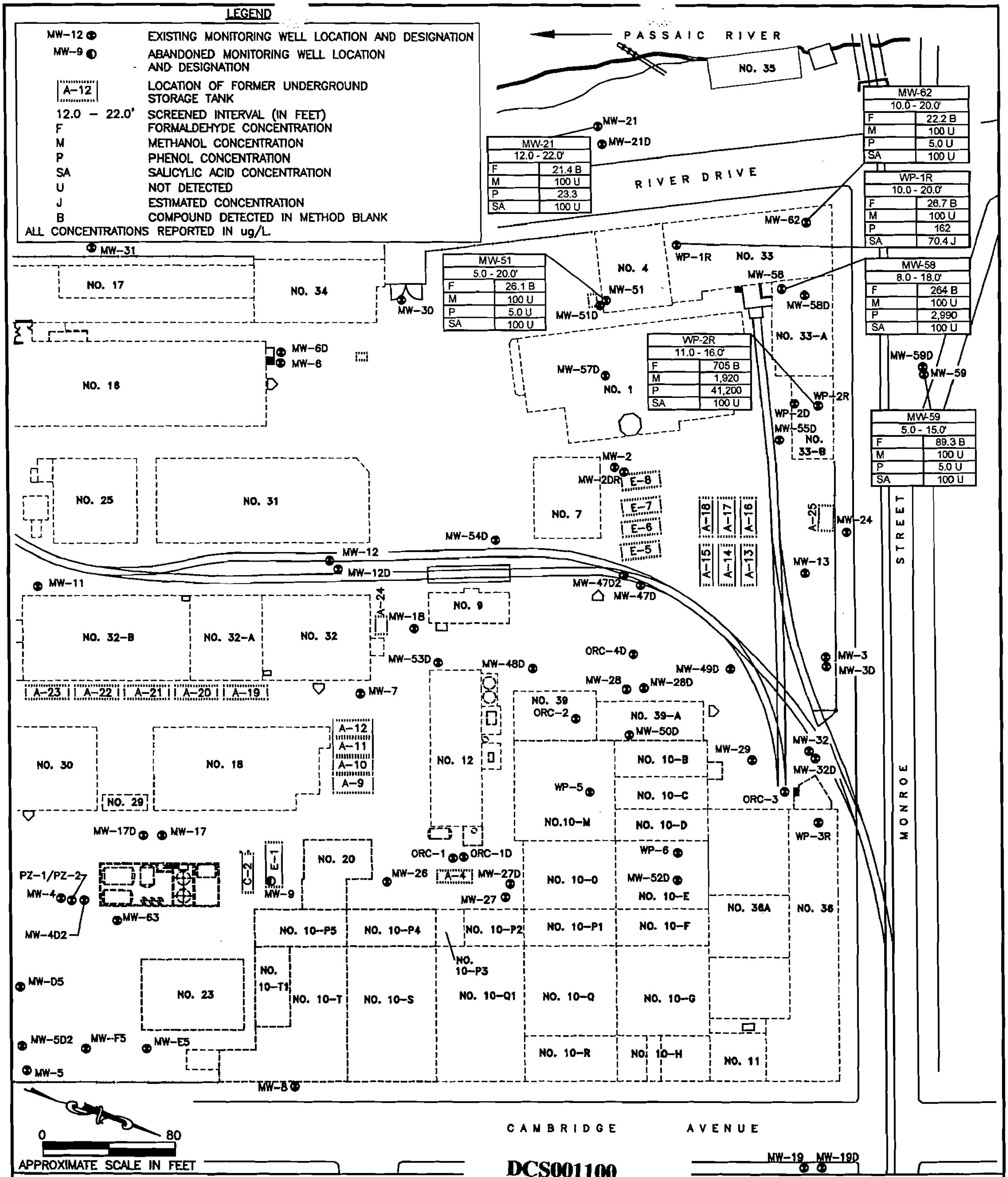
Project No.
File: POINTMAP\KAL-21-JULY04.dwg
Date: 12/10/04

FIGURE 21
GROUNDWATER ELEVATION CONTOURS
DEEP OVERBURDEN ZONE
20 JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



LEGEND

MW-12 ⊗	EXISTING MONITORING WELL LOCATION AND DESIGNATION
MW-9 ◐	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-12	LOCATION OF FORMER UNDERGROUND STORAGE TANK
12.0 – 22.0'	SCREENED INTERVAL (IN FEET)
F	FORMALDEHYDE CONCENTRATION
M	METHANOL CONCENTRATION
P	PHENOL CONCENTRATION
SA	SALICYLIC ACID CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
B	COMPOUND DETECTED IN METHOD BLANK

ALL CONCENTRATIONS REPORTED IN ug/L

MW-21	
12.0 - 22.0'	
F	21.4 B
M	100 U
P	23.3
SA	100 U

MW-62	
10.0 - 20.0'	
F	22.2 B
M	100 U
P	5.0 U
SA	100 U

WP-1R	
10.0 - 20.0'	
F	26.7 B
M	100 U
P	162
SA	70.4 J

MW-51	
5.0 - 20.0'	
F	26.1 B
M	100 U
P	5.0 U
SA	100 U

MW-58	
8.0 - 18.0'	
F	264 B
M	100 U
P	2,990
SA	100 U

WP-2R	
11.0 - 16.0'	
F	705 B
M	1,920
P	41,200
SA	100 U

MW-59	
5.0 - 15.0'	
F	89.3 B
M	100 U
P	5.0 U
SA	100 U

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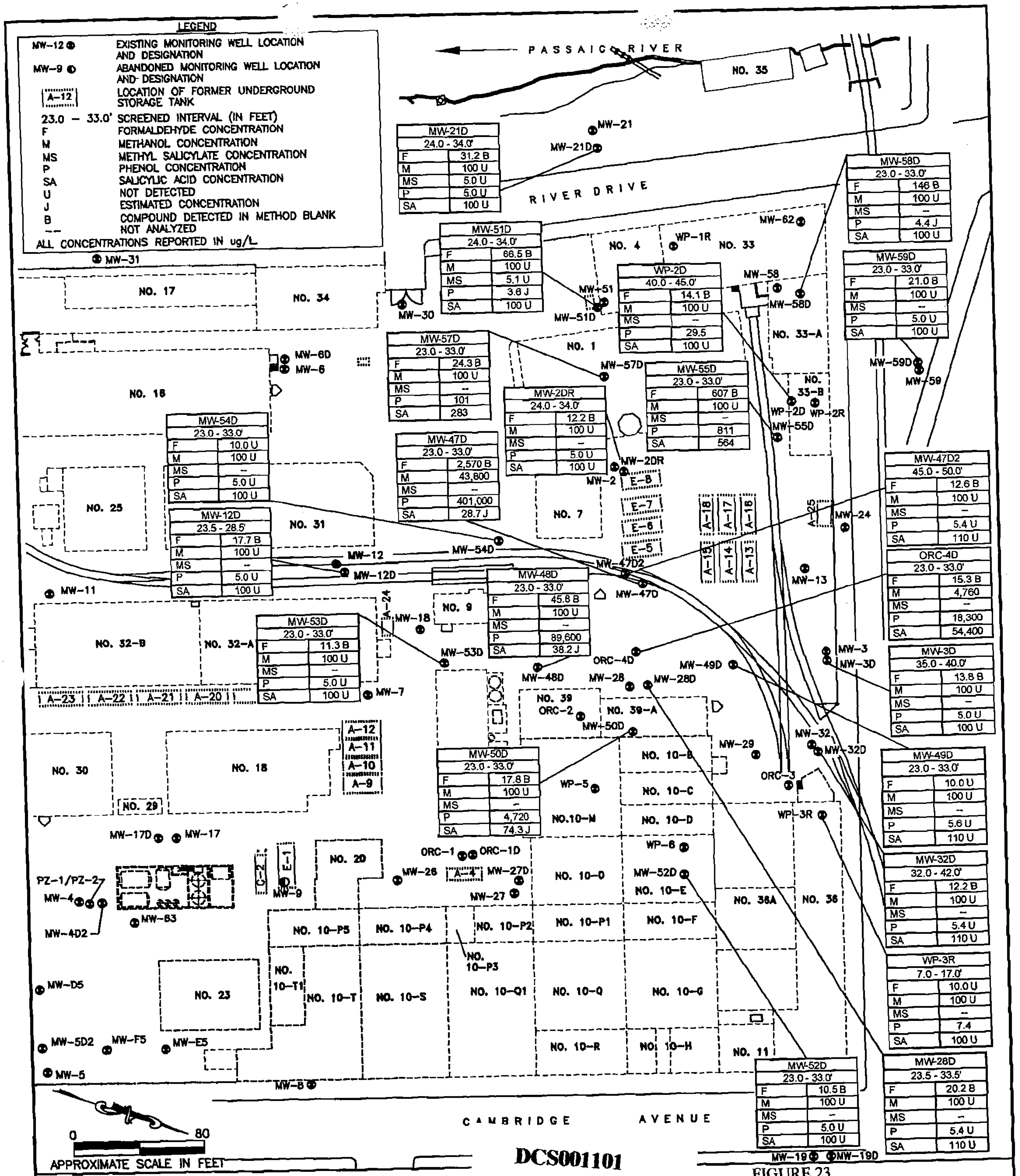
FIGURE 22
NORTHERN PHENOL AREA
PHENOL, METHANOL, FORMALDEHYDE,
& SALICYLIC ACID IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-22-JULY04.dwg Date: 12/10/04



LEGEND

MW-12 ⊕	EXISTING MONITORING WELL LOCATION AND DESIGNATION
MW-9 ◐	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-12	LOCATION OF FORMER UNDERGROUND STORAGE TANK
23.0 – 33.0'	SCREENED INTERVAL (IN FEET)
F	FORMALDEHYDE CONCENTRATION
M	METHANOL CONCENTRATION
MS	METHYL SALICYLATE CONCENTRATION
P	PHENOL CONCENTRATION
SA	SALICYLIC ACID CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
B	COMPOUND DETECTED IN METHOD BLANK
--	NOT ANALYZED

ALL CONCENTRATIONS REPORTED IN ug/L

MW-21D	
24.0 - 34.0'	
F	31.2 B
M	100 U
MS	5.0 U
P	5.0 U
SA	100 U

MW-51D	
24.0 - 34.0'	
F	66.5 B
M	100 U
MS	5.1 U
P	3.6 J
SA	100 U

WP-2D	
40.0 - 45.0'	
F	14.1 B
M	100 U
MS	–
P	29.5
SA	100 U

MW-58D	
23.0 - 33.0'	
F	146 B
M	100 U
MS	--
P	4.4 J
SA	100 U

MW-59D	
23.0 - 33.0'	
F	21.0 B
M	100 U
MS	--
P	5.0 U
SA	100 U

MW-57D	
23.0 - 33.0'	
F	24.3 B
M	100 U
MS	--
P	101
SA	283

MW-55D	
23.0 - 33.0'	
F	607 B
M	100 U
MS	–
P	811
SA	564

MW-2DR	
24.0 - 34.0'	
F	12.2 B
M	100 U
MS	–
P	5.0 U
SA	100 U

MW-54D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	–
P	5.0 U
SA	100 U

MW-47D	
23.0 - 33.0'	
F	2,570 B
M	43,800
MS	–
P	401,000
SA	28.7 J

MW-47D2	
45.0 - 50.0'	
F	12.6 B
M	100 U
MS	–
P	5.4 U
SA	110 U

MW-12D	
23.5 - 28.5'	
F	17.7 B
M	100 U
MS	--
P	5.0 U
SA	100 U

ORC-4D	
23.0 - 33.0'	
F	15.3 B
M	4,760
MS	--
P	18,300
SA	54,400

MW-48D	
23.0 - 33.0'	
F	45.8 B
M	100 U
MS	–
P	89,600
SA	38.2 J

MW-53D	
23.0 - 33.0'	
F	11.3 B
M	100 U
MS	–
P	5.0 U
SA	100 U

MW-3D	
35.0 - 40.0'	
F	13.8 B
M	100 U
MS	–
P	5.0 U
SA	100 U

MW-49D	
23.0 - 33.0'	
F	10.0 U
M	100 U
MS	--
P	5.6 U
SA	110 U

MW-50D	
23.0 - 33.0'	
F	17.8 B
M	100 U
MS	–
P	4,720
SA	74.3 J

MW-32D	
32.0 - 42.0'	
F	12.2 B
M	100 U
MS	--
P	5.4 U
SA	110 U

WP-3R	
7.0 - 17.0'	
F	10.0 U
M	100 U
MS	--
P	7.4
SA	100 U

MW-52D	
23.0 - 33.0'	
F	10.5 B
M	100 U
MS	–
P	5.0 U
SA	100 U

MW-28D	
23.5 - 33.5'	
F	20.2 B
M	100 U
MS	–
P	5.4 U
SA	110 U

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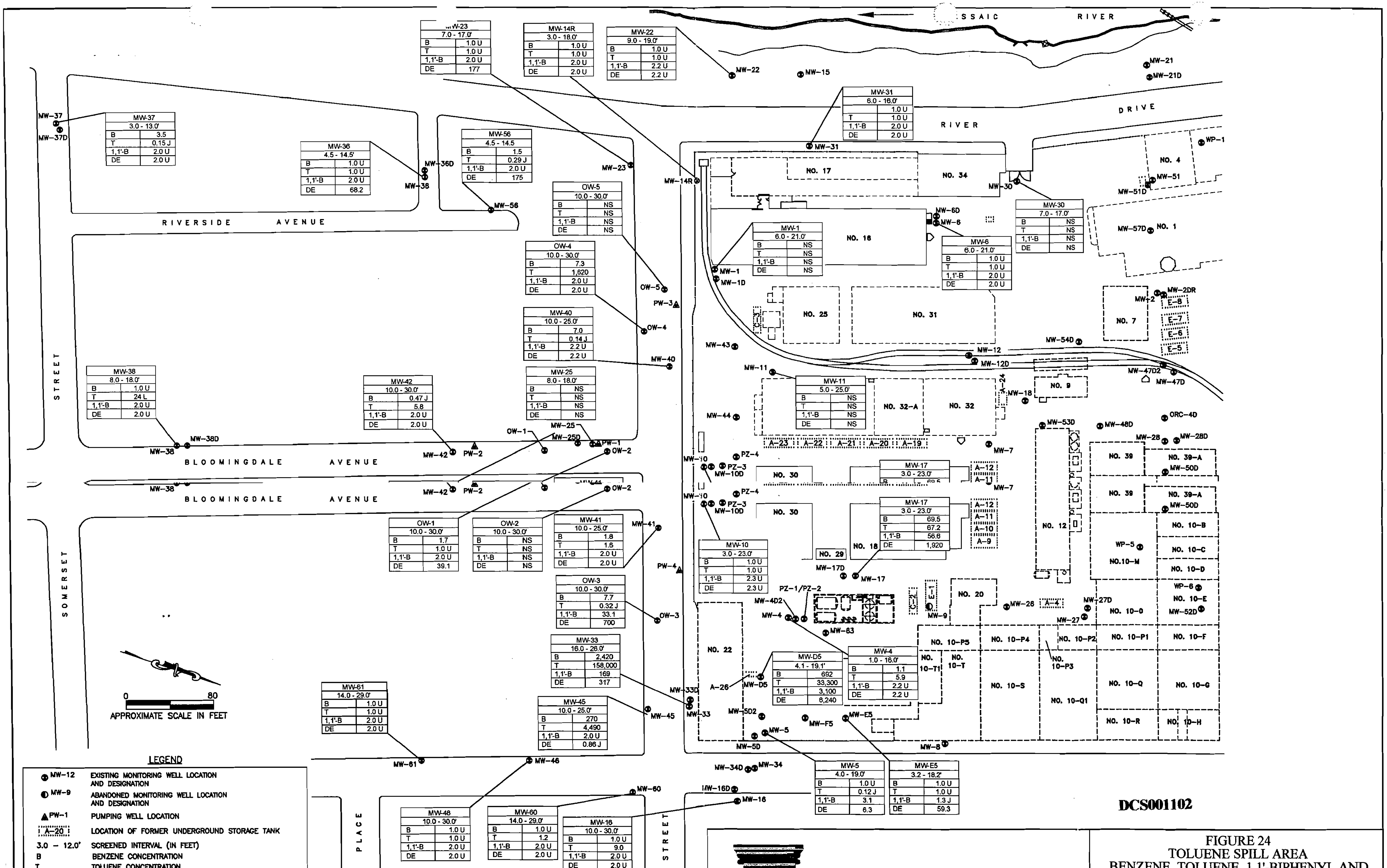
FIGURE 23
NORTHERN PHENOL AREA
PHENOL, METHANOL, FORMALDEHYDE,
SALICYLIC ACID & METHYL SALICYLATE
IN GROUNDWATER
DEEP OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-23-JULY04.dwg Date: 12/10/04



LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
3.0 – 12.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION
T	TOLUENE CONCENTRATION
1,1'–B	1,1'–BIPHENYL CONCENTRATION
DE	DIPHENYL ETHER CONCENTRATION
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
NS	NOT SAMPLED

ALL CONCENTRATIONS REPORTED IN ug/L.

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2–3.

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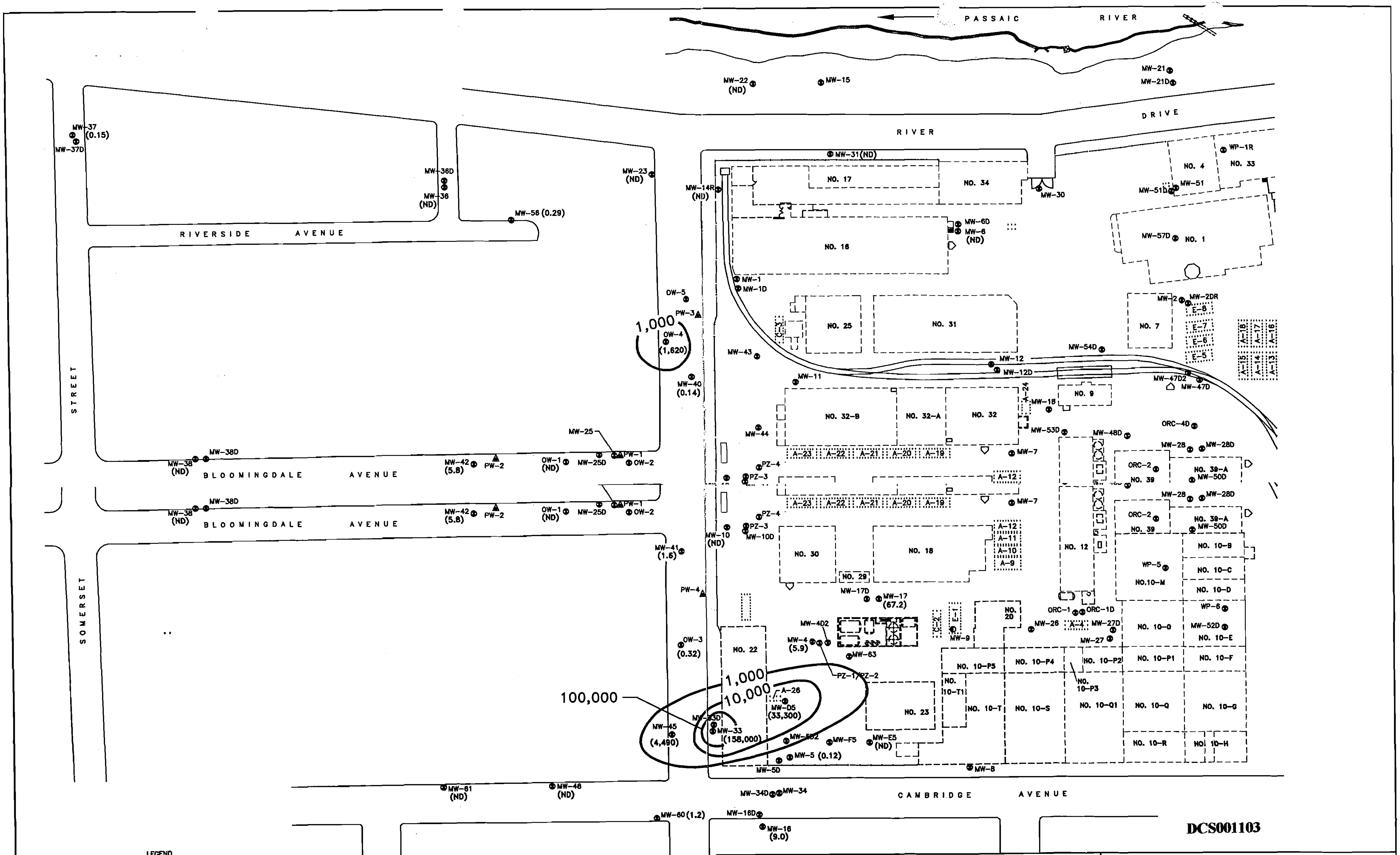
FIGURE 24
TOLUENE SPILL AREA
BENZENE, TOLUENE, 1,1'-BIPHENYL AND
DIPHENYL ETHER IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.



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LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(1,620)	TOLUENE CONCENTRATION IN (µg/l)

0 80
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.

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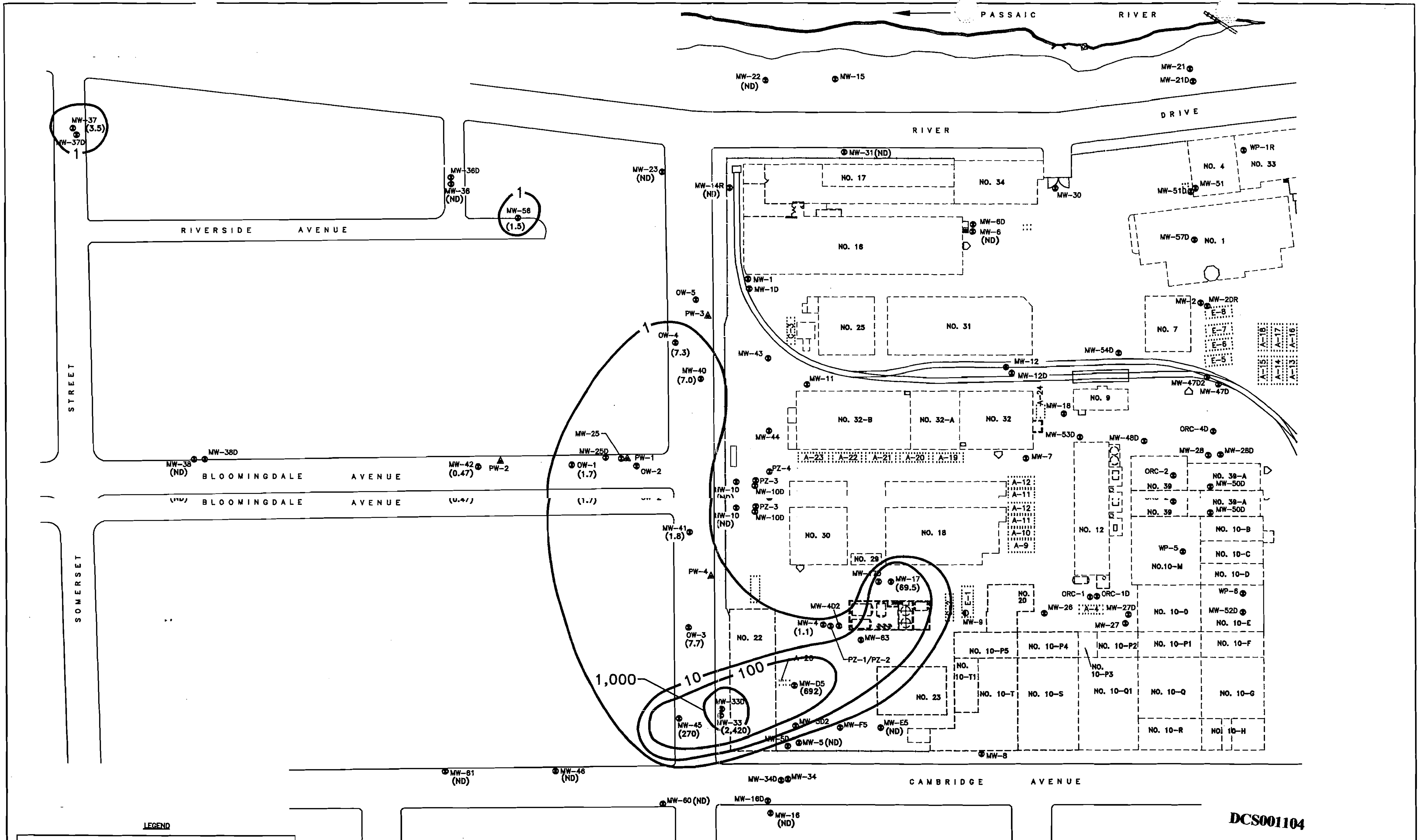
FIGURE 25
TOLUENE SPILL AREA
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC



LEGEND

- ⊕ MW-12 EXISTING MONITORING WELL LOCATION AND DESIGNATION
- ● MW-9 ABANDONED MONITORING WELL LOCATION AND DESIGNATION
- ▲ PW-1 PUMPING WELL LOCATION
- A-20 LOCATION OF FORMER UNDERGROUND STORAGE TANK
- (270) BENZENE CONCENTRATION IN (μg/l)
- (ND) NOT DETECTED
- 1 —— ISOCONCENTRATION LINE

0 80
APPROXIMATE SCALE IN FEET

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3.
REVISED DECEMBER 2002.

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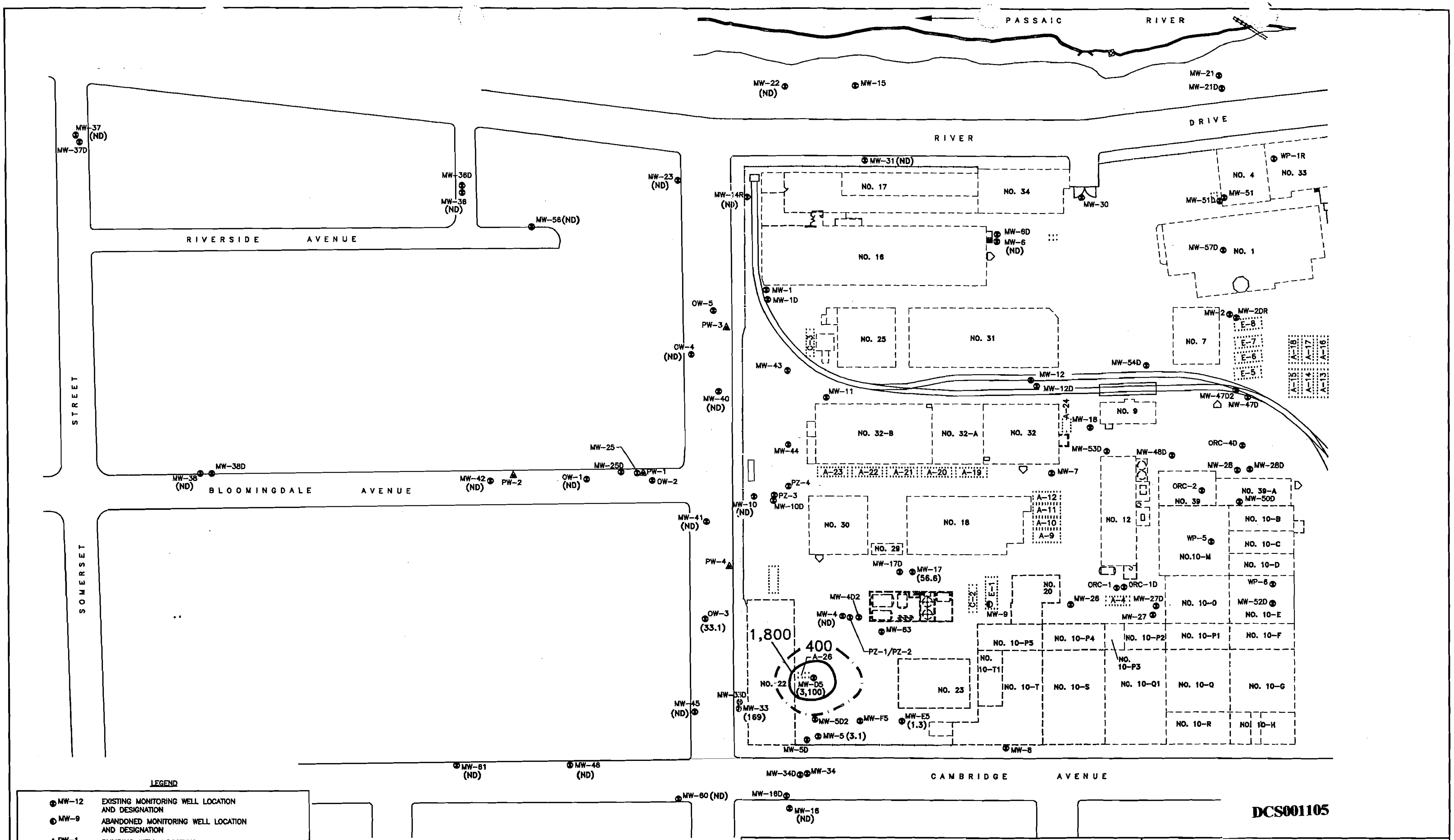
FIGURE 26
TOLUENE SPILL AREA
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-26-JULY04.dwg Date: 12/3/04



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(169)	1,1'-BIPHENYL CONCENTRATION IN ($\mu g/l$)
(ND)	NOT DETECTED
1,800 ——	ISOCONCENTRATION LINE (PROPOSED SITE SPECIFIC GWQS)
400 — · —	ISOCONCENTRATION LINE (INTERIM SPECIFIC GWQS)
GWQS	GROUNDWATER QUALITY STANDARD

REFERENCE: Geraghty & Miller, Inc. ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3. REVISED DECEMBER 2002.

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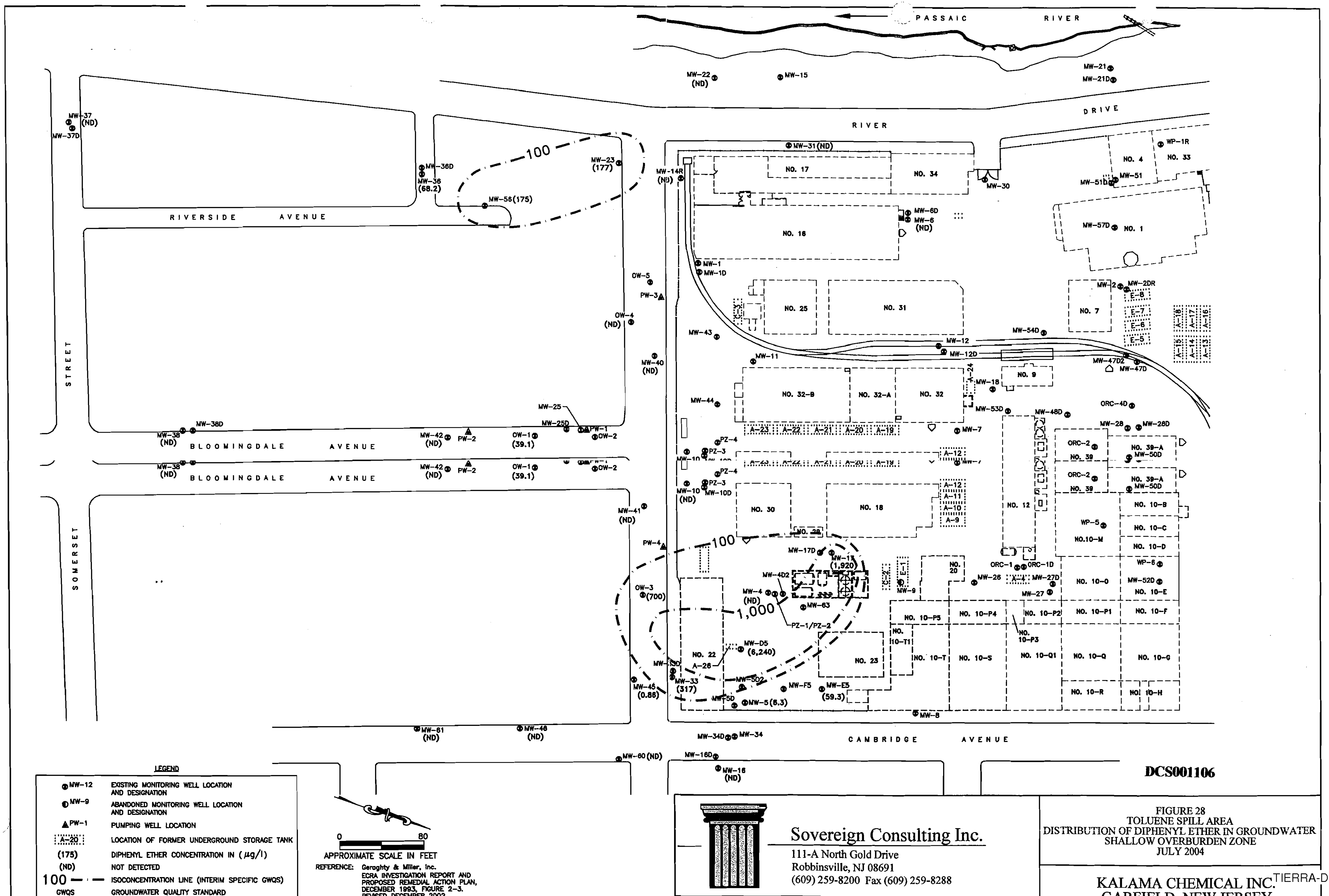
(609) 259-8200 Fax (609) 259-8288

FIGURE 27
TOLUENE SPILL AREA
DISTRIBUTION OF 1,1'-BIPHENYL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-27-July04.dwg Date: 12/10/04



LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
◐ MW-9	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(175)	DIPHENYL ETHER CONCENTRATION IN (μg/l)
(ND)	NOT DETECTED
100 — · —	ISOCONCENTRATION LINE (INTERIM SPECIFIC GWQS)
GWQS	GROUNDWATER QUALITY STANDARD

REFERENCE: Geraghty & Miller, Inc. ECRA INVESTIGATION REPORT AND PROPOSED REMEDIAL ACTION PLAN, DECEMBER 1993, FIGURE 2-3. REVISED DECEMBER 2002

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FIGURE 28
TOLUENE SPILL AREA
DISTRIBUTION OF DIPHENYL ETHER IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

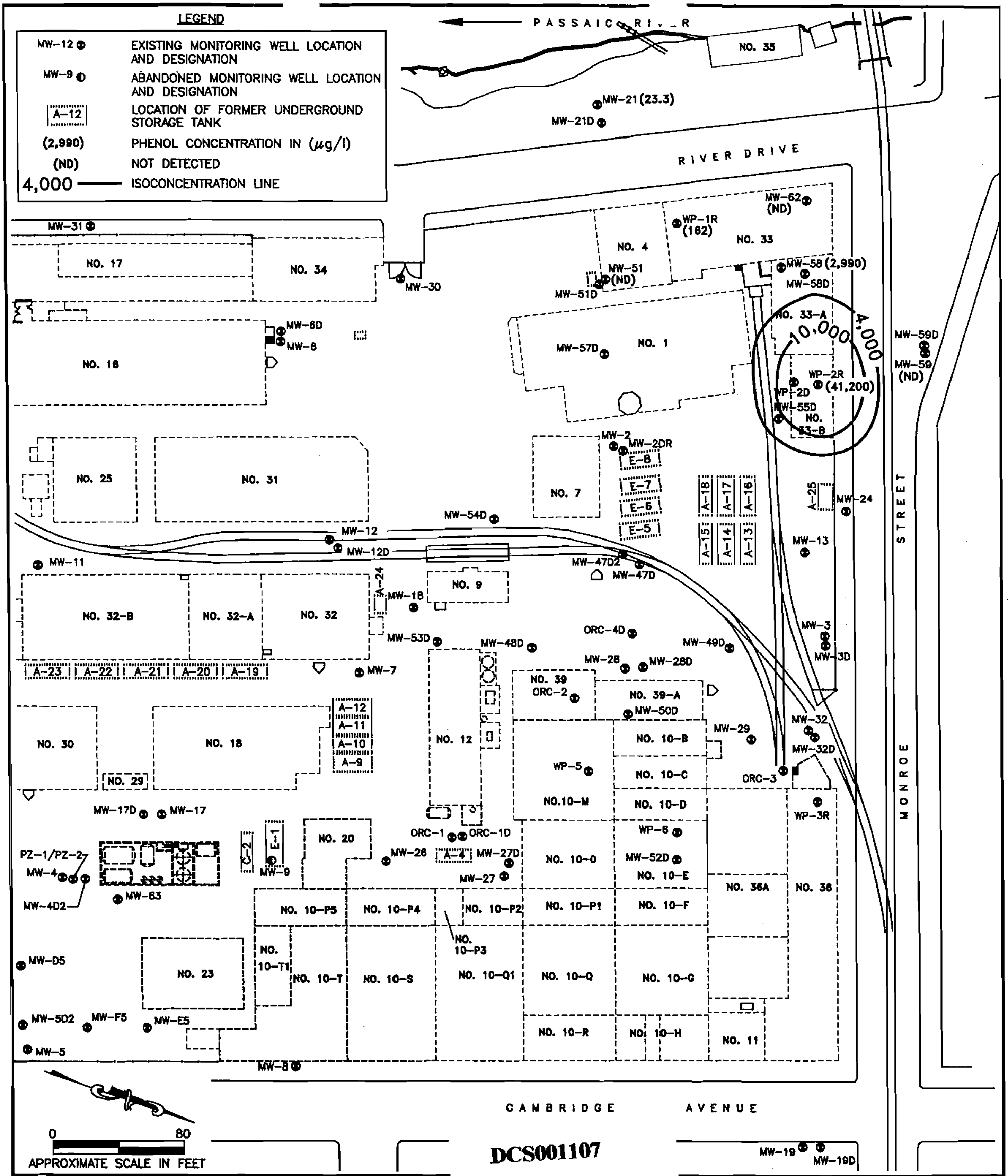

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FIGURE 29
NORTHERN PHENOL AREA DISTRIBUTION OF PHENOL IN GROUNDWATER SHALLOW OVERBURDEN ZONE JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-29-JULY04.dwg Date: 12/2/04

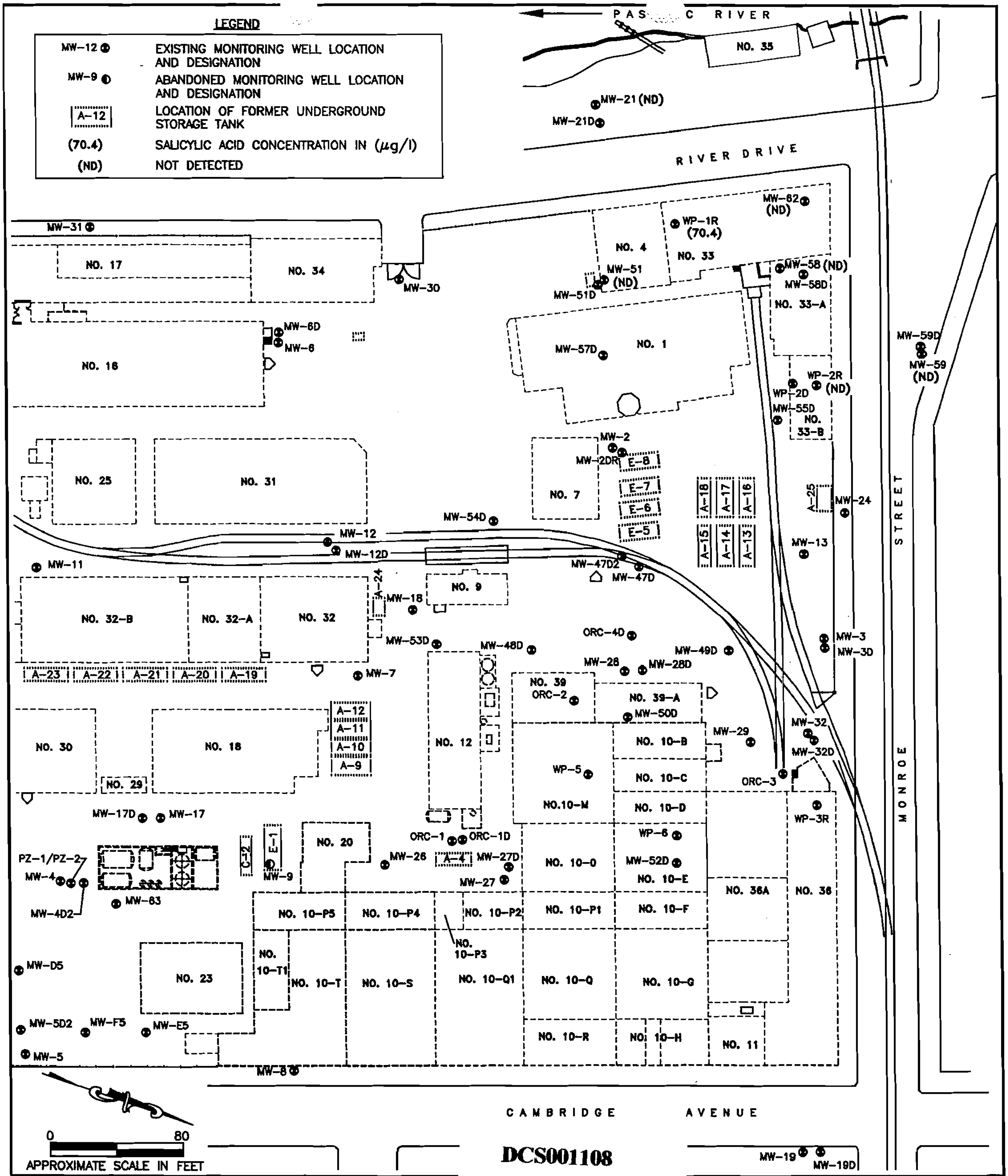

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FIGURE 30
NORTHERN PHENOL AREA DISTRIBUTION OF SALICYLIC ACID IN GROUNDWATER SHALLOW OVERBURDEN ZONE JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No.	File: POINTMAP\KAL-30-JULY04.dwg	Date: 12/2/04

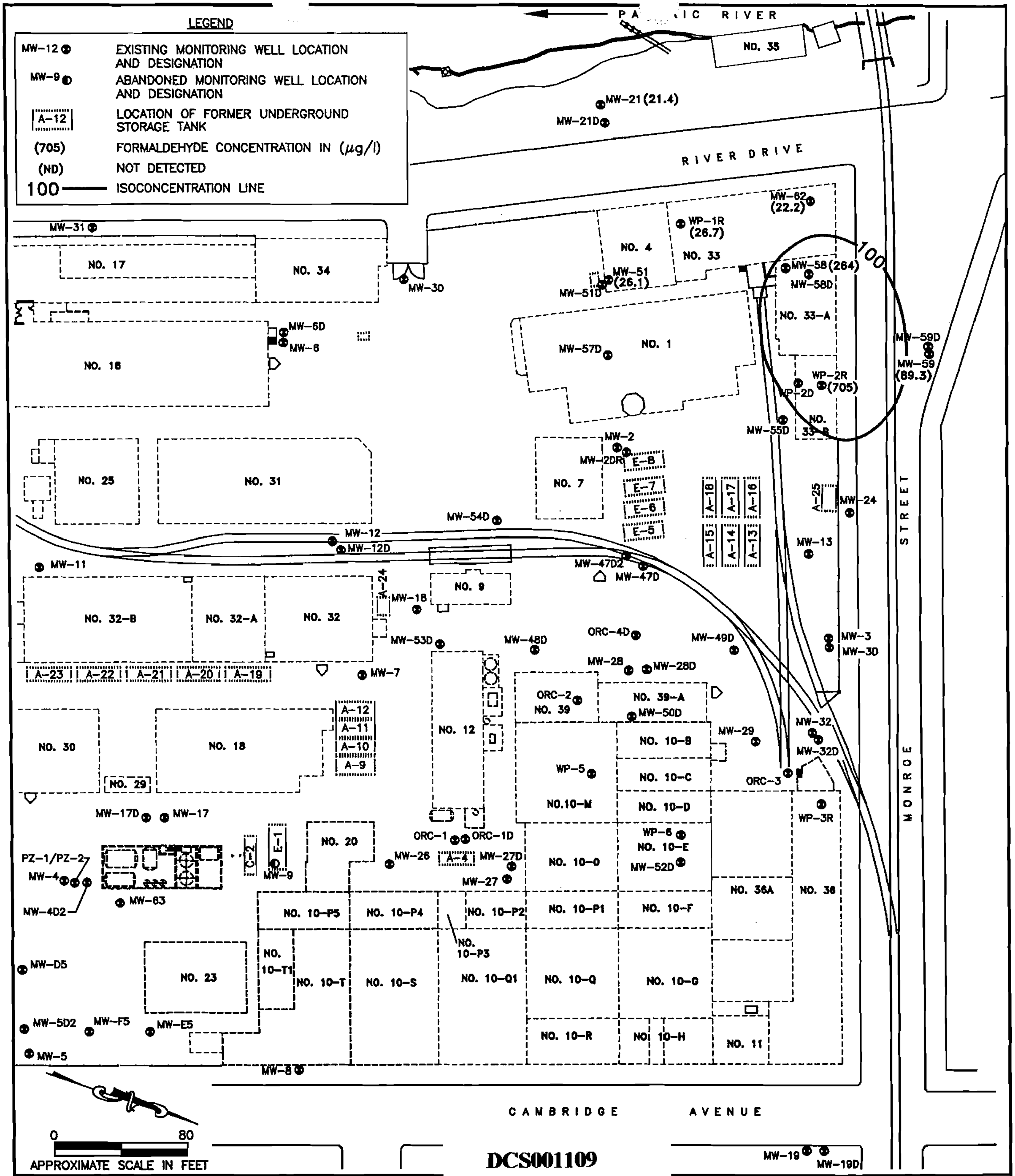

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FIGURE 31
NORTHERN PHENOL AREA DISTRIBUTION OF FORMALDEHYDE IN GROUNDWATER SHALLOW OVERBURDEN ZONE JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-31-JULY04.dwg Date: 11/29/04

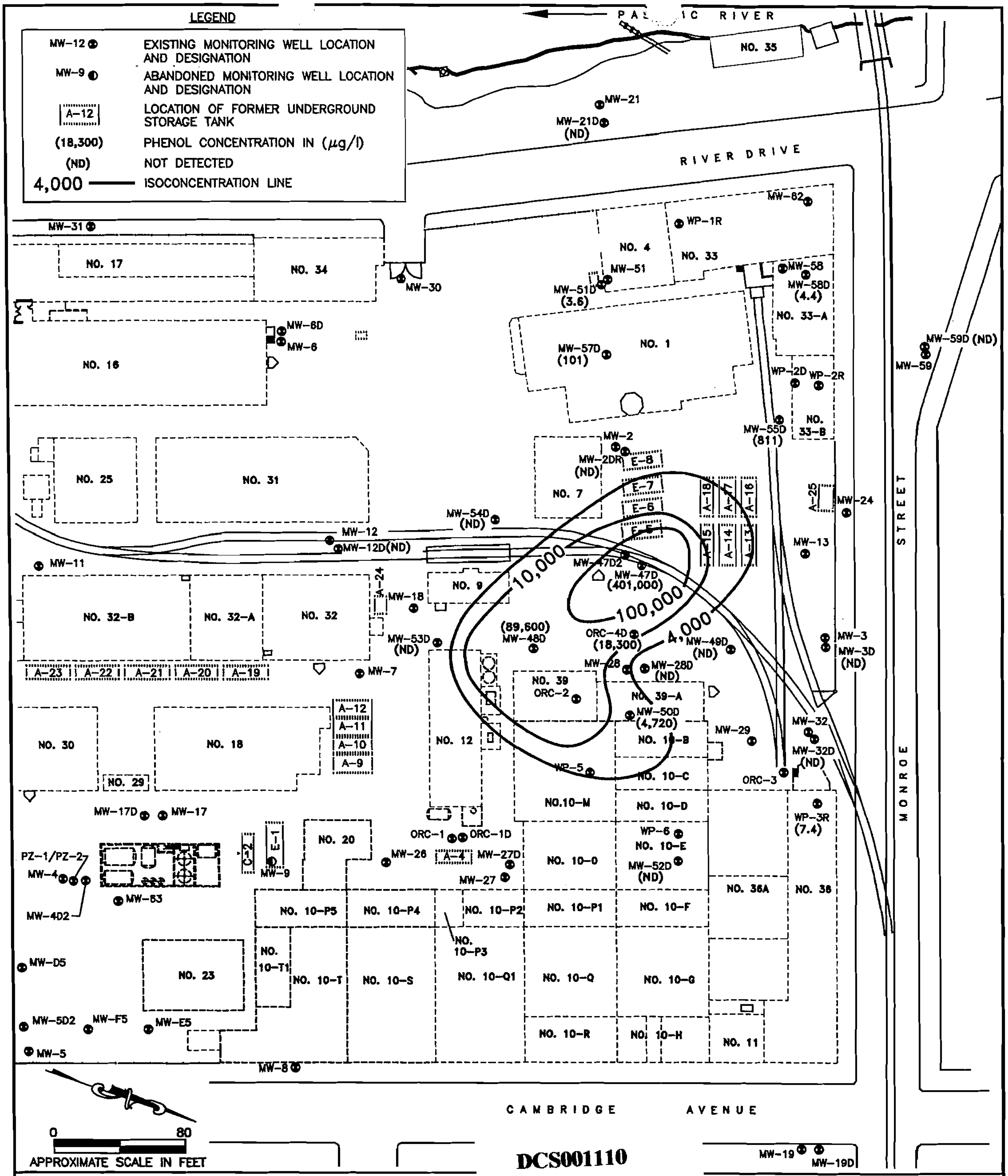

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FIGURE 32
NORTHERN PHENOL AREA
DISTRIBUTION OF PHENOL IN GROUNDWATER
DEEP OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No.

File: POINTMAP\KAL-32-JULY04.dwg

Date: 12/10/04

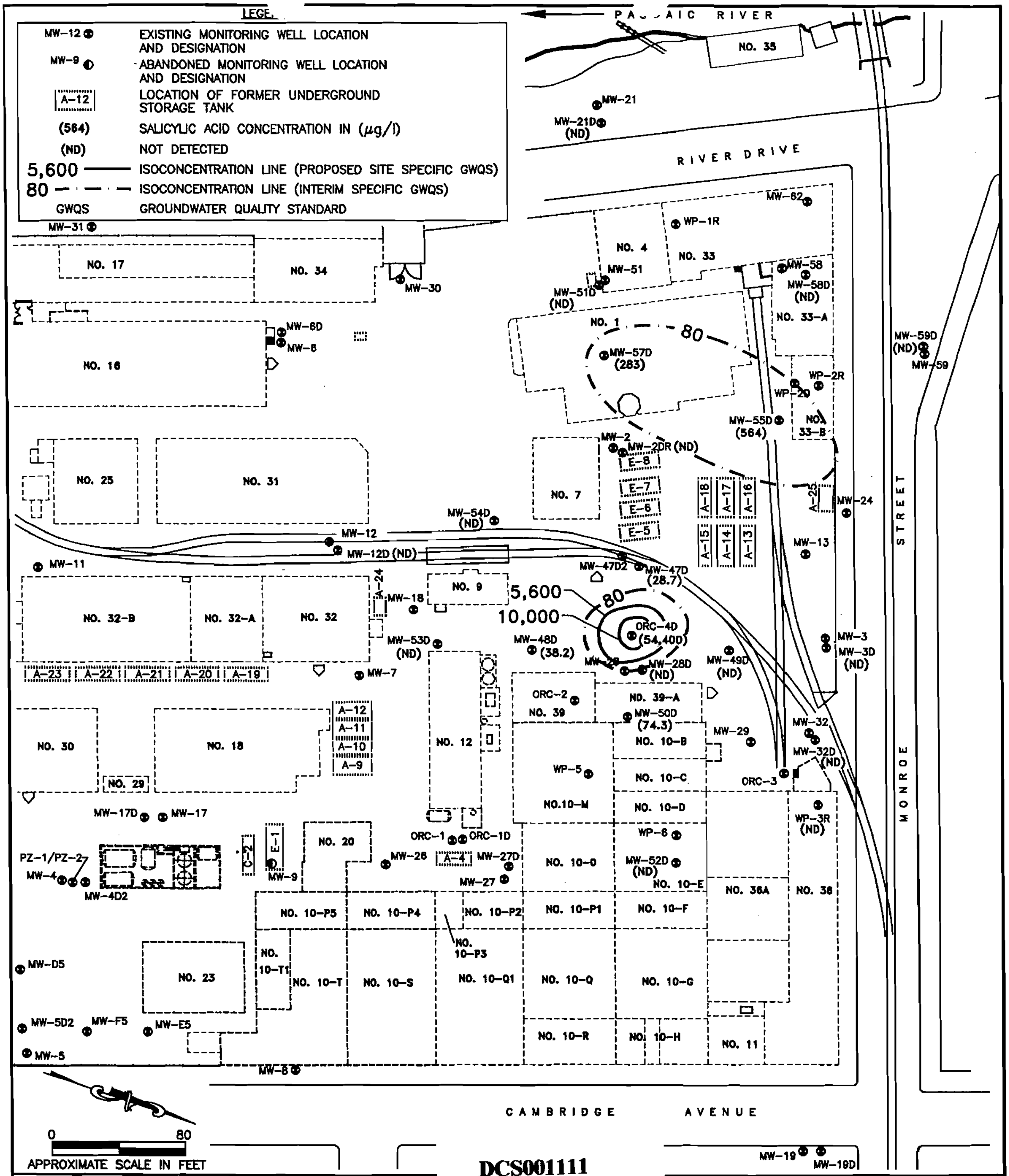

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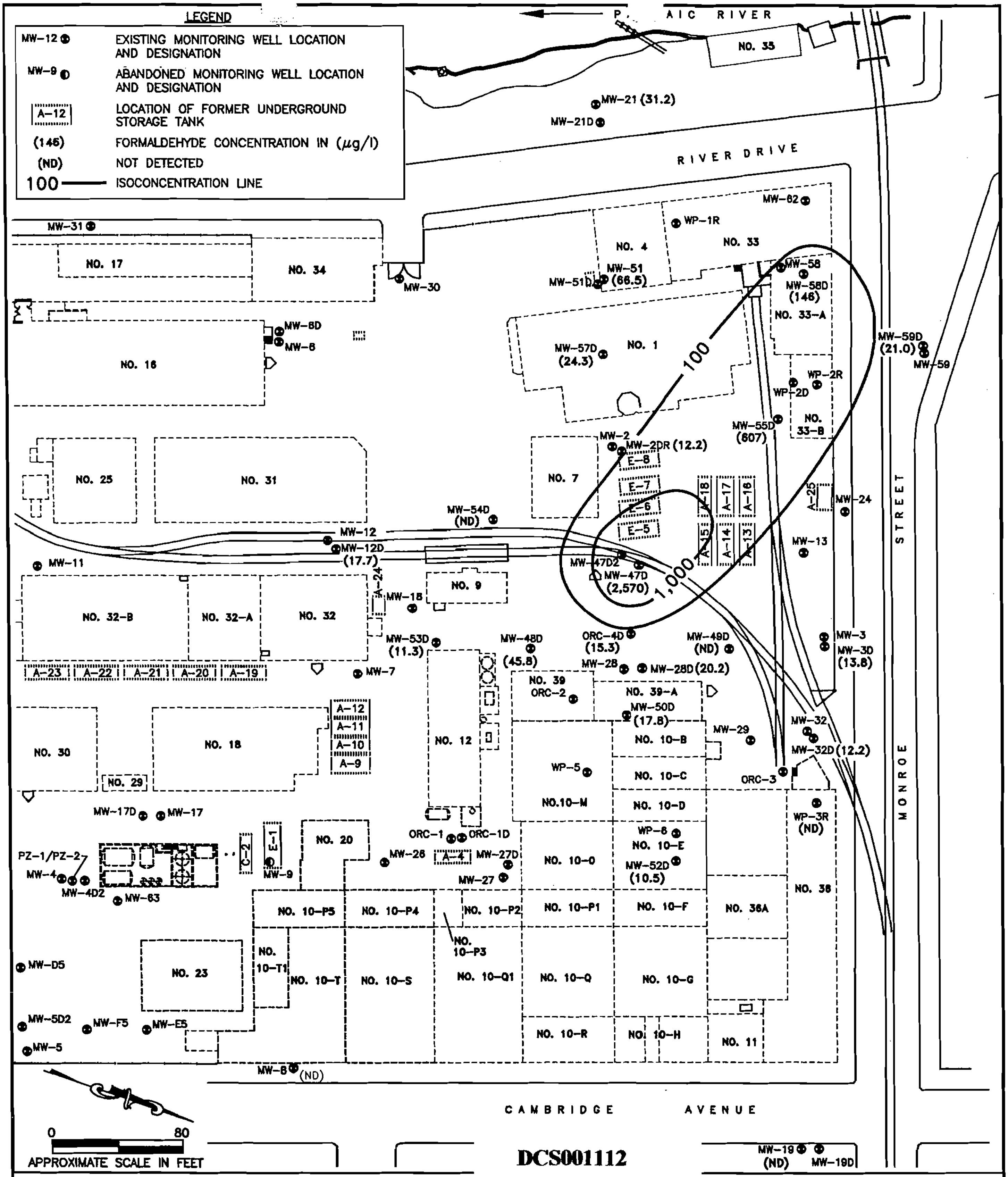
FIGURE 33
NORTHERN PHENOL AREA
DISTRIBUTION OF SALICYLIC ACID
IN GROUNDWATER
DEEP OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-33-JULY04.dwg Date: 12/2/04



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Project No. File: POINTMAP\KAL-35-JULY04.dwg Date: 12/10/04

FIGURE 34
NORTHERN PHENOL AREA
DISTRIBUTION OF FORMALDEHYDE
IN GROUNDWATER
DEEP OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

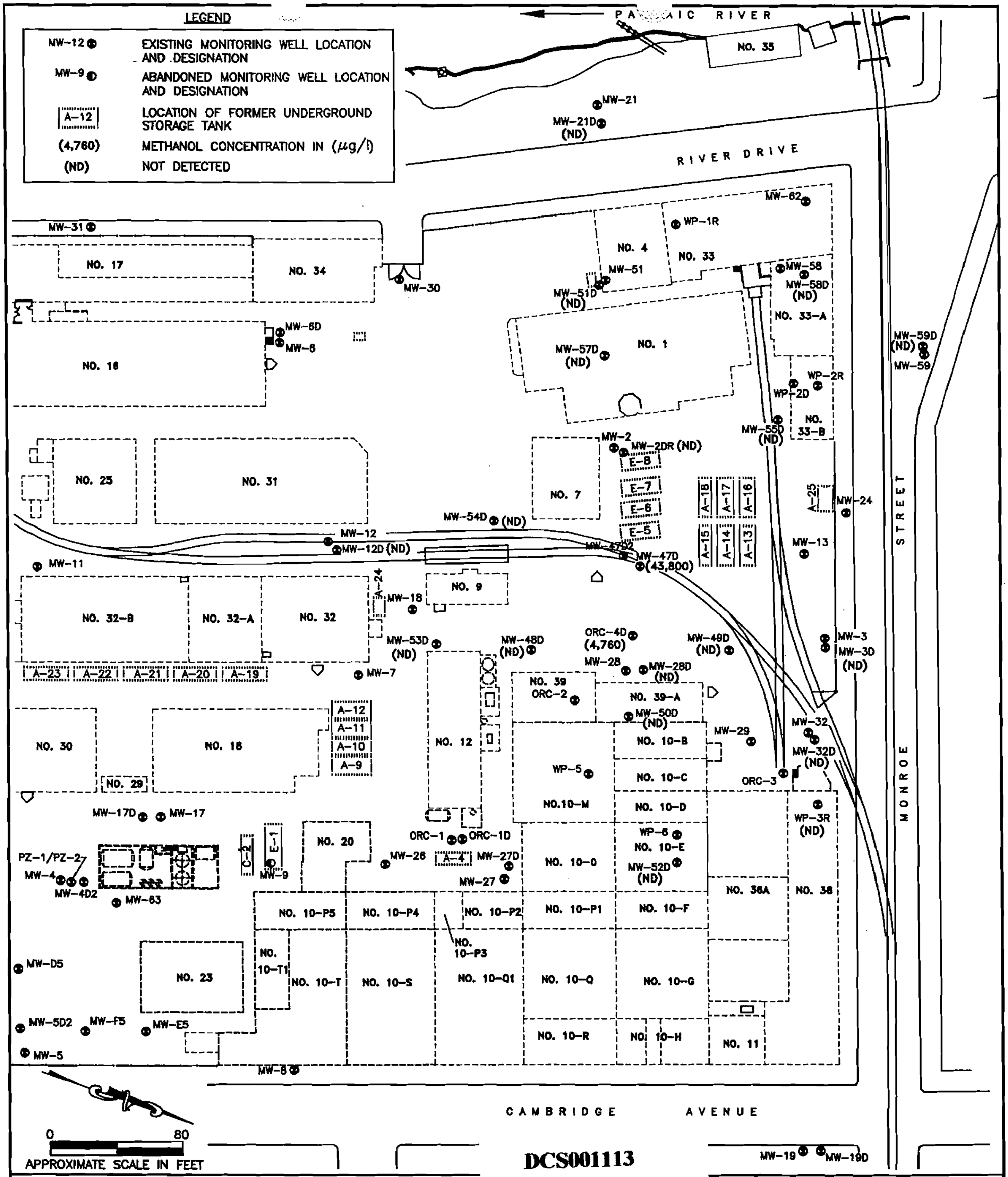

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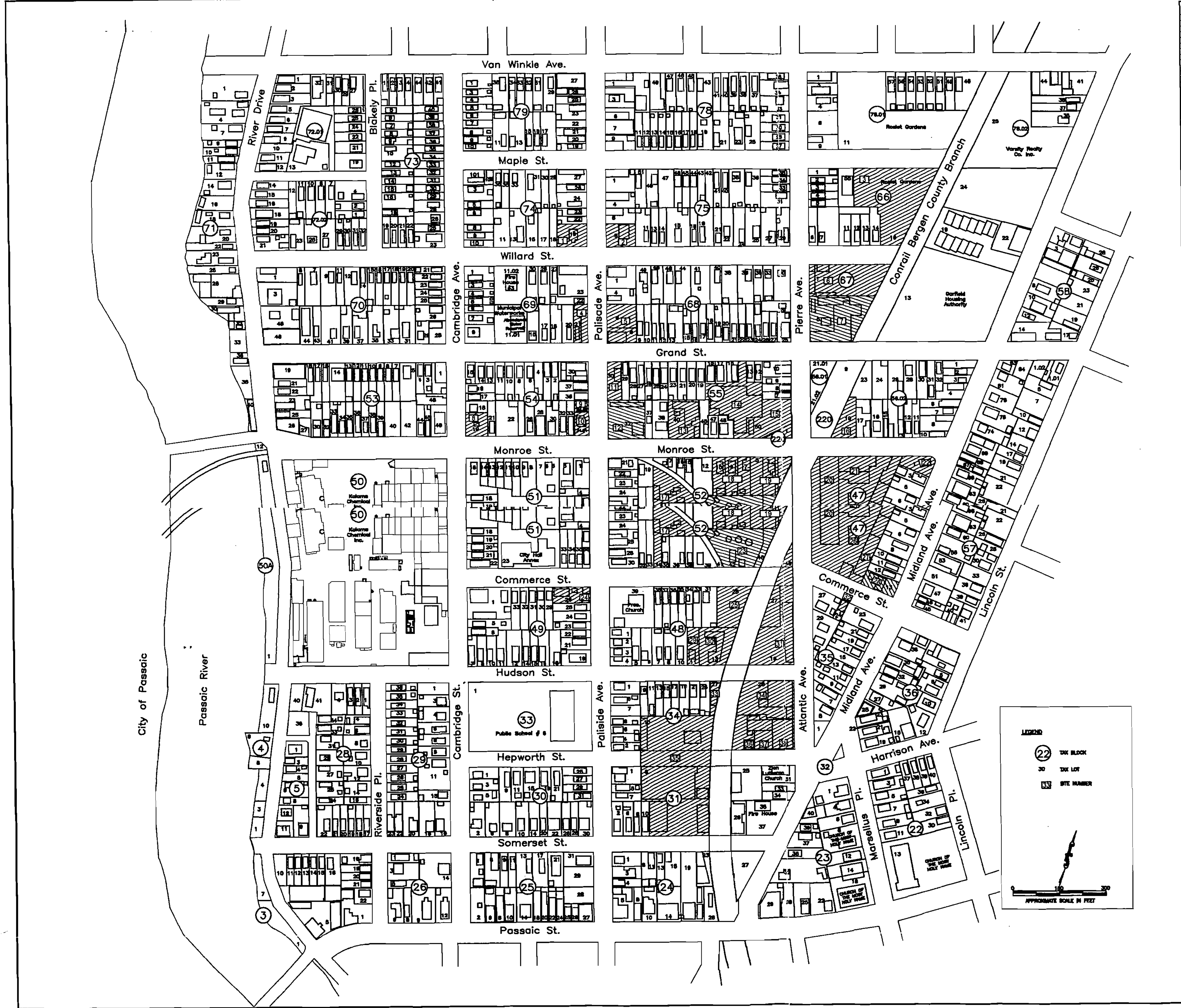
FIGURE 35
NORTHERN PHENOL AREA
DISTRIBUTION OF METHANOL IN GROUNDWATER
DEEP OVERBURDEN ZONE
JULY 2004

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-35-APRIL04.dwg Date: 12/3/04



Site #	Tax Block	Tax Lot	Current Operations	Historic Operations	Source of Data	Data Years
1	74	19	Joe's Service Station	Filling Station	Sanborn Fire Insurance Maps	1951, 1968
2	75	8	Betti's Auto, Truck Repair	Filling Station	Sanborn Fire Insurance Maps	1951, 1968
3	66	16	Roslet Gardens (Apartments)	The Jersey Brass Corpn.	Sanborn Fire Insurance Maps	1917
4	69	21	Palisade Cleaners	Drug Mfg.	Sanborn Fire Insurance Maps	1910
5	68	6,8	Commercial	Filling Station	Sanborn Fire Insurance Maps	1951
6	67	1	Gutter King, Wind-Tite Aluminum Prods	Bellet Coal Co.	Sanborn Fire Insurance Maps	1951, 1968
7	67	5	Frankies Express Movers	The Laurel Co. (mfg. of rubber goods)	Sanborn Fire Insurance Maps	1910, 1917, 1951, 1968
8	54	19	Chester's Auto Repair	Filling Station	Sanborn Fire Insurance Maps	1951, 1968
9	54	34.02	Commercial	Paint Store	Sanborn Fire Insurance Maps	1951
10	54	34.01	Unnamed Auto Repair Shop	Filling Station	Sanborn Fire Insurance Maps	1951, 1968
11	55	30	Palisades Hardware	Paint Store	Sanborn Fire Insurance Maps	1968
12	55	32	Multi-Family Residential	Bowling Alleys	Sanborn Fire Insurance Maps	1951, 1968
13	55	40	Longo's Cabinets, Mad Hatter Antiques, Acme Architectural Woodwork	Michael Shack Embroideries	Sanborn Fire Insurance Maps	1951, 1968
				Longo's Cabinets	City Directory	1987, 1992, 1997, 2002
				Acme Architecural Woodwork	City Directory	1992, 1997, 2002
				Mad Hatter Antiques	City Directory	2002
14	55	50	Scientific Electric Co.	Lacald Mfg.	Sanborn Fire Insurance Maps	1951
				Scientific Electric Co.	Sanborn Fire Insurance Maps	1968
15	55	50	Belmont Wholesale Fence Co.	Unspecified	Sanborn Fire Insurance Maps	1910, 1917, 1951, 1968
16	56.02	19	Auto Repair Shop	Sheet Metal Works	Sanborn Fire Insurance Maps	1968
17	52	34	Vinnie's Monroe Auto Repair	Unspecified	City Directory	2002
18	52	7,9,10	Bergen County Career Advancement Training Center	Druggists Specialties Warehouse	Sanborn Fire Insurance Maps	1968
19	52	1,3,5	Belmont Wholesale Fence Co.	Chain Link Fence Warehouse	Sanborn Fire Insurance Maps	1968
20	47	15	Quality Solid Surface Inc.	Instar Leather Co. (mfg imitation leather)	Sanborn Fire Insurance Maps	1910
				Fore Chemical Co	Sanborn Fire Insurance Maps	1917
				John Chattilon & Sons (metal works)	Sanborn Fire Insurance Maps	1951
				Stabilized Vitamins Inc.	Sanborn Fire Insurance Maps	1968
21	47	15	Amerchino Wholesale Candy	Instar Leather Co. (mfg imitation leather)	Sanborn Fire Insurance Maps	1910
				Fore Chemical Co	Sanborn Fire Insurance Maps	1917
				John Chattilon & Sons (metal works)	Sanborn Fire Insurance Maps	1951
				Stabilized Vitamins Inc.	Sanborn Fire Insurance Maps	1968
22	47	15	Mazzola Auto Repair	Filling Station	Sanborn Fire Insurance Maps	1951, 1968
23	52	42	Unnamed Storage Lot	H. E. Brunning Coal & Wood Yard	Sanborn Fire Insurance Maps	1910, 1917, 1951, 1968
24	49	26	Maitland Air & Electric (air conditioning repair services)	Maitland A/C	City Directory	1987, 1992, 1997, 2002
				Rybar Systems, Inc.	City Directory	1997, 2002
				Roller Mike	City Directory	2002
25	48	28	Zuccaro Bros. Excavating	Zuccaro & Sons	City Directory	2002
26	47	15	American Lighting Corp.	Instar Leather Co. (mfg imitation leather)	Sanborn Fire Insurance Maps	1910
				Fore Chemical Co.	Sanborn Fire Insurance Maps	1917
				John Chattilon & Sons (metal works)	Sanborn Fire Insurance Maps	1951
				Stabilized Vitamins Inc.	Sanborn Fire Insurance Maps	1968
27	47	15	Prodo Pak	Instar Leather Co. (mfg imitation leather)	Sanborn Fire Insurance Maps	1910
				Fore Chemical Co.	Sanborn Fire Insurance Maps	1917
				John Chattilon & Sons (metal works)	Sanborn Fire Insurance Maps	1951
				Stabilized Vitamins Inc.	Sanborn Fire Insurance Maps	1968
28	47	13	Lift Truck Technology Inc.	Filling Station	Sanborn Fire Insurance Maps	1951, 1968
				L & T Building Contractors Inc.	City Directory	1992, 1997, 2002
				Total Access Group	City Directory	2002
29	48	11	Staal's Fuel Oil (office, truck storage)	Unspecified	Sanborn Fire Insurance Maps	1910, 1917, 1951, 1968
30	48	13	Zuccaro Bros. Excavating	Hay & Feed Storage	Sanborn Fire Insurance Maps	1917, 1951
				Machine Shop, Paint Spraying, Baking on Metal	Sanborn Fire Insurance Maps	1968
31	48	16	East Coast Industries, Casing Tying Services of NJ	Gerritson & Stewart Lumber Co.	Sanborn Fire Insurance Maps	1910, 1917
				Chemical Stge & Blending	Sanborn Fire Insurance Maps	1951
				Metal Plating	Sanborn Fire Insurance Maps	1968
				East Coast Industries	City Directory	1997, 2002
				Casing Tying Services of NJ	City Directory	1997, 2002
32	35	24	Gryl Auto Haus (auto repair shop)	Gryl Auto Haus	City Directory	1997, 2002
				Tin Shop	Sanborn Fire Insurance Maps	1917
				Machine Shop	Sanborn Fire Insurance Maps	1968
33	34	27	American Sodas	Bottling Works	Sanborn Fire Insurance Maps	1951, 1968
34	34	41	Garofalo Brothers	Gerritson & Stewart Lumber Co.	Sanborn Fire Insurance Maps	1910, 1917
				Crate Storage	Sanborn Fire Insurance Maps	1951, 1968
				Garofalo Brothers	City Directory	1987, 1992, 1997, 2002
35	31,34	9,10	Royal Slide Sales Co., Inc.	East Jersey Match Co.	Sanborn Fire Insurance Maps	1910
				Standard Match Co.	Sanborn Fire Insurance Maps	1917
				Accurate Mfg. (mfg friction & rubber tape)	Sanborn Fire Insurance Maps	1951, 1968
				Kramer Coal Co. (northern portion)	Sanborn Fire Insurance Maps	1951
				Royal Slide Sales Co., Inc.	City Directory	2002
36	34	28	Garden State Architectural Glass	Gerritson & Stewart Lumber Co.	Sanborn Fire Insurance Maps	1910
				Garage	Sanborn Fire Insurance Maps	1917, 1951
				Chem Lab	Sanborn Fire Insurance Maps	1968
37	34	28	B & P Automotive (repair shop)	Gerritson & Stewart Lumber Co.	Sanborn Fire Insurance Maps	1910, 1917
				Cabinet Shop	Sanborn Fire Insurance Maps	1951, 1968
				B & P Automotive	City Directory	1997, 2002
38	34	28	Penta Glass Industries	Gerritson & Stewart Lumber Co.	Sanborn Fire Insurance Maps	1910, 1917
				Cabinet Shop	Sanborn Fire Insurance Maps	1951
				Machine Shop	Sanborn Fire Insurance Maps	1968
				Penta Glass Industries	City Directory	1992, 1997, 2002

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Project No.
File: Nov04/Fig36-properties.dwg
Date: 12/10/04

FIGURE 36
BACKGROUND PROPERTY SURVEY RESULTS

KALAMA CHEMIC
GARFIELD, NEW

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SOVEREIGN CONSULTING INC.

FEB 13 2004
NJ DEP
…zardous Site Mitigation Administration
…eau of Industrial
Evaluation
…028
Trenton, NJ

13 February 2004

Mr. Andrew Dillman
New Jersey Department of Environmental Protection
Bureau of Environmental Evaluation Cleanup & Responsibility Assessment
Division of Responsible Party Site Remediation
401 E. State Street, 5th Floor
P.O. Box 432
Trenton, New Jersey 08625-0432

RE: **Kalama Chemical Inc. Facility**
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

Hand Delivered

Dear Mr. Dillman:

Attached please find an original and two copies of the *Remedial Investigation Report and Remedial Action Work Plan for the Northern Phenol Area and Dowtherm DNAPL Areas* at the above referenced site. This report has been prepared by Sovereign Consulting Inc. (Sovereign) on behalf of EPEC Polymers Inc. (EPI). In addition, one copy of Attachments I through IV (10 volumes total) and three computer diskettes containing the required electronic data deliverables are also being provided.

If you should have any questions or require additional information, please feel free to contact me at (609) 259-8200 or Mr. Roger Towe of El Paso Corporation (EPC) at (713) 420-4755.

Sincerely,
Sovereign Consulting Inc.

Paul I. Lazaar
Principal Project Manager

c: Project File
R. Towe, EPC
B. Amig, Goodrich Corp.
R. Smith, Belkorp Industries

111-A N. Gold Drive • Robbinsville, NJ 08691 • Tel: 609-259-8200 • Fax: 609 259 8288

SOVEREIGN CONSULTING INC.

REMEDIAL INVESTIGATION REPORT AND REMEDIAL ACTION WORK PLAN FOR THE NORTHERN PHENOL AREA AND DOWTHERM DNAPL AREAS

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County New Jersey
ISRA Case No. 86B73

13 February 2004

Prepared for:

EPEC Polymers Inc.
1001 Louisiana Street
Houston, Texas 77002

Prepared by:

Sovereign Consulting Inc.
111-A North Gold Drive
Robbinsville, New Jersey 08691

Paul I. Lazaar, P.G.
Principal Project Manager

Ravi Gupta

Ravi Gupta
Principal Engir

EXECUTIVE SUMMARY

This report presents the *Remedial Investigation Report and Remedial Action Work Plan* (RIR/RAW) for the Northern Phenol Area and the Dowtherm dense non-aqueous phase liquids (DNAPLs) areas at the Kalama Chemical Inc. facility in Garfield, New Jersey. In June 1997, EPEC Polymers Inc. (EPI) began a groundwater monitoring program to determine if the concentrations of phenol, methanol, and formaldehyde in the shallow and deep overburden zones of the Northern Phenol Area were decreasing to below the applied groundwater quality standards. By July 2000, concentrations of the compounds of concern in the shallow overburden had decreased significantly and were at or below the applied groundwater quality criteria. However, the concentrations of phenol, salicylic acid, methanol, and formaldehyde in the deep overburden zone had not shown a similar decreasing trend. Therefore, an investigation was initiated to determine the source of these compounds in the deep overburden zone. This investigation was completed in October 2002 when the horizontal and vertical extent of the phenol and salicylic acid plumes in the deep overburden zone had been delineated.

In August 2001, the New Jersey Department of Environmental Protection (NJDEP) directed EPI to shut down the air sparge/soil vapor extraction (AS/SVE) system in the southeast corner of the site, pending submission and review of the performance data for the system. The performance data for the AS/SVE system was submitted to the NJDEP in May 2002. In their letter dated 30 July 2002, the NJDEP approved the performance data for the AS/SVE system, and allowed the AS component of the system to be re-started (the SVE component of the system had been re-started in November 2001 to take advantage of low water table conditions arising from an on-going drought). During preparations to re-start the AS system in August 2002, DNAPL was discovered in one of the air sparge wells (AS-12). The discovery of DNAPL in AS-12 (determined to be Dowtherm, a heat transfer fluid used at the facility when it was in operation) triggered a soil and groundwater investigation that was completed in August 2003.

In September 2002, the former process waste sewer line that ran parallel to Hudson Street along the southern property line was excavated to remediate soil containing elevated concentrations of 1,1'-biphenyl and diphenyl ether (the two compounds which comprise Dowtherm). When the excavation reached approximately 11.5 - 12.0 feet below grade adjacent to the southwest corner of Building 16, a dark fluid (later determined to be Dowtherm) entered the trench from beneath the building. It appears that this product came from a small section of pipe that connected a bathroom in Building 16 to the

Hudson Street sewer line. Although additional soil was excavated in the area where the Dowtherm entered the trench, elevated concentrations of 1,1'-biphenyl and diphenyl ether remained in the soil.

This RIR/RAW contains the results of the investigations conducted in the Northern Phenol Area, and the Dowtherm DNAPL areas around AS-12 and the southwest corner of Building 16. A review of available information and data for the Northern Phenol Area suggest that the extent of impact in the deep and shallow overburden zones are restricted to the site, but distributed over a wide area. Because of the extent and volume of impacted soil and groundwater in Northern Phenol Area, only the following *in situ* treatment technologies were considered in the remedial action selection:

- Air Sparging;
- Biosparging;
- Chemical Oxidation
- Pump and Treat; and,
- Containment

Biosparging has been selected to remediate the Northern Phenol Area. This technology will avoid costly pumping technologies and should prove to be very effective for the treatment of the large Northern Phenol Area. It should be noted that this technology has already been proven to be effective in remediating groundwater in the southwest corner of the site, where the air curtain has been in operation since 1998.

A review of available information and data for the Dowtherm DNAPL Areas suggests that the contamination is limited to discrete identified zones within the subsurface. Because the impacted soils are restricted to limited areas of the Dowtherm DNAPL Areas and residual and free product are anticipated, soil removal was considered in addition to other *in situ* treatment technologies in the remedial action selection. The following remedial action alternatives were evaluated for the Dowtherm DNAPL Areas:

- Air Sparging/Soil Vapor Extraction (AS/SVE);
- Biosparging;
- Chemical Oxidation;
- Pump and Treat;
- Containment; and,
- Soil Excavation & Off Site Disposal

Soil excavation and off-site disposal was the technology selected for the remediation of the Dowtherm DNAPL Areas. Soil excavation will serve to remove residual or free product that could potentially be a continued localized source of groundwater contamination, and would provide the optimum probability for attaining the required remediation objectives. Excavation of the residual and/or free product source soils would also meet site objectives for public health, safety, and the environment in the shortest time frame.

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Tables

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Appendices

Attachments (under separate cover)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this *Remedial Investigation Report and Remedial Action Work Plan* (RIR/RAW) for the Northern Phenol Area and the Dowtherm dense non-aqueous phase liquids (DNAPLs) areas at the Kalama Chemical Inc. facility in Garfield, New Jersey.

The groundwater monitoring program proposed in the 31 March 1995 *Revised Remedial Action Work Plan* (Revised RAW) called for three years of quarterly sampling from wells in the Northern Phenol Area to determine if the concentrations of phenol, methanol, and formaldehyde were decreasing to below the applied groundwater quality standards. EPI implemented the groundwater monitoring program proposed in the Revised RAW in June 1997. By July 2000, concentrations of the compounds of concern in the shallow overburden had decreased significantly and were at or below the applied groundwater quality criteria. However, the concentrations of phenol, salicylic acid, methanol, and formaldehyde in the deep overburden zone had not shown a similar decreasing trend. Therefore, EPI initiated an investigation to determine the source of these compounds in the deep overburden zone. This investigation was completed in October 2002 when the horizontal and vertical extent of the phenol and salicylic acid plumes in the deep overburden zone had been delineated.

In August 2001, the New Jersey Department of Environmental Protection (NJDEP) directed EPI to shut down the air sparge/soil vapor extraction (AS/SVE) system in the southeast corner of the site, pending submission and review of the performance data for the system. In November 2001, the NJDEP approved EPI's request to re-start the SVE component of this system to take advantage of the low water table conditions that existed due to the drought that was experienced in New Jersey at that time. The performance data for the AS/SVE system was submitted to the NJDEP in the 1 May 2002 *Remedial Investigation Report Addendum No. 2*. In their letter dated 30 July 2002, the NJDEP approved the performance data for the AS/SVE system, and allowed the AS component of the system to be re-started. During preparations to re-start the AS system in August 2002, DNAPL was discovered in one of the air sparge wells (AS-12). The discovery of DNAPL in AS-12 (determined to be Dowtherm, a heat transfer fluid used at the facility when it was in operation) triggered a soil and groundwater investigation that was completed in August 2003.

In September 2002, the former process waste sewer line that ran parallel to Hudson Street along the southern property line was excavated to remediate soil containing elevated concentrations of 1,1'-biphenyl and diphenyl ether (the two compounds which comprise Dowtherm). When the excavation reached approximately 11.5 - 12.0 feet below grade adjacent to the southwest corner of Building 16, a dark fluid (later determined to be Dowtherm) entered the trench from beneath the building. It appears that this product came from a small section of pipe that connected a bathroom in Building 16 to the Hudson Street sewer line. Although additional soil was excavated in the area where the Dowtherm entered the trench, elevated concentrations of 1,1'-biphenyl and diphenyl ether remained in the soil. The area near the southwest corner of Building 16 was designated area of environmental concern 36 in the 26 February 2003 *Remedial Investigations and Remedial Actions Report - Building 17 and Former Sewer Lines*. Subsequent soil sampling has sufficiently delineated the vertical and horizontal extent of the 1,1'-biphenyl and diphenyl ether to allow a remediation program for this area of the site to be developed.

This RIR/RAW contains the results of the investigations conducted in the Northern Phenol Area, and the Dowtherm DNAPL areas around AS-12 and the southwest corner of Building 16. EPI's proposed remedial actions for each of these areas of the site are also presented in this report.

A third area of potential DNAPL exists in the northwest corner of the site where methyl salicylate (i.e., synthetic oil of wintergreen) was formerly manufactured and stored. This area, located near the southeast corner of former Building 4, has previously been designated Area of Environmental Concern (AEC) No. 30. This AEC is not addressed by this report, since the vertical and horizontal delineation of the methyl salicylate in soil has not been completed. Once the conditions of AEC-30 have been adequately characterized, EPI will prepare a separate Remedial Investigation Report and Remedial Action Work Plan.

1.1 Site Location

The Kalama Chemical Inc. site is located at 290 River Drive in Garfield, Bergen County, New Jersey (Figure 1). The site consists of two properties, one measuring 6.4 acres (the manufacturing facility) and one measuring 0.5 acres (an employee parking area). As shown on Figure 2, the two properties are divided by River Drive, which runs roughly north-south along the Passaic River. The site is bordered to the north, south, and east by mixed residential, commercial, and industrial properties. The Passaic River forms the western property line.

1.2 Site History

The first buildings at the site were constructed in 1891 and chemical manufacturing has been performed since that time. Over the years, the ownership of the property changed hands several times. In 1963, the Heyden Newport Chemical Corporation was purchased by Tenneco Chemicals, Inc., who continued to operate the facility until 1982, when they sold the property to Kalama Chemical Inc. In 1986, the purchase of Kalama Chemical by BC Sugar triggered the NJDEP's Environmental Cleanup Responsibility Act (ECRA). In 1990, following four years of investigative activities, Kalama filed a lawsuit against Tenneco Polymers Inc. (TPI). In April 1994, Kalama and TPI settled the lawsuit, and TPI assumed primary responsibility for compliance with the NJDEP's Industrial Site Recovery Act (ISRA) regulations in accordance with the revised Administrative Consent Order. In January 1997, Tenneco Inc. merged with El Paso Energy Corporation (EPEC), and the former Tenneco subsidiaries became subsidiaries of EPEC. In January 2001, EPEC merged with the Coastal Corporation, and the Company was renamed El Paso Corporation (EPC). As a result of these mergers, Tenneco Polymers Inc. is now known as EPEC Polymers Inc.

The chemicals produced at the site were used in pharmaceuticals, cosmetics, food packaging and preservatives, synthetic flavorings, printing inks, dyestuffs, and other products. The following are the primary chemicals either used or produced at the site:

Primary Chemicals	Period Used/Produced
Salicylic acid Sodium, potassium, and methyl salicylate	Produced from turn of the century to 1994.
Parasepts (esters of para-hydroxy benzoic acid) Methylene disalicylic acid	Produced from the 1940s to 1994.
Formaldehyde	Produced from the 1930s to 1982.
Pentaerythritol (a glycerine substitute)	Produced from early 1940s to 1962.

Primary Chemicals	Period Used/Produced
Benzoic acid Benzaldehyde Sodium Benzoate	Produced from 1961 to February 1984.
Toluene	Used in benzoic acid/benzaldehyde production from 1961 to 1984.
Benzene	Used in Resorcinol production from early 1940s to 1950s. Also generated as a waste by-product of benzoic acid/benzaldehyde production from 1961 to 1984.
Phenol	Used in the production of salicylic acid from the turn of the century to 1994.
Methanol	Used in the production of methyl salicylate and formaldehyde from the turn of the century to 1994.

Manufacturing operations were conducted in approximately half of the buildings at the site. Several buildings have been subdivided into separately numbered structures such as Building 10-P1 through 10-P4. When the facility was in operation, the other buildings were either vacant, idle, or used for storage, machine shops, or offices. Between May 1994 and August 1994, most manufacturing equipment and all production related chemicals were removed from the site. Almost all of the buildings have been demolished over the years, and currently only five of the original buildings remain (Nos. 16, 18, 29, 30, and 34). The locations of these buildings are shown on Figure 2.

1.3 Topography and Drainage

The topography of the Kalama site is relatively flat with a maximum elevation above sea level of approximately 18.0 feet. The grade at the site dips slightly to the west, towards River Drive and the Passaic River. Approximately 50% of the site is covered by buildings and an additional 25% is covered by asphalt or concrete. Storm water run-off drains to either the on-site or River Drive storm sewer systems.

The Passaic River, the main surface water body in the area, is located approximately 100 feet to the west of the manufacturing facilities. The section of the Passaic River adjacent to the site is tidal, with an amplitude of 4.0 to 5.0 feet. Based on a review of "Surface water classifications for the waters of the State of New Jersey" (N.J.A.C. 7:9B-1.15), it has been determined that the portion of the Passaic river adjacent to the site has been classified as "FW2-NT/SE2"[1]. This classification applies to the section of the Passaic River between Dundee Lake Dam (located 1.3 miles upstream from the site) to the confluence with the Second River (located 7.0 miles downstream from the site).

1.4 Regional Geology & Hydrogeology

The Kalama site is located within the Piedmont Physiographic Province. Bedrock within this province consists of sedimentary and igneous formations of the Triassic and Jurassic Periods. In most areas of the Province, the bedrock is overlain by unconsolidated glacial and fluvial deposits of the Pleistocene and Recent Epochs. The bedrock underlying the site belongs to the sedimentary Brunswick Formation, which is composed primarily of reddish brown sandstone and shale beds that strike to the northeast and dip 10° to 15° to the northwest. The top of the Brunswick Formation is usually weathered and consists of rock fragments embedded in a matrix of clay, silt, and sand derived from the bedrock.

Groundwater is present as both overburden and bedrock aquifers. The overburden aquifer generally flows to local and regional recharge points, such as the Passaic River. Groundwater in the bedrock aquifer occurs in fractures, such as partings between bedding planes, and also flows towards local or regional discharge points. The bedrock aquifer is used as a source for domestic water supplies, but not within a 1.5-mile radius of the site (see Section 2.5, below).

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[1] FW2-NT/SE2 indicates fresh water that is not used for trout production or maintenance but which may have a salt water/fresh water interface. The demarcation line between fresh water (FW2) and saline water (SE2) is defined by a salinity greater than 3.5 parts per thousand (ppt) at mean high tide. Based on dissolved chloride data collected at the Lodi gauging station at the Outwater Lane Bridge (4,500 feet upstream from the site), the salinity of this section of the Passaic River is significantly below 1.0 ppt (Bauersfield *et al.*, 1993).

1.5 Site Geology

Soil borings have been advanced through both the unconsolidated material and bedrock beneath the Kalama site. The following sections summarize the lithologies encountered.

1.5.1 Overburden

The overburden materials consist of a complex sequence of fill and natural deposits. Fill material is present from immediately below ground surface to a depth of approximately 3.0 to 8.0 feet below grade. The fill typically consists of a mixture of sand, gravel, silt, clay, crushed stone, and brick and sandstone fragments. Where man-made materials are not encountered, it is difficult to differentiate between the fill material and the natural deposits. The fill is underlain by natural deposits consisting of sand, with varying amounts of silt, and silt and clay layers. A significant clay layer exists under the northeast portion of the site, primarily under the Building 10/36/39 complex. This clay layer pinches out to the west and south and is not contiguous across the site.

Glacial till was encountered immediately above the bedrock in most areas of the site. The depth to the top of the till varies from approximately 30 to 40 feet on-site to approximately 32 to 66 feet off-site. The till has been characterized as a heterogeneous mixture of clay, silt, sand, and gravel. Based on the four monitoring wells which were advanced into bedrock (MW-4D2, MW-5D2, MW-20D2, and MW-35D2), the thickness of the till ranges from 6.0 to 27.0 feet.

1.5.2 Bedrock

The bedrock in the area has been characterized as a reddish brown siltstone of the Brunswick Formation. The top of competent bedrock on-site was encountered at approximately 44 feet below grade. In the two bedrock wells drilled off-site (MW-20D2 and MW-35D2), the top of competent bedrock was encountered between 54 and 75 feet below grade. The greater depth to bedrock in the off-site wells can be attributed to the higher ground surface elevations at these locations (approximately 14.0 feet higher relative to the on-site wells).

1.6 Site Hydrogeology

The hydraulic conductivity of the overburden material at the site was determined based on the results of aquifer pumping and slug test data, soil sieve analyses, and the inspection of approximately 450 split-spoon soil samples. The slug test results indicated that the hydraulic conductivity (K) of the unconsolidated material ranged from 0.3 to 13.0 feet per day (ft/day), with an average value of 3.0 ft/day. This average K value is typical of a silty-fine sand, which is consistent with the findings of the sieve analyses and split spoon samples. Lower K values would be expected in the areas with greater amounts of silt and clay, while higher K values would be found in areas with more coarse sand. The pump test conducted on MW-10 in 1991/1992 indicated that the shallow overburden aquifer has the following hydraulic characteristics:

Transmissivity	3,500 gallons per day per foot (gpd/ft)
Storativity	0.001
Hydraulic Conductivity	13 ft/day (based on a saturated thickness of 35 feet)

These results were based on an analysis of calculated recovery versus distance plots, residual drawdown plots, time versus drawdown plots, and calculated recovery versus time plots.

Rising and falling head slug tests conducted by G&M in 1991 indicated average hydraulic conductivities of 0.52 ft/day (MW-3D) and 0.33 ft/day (MW-6D) in the deep overburden zone. Although G&M conducted a pump test on MW-3D in 1991, the results were considered inconclusive due to insufficient data being collected during the test.

In April 2002, EPI conducted a "diving plume" evaluation in accordance with the conditions of the NJDEP's letter dated 15 October 2001. The results of this evaluation were included in Section 6.0 of the RAPR dated 4 September 2002. For the following overburden monitoring wells, the groundwater elevations in the deep wells were lower than in the shallow wells (i.e., exhibited a downward gradient): MW-2/2DR, MW-3/3D, MW-6/6D, MW-27/27D, MW-28/28D, and MW-32/32D. With the exception of MW-6/6D, all of these wells are located in the northern portion of the site, and are influenced by the clay layer that separates the shallow and deep overburden zones and produces the northern water table mound. The elevation differences between the shallow and deep overburden wells observed during the April

2002 gauging event are consistent with the data from historical gauging events. Although a downward gradient exists between MW-6 and MW-6D, historical gauging data from these wells indicate that this condition can change to an upward gradient. These changes in vertical gradient may be related to the fact that MW-6 has been shown to be tidally influenced by the Passaic River.

Groundwater elevations in the deep wells were higher than in the shallow wells for the following overburden monitoring wells (i.e., exhibited an upward gradient): MW-5/5D, MW-16/16D, MW-35/35D, MW-37/37D. MW-16/16D and MW-35/35D are located to the east (upgradient) of the toluene spill area in the southeast corner of the site, while MW-5/5D are located within the spill area. MW-37/37D are located to the south of the site and represent the most downgradient monitoring points. These results are consistent with the historical gauging data for each well pair.

Groundwater elevations in the bedrock wells were higher than the corresponding overburden wells at locations MW-5D/5D2 and MW-20/20D2, which is consistent with the historic gauging events. However, a downward gradient was observed between MW-35D and MW-35D2, which is inconsistent with historical data. MW-5D/5D2 are located in the southeast corner of the site, while MW-20D/20D2 and MW-35/35D2 are located off-site to the east of the property.

With the exception of the northeastern corner of the site, the vertical gradient between shallow and deep zone overburden wells is upward. This observed upward gradient is expected given the proximity of the site to the Passaic River, a gaining surface water body (i.e., overburden groundwater discharges to the river).

Groundwater flow is towards the Passaic River (to the west-southwest) in both the shallow and deep overburden zones. A groundwater mound is present in the northeast corner of the site due to the presence of a clay layer separating the shallow and deep overburden zones. A smaller mound is also typically present around MW-4 in the southeast corner of the site due to a isolated lens of silty clay. See Section 5.0 of this report for a discussion of recent well gauging data.

Tidal fluctuations in the Passaic River can result in groundwater elevation changes of up to 0.6 feet in the upper portion of the unconsolidated water bearing zone. This influence was measured in MW-6, which is located on the west side of the facility, approximately 170 feet from the river. These fluctuations in groundwater elevations indicate that the Passaic River and the upper portion of the unconsolidated water bearing zone are hydraulically connected. However, the amplitude of these tidal fluctuations is not great enough to affect the direction of groundwater flow (to the west-southwest).

1.7 Local Water Usage

An extensive survey of local water usage was conducted by Kalama in 1992. A total of 1,902 properties were identified within a 0.5-mile radius of the Kalama site. Between reviewing the billing records provided by the City of Garfield Water Company and interviewing property owners, it was concluded that no private wells are being used to provide potable water. The results of this survey were submitted to the NJDEP in the July 1992 SPAN-2 Investigation Report and the December 1993 ECRA Investigation Report.

As per Item 7 on page 20 of the NJDEP's letter dated 15 October 2001, EPI conducted a new well search to update the original one performed by G&M. The goal of the well search was to identify any industrial, public, or domestic supply wells within a one-half mile radius of the site, whose operation may have contributed to the water table fluctuations noted during the 1998 pump tests. In addition, the NJDEP requested that specific information be obtained on the following wells identified in the 1992-1993 well search:

1. A public supply well (NJDEP Permit No. 26-5331) located southeast of the site on Hobart Street in the City of Garfield (original map ID No. 17);
2. A public supply well (NJDEP Permit No. 26-4010) located north of the site on Grand Street in the City of Garfield (original map ID No. 19);
3. A product recovery well (NJDEP Permit No. 26-5149) located north of the Site near Grand Street and Cambridge Avenue in the City of Garfield (original map ID No. 18);
4. An industrial supply well owned by Tender Brand Frozen Foods (NJDEP Permit No. 26-205) located south of the site at 176 Saddle River Avenue in South Hackensack (original map ID No. 24); and,
5. A private well owned by Most Holy Name Church (NJDEP Permit No. 26-3410) located southeast of the site at 99 Marsellins Place in the City of Garfield (original map ID No. 16).

In April 2002, Sovereign obtained the results of a five mile computer data base well search and a one-half mile manual well search for industrial, public, and domestic supply wells from the NJDEP's - Bureau of Water Allocations. As was discussed in Section 8.0 of the *Remedial Action Progress Report* (RAPR) dated 12 June 2003, no new supply wells were identified by the April 2002 well search, and none of the wells listed above were still in use. Based on the results of the original 1992-1993 well search, and the results of the April 2002 well search, there do not appear to be any active industrial, public, or domestic supply wells within a one-half mile radius of the site.

Item III.3 of the NJDEP's 23 October 2003 letter indicated that the results of the April 2002 well search were acceptable.

2.0 NORTHERN PHENOL AREA INVESTIGATION

Based on the results from the quarterly groundwater monitoring program, elevated concentrations of phenol, salicylic acid, and methanol exist in deep overburden well ORC-4D, located near the former Building 10/36 complex (i.e., the Northeast Phenol Hotspot area - see Figure 3). The following Sections summarize the findings of the soil and groundwater investigations conducted in the area of monitoring well ORC-4D between 1999 and 2001.

2.1 ORC Pilot Test

Between May 1996 and November 1996, EPI conducted a pilot test to study the effectiveness of Oxygen Release Compound (ORC) in enhancing the natural biodegradation of phenol, methanol, and formaldehyde which are present in groundwater beneath the Building 10/36 complex in the northeast portion of the site. ORC is a proprietary formulation of magnesium peroxide (MgO_2) which also includes magnesium oxide (magnesia, MgO) and a few percent of food grade potassium phosphate (KH_2PO_4 or K_2HPO_4); the phosphates are the same materials which are commonly used to support microbial growth for bioremediation. The ORC is designed to release oxygen upon contact with water as follows:

$$MgO_2 + H_2O \rightarrow \tfrac{1}{2}O_2 \uparrow + Mg(OH)_2$$

After comparing the apparent degradation rates for the three source area wells that contained the highest concentrations of phenol at the time of the test (i.e., WP-3, WP-5, and WP-6), EPI determined that the use of ORC did not result in a significant increase in the rate of reduction of dissolved concentrations. Although there appeared to be a slight increase in the degradation rates, it was determined that the time to reach the remediation goals would only be shorted by days rather than by a year or more. Therefore, EPI did not believe the slight benefits warranted the expense of a full-scale application of ORC.

A full discussion of the ORC pilot test conducted in the area of the Building 10/36 complex is included in Appendix A of this report.

2.2 Initial Interim Remedial Measures

The April 1999 groundwater sample from ORC-4D contained 40,000 parts per billion (ppb) of phenol, 137,000 ppb of salicylic acid, and no detectable concentrations of methanol or formaldehyde. Due to the phenol and salicylic acid concentrations, a one day pump out of this well was conducted using a vacuum truck on 9 June 1999. A total of 250 gallons of water were extracted from ORC-4D (equivalent to approximately 80 well volumes).

After the vacuum truck was disconnected from the well, a groundwater sample was collected from ORC-4D and analyzed for phenol and salicylic acid. The analytical results indicated that the concentration of phenol had decreased to 30,600 ppb, and the concentration of salicylic acid had decreased to 44,000 ppb. However, the July 1999 groundwater sample from ORC-4D contained 103,000 ppb of phenol, 564,000 ppb of salicylic acid, and 50,000 ppb of methanol.

The significant increase in phenol, salicylic acid, and methanol observed in ORC-4D was most likely caused by the vac-out in June 1999. In order to address the pocket of contaminated groundwater in this area, an extended pump-out from ORC-4D was conducted using a submersible pump rather than a vacuum truck. Between 10 November 1999 and 3 December 1999, groundwater was recovered from ORC-4D using a 2.0-inch diameter pneumatic-driven, bottom-loading submersible pump. The recovered groundwater was pumped into a 6,500 gallon portable tank located adjacent to the well. Due to the low flow rates obtained (0.09 gallons per minute [gpm] or 133 gallons per day), only 2,915 gallons of water were recovered over the course of the pump-out.

In order to evaluate changes in phenol, salicylic acid, and methanol concentrations over the course of the pump-out, groundwater samples were collected from the discharge tubing at the start of the pump-out, and then on day one, day four, day seven, day eight, and day 22 (immediately before the pump was shut down). Phenol, salicylic acid, and methanol were detected in all six samples at concentrations exceeding their respective groundwater quality standards. At the start of pumping, ORC-4D contained 10,400 ppb of phenol, 65,400 ppb of salicylic acid, and 14,200 ppb of methanol. After one day of pumping, the concentration of phenol had increased to 34,300 ppb, salicylic acid had increased to 116,000 ppb, and methanol had increased to 44,000 ppb. Over the next 21 days, the concentrations of salicylic acid and methanol decreased with each sample. Phenol concentrations increased slightly to 36,200 ppb on day four, but then decreased and stabilized at 11,900 ppb through the rest of the pump-out.

In January 2000, ORC-4D was sampled as part of the routine quarterly monitoring program. The methanol concentration in ORC-4D (3,600 ppb) continued the decreasing trend observed during the pump-out. However, the concentrations of phenol (31,000 ppb) and salicylic acid (69,800 ppb) in ORC-4D increased relative to the last day of the pump-out. As of the April 2000 groundwater sampling event, ORC-4D contained 69,900 ppb of phenol, 276,000 ppb of salicylic acid, and 3,980 ppb of methanol.

The fact that the concentrations of phenol, salicylic acid, and methanol had not decreased with time (unlike in the wells screened within the shallow overburden zone) suggested that a residual source of these compounds may be present within the deep overburden zone. However, before a remediation strategy could be developed, additional information was needed on the lithology of the area, as well as on the extent of the phenol, salicylic acid, and methanol affected area.

The initial investigation of the area around ORC-4D involved installing five soil borings and four monitoring wells, collecting 27 soil samples, and collecting two rounds of groundwater samples. In addition, a bench scale treatability study was performed using groundwater from ORC-4D. The details of each component of this investigation are discussed in the following sections.

2.3 Soil Boring and Well Installations

The installation of monitoring wells and the collection of soil samples from the Northern Phenol Area was conducted in four phases between July 2000 and October 2002. The work conducted during each of these phases is discussed in the following Sections.

2.3.1 Phase I - July 2000

Previous work in the area of the former Building 10/36 complex has determined that the shallow and deep overburden zones are separated by a clay layer that, in the vicinity of ORC-4D, is approximately

10.0 feet thick. A total of five soil borings and four monitoring wells were installed around ORC-4D to further define the thickness and areal extent of the clay layer, as well as to delineate the compounds of concern dissolved in groundwater. The locations of the soil borings and monitoring wells are shown on Figure 3.

Each soil boring (ORC4DSB-1 through ORC4DSB-5) was advanced to the top of the glacial till (33.0 to 36.0 feet below grade) using a hollow stem auger drill rig operated by Summit Drilling Co., Inc. under the supervision of a Sovereign geologist. Continuous split spoon soil samples were collected from each boring for lithologic characterization and to accurately define the top and bottom of the clay layer. At the completion of sampling, each boring was sealed with a cement/bentonite grout to grade.

The locations of monitoring wells MW-47D through MW-50D are also shown on Figure 3. The borehole for each well was also advanced to the top of the glacial till with split spoon samples collected for lithologic characterization. Each borehole was then sealed with grout to approximately 34.0 feet below grade. After placing approximately 1.0 foot of sand on top of the grout, a monitoring well was installed in the borehole. Each well is approximately 33.0 feet deep (the same as ORC-4D) and is constructed with 10 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 23.0 feet of PVC casing. Well construction details are shown on the boring logs for each well in Appendix B.

2.3.2 Phase II - November 2000

Based on the findings of the initial investigation around ORC-4D, monitoring wells MW-52D, MW-53D, MW-54D, and MW-55D were installed in November 2000 to complete the delineation of the phenol, salicylic acid, and methanol present in the deep overburden zone. The locations of these wells are shown on Figure 3. Monitoring well MW-52D was installed 16.0 feet to the north of well point WP-6 for the purposes of defining the up-gradient extent of the compounds of concern detected in MW-50D. In order to define the southern extent of the area, monitoring well MW-53D was installed approximately 50.0 feet south of MW-48D. MW-54D was installed between MW-2DR and MW-12D to close the data gap to the south-southwest of MW-47D. MW-55D was installed to the northwest of MW-47D to close the data gap between MW-2DR and the northern property line.

The borehole for each new well was advanced to the top of the glacial till (or 40 feet, whichever was encountered first), and continuous split spoon soil samples were collected for lithologic characterization. The borehole was then sealed with grout to approximately 34.0 feet below grade. After placing approximately 1.0 foot of sand on top of the grout, a monitoring well was installed in the borehole. Each well is approximately 33.0 feet deep and is constructed with 10.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 23.0 feet of PVC casing (similar to the construction of ORC-4D and MW-47D through MW-50D). Well construction details are shown on the boring logs for each well in Appendix B.

A total of three soil samples were collected during the installation of MW-52D for phenol, salicylic acid, and methanol analyses. The soil samples were collected from above, within, and below the clay layer that separates the shallow and deep overburden zones. The goal of the soil sampling at this location was to see if there was any source material in the soil beneath the former Building 10/36 complex. Soil samples for phenol and methanol analyses were also collected from the within the clay layer during the installation of MW-53D, MW-54D, and MW-55D.

2.3.3 Phase III - April 2002

In their letter dated 6 August 2001, the NJDEP required that a work plan be submitted for completing the horizontal and vertical delineation of the phenol, salicylic acid, methanol, and/or formaldehyde that are present in groundwater in the Northeast Phenol and Northwest Phenol Hot Spot areas of the site. Due to their proximity to each other, one work plan was developed for investigating both areas concurrently. The following scope of work was submitted to the NJDEP on 27 September 2001. Draft comments approving the scope of work were received from the NJDEP on 13 November 2001; final comments were included in the NJDEP's letter dated 18 July 2002.

Monitoring wells MW-47D2, MW-57D, MW-58, MW-58D, MW-59, MW-59D, and WP-2D were installed at the site between 8 and 17 April 2002. Monitoring wells MW-47D2 and WP-2D were installed to vertically delineate the compounds of concern present in MW-47D and WP-2R, respectively. Monitoring well MW-57D was installed approximately 60 feet to the west of MW-2DR to horizontally delineate the compounds of concern present in this well and in MW-55D. MW-58 and MW-58D were installed approximately 60 feet to the west of WP-2R to horizontally delineate both the shallow (for WP-

2R) and deep (for MW-55D) overburden zones. In order to complete the horizontal delineation of the compounds of concern present in WP-2R and MW-55D, MW-59 and MW-59D were installed on the north side of Monroe Street (approximately 70 feet away from WP-2R). The locations of the new and existing monitoring wells in the northwest corner of the site are shown on Figure 3. The construction details for each well are shown on the following Table.

Well ID	Diam. (in.)	Depth (feet)	Screened Interval (feet)	Zone Monitored
MW-47D2	2.0	50.0	45.0 - 50.0	Glacial Till
MW-57D	4.0	33.0	23.0 - 33.0	Deep Overburden
MW-58	4.0	18.0	8.0 - 18.0	Shallow Overburden
MW-58D	4.0	33.0	23.0 - 33.0	Deep Overburden
MW-59	2.0	15.0	5.0 - 15.0	Shallow Overburden
MW-59D	2.0	33.0	23.0 - 33.0	Deep Overburden
WP–2D	2.0	45.0	40.0 - 45.0	Glacial Till

With the exception of the total depth for MW-47D2, and the screen length for MW-47D2 and WP-2D, each well was installed and constructed as was originally proposed in the 27 September 2001 work plan. Due to the presence of weathered bedrock, the total depth of MW-47D2 was reduced from the proposed depth of 63.0 feet to 50.0 feet. In order to maximize the distances between the bottoms of shallow wells MW-47D and WP-2R and the tops of the screened intervals for the deeper wells, MW-47D2 and WP-2D were each constructed with only 5.0 feet of screen.

Monitoring wells MW-57D, MW-58, MW-58D, MW-59, and MW-59D were installed using hollow-stem auger drilling techniques. Due to the need to double case the deep wells, MW-47D2 and WP-2D were installed using air rotary/water rotary drilling techniques. The borehole for each well was advanced to the target depth (when possible), and split spoon soil samples were collected for lithologic characterization. Since MW-59 and MW-59D were located beneath overhead power lines, these wells were installed with a half-derrick for health and safety reasons. Since split spoon sample could not be collected with the hollow stem auger drill rig in this configuration, the soil lithologies for MW-59 and MW-59D were logged from the drill cuttings.

In order to keep the borehole from collapsing, 10.0-inch diameter steel casing was advanced during the installation of MW-47D2 and WP-2D. After advancing the boring approximately 5.0 feet into the glacial till, 6.0-inch diameter steel casing was installed through the outer casing and grouted into place. The 6.0-inch steel casing was allowed to sit for approximately 24 hours before attempting to advance the boring to the completion depth. At the initial location for WP-2D (approximately 5.0 feet from WP-2R), the 6.0-inch steel casing began to spin while advancing the boring to set the well materials. Attempts to re-grout the steel casing were unsuccessful, so the 6.0-inch and 10-inch casings were removed and the borehole was sealed to grade with a cement/bentonite grout. WP-2D was successfully installed in a new borehole located approximately 15.0 feet south of WP-2R. The 10.0-inch casing could not be removed from the boring for MW-47D2 or from the second boring for WP-2D. Therefore, the 6.0-inch steel casing was installed through the outer casing and was grouted into place.

For all seven wells, the annulus around the well screen was filled with No. 2 Morie sand to two feet above the top of the screened interval. The remainder of the borehole was then sealed with a cement/bentonite grout to grade. The well heads for MW-47D2, MW-57D, MW-58, MW-58D, and WP-2D were completed with steel standpipes, while MW-59 and MW-59D were completed with flush-mounted manholes. Well construction details are shown on the boring logs for each well in Appendix B.

2.3.4 Phase IV - July - October 2002

Based on the results of the 1 May 2002 groundwater samples from the new monitoring wells (see Section 4.24, below), EPI collected grab groundwater samples from temporary well points to horizontally delineate the phenol and salicylic acid detected in shallow overburden well MW-58 and deep overburden well MW-57D. Temporary well point TWP-2[2] was located adjacent to MW-51 (approximately 45.0 feet west of MW-57D) and TWP-3 was installed approximately 45.0 feet west of MW-58. Contingency groundwater samples were also collected from TWP-4 (located adjacent to MW-21) and from TWP-5 (located near Building 35). Although the contingency samples were collected across River Drive, they were still located on property that is part of the site. Therefore, no off-site access issues were involved.

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[2] The designation TWP-1 had previously been used for the temporary well point used to collect a groundwater sample from AEC-29 (the former underground storage tank beneath Building 1).

Groundwater samples from the temporary well points were collected using disposable, small diameter polyethylene bailers. TWP-2 contained 86,100 ppb of phenol, 186,000 ppb of salicylic acid, and 786,000 ppb of methyl salicylate[3]. TWP-3 contained 21.2 ppb of methyl salicylate, but no detectable concentrations of phenol or salicylic acid. Due to the concentrations found in TWP-2, contingency sample TWP-4 was also analyzed. No detectable concentrations of phenol were found in TWP-4, while salicylic acid and methyl salicylate were present at 61.3 ppb and 64.7 ppb, respectively. Since the concentrations of all three compounds of concern in TWP-3 were below their respective groundwater quality standards, the sample from TWP-5 was not analyzed.

In Section 2.5 of the 24 October 2002 RAPR, EPI proposed to install two deep overburden zone wells (MW-21D and MW-51D) and one shallow overburden zone well (MW-62) in the northwest corner of the site for the purposes of completing the horizontal delineation of the Northern Phenol Area. The purpose of MW-51D was also to try and confirm the presence of dense non-aqueous phase liquid (DNAPL) that had been detected during the installation of temporary well point TWP-2. EPI installed MW-21D, MW-51D, and MW-62 between 16 & 17 October 2002.

Monitoring wells MW-21D, MW-51D and MW-62 were installed using a hollow-stem auger drill rig operated by Summit Drilling Co., Inc. at the same locations as TWP-4, TWP-2, and TWP-3, respectively. Since the soil lithology at the locations of MW-21D, MW-51D, and MW-62 had previously been characterized during the installation of temporary well points TWP-4, TWP-2, and TWP-3, no split spoon samples were collected. MW-21D and MW-51D each have a total depth of 34.0 feet, and are constructed with 10.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 24.0 feet of PVC casing. MW-62 has a total depth of 20.0 feet, and is constructed with 10.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 10.0 feet of PVC casing. All three wells were completed with locking steel standpipes.

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[3] Based on the physical property data in the *Hand Book of Environmental Data on Organic Chemicals*, the reported solubility of methyl salicylate in water (at 30°C) ranges from 740 parts per million (ppm) to 5,000 ppm. The actual solubility would most likely be lower since the temperature of groundwater is typically below 30°C.

2.4 Soil Sampling Procedures

A total of three soil samples were collected from each of the initial nine borings for phenol, salicylic acid, and methanol analyses. Although actual sample depths varied in each boring, one sample was collected from above, within, and below the clay layer that separates the shallow and deep overburden zones. The goal of the soil sampling was to try and identify where the source of the on-going groundwater contamination in ORC-4D is located. During the second phase of the investigation, six soil samples were collected during the installation of four monitoring wells for delineation purposes.

Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. At the end of the day, the samples were either delivered to the analytical laboratory (Accutest in Dayton, New Jersey; Certification No. 12129) or returned to the office where they were picked up by an Accutest courier the following morning. Each Phase I and Phase II soil sample was analyzed for phenol and salicylic acid by USEPA Method 8270 and methanol by USEPA Method 8015 (Direct Aqueous Injection - DAI). The results of these analyses are discussed in Section 3.2. Copies of the analytical data packages for these samples (along with the electronic data deliverables diskette [EDD]) are included under separate cover as Attachment I.

2.5 Groundwater Sampling Procedures

Groundwater samples from the Northern Phenol Area wells have been collected on a quarterly basis since June 1997. The current monitoring program calls for samples to be collected in January, April, July, and October. Groundwater samples collected in January, July, and October are analyzed for phenol, salicylic acid, methyl salicylate, methanol, and/or formaldehyde. Starting in 2002, groundwater samples collected in April were analyzed for volatile organic compounds (VOCs) and base neutral/acid extractable compounds (BNAs), plus methanol and formaldehyde.

Prior to January 2002, groundwater sampling in the Northern Phenol Area was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". However, in accordance with the NJDEP's letter dated 6 August 2001, and as discussed during the 6 December 2001 conference call, wells that exhibited poor recharge or excessive drawdown were purged and sampled using Low Flow methodology starting with the January 2002 sampling event.

2.5.1 Standard Purging & Sampling Methodology

Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of light non-aqueous phase liquids (LNAPLs) and dense non-aqueous phase liquids (DNAPLs) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rates did not exceed approximately two gallons per minute (gpm). In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

Before Purging

- Date, time, and weather conditions
- Well number
- Head space reading immediately after well cap is removed
- Product thickness, if any
- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

Well purging information for the first 13 rounds of samples collected between June 1997 and August 2000 are included under separate cover as Attachment II. Well purging information for samples collected since October 2000 have previously been submitted to the NJDEP as part of the quarterly Remedial Action Progress Reports (RAPRs).

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for VOC analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

2.5.2 Low Flow Purging & Sampling Methodology

As discussed above, the NJDEP has approved the use of low flow purging and sampling for collecting samples from wells that exhibit poor recharge or excessive drawdown during purging. Starting with the

January 2002 sampling event, the following eight wells in the Northern Phenol Area have been purged and sampled using low flow methodology:

Northern Phenol Area Wells Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-28D	Excessive Drawdown (>10 feet)
MW-32D	Excessive Drawdown (>10 feet)
MW-47D	Poor Recharge
MW-47D2	Excessive Drawdown (>10 feet)
MW-48D	Excessive Drawdown (>10 feet)
MW-51D	Excessive Drawdown (>10 feet)
MW-53D	Poor Recharge
MW-57D	Excessive Drawdown (>10 feet)

The low flow purging and sampling procedures used were taken from the USEPA Region II's *Groundwater Sampling Procedure - Low Stress (Low Flow) Purging and Sampling* document that was provided by the NJDEP following the 6 December 2001 conference call.

2.6 Treatability Study

Between July and August 2000, the Center for Environmental Microbiology, Inc. (CEMI) in Riverside, California performed a bench scale treatability test on groundwater from ORC-4D to determine if the indigenous bacteria population is capable of degrading phenol, salicylic acid, and methanol. Approximately five gallons of groundwater (collected from ORC-4D) and five gallons of soil (collected from ORC4DSB-2) were used to conduct this test. The results of the treatability study are discussed in Section 6.0.

2.7 Applied Remediation Criteria

Soil and groundwater in the Northern Phenol Area contain compounds of concern for which the NJDEP had not established Residential Direct Contact, Non-Residential Direct Contact, or Impact to Groundwater Cleanup Criteria for soil, or Groundwater Quality Standards for groundwater. The following sections discuss the remediation criteria being applied to the compounds of concern in this area of the site.

2.7.1 Groundwater Quality Standards

The groundwater quality standards (GWQS) for the original compounds of concern identified in groundwater in the Northern Phenol Area of the Kalama Chemical site are summarized below.

Compound of Concern	GWQS (in ug/L)
Phenol	4,000
Methanol	50,000
Formaldehyde	100

The standard for phenol is from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The standards for methanol and formaldehyde are from the "Interim Specific & Generic Groundwater Quality Criteria" posted on the NJDEP's Water Monitoring & Standards (WM&S) web page.

Groundwater in the Northern Phenol Area has also been found to contain salicylic acid. However, since the NJDEP did not have an established groundwater quality standard for salicylic acid at the start of the investigation of the Northern Phenol Area, a generic value of 100 parts per billion (ppb) was applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believed the generic100 ppb criterion was too conservative, since it did not incorporate toxicological data specific to salicylic acid. Since salicylic acid is not volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the

NJDEP's 100 ppb criterion is based, an acceptable groundwater concentration for salicylic acid at the Kalama site should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request to establish alternate groundwater quality standards for salicylic acid and methyl salicylate[4]. In their letter dated 24 June 2002, the NJDEP responded to EPI's 17 April 2001 correspondence, and listed Interim Groundwater Standards for these compounds that had been posted on the NJDEP-WM&S web page:

Interim Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	EPI's Proposed IGWQS (ug/L)	NJDEP's IGWQS (ug/L)
Methyl Salicylate	5,900	4,000
Salicylic Acid	5,600	80.0

Given the disparity between the alternate groundwater standard proposed by EPI for salicylic acid (5,600 ppb) and the Interim Groundwater Quality Standards (IGWQS) established by the NJDEP (80.0 ppb), EPI believes further discussions are required before this value is formally adopted for the Kalama Chemical site. Appendix C contains an additional discussion on the IGWQS for salicylic acid. Appendix C also contains a letter from Accutest regarding the NJDEP's IGWQS and Practical Quantitation Limit (PQL) for salicylic acid. Due to the physical and chemical properties of salicylic acid, the lowest concentration that can be reliably detected by USEPA Method 8270 is 100 ppb. Accutest believes that a reporting limit of 80.0 ppb and a PQL of 25.0 ppb are unrealistic, and cannot be supported based on their experimental data, experience, and judgement. However, for comparison purposes, the results of the groundwater sampling events discussed in this report have been evaluated using both sets of groundwater quality standards.

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[4] Although methyl salicylate (oil of wintergreen) had not previously been detected in groundwater, an alternate standard had been requested since this compound had been detected in the soil of AEC-30 at concentrations requiring remediation (i.e., excavation and off-site disposal).

2.7.2 Soil Cleanup Criteria

EPI applied a remediation criterion of 50.0 ppm for phenol in soil, based on the Impact to Groundwater Cleanup Criterion (IGWCC) listed in the NJDEP's *Soil Cleanup Criteria* Table (last updated on 12 may 1999). The site specific remediation criteria for methanol (724 ppm) and formaldehyde (289 ppm) in soil are the same as those that were proposed to the NJDEP in the 31 March 1995 *Revised Remedial Action Work Plan.*

EPI's 17 April 2001 submission to the NJDEP also proposed to establish soil clean up criteria for salicylic acid and methyl salicylate. In their letter dated 24 June 2002, the NJDEP responded to EPI's 17 April 2001 correspondence, and listed the following Residential Direct Contact Cleanup Criteria (RDCCC), Non-Residential Direct Contact Cleanup Criteria (NRDCCC), and Impact to Groundwater Cleanup Criteria for soil at the site:

Soil Cleanup Criteria
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

	Methyl Salicylate (mg/Kg)	Salicylic Acid (mg/Kg)
EPI's RDCCC	10,000	10,000
NJDEP's RDCCC	10,000	980
EPI's NRDCCC	10,000	10,000
NJDEP NRDCCC	10,000	10,000
EPI's IGWCC	1,400	1,300
NJDEP's IGWCC	30.0	0.134

Given the disparity in the RDCCC for salicylic acid, and the disparity in the IGWCCs for methyl salicylate and salicylic acid, EPI believes further discussions are also required before these values are formally adopted for the Kalama Chemical site. In particular, EPI questions the IGWCC for salicylic acid. Although salicylic acid is a non-cancer-causing chemical with relatively low systemic toxicity, the IGWCC proposed by the NJDEP is more stringent than the IGWCC for benzene (1.0 ppm) and the RDCCC & NRDCCC for benzo(a)pyrene (0.66 ppm), both of which are known to be carcinogens.

Appendix C contains an additional discussion on the soil cleanup criteria for methyl salicylate and salicylic acid. However, for comparison purposes, the results of the soil sampling events discussed in this report have been evaluated using both sets of cleanup criteria.

3.0 NORTHERN PHENOL AREA INVESTIGATION RESULTS - SOIL

The following sections discuss the results of the soil sampling conducted as part of the investigation of the Northern Phenol Area.

3.1 Soil Lithologies

Previous soil and groundwater investigations in the northeast corner of the site had identified a clay layer separating the shallow and deep overburden zones. The areal extent of this clay layer, as determined by Geraghty & Miller (G&M), but slightly modified by Sovereign, is shown on Figure 4. As can be seen, the entire investigation area is underlain by the clay layer. Using the lithologies previously identified by G&M, and those identified by Sovereign during the installation of soil borings ORC4DSB-1 through ORC4DSB-5, and monitoring wells MW-47D through MW-59D and MW-62, four geologic cross-sections through the area have been prepared (see Figure 5). Soil boring logs for ORC4DSB-1 through ORC4DSB-5 are included in Appendix D, while well logs for ORC-4D and MW-47D through MW-50D are included in Appendix B.

Boring ORC4DSB-1 was located 40.0 feet to the south of monitoring well ORC-4D, and had a completion depth of 40.0 feet below grade. Groundwater was encountered at approximately 6.0 feet below grade at the time of sampling. The soil at this location consisted of 6.0 feet of fill material (poorly sorted sand, gravel, and trace amounts of silt), followed by silty sand and clayey sand to 14.0 feet below grade. A brown clay was encountered from 14.0 - 20.0 feet below grade, followed by alternating layers of silty and clayey sand to 36.0 feet below grade. Glacial till consisting of red/brown clay, poorly sorted sand and gravel, and rock fragments was found to the completion depth of the boring. No signs of contamination were observed in the soil above the clay layer, so sample ORC4DSB-1A was collected from 7.0 - 7.5 feet. Sample ORC4DSB-1B was collected from within the clay layer (18.0 - 18.5 feet) from an interval exhibiting the highest PID readings (15.7 ppm). Sample ORC4DSB-1C was collected from an interval of stained soil at 23.5 - 24.0 feet below grade.

Boring ORC4DSB-2 was located 20.0 feet to the south of monitoring well ORC-4D, and had a completion depth of 40.0 feet below grade. Groundwater was encountered at approximately 8.0 feet below grade at the time of sampling. The soil at this location consisted of 9.5 feet of fill material (silt and fine to medium grained sand), followed by 10.0 feet of gray clay to 19.5 feet below grade. From beneath the clay layer to 34.0 feet below grade, the soil was comprised of alternating layers of silty and clayey sand. Glacial till consisting of clay, silt, and fine sand with increasing amounts of rock fragments and coarse sand was found to the completion depth of the boring. No signs of contamination were observed in the soil above the clay layer, so sample ORC4DSB-2A was collected from 9.0 - 9.5 feet. Sample ORC4DSB-2B was collected from within the clay layer (18.5 - 19.0 feet) from an interval exhibiting the highest PID readings (7.6 ppm). Sample ORC4DSB-2C was collected from below the clay layer at 24.0 - 24.5 feet below grade.

Boring ORC4DSB-3 was located 20.0 feet to the west of monitoring well ORC-4D, and had a completion depth of 40.0 feet below grade. Groundwater was encountered at approximately 8.0 feet below grade at the time of sampling. The soil at this location consisted of clay and silt with little fine sand to 4.0 feet below grade, with increasing amounts of medium to coarse sand and gravel to 9.0 feet below grade. A gray/brown clay was encountered from 9.0 - 20.0 feet below grade, followed by alternating layers of silty and clayey sand to the top of glacial till at 36.0 feet below grade. The glacial till in this boring consisted primarily of gravel and rock fragments, and extended to the completion depth of the boring. Sample ORC4DSB-3A was collected from an interval of stained soil at 3.0 - 3.5 feet below grade. Sample ORC4DSB-3B was collected from within the clay layer (16.5 - 17.0 feet) from an interval exhibiting the highest PID readings (8.2 ppm). Sample ORC4DSB-3C was collected at 25.0 - 25.5 feet below grade, from an interval exhibiting the highest PID reading (7.0 ppm) below the clay layer.

Boring ORC4DSB-4 was located 20.0 feet to the north of monitoring well ORC-4D, and had a completion depth of 40.0 feet below grade. Groundwater was encountered at approximately 12.0 feet below grade at the time of sampling. The soil at this location consisted of 8.0 feet of fill material (poorly sorted sand and gravel), followed by a brown/gray clay to 20.5 feet below grade. A lens of fine to coarse sand and gravel was encountered within the clay layer at 12.0 - 14.0 feet below grade. From 20.5 feet to the top of glacial till at 36.0 feet below grade, the soil consisted of brown fine sand with varying amounts of silt and clay. Glacial till extended to the completion depth of the boring at 40.0 feet below grade. No signs of contamination were observed in the soil above the clay layer, so sample ORC4DSB-4A was collected from 7.0 - 7.5 feet. Sample ORC4DSB-4B was collected from within the clay layer (19.0 - 19.5 feet), and sample ORC4DSB-4C was collected from below the clay layer at 25.0 - 25.5 feet below grade.

Boring ORC4DSB-5 was located 40.0 feet to the north of monitoring well ORC-4D, and had a completion depth of 40.0 feet below grade. Groundwater was encountered at approximately 8.0 feet below grade at the time of sampling. The soil at this location consisted of fill material (fine sand, clay, and silt, trace amounts of medium to coarse sand and gravel) to 9.0 feet below grade. A gray/brown clay was encountered from 9.0 - 21.5 feet below grade, followed by fine sand, silt, and clay to the top of glacial till at 36.0 feet below grade; trace amounts of coarse sand and gravel were present from 31.0 - 36.0 feet. No signs of contamination were observed in the soil above the clay layer, so sample ORC4DSB-5A was collected from 7.5 - 8.0 feet. Sample ORC4DSB-5B was collected from within the clay layer (13.0 - 13.5 feet), while sample ORC4DSB-5C was collected at 25.0 - 25.5 feet below grade, from a slightly stained interval of soil.

At the location of MW-21D/TWP-4, located approximately 100 feet downgradient from MW-51D next to monitoring well MW-21 on the west side of River Drive, the first 16.0 feet of soil consisted of fill material comprised of silt, sand, gravel, and cinders. From 16.0 - 20.0 feet below grade, a fine to medium sand was encountered, followed by a silt with very fine sand to the completion depth of 34.0 feet.

Monitoring well MW-47D was installed approximately 40.0 west (i.e., downgradient) of monitoring well ORC-4D. Although MW-47D was completed at 33.0 feet below grade, the boring was advanced to split spoon refusal at 38.0 feet below grade. Groundwater was encountered at approximately 9.0 feet below grade at the time of sampling. The soil at this location consisted of 9.0 feet of fill material (fine sand, silt, and clay, trace amounts of medium to coarse sand and gravel), followed by 12.5 feet of gray clay to 21.5 feet below grade. From beneath the clay layer to the top of glacial till at 33.0 feet below grade, the soil was comprised of fine sand, silt, and clay. Glacial till extended to the completion depth of the boring at 38.0 feet below grade. No signs of contamination were observed in the soil above the clay layer, so sample MW47DA was collected from 7.0 - 7.5 feet. Sample MW-47DB was collected from within the clay layer (15.0 - 15.5 feet) from an interval exhibiting the highest PID readings (11.3 ppm). Sample MW-47DC was collected from an interval of stained soil from below the clay layer (26.75 - 27.5 feet below grade).

Due to its proximity to MW-47D, split spoon samples were not collected during the installation of MW-47D2 from the first 33.0 feet of soil. Split spoon samples could not be collected from below 33.0 feet due to the presence of glacial till (which extended to 43.0 feet below grade). A weathered sandstone bedrock was encountered at 43.0 feet, and continued to the completion depth of the boring at 50.0 feet below grade. No soil samples were collected for laboratory analysis during the installation of this well.

Monitoring well MW-48D was installed approximately 60.0 south of monitoring well ORC-4D. Although MW-48D was completed at 33.0 feet below grade, the boring was advanced to split spoon refusal at 38.0 feet below grade. Groundwater was encountered at approximately 8.0 feet below grade at the time of sampling. The soil at this location consisted of 9.0 feet of fill material (fine sand, silt, and clay, trace amounts of medium to coarse sand and gravel), followed by 13.0 feet of gray and brown clay to 22.0 feet below grade. Fine to medium sand, silt, and clay were encountered from 22.0 - 28.0 feet below grade, followed by clay with trace amounts of fine to coarse sand and gravel to the top of glacial till at 34.0 feet below grade. Glacial till extended to the completion depth of the boring at 38.0 feet below grade. No signs of contamination were observed in the soil above the clay layer, so sample MW48DA was collected from 8.0 - 8.5 feet. Sample MW-48DB was collected from a stained interval within the clay layer (19.5 - 20.0 feet), while sample MW-48DC was collected from an interval of stained soil from below the clay layer (23.5 - 24.0 feet below grade).

Monitoring well MW-49D was installed approximately 60.0 north of monitoring well ORC-4D. Although MW-49D was completed at 33.0 feet below grade, the boring was advanced to split spoon refusal at 38.0 feet below grade. Groundwater was encountered at approximately 8.0 feet below grade at the time of sampling. The soil at this location consisted of 9.5 feet of fill material (fine sand, silt, and clay, trace amounts of medium to coarse sand and gravel), followed by 10.5 feet of gray clay to 20.0 feet below grade. From beneath the clay layer to 36.0 feet below grade, the soil was comprised of fine sand, silt, and clay. Although the no soil was recovered by the split spoon sampler from 36.0 - 38.0 feet, the presence of glacial till was inferred by split spoon refusal at 38.0 feet below grade. Soil sample MW-49DA was collected from stained soil above the clay layer at 7.5 - 8.0 feet below grade. Sample MW-49DB was collected from a stained interval within the clay layer (12.0 - 12.5 feet), while sample MW-49DC was collected from an interval of stained soil from below the clay layer (26.0 - 26.5 feet below grade).

Monitoring well MW-50D was installed approximately 50.0 east (i.e., upgradient) of monitoring well ORC-4D. Although MW-50D was completed at 33.0 feet below grade, the boring was advanced to a completion depth of 40.0 feet below grade. Groundwater was encountered at approximately 6.0 feet below grade at the time of sampling. The soil at this location consisted of 11.5 feet of fill material (fine sand, silt, and clay, trace amounts of medium to coarse sand and gravel), followed by 9.5 feet of brown clay to 21.0 feet below grade. From beneath the clay layer to the top of glacial till at 36.0 feet below grade, the soil was comprised of fine sand, silt, and clay. Glacial till extended to the completion depth of the boring at 40.0 feet below grade. Soil sample MW-50DA was collected from stained soil above the clay layer at 9.5 - 10.0 feet below grade. Sample MW-50DB was collected from a stained interval within the clay layer (17.0 - 17.5 feet), while sample MW-50DC was collected from an interval of stained soil from below the clay layer (25.5 - 26.0 feet below grade).

The initial 14.0 feet of soil at the location of MW-51D/TWP-2 consisted of the quarry process material used to backfill the excavation. This material was underlain by a coarse sand and poorly graded gravel to 17.5 feet below grade. An oil of wintergreen (i.e., methyl salicylate) odor was first noted in these native soils, and this odor persisted throughout the remainder of the boring. Multiple changing lithologies were noted, including silt and very fine sand (17.5 - 20.0 feet), coarse sand and gravel (20.0 - 22.0 feet), coarse sand and silt (22.0 - 24.0 feet), silt (24.0 - 27.0 feet), very fine sand (27.0 - 28.0 feet), rock fragments and silt (30.0 - 31.0 feet), and very fine to fine sand (31.0 - 34.0 feet); no soil was recovered from 28.0 - 30.0 feet. At 32.5 - 33.5 feet below grade, the soil appeared to be saturated with product.

A shake test was subsequently conducted on a soil sample from the 32.5 - 33.5 feet interval in TWP-2. Soil was placed in a jar, water was added, and the contents were shaken for 20 to 30 seconds. The jar was then allowed to sit to see if a separate phase had been flushed from the soil. Although only a slight sheen was observed at first, with time (on the order of several days), the sediment settled out of the water, and a layer of product accumulated on top of the soil, but below the top of the water in the jar. These results suggested that a DNAPL was present at the location of TWP-2/MW-51D. Based on the odor observed during sampling, and the previous environmental conditions in this area of the site, the DNAPL is most likely methyl salicylate. However, as of 18 December 2003, no measurable amounts of DNAPL have been found in MW-51D.

Due to the concentrations of phenol, salicylic acid, and methanol detected in the groundwater samples from MW-50D (see Section 4.14), monitoring well MW-52D was installed approximately 90.0 feet east (i.e., upgradient) of MW-50D. Similar to MW-50D, MW-52D has a total depth of 33.0 feet below grade, although the boring was advanced to a completion depth of 40.0 feet. Groundwater was encountered at approximately 9.0 feet below grade at the time of sampling. The soil at this location consisted of 6.0 feet of fill material (fine sand, silt, and clay, trace amounts of coarse sand), followed by 8.0 feet of fine to medium sand to 14.0 feet below grade. Brown clay was encountered from 14.0 - 18.0 feet below grade, followed by clay, silt, and fine sand to 34.0 feet. Fine to medium sand and silt was present from 34.0 feet to the completion depth of the boring at 40.0 feet below grade (where glacial till was encountered). Soil sample MW-52DA was collected from the interval above the clay layer (11.5 - 12.0 feet) that exhibited the highest PID reading (311 ppm). Sample MW-52DB was collected from the interval within the clay layer (14.5 - 15.0 feet) exhibiting the highest PID reading (11.4 ppm). Sample MW-52DC was collected from the interval below the clay layer (19.0 - 19.5 feet) with the highest PID reading (200 ppm).

Due to the concentrations of phenol, salicylic acid, and methanol detected in groundwater samples from MW-48D, monitoring well MW-53D was installed approximately 60.0 feet south of monitoring well MW-48D. MW-53D was completed at 33.0 feet below grade, which was also the completion depth of the boring. Groundwater was encountered at approximately 13.0 feet below grade at the time of sampling. The soil at this location consisted of 10.0 feet of fill material (fine to coarse sand and gravel with trace amounts of silt), followed by 10.0 feet of brown clay to 20.0 feet below grade. Fine to coarse sand with trace amounts of gravel, silt, and clay were encountered from 20.0 - 28.0 feet below grade, followed by glacial till to the completion depth of the boring at 33.0 feet below grade. Soil sample MW-53D was collected from an interval of stained soil within the clay layer (13.5 - 14.0 feet below grade).

In order to close the data gap between downgradient wells MW-2D (since abandoned and replaced by MW-2DR) and MW-12D, monitoring well MW-54D was installed approximately 90.0 feet southwest of MW-47D. MW-54D was completed at 33.0 feet below grade, which was also the completion depth of the boring. Groundwater was encountered at approximately 15.0 feet below grade at the time of sampling. The soil at this location consisted of 12.0 feet of fill material (fine to medium sand with trace amounts of silt), followed by 8.0 feet of gray clay to 20.0 feet below grade; a clay and gravel lens was encountered from 16.0 - 18.0 feet below grade. Red/gray fine sandy clay extended from the bottom of the clay layer to the top of glacial till at 30.0 feet below grade. Soil sample MW-54D was collected at 14.5 - 15.0 feet below grade, from an interval of stained soil within the clay layer.

In order to close the data gap between MW-2D and the northern property line, monitoring well MW-55D was installed approximately 120 feet northwest of MW-47D. MW-55D was completed at 33.0 feet below grade, although the boring extended to 40.0 feet below grade. Groundwater was encountered at approximately 11.0 feet below grade at the time of sampling. The soil at this location consisted of 12.0 feet of fill material (fine to coarse sand and gravel), followed by 18.0 feet of gray clay to 30.0 feet below grade. Brown fine to coarse sand (with some clay and trace amounts of silt) was present from 30.0 - 38.0 feet below grade, where glacial till was encountered. Soil sample MW-55D was collected at 15.0 - 15.5 feet below grade, from an interval within the clay layer exhibiting the highest PID reading (0.80 ppm).

At the location of MW-57D, located 130 feet to the west of MW-47D, the top 12.0 feet of soil consisted of fill material (comprised primarily of concrete, brick, rock, and asphalt) with some sand and silt. A well graded sand was encountered from 12.0 to 14.0 feet below grade, followed by a 10.0 feet thick clay layer. The clay layer was underlain by a silty sand to the completion depth of the boring at 33.0 feet below grade.

Monitoring wells MW-58 and MW-58D were installed through the basement of former Building 33-A. As such, the first 15.0 feet of material encountered consisted of the crushed concrete and brick used to backfill the basement. Once the boring advanced through the basement, split spoon samples could be collected. A well graded sand with silt was encountered from 15.0 to 16.0 feet below grade, followed by a seven feet thick clay layer. Silty sand was found from 23.0 to 25.0 feet below grade, underlain by another two feet of clay, and then six feet of well graded sand with silt to the completion depth of 33.0 feet below grade.

The soil lithologies at the location of MW-59 and MW-59D were logged from the drill cuttings, since split spoon samples could not be collected with the half-derrick drill rig configuration (due to overhead electrical lines). The first 10.0 feet of soil at this location consisted of a silty sand, followed by a well graded sand and silt to the completion depth of 33.0 feet below grade. The clay layer that was observed during the installation of MW-58D and WP-2D was not encountered at the location of MW-59 or MW-59D on the north side of Monroe Street.

MW-62/TWP-3 was installed through the basement of former Building 33. As such, the first 12.0 feet of material encountered in this boring consisted of the crushed brick and concrete fragments used to backfill the basement. Native soil consisting of coarse to medium sand was encountered at 12.0 feet below grade, and continued to the completion depth of the boring at 20.0 feet below grade.

Split spoon samples were not collected during the installation of WP-2D. However, since the well is located within the footprint of former Building 33-B, the top 16.0 feet of soil would be expected to consist of the poorly sorted sand, silt, and gravel fill material noted during the installation of WP-2R. Based on drill cuttings, the clay layer that had been observed in other wells in the Northern Phenol area was encountered from 16.0 to 25.0 feet below grade. The clay layer was underlain by 8.0 feet of sandy silt and clay, followed by glacial till from 33.0 to 42.0 feet below grade. Weathered sandstone bedrock was encountered from 42.0 feet to the completion depth of 45.0 feet below grade.

As shown on cross section A-A' running from west to east through the middle of the investigation area (Figure 6), the shallow overburden zone is 8.5 to 14.0 feet thick and is primarily fill material consisting of fine to coarse sand with varying amounts of silt and gravel. The thickness of the shallow overburden zone increases to the west, as the clay layer appears to begin to thin in the vicinity of MW-57D, and ends between MW-57D and MW-51D. The clay layer has a maximum thickness of 20.0 feet in MW-52D, but is typically is only 8.0 - 12.0 feet thick between MW-28D and MW-57D.

The deep overburden zone underlying the clay layer is also comprised of poorly sorted sands containing varying amounts of gravel, silt, and clay. However, 4.0 to 9.0 feet of clay was identified between MW-50D and ORC4DSB-3. Glacial till was generally encountered at 33.0 to 36.0 feet below grade. Therefore, the deep overburden zone, including the silt and clay layers, ranges in thickness from 5.0 feet near MW-52D to 15.0 feet near MW-50D and ORC4DSB-3.

Figure 7 shows cross section B-B', which runs from west to east along the northern portion of the investigation area. No significant changes in lithology were observed in the shallow overburden zone along this cross-section line. The clay layer was found to be approximately 18.0 feet thick near MW-55D. In addition, the clay layer extends further to the west along the northern property line than through the middle of the investigation area (where it appears to pinch out near MW-57D).

Cross sections C-C' (Figure 8) and D-D' (Figure 9) run from south to north through the investigation area. No significant changes in lithologies were observed along these cross section lines. As shown on Figure 9, the clay layer pinches out to the south of MW-57D, and does not appear to extend significantly to the north of the site (based on the absence of clay at the location of MW-59D in Monroe Street).

3.2 Soil Sampling Results

A total of 33 soil samples were collected from 13 borings during the investigation of the Northern Phenol Area. Continuous split spoon samples were collected during the installation of each boring, and the soil was screened for organic vapors using a PID. In most instances, no detectable concentrations were recorded by the PID, although when they were, they were from samples within the clay layer. In the absence of PID readings, soil samples were collected on the basis of staining and/or odors.

The analytical results for the soil samples collected from borings ORC4DSB-1 through ORC4DSB-5 and monitoring wells MW-47D, MW-48D, MW-49D, MW-50D, MW-52D, MW-53D, MW-54D, and MW-55D are summarized on Table 1, and are presented on Figure 10 (above the clay layer), Figure 11 (within the clay layer), and Figure 12 (below the clay layer). Methanol was detected in all 33 samples, phenol was detected in 31 samples, and salicylic acid was detected in 13 of the samples. The concentrations of methanol and phenol were below their respective applied remediation criteria in all of the soil samples from above and below the clay layer. However, eight of the 12 samples collected from within the clay layer contained elevated concentrations of either phenol or methanol.

Phenol was detected at concentrations exceeding its 50.0 ppm IGWCC in samples ORC4DSB-1B (185 ppm), ORC4DSB-2B (118 ppm), ORC4DSB-4B (116 ppm), ORC4DSB-5B (97.1 ppm), MW-48D-B (87.3 ppm), and MW-50D-B (134 ppm). Methanol exceeded the applied remediation criterion of 724 ppm in samples ORC3DSB-3B (5,700 ppm) and MW-47D-B (1,010 ppm).

Salicylic acid was not detected in all of the soil samples from above the clay layer, with the exception of MW-52DA (9.59 ppm). Salicylic acid was detected in nine of the 13 samples from within the clay layer, including ORC4DSB-1B (3.96 ppm), ORC4DSB-2B (3.86 ppm), ORC4DSB-4B (21.6 ppm), ORC4DSB-5B (1.84 ppm), MW-48D-B (5.63 ppm), MW-49D-B (3.44 ppm), MW-50D-B (11.4 ppm), MW-52D-B (6.56 ppm), and MW-55D (0.64 ppm). Salicylic acid was detected below the clay layer in soil samples ORC4DSB-1C (3.69 ppm), ORC4DSB-2C (0.33 ppm), and ORC4DSB-5C (9.4 ppm). Although the salicylic acid concentrations in all of these samples exceed the NJDEP's proposed IGWCC of 0.138 ppm, they are well below EPI's proposed alternate IGWCC of 1,300 ppm. It should also be noted that all of these samples were collected from below the water table, and that the salicylic acid concentrations in groundwater exceed those seen in the soil samples. Therefore, it is likely that the salicylic acid found in the soil samples from within and below the clay layer is related to groundwater, rather than soil, contamination.

3.3 Discussion of Results

The results of the soil sampling program were inconclusive in that they did not identify an obvious source area for the phenol, salicylic acid, and methanol being detected in groundwater. It was anticipated that the highest concentrations of these compounds would have been found in the shallow overburden soils closest to the source (i.e., the former leaking process lines). High concentrations would also have been expected in the deep overburden zone soil due to the dissolved concentrations that are known to exist in groundwater. However, elevated concentrations were only found in the clay layer, which had not been expected due to its low permeability.

The distribution of phenol and methanol may be related to the physical properties of the two compounds. Both phenol and methanol are extremely soluble in water, and both have low partitioning coefficients (Koc). Therefore, they would be more easily flushed from the soil into groundwater. Due to the low permeability of the clay, which limits the flow of groundwater through this zone, the phenol and methanol would not be flushed out as readily and would persist longer. It should be noted, however, that since the concentrations of phenol, salicylic acid, and methanol tend to be higher in groundwater than in the soil, it does not appear that the levels found within the clay layer are substantially contributing to the dissolved phase plumes.

The highest concentrations of phenol, methanol, and salicylic acid were found in MW-47D, located 40 feet <u>downgradient</u> from ORC-4D (which had originally been considered the source area well). Elevated concentrations of methanol and phenol were also found in MW-50D, located 50 feet upgradient from ORC-4D. The fact that MW-50D, located much closer to the suspected source area (i.e., the former Building 10/36 complex) for the three compounds of concern, contained lower levels of methanol, phenol, and salicylic acid than downgradient wells ORC-4D, MW-47D, and MW-48D, suggests that the distribution reflects a plume that has migrated away from the source area. The concentrations in MW-47D represent the leading edge of the plume, while the concentrations in ORC-4D, MW-48D, and MW-50D represent residual concentrations that were left behind as the plume migrated. Since the source has been eliminated (the facility is no longer operating and the process lines have been removed), the plume may have achieved a steady-state and may no longer be migrating.

A second potential source for the methanol in MW-47D could have been area of environmental concern (AEC) No. 2, which consisted of six former methanol underground storage tanks (USTs; Nos. A-13 through A-18). EPI believes these USTs are less likely to be the source for the methanol in MW-47D due to the fact that:

- the post-excavation samples collected following the removal of the USTs (between May and September 1988) only contained low to non-detectable concentrations of methanol. Only two samples (A-13C and A-14B) contained methanol at a concentrations above 100 ppm (116 ppm and 122 ppm, respectively).

- MW-47D contains the highest concentrations of phenol and salicylic acid, as well as the highest concentration of methanol (see Section 4.13). Since phenol was not stored in the area of MW-47D, and since salicylic acid was not produced in this area of the site, the distribution of these compounds suggests that they migrated to this location from the former Building 10/36 complex.

Given the areal extent and thickness of the clay layer in the northeast corner of the site, there are two possibilities to explain the presence of methanol, phenol, and salicylic acid in the deep overburden zone. It is possible that the clay layer may have been breached by the excavation to install the basement for former Building 36, thereby forming a conduit allowing groundwater from the shallow overburden zone to mix with the deep overburden zone. Another possible route by which the two zones could be connected is shown on Figure 4. The clay layer pinches out beneath the Building 10/36 complex. Therefore, it is possible that process water may have spilled over the eastern (i.e., upgradient) edge of the clay layer and migrated to the deep overburden zone. It should be noted, however, that the soil and groundwater results from MW-52D indicate that a source for the phenol, methanol, and salicylic acid no longer exists to the east of MW-50D beneath the former Building 10/36 complex.

4.0 NORTHERN PHENOL AREA - HISTORICAL GROUNDWATER RESULTS

EPI initiated a quarterly groundwater monitoring program for the Northeast and Northwest Phenol Hotspot Areas (subsequently combined into the Northern Phenol Area) in June 1997 (prior to commencing active remediation along the southern property boundary). The following sections discuss the results of groundwater sampling events conducted between June 1997 and April 2003. Starting with the October 2000 sampling event, quarterly reports on the groundwater monitoring program have been submitted to the NJDEP. Unless otherwise indicated, the analytical data packages and EDD diskettes for the sampling events discussed below were previously submitted to the NJDEP as part of the 3 August 2001 *Remedial Investigation Report Addendum*. Monitoring well construction details are summarized on Table 2. Concentration vs. Time graphs for all of the wells discussed in the following Sections are included in Appendix E.

4.1 June 1997 Sampling Event

Groundwater samples from wells addressing the Northeast and Northwest Phenol Hot Spot areas were collected between 23 and 25 June 1997. The results of this sampling event are summarized below.

4.1.1 Northeast Phenol Hot Spot (Buildings 10/36)

In order to monitor the natural degradation of the phenol, methanol, and formaldehyde present in the shallow and deep overburden zones in the area of the Building 10/36 complex in the northeast corner of the site, groundwater samples were collected from the following wells:

Source Area Wells	MW-28D, WP-3, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

Both the shallow overburden zone (i.e., above the clay layer) and the deep overburden zone (below the clay layer) contain compounds of concern at concentrations exceeding the GWQS. Each groundwater sample was analyzed for phenol by USEPA Method 8270, methanol by USEPA Method 8015-Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315. The results of these analyses are summarized on Table 3.

4.1.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. No detectable concentrations of phenol, methanol, or formaldehyde were found in WP-5. Well point WP-6 contained 450 parts per billion (ppb) of formaldehyde and 60,000 ppb of phenol. Well ORC-2 contained 53.0 ppb of formaldehyde and 7,900 ppb of phenol. None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained compounds of concern at concentrations exceeding the GWQS.

The results for the June 1997 samples indicate that the concentrations of phenol, methanol, and formaldehyde in the shallow overburden zone are continuing to decline, most likely through natural biodegradation processes. The fact that concentrations of these compounds have not increased in the downgradient monitoring points supports the biodegradation scenario.

4.1.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, WP-3, and ORC-4D. All three compounds of concern were detected in samples from the deep overburden zone. Phenol was detected in all three wells at concentrations of 67,000 ppb (ORC-4D), 75,000 ppb (MW-28D), and 150,000 ppb (WP-3). Formaldehyde was detected in ORC-4D (170 ppb) and MW-28D (290 ppb), while methanol was only detected in ORC-4D (86,000 ppb). The concentrations of the three compounds of concern were below their respective GWQS in all of the downgradient monitoring points with the exception of phenol in MW-2D (9,400 ppb).

4.1.2 Northwest Phenol Hot-Spot (Building 33-B)

The January 1995 sampling event identified well point WP-2 as a hot spot of phenol and possibly formaldehyde. Therefore, in order to determine if the concentrations of phenol and formaldehyde in the shallow overburden zone beneath Building 33-B are being naturally attenuated to below the closure criteria, groundwater samples were collected from the following wells:

Source Area Wells	WP-2
Monitoring Points	WP-1, MW-21

Each groundwater sample was analyzed for phenol by USEPA Method 8270 and formaldehyde by USEPA Method 8315. Analytical results for these samples are summarized on Table 4.

The results of the June 1997 sampling indicated that formaldehyde concentrations were below the GWQS in both the source area and downgradient monitoring wells in this area. Phenol was detected in WP-2 at a concentration of 180,000 ppb. However, this concentration is less than has historically been detected in WP-2 (up to 1,200,000 ppb in October 1992). Although downgradient monitoring point WP-1 contained 9,100 ppb of phenol, no detectable concentrations of this compound were found in MW-21 (located 80 feet to the west of WP-1, across River Drive).

4.2 September 1997 Sampling Event

Groundwater samples from wells addressing the Northeast and Northwest Phenol Hot Spot areas were collected between 15 and 18 September 1997. The results of this sampling event are summarized below.

4.2.1 Northeast Phenol Hot Spot (Buildings 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3, WP-5, WP-6, ORC-2, ORC-4D

Monitoring Points MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 5.

4.2.1.1 *Shallow Overburden Zone*

Detectable concentrations of phenol (2,800 ppb) and formaldehyde (71.0 ppb) were found in WP-5. Well point WP-6 contained 2,700 ppb of phenol, 140 ppb of formaldehyde and 24,000 ppb of methanol. Well ORC-2 contained 2,300 ppb of phenol, with no detectable concentrations of formaldehyde or methanol. None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained compounds of concern at concentrations exceeding the GWQS.

During the June 1997 sampling event, phenol was not detected in WP-5 and WP-6. The phenol concentrations found in September 1997 are below the GWQS for this compound, and appear to confirm that a significant drop in concentrations has occurred. When compared to the November 1996 results (see Appendix E), phenol concentrations have dropped 90% (from 28,000 ppb) in WP-5 and 93% (from 36,000 ppb) in WP-6.

The methanol concentration in WP-5 is consistent with the last four rounds of sampling. Although formaldehyde increased to 71.0 ppb, this concentration is still below the GWQS. The formaldehyde concentration in WP-6 showed a 69% decrease when compared to the June 1997 results, while methanol had decreased by 60%. These trends are consistent with those previously seen in this well. The phenol concentration in ORC-2 represents a 71% decrease from the June 1997 sampling event, and represents the first time that levels of this compound have been below the GWQS in this well.

The results for the September 1997 samples indicate that the concentrations of phenol, methanol, and formaldehyde in the shallow overburden zone are continuing to decline, most likely through natural biodegradation processes. The fact that concentrations of these compounds have not increased in the downgradient monitoring points supports the biodegradation scenario.

4.2.1.2 *Deep Overburden Zone*

All three compounds of concern were detected in samples from the deep overburden zone. Phenol was detected in all three source area wells at concentrations of 4,900 ppb (MW-28D), 11,000 ppb (ORC-4D), and 110,000 ppb (WP-3). Formaldehyde and methanol concentrations were below their respective IGWQS in all three source area wells. The concentrations of the three compounds of concern were below their respective GWQS in all of the downgradient monitoring points.

The concentrations of methanol and formaldehyde in WP-3 are consistent with those from recent sampling events; the phenol concentration decreased 26% from the June 1997 sampling event (150,000 ppb). The methanol concentration in MW-28D is consistent with the last three rounds of samples from this well. Phenol and formaldehyde concentrations in MW-28D decreased 93% and 75%, respectively, when compared to the last round of samples. In ORC-4D, the concentrations of phenol and methanol both decreased approximately 80%, while formaldehyde decreased 48%.

The results for the September 1997 samples indicate that the concentrations of phenol, methanol, and formaldehyde in the deep overburden zone are continuing to decline, most likely through natural biodegradation processes. The fact that concentrations of these compounds have not increased in the downgradient monitoring points supports the biodegradation scenario.

4.2.2 Northwest Phenol Hot-Spot (Building 33-B)

The January 1995 sampling event identified well point WP-2 as a hotspot of phenol and possibly formaldehyde. The results of the June 1997 sampling event confirmed that phenol is still a compound of concern in this area. In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Wells</u>	WP-2
<u>Monitoring Points</u>	WP-1, MW-21

Analytical results for these samples are summarized on Table 6.

The results of the September 1997 sampling confirm that formaldehyde concentrations are below the GWQS in both the source area and downgradient monitoring wells in this area. The concentration of phenol in WP-2 was found to have increased to 270,000 ppb (from 180,000 ppb in June 1997). No detectable concentrations of phenol were found in downgradient monitoring points WP-1 and MW-21.

4.3 January 1998 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 27 and 29 January 1998. The results of this sampling event are summarized below.

4.3.1 Northeast Phenol Hot Spot (Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 7.

4.3.1.1 *Shallow Overburden Zone*

Detectable concentrations of phenol (4,500 ppb), methanol (2,600 ppb) and formaldehyde (83.0 ppb) were found in WP-5. Well point WP-6 contained 2,200 ppb of phenol, 5,200 ppb of methanol, and 900 ppb of formaldehyde. Well ORC-2 contained 1,300 ppb of phenol and 1,000 ppb of methanol, but no detectable concentrations of formaldehyde. None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained phenol or methanol at concentrations exceeding the GWQS. However, formaldehyde was detected in MW-28 and MW-32 at concentrations of 120 ppb and 140 ppb, respectively.

The phenol concentrations in WP-5 and WP-6 continue to remain low, which is consistent with the last two rounds of samples collected from these wells. The formaldehyde concentration in WP-6 increased during this sampling event, but is still lower than historical results. The concentration of methanol in WP-6 decreased 78% when compared to the September 1997 sampling event, which is consistent with the trend exhibited by this well since November 1996.

The phenol concentration in ORC-2 decreased an additional 43% from the September 1997 sampling event; levels of this compound have been below the GWQS in ORC-2 for two consecutive quarters.

The results for the January 1998 samples indicate that the concentrations of phenol, methanol, and formaldehyde in the shallow overburden zone are continuing to decline, most likely through natural biodegradation processes. Although the concentrations of these compounds may have increased slightly in several wells, the levels seen were below those historically seen, and do not disrupt the over-all trend of decreasing concentrations.

4.3.1.2 *Deep Overburden Zone*

All three compounds of concern were detected in samples from the deep overburden zone source area wells MW-28D, WP-3, and ORC-4D. Phenol was detected in all three wells at concentrations of 1,400 ppb (MW-28D), 16,000 ppb (ORC-4D), and 50,000 ppb (WP-3). Formaldehyde and methanol concentrations were below their respective IGWQS in all three source area wells. The concentrations of the three compounds of concern were also below their respective GWQS in all of the downgradient monitoring points.

The concentrations of methanol and formaldehyde in WP-3 are consistent with those from recent sampling events; the phenol concentration decreased 55% from the September 1997 sampling event (110,000 ppb). The methanol concentration in MW-28D is consistent with the last four rounds of samples from this well. In ORC-4D, phenol and methanol both increased relative to the September 1997 sampling event, although the levels are still below historical concentrations.

The results for the January 1998 samples indicate that the concentrations of phenol, methanol, and formaldehyde in the deep overburden zone are continuing to decline, most likely through natural biodegradation processes. The fact that concentrations of these compounds have not increased in the downgradient monitoring points supports the biodegradation scenario.

4.3.2 Northwest Phenol Hot Spot (Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

Source Area Wells	WP-2
Monitoring Points	WP-1, MW-21

Analytical results for these samples are summarized on Table 8.

The concentration of phenol in WP-2 was found to have decreased 96% to 10,000 ppb (from 270,000 ppb in September 1997). Only trace amounts of phenol were found in downgradient monitoring points WP-1 (60.0 ppb) and MW-21 (7.0 ppb).

4.4 April 1998 Sampling Event

Due to the on-going demolition of the Building 10/36 complex, no groundwater samples were collected from wells that monitor the Northeast Phenol Hot Spot during this sampling event. Groundwater samples were collected from wells addressing the Northwest Phenol Hot Spot on 14 and 15 April 1998. The results of this sampling event are summarized below.

4.4.1 Northwest Phenol Hot Spot (Building 33-B)

The last three rounds of sampling confirmed that well point WP-2 is a hot spot for phenol in groundwater, and that formaldehyde is not a compound of concern in this area. In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2
Monitoring Points	WP-1, MW-21

Analytical results for these samples are summarized on Table 9.

The concentration of phenol in WP-2 was found to have rebounded to 24,000 ppb, up from the 10,000 ppb seen in January 1998. However, this concentration is still 90% lower than the 270,000 ppb seen in September 1997. Low concentrations of phenol were found in downgradient monitoring point WP-1 (280 ppb), but no detectable concentrations were found in MW-21.

4.5 July 1998 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 15 and 17 July 1998. The results of this sampling event are summarized below. Based on the results of grab groundwater samples collected following the demolition of the Building 10/36 complex, salicylic acid (or 2-hydroxybenzoic acid) was added to the list of analytical parameters for the monitoring wells in the Northeast Phenol Hot Spot. As part of the demolition of the Building 10/36 complex, deep overburden zone well point WP-3, which was located in the basement of Building 36, was abandoned by a licensed New Jersey well sealer on 29 June 1998.

4.5.1 Northeast Phenol Hot Spot (Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

Groundwater samples from these wells were also analyzed for salicylic acid (by USEPA Method 8270) to determine the distribution of this compound in the shallow and deep overburden zones. The analytical results for these samples are summarized on Table 10.

4.5.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. Detectable concentrations of salicylic acid (9,100 ppb) and formaldehyde (190 ppb) were found in WP-5. Well point WP-6 contained 1,500 ppb of phenol, 51,000 ppb of salicylic acid, and 110 ppb of formaldehyde. Well ORC-2 contained 480 ppb of phenol and 120 ppb of formaldehyde. Phenol concentrations in the source area wells are below the GWQS of 4,000 ppb. Methanol was not detected in any of the source area wells.

None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained phenol or methanol at concentrations exceeding the GWQS. However, formaldehyde was detected in four wells at concentrations of 160 ppb (MW-3), 120 ppb (MW-18), 130 ppb (MW-28), and 330 ppb (MW-32). None of the downgradient monitoring wells contained salicylic acid, except MW-2 (44,000 ppb).

The phenol concentrations in WP-5 and WP-6 continue to remain low, which is consistent with the last three rounds of samples collected from these wells. The phenol concentration in ORC-2 decreased an additional 63% from the January 1998 sampling event; levels of this compound have been below the GWQS for three consecutive quarters.

The absence of methanol in all of the shallow overburden zone wells is consistent with the decreasing concentration trends observed during previous sampling events. Formaldehyde concentrations spiked upward in both the source area and downgradient monitoring wells. This increase may be related to the heavy precipitation experienced following the demolition of the Building 10/36 complex. Since formaldehyde has a very low K_{oc} value (0.56), it is possible that it was flushed from the soil that had previously been covered by the buildings.

Salicylic acid was only detected in three of the eight shallow overburden zone monitoring wells. With the exception of downgradient monitoring well MW-2, salicylic acid is limited to source area wells WP-5 and WP-6. All of the concentrations detected were above the NJDEP's IGWQS of 80.0 ppb, and EPI's proposed IGWQS of 5,600 ppb.

The results for the July 1998 samples indicate that the concentrations of phenol and methanol in the shallow overburden zone are continuing to decline, most likely through natural biodegradation processes. It is anticipated that as the soil beneath the former Building 10/36 complex continues to be flushed by precipitation, the formaldehyde concentrations will start decreasing again through natural degradation and attenuation processes.

4.5.1.2 *Deep Overburden Zone*

The remaining deep overburden wells within the source area are MW-28D and ORC-4D. Phenol was detected in MW-28D at a concentration of 1,400 ppb. Formaldehyde was detected in both wells at 91.0 ppb (MW-28D) and 140 ppb (ORC-4D). Salicylic acid was detected in MW-28D (15,000 ppb) but not in ORC-4D. No detectable concentrations of methanol were found in the source area wells. The concentrations of the four compounds of concern were below their respective GWQS in all of the downgradient monitoring points.

Phenol in MW-28D increased slightly relative to the January 1998 sampling event, although the level is still below historical concentrations (and the GWQS). The methanol results for MW-28D are consistent with the last four rounds of data from this well. The absence of phenol and methanol in ORC-4D represent the first time the concentrations of these compounds have been below their respective GWQS in this well.

The results for the July 1998 samples indicate that the concentrations of phenol, methanol, and formaldehyde in the deep overburden zone are continuing to decline, most likely through natural biodegradation processes. Formaldehyde concentrations did not spike upwards as had been observed in the shallow overburden zone. This would be consistent with the deep overburden zone being isolated by the overlying clay layer.

4.5.2 Northwest Phenol Hot Spot (Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2
<u>Monitoring Points</u>	WP-1, MW-21

Analytical results for these samples are summarized on Table 11.

The concentration of phenol in WP-2 was found to have increased to 290,000 ppb, up from the 24,000 ppb seen in April 1998. However, this concentration is comparable to the 270,000 ppb detected in September 1997. Elevated concentrations of phenol were found in downgradient monitoring point WP-1 (14,000 ppb), but no detectable concentrations were found in MW-21. The phenol concentration in WP-1 is significantly higher than what had been detected in April 1998 (280 ppb), but it is comparable to the levels that have historically been seen in this well.

4.6 October 1998 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 13 and 16 October 1998. The results of this sampling event are summarized below. Replacement deep overburden zone monitoring well WP-3R was installed on 1 October 1998.

4.6.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 12.

4.6.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. The concentrations of phenol and methanol were below their GWQS in each well. Formaldehyde exceed the GWQS of 100 ppb in ORC-2 (120 ppb) and WP-6 (250 ppb). Salicylic acid was detected in WP-5 (330 ppb), WP-6 (2,100 ppb), and ORC-2 (17,000 ppb). Although salicylic acid concentrations in these wells exceeded the NJDEP's IGWQS of 80.0 ppb, only the level in ORC-2 exceeded EPI's proposed IGWQS of 5,600 ppb.

Methanol and formaldehyde were not detected in any of the downgradient, shallow overburden zone monitoring points (MW-2, MW-3, MW-18, MW-28, and MW-32). Salicylic acid was detected in MW-2 (210 ppb) and MW-3 (23,000 ppb). Phenol was detected in MW-3 at a concentration of 5,000 ppb. This represents the first time that phenol exceeded the 4,000 ppb GWQS in this well since February 1993 (when 53,000 ppb of phenol was detected).

The phenol concentrations in WP-5, WP-6, and ORC-2 continue to remain low, which is consistent with the last three rounds of samples collected from these wells. The absence of methanol in all of the shallow overburden zone wells is consistent with the decreasing concentration trends observed during previous sampling events. The concentrations of formaldehyde in the shallow overburden zone decreased in most wells relative to July 1998, when concentrations spiked upward following the demolition of the Building 10/36 complex. This type of decrease was anticipated given that as the soil beneath the former Building 10/36 complex was flushed by precipitation, the formaldehyde concentrations would be reduced through natural degradation and attenuation processes.

4.6.1.2 *Deep Overburden Zone*

Phenol was detected in all three source area wells at concentrations of 780 ppb (WP-3R), 2,700 ppb (MW-28D), and 16,000 ppb (ORC-4D. Formaldehyde was detected in MW-28D and ORC-4D at 130 ppb and 150 ppb, respectively. Salicylic acid was detected in WP-3R (510 ppb), MW-28D (6,400 ppb), and ORC-4D (21,000 ppb). No detectable concentrations of methanol were found in the source area wells.

The concentrations of phenol, methanol, and formaldehyde were below their respective GWQS in all of the downgradient monitoring points except MW-2D, which contained 150 ppb of formaldehyde. Salicylic acid was detected at concentrations below EPI's proposed IGWQS of 5,600 ppb in MW-2D (4,800 ppb) and MW-12D (120 ppb)

4.6.2 Northwest Phenol Hot Spot (Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2
Monitoring Points	WP-1, MW-21

Analytical results for these samples are summarized on Table 13.

The concentration of phenol in WP-2 was found to have decreased slightly to 220,000 ppb, down from the 290,000 ppb seen in July 1998. Downgradient monitoring point WP-1 contained 3.0 ppb of phenol, but no detectable concentrations of this compound were found in MW-21. The results for WP-1 and MW-21 are consistent with historical data, suggesting that the elevated concentration seen in WP-1 (14,000 ppb) in July 1998 was anomalously high.

4.7 January 1999 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 12 and 18 January 1999. The results of this sampling event are summarized below.

4.7.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 14.

4.7.1.1 *Shallow Overburden Zone*

The concentrations of phenol, formaldehyde, and methanol were below their GWQS in source area wells WP-5, WP-6, and ORC-2. Salicylic acid was detected in WP-5 (256 ppb), WP-6 (436 ppb), and ORC-2 (5,500 ppb) at concentrations that exceed the NJDEP's IGWQS of 80.0 ppb, but below EPI's proposed IGWQS of 5,600 ppb. With the exception of MW-28, none of the four compounds of concern were detected in the downgradient, shallow overburden zone monitoring points (MW-2, MW-3, MW-18, MW-28, and MW-32). Phenol and salicylic acid were detected in MW-28 at concentrations of 2,200 ppb and 1,680 ppb, respectively.

4.7.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, ORC-4D, and WP-3R. Phenol was detected in all three wells at concentrations of 244 ppb (WP-3R), 3,420 ppb (MW-28D), and 30,400 ppb

(ORC-4D). Salicylic acid was detected in WP-3R (30.0 ppb), MW-28D (11,900 ppb), and ORC-4D (113,000 ppb). No detectable concentrations of methanol or formaldehyde were found in the source area wells.

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were below their respective GWQS in all of the downgradient monitoring points, with the exception of 2,330 ppb of salicylic acid in MW-2D.

4.7.2 Northwest Phenol Hot Spot (Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2
<u>Monitoring Points</u>	WP-1, MW-21

Analytical results for these samples are summarized on Table 15.

The concentration of phenol in WP-2 was found to have decreased to 144,000 ppb, down from the 220,000 ppb seen in October 1998. However, this concentration may not be truly representative of groundwater quality since WP-2 was not purged prior to collecting the sample. Downgradient monitoring point WP-1 contained 18.3 ppb of phenol, but no detectable concentrations of this compound were found in MW-21. The results for WP-1 and MW-21 are consistent with the historical data for each well.

4.8 April 1999 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 13 and 15 April 1999. The results of this sampling event are summarized below.

4.8.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 16.

4.8.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. The concentrations of methanol and formaldehyde were not detectable in each well. WP-5 contained 5,750 ppb of phenol, which exceeds the GWQS of 4,000 ppb, and 3,570 ppb of salicylic acid, which exceeds the NJDEP's IGWQS of 80.0 ppb, but is below EPI's proposed IGWQS of 5,600 ppb.

None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained detectable concentrations of formaldehyde, methanol, or salicylic acid. Phenol was detected in MW-18, MW-28, and MW-32 at concentrations of 2.3 ppb, 9.0 ppb, and 1.5 ppb, respectively.

4.8.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, ORC-4D, and WP-3R. Phenol was detected in all three wells at concentrations of 2.2 ppb (WP-3R), 2,400 ppb (MW-28D), and 40,000 ppb (ORC-4D). Salicylic acid (137,000 ppb) and formaldehyde (61.0 ppb) were only detected in ORC-4D. No detectable concentrations of methanol were found in the source area wells.

No detectable concentrations of methanol or formaldehyde were found in the downgradient monitoring points in the deep overburden zone. Phenol and salicylic acid were detected at concentrations below the GWQS in all of the downgradient monitoring points except MW-2D (5,320 ppb of phenol and 9,100 ppb of salicylic acid).

4.8.2 Northwest Phenol Hot Spot (Building 33-B)

Previous rounds of sampling have confirmed that well point WP-2 is a hotspot for phenol in groundwater. Unlike in the wells located in the Northeast Phenol Hot Spot, phenol concentrations have not significantly decreased over the last several years. Based on observations made during the demolition of other buildings at the site, it is possible that WP-2 is installed within a honeycomb of footings that create isolated pockets of groundwater.

On 25 and 26 February 1999, a vacuum truck was used to extract groundwater from WP-2. The goal of this work was to 1) remove groundwater containing the highest concentrations of phenol; and 2) draw water from outside the immediate vicinity of the well into the area to stimulate biodegradation of the phenol. Previous work at the site had demonstrated that phenol will readily degrade when the oxygen content of the groundwater is increased.

After 11.25 hours of applying a vacuum of approximately 15 inches of mercury to WP-2, only 110 gallons of groundwater were recovered. This represents approximately 100 well volumes of water, significantly more than has ever been removed from this well point. An insufficient volume of water was present in WP-2 after the first day of extracting groundwater, so a sample was not collected until the morning of 26 February 1999. A second groundwater sample was collected from WP-2 in the afternoon of 26 February 1999 after vacuum extraction had been completed. Each groundwater sample was analyzed for phenol to evaluate changes in dissolved concentrations. The results of these analyses are summarized on Table 17.

The sample from WP-2 collected in the morning of 26 February 1999 contained 11,900 ppb of phenol, while sample collected in the afternoon contained 51,000 ppb of phenol. For comparison, the concentrations of phenol in the last three quarters of sampling were 290,000 ppb (July 1998), 220,000 ppb (October 1998), and 144,000 ppb (January 1999).

In order to evaluate the long term effects of the vacuum extraction on phenol concentrations, as well as to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected in April 1999 from the following wells:

Source Area Well	WP-2
Monitoring Points	WP-1, MW-21

Analytical results for these samples are summarized on Table 18.

The concentration of phenol in WP-2 was found to have decreased from the 51,000 ppb seen on 26 February 1999 to 17,400 ppb on 15 April 1999. Downgradient monitoring point WP-1 contained 710 ppb of phenol, but no detectable concentrations of this compound were found in MW-21. The results for WP-1 and MW-21 are consistent with the historical data for each well. The relatively low concentration of phenol in WP-2 suggests that the vacuum extraction of groundwater may have been successful in stimulating biodegradation.

4.9 July 1999 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 13 and 15 July 1999. The results of this sampling event are summarized below.

4.9.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D

Monitoring Points MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 19.

4.9.1.1 *Remedial Measures*

The April 1999 groundwater sample from ORC-4D contained 40,000 ppb of phenol and 137,000 ppb of salicylic acid. Due to these concentrations, a one day pump out of this well was conducted using a vacuum truck on 9 June 1999. A two day vac-out from ORC-4D was originally planned, but the vacuum truck broke down on 8 June 1999, and no water could be extracted from the well. A total of 250 gallons of water were extracted from ORC-4D (equivalent to approximately 80 well volumes).

After the vacuum truck was disconnected from the well, a groundwater sample was collected from ORC-4D and analyzed for phenol and salicylic acid. The analytical results indicated that the concentration of phenol had decreased to 30,600 ppb, and the concentration of salicylic acid had decreased to 44,000 ppb (see Table 20).

4.9.1.2 *Shallow Overburden Zone*

The concentrations of phenol, methanol, and formaldehyde were either not detectable or below their GWQS in source area wells WP-5, WP-6, and ORC-2. Salicylic acid was detected at 3,570 ppb in WP-5, which is above the NJDEP's IGWQS of 80.0 ppb, but below EPI's proposed IGWQS of 5,600 ppb.

None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained detectable concentrations of formaldehyde or methanol. Phenol was detected in MW-2, MW-28, and MW-32 at concentrations of 3.4 ppb, 38.0 ppb, and 2.1 ppb, respectively. These three wells also contained salicylic acid at concentrations of 14.8 ppb (MW-2), 28.4 ppb (MW-28), and 5.2 ppb (MW-32).

4.9.1.3 *Deep Overburden Zone*

Phenol was detected in all three source area wells at concentrations of 3.0 ppb (WP-3R), 2,420 ppb (MW-28D), and 103,000 ppb (ORC-4D). Formaldehyde and methanol were only detected in ORC-4D (100 ppb and 50,000 ppb, respectively). Salicylic acid was detected in all three source area wells at concentrations of 13.6 ppb (WP-3R), 3,250 ppb (MW-28D), and 564,000 ppb (ORC-4D).

The concentrations of phenol, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone. Salicylic acid was detected at 4,940 ppb in MW-2D and 119 ppb in MW-3D.

4.9.2 Northwest Phenol Hot Spot (Building 33-B)

In order to evaluate the long term effects of the vacuum extraction on phenol concentrations, as well as to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2
<u>Monitoring Points</u>	WP-1, MW-21

Analytical results for these samples are summarized on Table 21.

The concentration of phenol in WP-2 was found to have increased to 115,000 ppb from the 17,400 ppb seen in April 1999. Downgradient monitoring point WP-1 contained 15,600 ppb of phenol, but no detectable concentrations of this compound were found in MW-21. The results for MW-21 are consistent with the historical data for this well.

4.10 October 1999 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 12 and 14 October 1999. The results of this sampling event are summarized below.

4.10.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 22.

4.10.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. The concentrations of phenol, methanol, formaldehyde, and salicylic acid were either not detectable or below their GWQS in each well. Due to an insufficient volume of water in the well, the samples from WP-5 could only be analyzed for methanol and formaldehyde.

None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained detectable concentrations of salicylic acid, formaldehyde or methanol. Phenol was only detected in MW-28, at a concentration of 3.0 ppb.

4.10.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, ORC-4D, and WP-3R. Phenol was detected in MW-28 and ORC-4D at concentrations of 4,120 ppb and 104,000 ppb, respectively. Formaldehyde was not detected in any of the source area wells. The only well within the deep overburden zone that contained methanol was ORC-4D (11,000 ppb). Salicylic acid was detected in two of the source area wells at concentrations of 4,240 ppb (MW-28D) and 561,000 ppb (ORC-4D).

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone (MW-2D, MW-3D, MW-12D, and MW-32D).

4.10.2 Northwest Phenol Hot Spot (Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2
<u>Monitoring Points</u>	WP-1, MW-21

Analytical results for these samples are summarized on Table 23.

The concentration of phenol in WP-2 was found to have decreased to 1,120 ppb from the 115,000 ppb seen in July 1999. This represents the first time since April 1997 that phenol concentrations have been below the GWQS of 4,000 ppb. However, the basement of Building 33-B still contained approximately 6.0-inches of flood water from Hurricane Floyd on the day of sampling. The atypical rapid recharge that was observed in WP-2 during purging suggests that this standing water may have been leaking through the floor of the building. Therefore, it is possible that this leakage may have resulted in a diluted groundwater sample.

Downgradient monitoring point WP-1 contained 7,950 ppb of phenol, but no detectable concentrations of this compound were found in MW-21. The results for MW-21 are consistent with the historical data for this well. The concentration of phenol in WP-1 has decreased since July 1999 when 15,600 ppb was detected. The decrease in phenol in WP-1 during this sampling event is consistent with a pattern dating back to June 1997.

4.11 January 2000 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 10 and 13 January 2000. The results of this sampling event are summarized below. As was discussed in Section 2.2, on 11 November 1999 a pneumatic submersible pump was installed in ORC-4D to conduct an extended pump-out to address the elevated concentrations of phenol, salicylic acid, and methanol that had been detected in this well during the past two groundwater sampling events. Details of the pump-out, which continued until 3 December 1999, are discussed below. On 6 January 2000, well points WP-1 and WP-2 were abandoned in preparation for the demolition of the Building 4/33/33-A/33-B complex. Each well was sealed by a licensed New Jersey well driller from Summit Drilling Co., Inc. (Summit).

4.11.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 24.

4.11.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. The concentrations of phenol, methanol, formaldehyde, and salicylic acid were either not detectable or below their GWQS in each well, except WP-5 which contained 2,410 ppb of salicylic acid.

None of the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) contained detectable concentrations of phenol, salicylic acid, formaldehyde or methanol.

4.11.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, ORC-4D, and WP-3R. Phenol was detected in MW-28D and ORC-4D at concentrations of 5,410 ppb and 31,000 ppb, respectively. Methanol and formaldehyde were only detected in ORC-4D at concentrations of 3,600 ppb and 57.0 ppb, respectively. Salicylic acid was detected in two of the source area wells at concentrations of 20,700 ppb (MW-28D) and 69,800 ppb (ORC-4D).

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone (MW-2D, MW-3D, MW-12D, and MW-32D).

The methanol concentration in ORC-4D (3,600 ppb) continued the decreasing trend observed during the pump-out. The concentration of phenol (31,000 ppb) and salicylic acid (69,800 ppb) in ORC-4D increased relative to the last day of the pump-out. However, the concentrations seen in January 2000 were still 70% (phenol) and 88% (salicylic acid) lower than in October 1999.

4.11.2 Northwest Phenol Hot Spot (Building 33-B)

On 6 January 2000, WP-1 and WP-2 were abandoned in preparation for the demolition of the Building 4/33/33-A/33-B complex. Therefore, only MW-21 was sampled during the January 2000 monitoring event. The analytical result for this sample is summarized on Table 25. No detectable concentration of phenol was found in MW-21 during this monitoring event. This result is consistent with the historical data for this well.

4.12 April 2000 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 12 and 13 April 2000. Monitoring wells MW-2 and MW-2D could not be sampled this quarter since they were both buried under demolition debris from the Building 4/33/33-A/33-B complex. The results of this sampling event are summarized below.

4.12.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 26.

4.12.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. The concentrations of phenol, methanol, and formaldehyde were either not detectable or below their GWQS in each well. Salicylic acid was detected in WP-5 (765 ppb) and ORC-2 (536 ppb) at concentrations that exceeded the NJDEP's IGWQS of 80.0 ppb, but were below EPI's proposed IGWQS of 5,600 ppb.

None of the downgradient monitoring points in the shallow overburden zone (MW-3, MW-18, MW-28, and MW-32) had detectable concentrations of phenol, salicylic acid, formaldehyde or methanol (except MW-18 which contained 73.0 ppb of formaldehyde).

4.12.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, ORC-4D, and WP-3R. Phenol was detected in MW-28D and ORC-4D at concentrations of 6,040 ppb and 69,600 ppb, respectively. Methanol and formaldehyde were detected in ORC-4D at concentrations of 3,980 ppb and 100 ppb, respectively. Salicylic acid was detected in two of the source area wells at concentrations of 7,850 ppb (MW-28D) and 276,000 ppb (ORC-4D).

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, and MW-32D).

4.12.2 Northwest Phenol Hot Spot (Building 33-B)

On 6 January 2000, WP-1 and WP-2 were abandoned in preparation for the demolition of the Building 4/33/33-A/33-B complex. Therefore, only MW-21 was sampled during the April 2000 monitoring event. The analytical result for this sample is summarized on Table 27. No detectable concentration of phenol was found in MW-21 during this monitoring event. This result is consistent with the historical data for this well.

4.13 July 2000 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 11 and 13 July 2000. Replacement wells WP-1R and WP-2R were installed on 16 June 2000, and were available for sampling during the July 2000 monitoring event. MW-2 and MW-2D were still buried under demolition debris and could not be sampled during this monitoring event. The results of this sampling event are summarized below.

4.13.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

The analytical results for these samples are summarized on Table 28.

4.13.1.1 *Shallow Overburden Zone*

The concentrations of phenol, methanol, formaldehyde, and salicylic acid were either not detectable or below their GWQS in source are wells WP-5, WP-6, and ORC-2.

None of the downgradient monitoring points in the shallow overburden zone (MW-3, MW-18, MW-28, and MW-32) had detectable concentrations of phenol, salicylic acid, formaldehyde or methanol (except MW-3 which contained 5.8 ppb of phenol).

4.13.1.2 *Deep Overburden Zone*

The deep overburden wells within the source area are MW-28D, ORC-4D, and WP-3R. Phenol was detected in MW-28D and ORC-4D at concentrations of 7,760 ppb and 95,500 ppb, respectively.

Methanol and formaldehyde were detected in ORC-4D at concentrations of 11,800 ppb and 62.0 ppb, respectively. Salicylic acid was detected in two of the source area wells at concentrations of 10,000 ppb (MW-28D) and 296,000 ppb (ORC-4D).

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, and MW-32D).

4.13.2 Northwest Phenol Hot Spot (Former Building 33-B)

Previous rounds of sampling have confirmed that well point WP-2 is a hot spot for phenol in groundwater. Unlike in the wells located in the Northeast Phenol Hot Spot, phenol concentrations in the shallow overburden zone have not significantly decreased over the last several years. Based on observations made during the demolition of other buildings at the site, it is possible that WP-2 was installed within a honeycomb of footings that created isolated pockets of groundwater. The demolition of the Building 4/33/33-A/33-B complex and the removal of the footings should create more favorable conditions for biodegradation to occur.

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2R
Monitoring Points	WP-1R, MW-21

The analytical results for these samples are summarized on Table 29.

WP-2R contained 173,000 ppb of phenol, which is consistent with the historical concentrations for original well WP-2. This is the highest concentration of phenol seen since January 1999 (144,000 ppb), and may reflect phenol being flushed from the soil into the groundwater. A similar type of concentration spike was observed in several of the wells in the Northeast Phenol Hot Spot area after the Building 10/36 complex was demolished.

Downgradient monitoring point WP-1R contained 71.4 ppb of phenol, significantly less than the last time the well was sampled (7,950 ppb in October 1999). No detectable concentrations of phenol were found in MW-21, which is consistent with the historical data for this well.

4.14 26 July 2000 Sampling Event

Monitoring wells ORC-4D, MW-47D, MW-48D, MW-49D, and MW-50D were sampled on 26 July 2000 as part of the investigation to determine a potential source of the phenol, methanol, and salicylic acid in ORC-4D. The analytical results for this sampling event are summarized on Table 30. Methanol was detected at a concentration exceeding the 50,000 ppb IGWQS only in MW-47D (6,600,000 ppb). Phenol exceeded the GWQS of 4,000 ppb in ORC-4D (79,600 ppb), MW-47D (171,000 ppb), MW-48D (20,400 ppb), and MW-50D (47,800 ppb). Salicylic acid concentrations exceeded EPI's proposed IGWQS of 5,600 ppb in ORC-4D (91,700 ppb), MW-47D (225,000 ppb), MW-48D (19,200 ppb), and MW-50D (13,800 ppb). Salicylic acid exceeded the NJDEP's IGWQS of 80.0 ppb in MW-49D (3,060 ppb).

4.15 23 August 2000 Sampling Event

A second, confirmatory round of samples was collected from ORC-4D, MW-47D, MW-48D, MW-49D, and MW-50D on 23 August 2000. The analytical results for these samples are summarized on Table 31. Consistent with the 26 July 2000 sampling results, ORC-4D, MW-47D, MW-48D, and MW-50D contained concentrations of methanol, phenol, and/or salicylic acid exceeding their respective GWQS. Elevated concentrations of methanol were only detected in MW-47D (10,900,000 ppb). Phenol exceeded the GWQS of 4,000 ppb in ORC-4D (51,900 ppb), MW-47D (170,000 ppb), MW-48D (22,600 ppb), and MW-50D (17,600 ppb). Salicylic acid concentrations exceeded EPI's proposed IGWQS of 5,600 ppb in ORC-4D (185,000 ppb), MW-47D (429,000 ppb), MW-48D (135,000 ppb), and MW-50D (26,600 ppb). Salicylic acid exceeded the NJDEP's IGWQS of 80.0 ppb in MW-49D (3,410 ppb).

4.16 October 2000 Sampling Event

During the demolition of Building 1, the top of MW-2D was severely damaged, which allowed soil and debris to enter and fill the bottom 10.0 feet of the well. Several attempts to redevelop MW-2D to remove the obstruction were unsuccessful, and it became necessary to abandon the well. On 26 October 2000, Summit abandoned MW-2D by first over-drilling the well to remove all well materials from the subsurface, and then sealing the borehole to grade with grout. Since MW-2D monitored the downgradient extent of compounds of concern from the Northeast Phenol Hot Spot in the deep overburden zone, a replacement well was installed.

The replacement well for MW-2D was also installed by Summit on 26 October 2000. MW-2DR is located approximately 3.0 feet of the original well location, has a depth of 34.0 feet, and is constructed with 10.0 feet of 4.0-inch diameter, 20-slot, Sch. 40 PVC screen and approximately 26.0 feet of PVC casing (to account for the stick-up above grade). The screened interval of MW-2DR is identical to that of the original well. The well head was completed with a protective steel standpipe and locking cap.

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas between 10 and 12 October 2000. The results of this sampling event are summarized below.

4.16.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

<u>Source Area Wells</u>	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
<u>Monitoring Points</u>	MW-2, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

As was discussed above, MW-2D was damaged during building demolition activities and could not be sampled, and MW-2DR was not installed until after this monitoring event was completed. The analytical results for these samples are summarized on Table 32.

4.16.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. The concentrations of phenol, methanol, and formaldehyde in WP-5 and ORC-2 were either not detectable or below their GWQS in each well during this monitoring event. Salicylic acid was detected at 1,560 ppb in WP-5 and 14.8 ppb in ORC-2. Well point WP-6 did not recharge after purging and could not be sampled.

None of the groundwater samples from the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) had detectable concentrations of phenol, salicylic acid, formaldehyde, or methanol (except MW-18 which contained 2.3 ppb of phenol and 8.9 ppb of salicylic acid).

4.16.1.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (7,170 ppb), MW-47D (330,000 ppb), MW-48D (14,500 ppb), MW-50D (49,000 ppb), and ORC-4D (94,500 ppb). Methanol and formaldehyde were detected in ORC-4D at concentrations of 2,470 ppb and 52.0 ppb, respectively, and in MW-47D at concentrations of 7,550,000 ppb and 1,600 ppb, respectively. Salicylic acid was detected in six of the source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, including MW-28D (10,300 ppb), MW-47D (573,000 ppb), MW-48D (346,000 ppb), MW-49D (7,410 ppb), MW-50D (7,920 ppb), and ORC-4D (243,000 ppb).

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, and MW-32D).

4.16.2 Northwest Phenol Hot Spot (Former Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2R
Monitoring Points	WP-1R, MW-21

The analytical results for these samples are summarized on Table 33.

WP-2R contained 180,000 ppb of phenol, which is consistent with the historical concentrations for original well WP-2. This is the highest concentration of phenol seen since January 1999 (144,000 ppb), and may reflect phenol being flushed from the soil into the groundwater. A similar type of concentration spike was observed in several of the wells in the Northeast Phenol Hot Spot area after the Building 10/36 complex was demolished.

Downgradient monitoring point WP-1R contained 71.4 ppb of phenol, while no detectable concentrations of phenol were found in MW-21. These results are consistent with the historical data for both wells.

4.17 19 December 2000 Sampling Event

Monitoring wells MW-52D, MW-53D, MW-54D, and MW-55D were installed in November 2000 for the purposes of delineating the phenol, methanol, and salicylic acid detected in ORC-4D and MW-47D. These new wells, plus replacement well MW-2DR, were sampled for the first time on 19 December 2000. The analytical results for this sampling event are summarized on Table 34. Methanol concentrations were below the 50,000 ppb IGWQS in all five wells. Phenol only exceeded the GWQS of 4,000 ppb in MW-55D (143,000 ppb). Salicylic acid concentrations exceeded EPI's proposed IGWQS of 5,600 ppb in MW-55D (79,400 ppb), and exceeded the NJDEP's IGWQS of 80.0 ppb in MW-2DR (4,870 ppb) and MW-52D (404 ppb).

4.18 January 2001 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas on 24 and 25 January 2001. The results of this sampling event are summarized below.

4.18.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-50D, MW-55D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2DR, MW-3, MW-3D, MW-12D, MW-18, MW-27D, MW-28, MW-32, MW-32D, MW-49D, MW-52D, MW-53D, MW-54D

Monitoring well MW-27D was added to this sampling event to monitor groundwater quality to the south of MW-50D and MW-52D. MW-53D was buried under snow and ice and could not be opened for sampling. The analytical results for these samples are summarized on Table 35.

4.18.1.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2. With the exception of 165 ppb of salicylic acid in WP-5, the concentrations of phenol, methanol, formaldehyde, and salicylic acid in WP-5 and ORC-2 were either not detectable or below their GWQS in each well during this monitoring event. The concentrations of methanol and formaldehyde were also below their respective GWQS in WP-6. Well point WP-6 did not recharge sufficiently after purging to allow a phenol and salicylic acid sample to be collected.

The concentrations of phenol, salicylic acid, methanol, and formaldehyde were below their respective GWQS in all of the samples from the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32).

In ORC-2 and WP-6, the concentrations of phenol, salicylic acid, methanol, and formaldehyde have been below their respective GWQS since April 1999 (with the exception of salicylic acid in ORC-2 in April 2000). In WP-5, methanol and formaldehyde concentrations have been below their GWQS since October 1998, and phenol concentrations have been below its GWQS since July 1999. Although salicylic acid concentrations in WP-5 exceed the NJDEP's IGWQS of 80.0 ppb, they have been below EPI's proposed alternate GWQS of 5,600 ppb since October 1998. In addition, a Mann-Whitney U-Test conducted using data from the last eight rounds of samples (January 1999 through January 2001, excluding October 1999 when a sample could not be collected) indicates that a decreasing trend exists for salicylic acid concentrations in WP-5. In the downgradient monitoring wells, the concentrations of all four compounds of concern have been below their applied GWQS since October 1998 (MW-18, MW-32), January 1999 (MW-2, MW-3), and April 1999 (MW-28). Therefore, no additional samples will be collected from the shallow overburden zone wells in the Northeast Phenol Hot Spot area.

4.18.1.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-50D, MW-52D, MW-55D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (17,700 ppb), MW-47D (517,000 ppb), MW-48D (104,000 ppb), MW-50D (273,000 ppb), MW-55D (693,000 ppb), and ORC-4D (129,000 ppb). Methanol was detected in ORC-4D at 2,740 ppb, and in MW-47D at 6,280,000 ppb. Formaldehyde exceeded the GWQS of 100 ppb in MW-47D (1,500 ppb), MW-50D (360 ppb), MW-55D (250 ppb), and ORC-4D (160 ppb). Salicylic acid was detected in six of the source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, including MW-28D (23,000 ppb), MW-47D (980,000 ppb), MW-48D (1,200,000 ppb), MW-50D (39,000 ppb), MW-55D (356,000 ppb), and ORC-4D (509,000 ppb).

The concentrations of the phenol, salicylic acid, and methanol were either not detectable or below their respective GWQS in all of the side and downgradient monitoring points in the deep overburden zone (MW-2DR, MW-3D, MW-12D, MW-27D, MW-32D, MW-49D, MW-52D, and MW-54D), with the exception of MW-2DR and MW-49D which contained 4,760 ppb and 5,360 ppb of salicylic acid, respectively. Formaldehyde concentrations were below the GWQS in all of the side and downgradient monitoring points except MW-2DR (140 ppb).

4.18.2 Northwest Phenol Hot Spot (Former Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2R
Monitoring Points	WP-1R, MW-21

Due to the concentrations seen in MW-55D, each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270. The analytical results for these samples are summarized on Table 36.

WP-2R contained 166,000 ppb of phenol, which is consistent with the historical concentrations for original well WP-2. This concentration is slightly lower than in October 2000 (180,000 ppb). Salicylic acid was detected at 59,800 ppb in WP-2R.

Downgradient monitoring point WP-1R contained 2,810 ppb of phenol and 354 ppb of salicylic acid; no detectable concentrations of these compounds were found in MW-21. These results are consistent with the historical data for both wells.

4.19 April 2001 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas on 10 and 11 April 2001. The results of this sampling event are summarized below.

4.19.1 Northeast Phenol Hot Spot (Former Building 10/36)

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the deep overburden zone (i.e., below the clay layer) in the area of former Building 10/36 in the northeast corner of the site, groundwater samples were collected from the following wells:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, WP-3R, ORC-4D
Monitoring Points	MW-2DR, MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, MW-54D

The analytical results for these samples are summarized on Table 37.

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-52D, MW-55D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (5,110 ppb), MW-47D (21,200 ppb), MW-48D (12,900 ppb), MW-50D (12,100 ppb), MW-55D (134,000 ppb), and ORC-4D (24,800 ppb). Methanol only exceeded the IGWQS of 50,000 ppb in MW-47D (9,590,000 ppb). Formaldehyde exceeded the GWQS of 100 ppb in MW-47D (990 ppb), MW-50D (200 ppb), and ORC-4D (140 ppb). Salicylic acid was detected in seven of the source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, including MW-28D (8,200 ppb), MW-47D (36,300 ppb), MW-48D (56,900 ppb), MW-49D (15,500 ppb), MW-50D (6,040 ppb), MW-55D (144,000 ppb), and ORC-4D (36,100 ppb).

The concentrations of the phenol, salicylic acid, and methanol were either not detectable or below their respective GWQS in all of the side and downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, and MW-54D), with the exception of MW-2DR, which contained 7,670 ppb of salicylic acid. Formaldehyde concentrations were below the GWQS in all of the side and downgradient monitoring points except MW-2DR (270 ppb) and MW-52D (270 ppb).

4.19.2 Northwest Phenol Hot Spot (Former Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2R
Monitoring Points	WP-1R, MW-21

The analytical results for these samples are summarized on Table 38.

WP-2R contained 1,570 ppb of phenol, which is only the second time since April 1997 that the concentration of this compound has been below the GWQS of 4,000 ppb. This concentration is significantly lower than in January 2001 (166,000 ppb), and may be related to an unusually high water level in the well. As shown on the concentration vs. time graph in Appendix E, the last time the concentration of phenol in WP-2/WP-2R was below the GWQS was in October 1999, which was also a period of high water levels in the well (due to Hurricane Floyd). Salicylic acid was detected in WP-2R at a concentration of 665 ppb.

Downgradient monitoring point WP-1R contained 8,200 ppb of phenol and 248 ppb of salicylic acid; no detectable concentrations of these compounds were found in MW-21. The phenol concentration in WP-1R is the highest observed since October 1999, which is the last time the levels exceeded the GWQS.

4.20 July 2001 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas on 18 and 19 July 2001. The results of this sampling event are summarized below.

4.20.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following deep overburden zone wells during this monitoring event:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, WP-3R, ORC-4D
Monitoring Points	MW-2DR, MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, MW-54D

The analytical results for these samples are summarized on Table 39.

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-52D, MW-55D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (4,340 ppb), MW-47D (302,000 ppb), MW-48D (15,000 ppb), MW-50D (10,800 ppb), MW-55D (144,000 ppb), and ORC-4D (20,400 ppb). Methanol only exceeded the IGWQS of 50,000 ppb in MW-47D (8,540,000 ppb). Formaldehyde only exceeded the GWQS of 100 ppb in MW-47D (660 ppb). Salicylic acid was detected in four source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (4,070 ppb), MW-47D (1,370,000 ppb), MW-48D (88,200 ppb), MW-49D (2,770 ppb), MW-50D (2,570 ppb), MW-55D (58,100 ppb), and ORC-4D (79,100 ppb).

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all of the side and downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, and MW-54D), with the exception of MW-2DR, which contained 2,380 ppb of salicylic acid and 140 ppb of formaldehyde.

4.20.2 Northwest Phenol Hot Spot (Former Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2R
<u>Monitoring Points</u>	WP-1R, MW-21

The analytical results for these samples are summarized on Table 40.

The phenol concentration in WP-2R rebounded to 154,000 ppb in July 2001. This increase in concentration, in conjunction with a lower groundwater elevation, appears to confirm that the April 2001 results for this well were anomalously low due to a greater volume of water in the well. The concentration of salicylic acid also increased during this sampling event (to 50,100 ppb).

Downgradient monitoring point WP-1R contained 3.7 ppb of phenol and no detectable concentration of salicylic acid. Consistent with previous sampling events, no detectable concentrations of phenol or salicylic acid were found in MW-21.

4.21 October 2001 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas on 24 and 25 October 2001. Monitoring well MW-12D was covered by debris from the demolition of Building 31 and Building 32 and could not be sampled. The results of this sampling event are summarized below.

4.21.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following deep overburden zone wells during this monitoring event:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-3R
Monitoring Points	MW-2DR, MW-3D, MW-32D, MW-52D, MW-53D, MW-54D

The analytical results for these samples are summarized on Table 41.

Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (15,600 ppb), MW-47D (179,000 ppb), MW-48D (34,000 ppb), MW-50D (11,500 ppb), and MW-55D (113,000 ppb). MW-47D was the only well that contained methanol (8,280,000 ppb) at a concentration exceeding its IGWQS of 50,000 ppb. Formaldehyde concentrations exceeded the IGWQS of 100 ppb in MW-47D (620 ppb) and MW-50D (110 ppb). Salicylic acid was detected in five source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in six of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (17,000 ppb), MW-47D (568,000 ppb), MW-48D (251,000 ppb), MW-49D (6,960 ppb), MW-50D (2,680 ppb), and MW-55D (79,900 ppb).

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all of the side and downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, and MW-54D), with the exception of MW-2DR, which contained 1,540 ppb of salicylic acid and 140 ppb of formaldehyde.

4.21.2 Northwest Phenol Hot Spot (Former Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2R
<u>Monitoring Points</u>	WP-1R, MW-21

The analytical results for these samples are summarized on Table 42.

Phenol and salicylic acid were detected at 101,000 ppb and 59,300 ppb, respectively, in WP-2R during the October 2001 sampling event. Downgradient monitoring point WP-1R contained 32.4 ppb of phenol and no detectable concentration of salicylic acid. Consistent with previous sampling events, no detectable concentrations of phenol or salicylic acid were found in MW-21.

4.22 January 2002 Sampling Event

Groundwater samples were collected from wells addressing the Northeast and Northwest Phenol Hot Spot areas on 15 and 16 January 2002. The results of this sampling event are summarized below.

4.22.1 Northeast Phenol Hot Spot (Former Building 10/36)

Groundwater samples were collected from the following deep overburden zone wells during this monitoring event:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-3R
Monitoring Points	MW-2DR, MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, MW-54D

The analytical results for these samples are summarized on Table 43.

Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (228,000 ppb), MW-48D (85,600 ppb), MW-50D (8,660 ppb), MW-55D (89,200 ppb), and ORC-4D (18,600 ppb). MW-47D was the only well that contained methanol (6,420,000 ppb) at a concentration exceeding its IGWQS of 50,000 ppb. Salicylic acid was detected in six source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (151 ppb), MW-47D (191,000 ppb), MW-48D (219,000 ppb), MW-49D (12,400 ppb), MW-50D (6,890 ppb), MW-55D (15,100 ppb), and ORC-4D (24,700 ppb).

Formaldehyde was detected at concentrations exceeding its IGWQS of 100 ppb in MW-47D (490 ppb) and MW-50D (150 ppb). However, since the analytical laboratory inadvertently preserved all of the samples with sulfuric acid (the analytical method for formaldehyde requires that the groundwater samples be un-acidified), all of the formaldehyde results for the January 2002 sampling event are considered to be estimated.

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all of the side and downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, and MW-54D), with the exception of MW-2DR, which contained 1,960 ppb of salicylic acid.

4.22.2 Northwest Phenol Hot Spot (Former Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2R
Monitoring Points	WP-1R, MW-21

The analytical results for these samples are summarized on Table 44.

Phenol and salicylic acid were detected at 23,800 ppb and 3,090 ppb, respectively, in WP-2R during the January 2002 sampling event. Downgradient monitoring point WP-1R contained 77.2 ppb of phenol and 12.4 ppb of salicylic acid. MW-21 contained 26.9 ppb of phenol but no detectable concentration of salicylic acid.

4.23 April 2002 Sampling Event

As per the monitoring program for the Northeast and Northwest Phenol Hot Spot Area wells that was proposed in Section 7.0 of the 1 May 2002 *Remedial Investigation Report Addendum No. 2* (RIRA-2), all of the groundwater samples collected during the April 2002 monitoring event were analyzed for volatile organic compounds (VOCs) by USEPA Method 624 and base neutral/acid extractable compounds (BNAs) by USEPA Method 8270 (including calibrations for salicylic acid).

Although at one time the Northeast and Northwest Phenol Hot Spots appeared to be distinct areas, current groundwater sampling results suggest that they completely overlap and cannot be differentiated. Therefore, starting with this sampling event, these two areas will be combined and referred to as the Northen Phenol Area. Groundwater samples were collected from wells addressing the Northern Phenol Area between 16 and 18 April 2002. The results of this sampling event are summarized below.

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-2R, WP-3R
Monitoring Points	MW-2DR, MW-3D, MW-12D, MW-21, MW-32D, MW-52D, MW-53D, MW-54D, WP-1R

The analytical results for these samples are summarized on Table 45.

The formaldehyde samples from MW-47D, MW-48D, MW-53D, MW-55D, and ORC-4D were mishandled by the overnight courier and did not arrive at the analytical laboratory until after the holding time had expired. Therefore, the formaldehyde samples for these wells were not analyzed during the April 2002 sampling event.

4.23.1 Shallow Overburden Zone

No VOCs were detected in shallow overburden zone wells MW-21, WP-1R, or WP-2R at concentrations exceeding their respective GWQS. Phenol and salicylic acid were detected at 33,700 ppb and 13,700 ppb, respectively, in WP-2R during the April 2002 sampling event. Downgradient monitoring point WP-1R contained 14.3 ppb of phenol, but no detectable concentration of salicylic acid. Phenol and salicylic acid were not detected in MW-21 during this sampling event. Formaldehyde and methanol were either not detected or present at concentrations below their respective IGWQS in all three wells, with the exception of WP-1R which contained 170 ppb of formaldehyde.

4.23.2 Deep Overburden Zone

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (295,000 ppb), MW-48D (36,000 ppb), MW-50D (23,200 ppb), MW-

55D (196,000 ppb), and ORC-4D (36,800 ppb). MW-47D was the only well that contained methanol at a concentration (5,690,000 ppb) exceeding its IGWQS of 50,000 ppb. Salicylic acid was detected in six source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (1,240 ppb), MW-47D (176,000 ppb), MW-48D (139,000 ppb), MW-49D (7,810 ppb), MW-50D (5,870 ppb), MW-55D (11,400 ppb), and ORC-4D (138,000 ppb).

Formaldehyde was detected in the source area wells at concentrations exceeding its IGWQS of 100 ppb in MW-28D (210 ppb) and MW-50D (330 ppb).

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all but two of the side and downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, and MW-54D). MW-2DR contained 3,490 ppb of salicylic acid and 150 ppb of formaldehyde, while MW-52D contained 160 ppb of formaldehyde.

Tetrachloroethene (PCE) exceeded its GWQS of 1.0 ppb in MW-52D (5.6 ppb). Trichloroethene (TCE) exceeded its GWQS in MW-2DR (2.7 ppb), MW-12D (41.1 ppb), MW-48D (2.9 ppb), MW-50D (6.2 ppb), MW-52D (127 ppb), MW-53D (59.2 ppb), MW-54D (36.7 ppb), and ORC-4D (3.5 ppb). Vinyl chloride exceeded its GWQS of 5.0 ppb in MW-2DR (21.0 ppb), MW-3D (33.0 ppb), MW-32D (25.9 ppb), MW-49D (79.0 ppb), MW-50D (29.3 ppb), and ORC-4D (7.9 ppb).

It should be noted that chlorinated VOCs were detected at concentrations exceeding their respective GWQS in all three deep overburden zone background wells. 1,1-Dichloroethane (1,1-DCA) and methylene chloride were detected in MW-35D at concentrations of 6.5 ppb and 3.1 ppb, respectively; the NJDEP's GWQS for these compounds are 2.0 ppb and 3.0 ppb, respectively. PCE exceeded 1.0 ppb in MW-20D (2.9 ppb) and MW-35D (7.3 ppb), while TCE also exceeded 1.0 ppb in MW-19D (7.4 ppb), MW-20D (21.7 ppb), and MW-35D (803 ppb).

2-Methylphenol and 3&4-methylphenol were detected in two deep overburden wells at concentrations exceeding the NJDEP's Interim Generic GWQS of 100 ppb for each of these compounds. 2-Methylphenol exceeded 100 ppb in MW-47D (215 ppb) and MW-55D (190 ppb), while 3&4-

methylphenol also exceeded 100 ppb in MW-47D (682 ppb) and MW-55D (130 ppb). Both of these wells also contained elevated concentrations of phenol during this monitoring event.

4.24 1 May 2002 Sampling Event

Monitoring wells MW-47D2, MW-57D, MW-58, MW-58D, MW-59, MW-59D, and WP-2D were installed in April 2002 for the purposes of completing the horizontal and vertical delineation of the phenol, salicylic acid, methanol, and formaldehyde in the Northern Phenol Area. These new wells were sampled for the first time on 1 May 2002. The analytical results for this sampling event are summarized on Table 46. Methanol and formaldehyde concentrations were their respective IGWQS' in all seven wells. Phenol exceeded the GWQS of 4,000 ppb in shallow overburden zone well MW-58 (9,230 ppb) and MW-57D (19,900 ppb). Salicylic acid concentrations exceeded EPI's proposed IGWQS of 5,600 ppb in MW-57D (119,000 ppb), and exceeded the NJDEP's IGWQS of 80.0 ppb in MW-47D2 (231 ppb), MW-58 (1,890 ppb) and WP-2D (567 ppb).

4.25 July 2002 Sampling Event

Groundwater samples were collected from wells addressing the Northern Phenol Area between 16 and 18 July 2002. The results of this sampling event are summarized below.

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells during this monitoring event:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, WP-1R

The analytical results for these samples are summarized on Table 47.

The formaldehyde sample bottle for MW-2DR broke while in transit to the analytical laboratory. Therefore, MW-2DR was not analyzed for this parameter during the July 2002 monitoring event.

4.25.1 Shallow Overburden Zone

The shallow overburden zone wells within the source area include WP-2R and MW-58. Phenol was detected at 90,700 ppb in WP-2R and at 9,880 ppb in MW-58. Salicylic acid was detected at 48,700 ppb and 379 ppb in WP-2R and MW-58, respectively. WP-2R also contained 300 ppb of formaldehyde and 10,800 ppb of methanol, while MW-58 contained 62.0 ppb of formaldehyde but no detectable concentration of methanol. The concentrations of phenol, formaldehyde, and methanol were either not detectable or below their respective groundwater quality standards in monitoring points MW-21, MW-51, MW-59, and WP-1R. Salicylic acid only exceeded its IGWQS of 80.0 ppb in WP-1R (145 ppb).

Vertical delineation well WP-2D contained 380 ppb of phenol and 293 ppb of salicylic acid, but no detectable concentrations of methanol or formaldehyde.

4.25.2 Deep Overburden Zone

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, MW-57D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (228,000 ppb), MW-48D (119,000 ppb), MW-50D (53,700 ppb), MW-55D (57,700 ppb), and ORC-4D (30,300 ppb). MW-47D was the only well that contained methanol at a concentration (2,930,000 ppb) exceeding its IGWQS of 50,000 ppb. Salicylic acid was detected in five source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in nine of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (116 ppb), MW-47D (684,000 ppb), MW-48D (164,000 ppb), MW-49D (756 ppb), MW-50D (13,000 ppb), MW-55D (4,320 ppb), MW-57D (295,000 ppb), ORC-4D (112,000 ppb), and WP-3R (90.7 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb only in MW-47D (360 ppb).

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all of the monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-58D, and MW-59D) except MW-2DR, which contained 295 ppb of salicylic acid.

Vertical delineation well MW-47D2 contained 14.5 ppb of phenol, 56.1 ppb of salicylic acid, and no detectable concentrations of formaldehyde or methanol.

4.26 October/November 2002 Sampling Event

The groundwater monitoring program for the Northern Phenol Area that was proposed in the 1 May 2002 RIRA-2 was approved by the NJDEP in their letter dated 30 July 2002. Groundwater samples were collected from wells addressing the Northern Phenol Area between 15 and 17 October 2002 and on 6 November 2002. The results of this sampling event are summarized below.

Groundwater samples were collected from the following shallow and deep overburden zone wells during this monitoring event:

<u>Source Area Wells</u>:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
<u>Monitoring Points</u>:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-51D, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

In addition to phenol, salicylic acid, methanol, and formaldehyde, the groundwater samples from MW-21D and MW-51D were analyzed for methyl salicylate by USEPA Method 8270. The analytical results for these samples are summarized on Table 48.

4.26.1 Shallow Overburden Zone

The shallow overburden zone wells within the source area include WP-2R and MW-58. Phenol was detected at 74,400 ppb in WP-2R and at 14,400 ppb in MW-58. Salicylic acid was detected at 49,100 ppb and 10,300 ppb in WP-2R and MW-58, respectively. WP-2R also contained 11,800 ppb of methanol; no detectable concentrations of formaldehyde were found in these two wells. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-59, MW-62, and WP-1R. Vertical delineation well WP-2D contained 51.0 ppb of phenol, but no detectable concentrations of salicylic acid, methanol or formaldehyde.

4.26.2 Deep Overburden Zone

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, MW-57D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (299,000 ppb), MW-48D (209,000 ppb), MW-49D (6,250 ppb), MW-50D (17,700 ppb), MW-51D (12,600 ppb), MW-55D (93,700 ppb), and ORC-4D (98,500 ppb). MW-47D was the only well that contained methanol at a concentration (913,000 ppb) exceeding its IGWQS of 50,000 ppb. This is the lowest methanol concentration ever detected in MW-47D, and represents the sixth consecutive quarter that concentrations of this compound have decreased in this well. Salicylic acid was detected in five source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-47D (1,490,000 ppb), MW-48D (659,000 ppb), MW-49D (24,600 ppb), MW-50D (2,960 ppb), MW-51D (70,700 ppb), MW-57D (1,760 ppb), and ORC-4D (520,000 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb only in MW-47D (230 ppb). Methyl salicylate was detected in MW-51D at a concentration of 59.9 ppb, well below its IGWQS of 4,000 ppb.

The concentrations of the phenol, salicylic acid, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-58D, and MW-59D) except MW-2DR and MW-58D. Salicylic acid was detected at 7,470 ppb in MW-2DR, and formaldehyde was detected in MW-2DR and MW-58D at concentrations of 120 ppb and 490 ppb, respectively.

Vertical delineation well MW-47D2 contained 14.8 ppb of phenol, and no detectable concentrations of salicylic acid, formaldehyde or methanol.

4.27 January 2003 Sampling Event

Groundwater samples were collected from wells addressing the Northern Phenol Area between 14 and 16 January 2003. The results of this sampling event are summarized below.

Groundwater samples were collected from the following shallow and deep overburden zone wells during this monitoring event:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

The analytical results for these samples are summarized on Table 49.

4.27.1 Shallow Overburden Zone

The shallow overburden zone wells within the source area include WP-2R and MW-58. Phenol was detected at 41,100 ppb in WP-2R and at 1,930 ppb in MW-58. Salicylic acid was detected at 22,900 ppb and 1,480 ppb in WP-2R and MW-58, respectively. WP-2R also contained 2,010 ppb of methanol; no detectable concentrations of formaldehyde were found in these two wells. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-59, MW-62, and WP-1R.

Vertical delineation well WP-2D contained 14.5 ppb of phenol, but no detectable concentrations of salicylic acid, methanol or formaldehyde.

4.27.2 Deep Overburden Zone

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (184,000 ppb), MW-48D (189,000 ppb), MW-50D (12,200 ppb), MW-51D (13,100 ppb), MW-55D (41,000 ppb), and ORC-4D (95,300 ppb). MW-47D was the only well that contained methanol at a concentration (477,000 ppb) exceeding its IGWQS of 50,000 ppb. This is the lowest methanol concentration ever detected in MW-47D, and represents the seventh consecutive quarter that concentrations of this compound have decreased in this well. Salicylic acid was detected in three source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (88.2 ppb), MW-47D (583,000 ppb), MW-48D (563,000 ppb), MW-50D (1,460 ppb), MW-51D (5,280 ppb), MW-55D (1,070 ppb), and ORC-4D (258,000 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb only in MW-47D (450 ppb). Methyl salicylate was detected in MW-51D at a concentration of 2.3 ppb, well below its IGWQS of 4,000 ppb. The methyl salicylate concentration in MW-51D confirms the results from this well in October 2002 (59.9 ppb), and suggests that the methyl salicylate in soil is not impacting groundwater quality. The high concentration of methyl salicylate seen in the July 2002 groundwater sample from temporary well point TWP-2 was probably caused by globules of product in the sample. In order to confirm that the low concentrations of methyl salicylate are not due to problems related to the analytical method, matrix spike and matric spike duplicate samples will be collected from MW-51D during the April 2003 and July 2003 monitoring events.

The concentrations of the phenol, salicylic acid, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, MW-58D, and MW-59D) except MW-2DR, which contained 113 ppb of salicylic acid. Vertical delineation well MW-47D2 contained no detectable concentrations of phenol, salicylic acid, formaldehyde or methanol during this sampling event.

4.28 April 2003 Sampling Event

As per the approved monitoring program for the Northern Phenol Area, all of the groundwater samples collected during the April 2003 monitoring event were analyzed for VOCs by USEPA Method 624 and BNAs by USEPA Method 8270. The BNA analyses included calibrations for salicylic acid for all samples, and methyl salicylate for samples from MW-21D and MW-51D.

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

<u>Source Area Wells</u>:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
<u>Monitoring Points</u>:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

In addition to VOCs and BNAs, each groundwater sample was analyzed for methanol and formaldehyde. The analytical results for these samples are summarized on Table 50.

4.28.1 Shallow Overburden Zone

The shallow overburden zone wells within the source area include WP-2R and MW-58. Phenol was detected at 31,800 ppb in WP-2R and at 1,580 ppb in MW-58. Salicylic acid was detected at 15,300 ppb and 541 ppb in WP-2R and MW-58, respectively. WP-2R also contained 2,660 ppb of methanol and 626 ppb of formaldehyde, while MW-58 contained 357 ppb of formaldehyde. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-59, MW-62, and WP-1R. Benzene was detected at 13.6 ppb in MW-21; no other VOCs were detected in the shallow overburden zone monitoring wells at concentrations exceeding their respective GWQS or IGWQS.

Vertical delineation well WP-2D contained 0.87 ppb of phenol, but no detectable concentrations of salicylic acid, methanol or formaldehyde.

4.28.2 Deep Overburden Zone

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R. Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (109,000 ppb), MW-48D (168,000 ppb), and ORC-4D (50,400 ppb). Methanol did not exceed its IGWQS of 50,000 ppb, and was only detected in MW-47D (35,600 ppb) and ORC-4D (5,290 ppb). The methanol concentration in MW-47D is the lowest ever detected, and represents the eighth consecutive quarter that concentrations of this compound have decreased in this well. Salicylic acid was detected in four source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in six source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-47D (139,000 ppb), MW-48D (253,000 ppb), MW-49D (11,800 ppb), MW-51D (2,380 ppb), MW-55D (1,600 ppb), and ORC-4D (116,000 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb in MW-47D (3,180 ppb) and MW-55D (2,170 ppb). Methyl salicylate was detected in MW-51D at a concentration of 16.8 ppb, well below its IGWQS of 4,000 ppb. The methyl salicylate concentration in MW-51D is consistent with the results from this well in October 2002 (59.9 ppb) and January 2003 (2.3 ppb), and suggests that the methyl salicylate in soil is not impacting groundwater quality. In order to confirm that the low concentrations of methyl salicylate are not due to problems related to the analytical method, matrix spike and matric spike duplicate samples were collected from MW-51D during this sampling event; no QA/QC problems were encountered during the analysis of the BNA samples from MW-51D.

Benzene was detected at 2.8 ppb in MW-47D, 1.8 ppb in MW-51D, 1.4 ppb in MW-55D, and 2.7 ppb in ORC-4D. No other site related VOCs were detected in the deep overburden zone source area wells at concentrations exceeding their respective GWQS or IGWQS.

The concentrations of the phenol, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-2DR, MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, and MW-59D) except MW-58D, which contained 138 ppb of formaldehyde. Salicylic acid exceeded the NJDEP's IGWQS of 80.0 ppb in MW-2DR (424 ppb), MW-21D (797 ppb), and MW-53D (98.9 ppb). Benzene was detected in MW-2DR at a concentrations of 1.4 ppb. No other site related VOCs were detected in the deep overburden zone monitoring points at concentrations exceeding their respective GWQS or IGWQS.

Vertical delineation well MW-47D2 contained 6.1 ppb of phenol, but no detectable concentrations of salicylic acid, formaldehyde or methanol during this sampling event.

PCE exceeded its GWQS of 1.0 ppb in one deep overburden well (4.5 ppb in MW-52D). TCE exceeded its GWQS of 1.0 ppb in deep overburden wells MW-2DR (1.4 ppb), MW-12D (20.0 ppb), MW-48D (78.2 ppb), MW-52D (106 ppb), MW-53D (114 ppb), MW-54D (46.0 ppb), and ORC-4D (1.7 ppb). Vinyl chloride exceeded its GWQS of 5.0 ppb in deep overburden wells MW-2DR (19.5 ppb), MW-3D (27.8 ppb), MW-32D (16.4 ppb), MW-49D (62.9 ppb), MW-50D (6.3 ppb), and WP-2D (13.3 ppb).

It should be noted that PCE and TCE were detected at concentrations exceeding their respective GWQS in five of the seven background wells. PCE exceeded 1.0 ppb in MW-20D (1.6 ppb) and MW-35D (7.8 ppb), while TCE also exceeded 1.0 ppb in MW-19D (6.6 ppb), MW-20 (1.2 ppb), MW-20D (13.0 ppb), MW-35 (48.7 ppb), and MW-35D (694 ppb).

2-Chlorophenol exceeded its GWQS of 40.0 ppb only in deep overburden well MW-47D (74.3 ppb). 2-Methylphenol and 3&4-methylphenol were also detected in MW-47D at concentrations (128 ppb and

2,510 ppb, respectively) that exceeded their IGWQS of 100 ppb. 3&4-Methylphenol also exceeded its IGWQS in MW-48D (163 ppb). It should be noted that MW-47D and MW-48D also contain elevated concentrations of phenol.

5.0 NORTHERN PHENOL AREA - RECENT GROUNDWATER RESULTS

The following sections discuss the results of groundwater sampling events conducted in July 2003 and October 2003 that have not yet been submitted to the NJDEP. The supporting documentation for these sampling events (i.e., purging/sampling data, laboratory data packages, EDD diskettes) will be submitted to the NJDEP as a separate Remedial Action Progress Report.

5.1 July 2003 Sampling Event

Groundwater samples were collected from wells addressing the Northern Phenol Area between 15 and 18 July 2003. Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 51 and were used to prepare the groundwater elevation contour maps shown on Figure 13 and Figure 14.

Figure 13 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. None of the remediation systems in the southern half of the site (i.e., the air sparge/soil vapor extraction (AS/SVE) system in the southeast corner of the site, the vertical and horizontal injection wells of the air curtain in the southwest corner of the site, and the off-site SVE system beneath Hudson Street and Bloomingdale Avenue) were in operation at the time of sampling. Consistent with historical site conditions, a water table mound was present in the northeast corner of the site. A smaller water table mound was also observed around MW-4 and MW-17 in the southeast corner of the site. A slight water table depression was present around MW-5 in the southeast corner of the site.

Groundwater elevation contours for the deep overburden zone are shown on Figure 14. The direction of groundwater flow in the deep overburden zone continues to be to the west.

5.1.1 Northern Phenol Area

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

Each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015 - Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315. In addition, the groundwater samples from MW-21D and MW-51D were also analyzed for methyl salicylate by USEPA Method 8270. The results of these analyses are summarized on Table 52 and are presented on Figure 15 (shallow overburden zone) and Figure 16 (deep overburden zone). Concentration vs. Time graphs summarizing historical data for each well are included in Appendix E.

5.1.1.1 *Shallow Overburden Zone*

The shallow overburden zone wells within the source area include WP-2R and MW-58. As shown on Figure 15, phenol was detected at 24,600 ppb in WP-2R and at 6,280 ppb in MW-58. Salicylic acid was detected at 5,980 ppb and 1,770 ppb in WP-2R and MW-58, respectively. WP-2R also contained 865 ppb of methanol and 513 ppb of formaldehyde, while MW-58 contained 28.6 ppb of formaldehyde. The concentrations of phenol, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-59, MW-62, and WP-1R. MW-51 contained 17,000 ppb of phenol and 412 ppb of salicylic acid, but no detectable concentrations of formaldehyde or methanol. Salicylic acid was detected at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, but below EPI's proposed alternate GWQS of 5,600 ppb, in MW-62 (116 ppb) and WP-1R (147 ppb).

Vertical delineation well WP-2D contained 8.3 ppb of phenol, but no detectable concentrations of salicylic acid, methanol or formaldehyde.

5.1.1.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R (Figure 16). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (68,700 ppb), MW-48D (193,000 ppb), MW-50D (12,000 ppb), MW-55D (23,200 ppb), and ORC-4D (71,400 ppb). Methanol only exceeded its IGWQS of 50,000 ppb in MW-47D (562,000 ppb). Salicylic acid was detected in four source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in eight source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (123 ppb), MW-47D (326,000 ppb), MW-48D (586,000 ppb), MW-49D (7,640 ppb), MW-50D (1,340 ppb), MW-51D (176 ppb), MW-55D (128 ppb), and ORC-4D (193,000 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb in MW-47D (458 ppb) and MW-55D (2,180 ppb). Methyl salicylate was detected in MW-51D at a concentration of 9.6 ppb, well below its IGWQS of 4,000 ppb. The methyl salicylate concentration in MW-51D is consistent with the results from this well in October 2002 (59.9 ppb), January 2003 (2.3 ppb), and April 2003 (16.8 ppb) and suggests that the methyl salicylate in soil is not impacting groundwater quality. The high concentration of methyl salicylate seen in the July 2002 groundwater sample from temporary well point TWP-2 was probably caused by globules of product in the sample. In order to confirm that the low concentrations of methyl salicylate are not due to problems related to the analytical method, matrix spike and matric spike duplicate samples were collected from MW-51D during this sampling event; no QA/QC problems were encountered during the analysis of the BNA samples from MW-51D.

The concentrations of the phenol, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-2DR, MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, and MW-59D) except MW-57D, which contained 5,350 ppb of phenol, and MW-

58D, which contained 195 ppb of formaldehyde. Salicylic acid exceeded the NJDEP's IGWQS of 80.0 ppb in MW-3D (119 ppb), MW-21D (159 ppb), and MW-58D (120 ppb), and exceeded EPI's proposed alternate GWQS of 5,600 ppb in MW-2DR (13,500 ppb) and MW-57D (12,400 ppb).

Vertical delineation well MW-47D2 contained no detectable concentrations of phenol, salicylic acid, formaldehyde or methanol during this sampling event.

5.1.2 Distribution of Compounds of Concern

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 17 and 18, respectively. The area with the highest concentration of phenol in the shallow overburden zone extends to the south from former Building 33-B (24,600 ppb in WP-2R) to former Building 4 (17,000 ppb in MW-51). The area containing salicylic acid at concentrations exceeding the NJDEP's proposed IGWQS of 80.0 ppb encompasses all of the wells within the footprint of the former Building 4/33/33-A/33-B complex.

The distribution of formaldehyde in the shallow overburden zone is shown on Figure 19. Formaldehyde concentrations exceeding the IGWQS pf 100 ppb are limited to WP-2R (513 ppb). The concentrations of methanol in the shallow overburden zone did not exceed the IGWQS of 50,000 ppb during the July 2003 sampling event.

The distribution of phenol in the deep overburden zone is depicted on Figure 20. Phenol concentrations over 100,000 ppb were limited to MW-48D, with concentrations exceeding 10,000 ppb also encompassing MW-47D, MW-50D, MW-55D, and ORC-4D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-28D, MW-49D, MW-53D, and MW-54D.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 21. The areal extent of salicylic acid in the deep overburden zone is larger than that of phenol, with the highest concentrations (exceeding 100,000 ppb) being found in ORC-4D, MW-47D, and MW-48D. The area of the salicylic acid plume as defined by the NJDEP's proposed IGWQS of 80.0 ppb encompassed the entire northwest portion of the site.

The distribution of formaldehyde in the deep overburden zone is shown on Figure 22. Formaldehyde concentrations above 1,000 ppb were found in MW-55D, with concentrations exceeding the IGWQS of 100 ppb also being found in MW-47D and MW-58D.

The distribution of methanol in the deep overburden zone is shown on Figure 23. Methanol concentrations exceeding the NJDEP's IGWQS of 50,000 ppb are limited to the area around MW-47D.

5.2 October 2003 Sampling Event

Groundwater samples were collected from wells addressing the Northern Phenol Area between 14 and 17 October 2003. Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 53 and were used to prepare the groundwater elevation contour maps shown on Figure 24 and Figure 25.

Figure 24 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. None of the remediation systems in the southern half of the site were in operation at the time of sampling. Consistent with historical site conditions, a water table mound was present in the northeast corner of the site. Although the smaller water table mound typically observed around MW-4 and MW-17 in the southeast corner of the site was not present during this gauging event, a slight water table depression was observed around MW-5.

Groundwater elevation contours for the deep overburden zone are shown on Figure 25. The direction of groundwater flow in the deep overburden zone continues to be to the west.

5.2.1 Northern Phenol Area

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

Each groundwater sample was analyzed for phenol, salicylic acid, methanol, and formaldehyde. In addition, the groundwater samples from MW-21D and MW-51D were analyzed for methyl salicylate. The results of these analyses are summarized on Table 54 and are presented on Figure 26 (shallow overburden zone) and Figure 27 (deep overburden zone). Concentration vs. Time graphs summarizing historical data for each well are included in Appendix E.

5.2.1.1 *Shallow Overburden Zone*

The shallow overburden zone wells within the source area include WP-2R and MW-58. As shown on Figure 26, phenol was detected at 31,900 ppb in WP-2R and at 6,460 ppb in MW-58. Salicylic acid was detected at 7,770 ppb and 817 ppb in WP-2R and MW-58, respectively. WP-2R also contained 466 ppb of methanol and 1,920 ppb of formaldehyde, while MW-58 contained 294 ppb of formaldehyde. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-59, MW-62, and WP-1R, with the exception of 139 ppb of formaldehyde in MW-59.

Vertical delineation well WP-2D contained 113 ppb of phenol and 11.1 ppb of formaldehyde, but no detectable concentrations of salicylic acid or methanol during the October 2003 monitoring event.

5.2.1.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R (Figure 27). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (53,300 ppb), MW-48D (109,000 ppb), MW-50D (32,300 ppb), MW-55D (11,300 ppb), and ORC-4D (75,200 ppb). Methanol only exceeded its IGWQS of 50,000 ppb in MW-47D (206,000 ppb). Salicylic acid was detected in three source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (615 ppb), MW-47D (20,700 ppb), MW-48D (440,000 ppb), MW-49D (5,330 ppb), MW-50D (1,380 ppb), MW-55D (2,210 ppb), and ORC-4D (232,000 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb in MW-47D (2,760 ppb) and MW-55D (821 ppb). Methyl salicylate was not detected in MW-51D during this sampling event.

The concentrations of the phenol, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-2DR, MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, and MW-59D) except MW-58D, which contained 263 ppb of formaldehyde. Salicylic acid exceeded the NJDEP's IGWQS of 80.0 ppb in MW-2DR (184 ppb) and MW-57D (806 ppb).

Vertical delineation well MW-47D2 contained no detectable concentrations of phenol, salicylic acid, formaldehyde, or methanol during this sampling event.

5.2.2 Distribution of Compounds of Concern

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 28 and 29, respectively. The area with the highest concentration of phenol in the shallow overburden zone is limited to beneath former Buildings 33-A and 33-B (6,460 ppb and 31,900 ppb in MW-58 and

WP-2R, respectively). The area containing salicylic acid at concentrations exceeding the NJDEP's proposed IGWQS of 80.0 ppb also encompasses WP-2R (7,770 ppb) and MW-58 (817 ppb).

The distribution of formaldehyde in the shallow overburden zone is shown on Figure 30. The area of the plume containing greater than 100 ppb of formaldehyde encompasses MW-58 (294 ppb), MW-59 (139 ppb), and WP-2R (466 ppb). The concentrations of methanol in the shallow overburden zone did not exceed the IGWQS of 50,000 ppb during the October 2003 sampling event.

The distribution of phenol in the deep overburden zone is depicted on Figure 31. Phenol concentrations over 100,000 ppb were limited to MW-48D, with concentrations exceeding 10,000 ppb also encompassing MW-47D, MW-50D, MW-55D, and ORC-4D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-28D, MW-49D, MW-53D, and MW-54D.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 32. The areal extent of salicylic acid in the deep overburden zone is larger than that of phenol, with the highest concentrations (exceeding 100,000 ppb) being found in ORC-4D and MW-48D. The area of the salicylic acid plume as defined by the NJDEP's proposed IGWQS of 80.0 ppb encompasses MW-49D, MW-55D, and MW-57D in the north-central portion of the site.

The distribution of formaldehyde in the deep overburden zone is shown on Figure 33. Formaldehyde concentrations above 1,000 ppb were found in MW-47D, with concentrations exceeding the IGWQS of 100 ppb also being found in MW-55D and MW-58D.

The distribution of methanol in the deep overburden zone is shown on Figure 34. Methanol concentrations exceeding the NJDEP's IGWQS of 50,000 ppb were limited to the area around MW-47D during the October 2003 monitoring event.

6.0 DOWTHERM DNAPL AREAS INVESTIGATION

Dowtherm is a dense non-aqueous phase liquid (DNAPL) that was used as a heat transfer fluid at the Kalama Chemical facility. Soil contaminated with Dowtherm is known to exist in two areas of environmental concern (AEC). In the southeast corner of the site, the presence of DNAPL has been confirmed in AEC-14 (Benzoic Acid/ Benzaldehyde Plant and Toluene Spill Area). In the southwest corner of the site, Dowtherm is known to be present in the soil at the south end of Building 16 (AEC-36). In AEC-14, five separate soil and/or groundwater investigations were conducted in June 1996, August 1996, September 1998, September 2002, and February - August 2003. In AEC-36, two rounds of soil sampling were conducted in April and August 2003. The following sections discuss the phases of soil and groundwater sampling that have been conducted to investigate each of these AECs.

6.1 Applied Remediation Criteria

Dowtherm is comprised of 1,1'-biphenyl and diphenyl ether, two compounds for which the NJDEP had not established RDCCC, NRDCCC, IGWCC, or GWQS at the time the initial investigations were conducted at the site. The following sections discuss the remediation criteria being applied to the 1,1'-biphenyl and diphenyl ether present in the Dowtherm DNAPL areas.

6.1.1 Groundwater Quality Standards

Groundwater in AEC-14 and AEC-36 has been found to contain 1,1'-biphenyl and diphenyl ether. However, since the NJDEP did not have established groundwater quality standards for these compounds at the start of the investigation of AEC-14, a generic value of 100 ppb was applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believed the generic100 ppb criterion was too conservative, since it did not incorporate toxicological data specific to 1,1'-biphenyl or diphenyl ether. Since neither of these compounds are volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the NJDEP's 100 ppb criterion is based, acceptable groundwater concentrations for 1,1'-biphenyl and diphenyl ether should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request to establish alternate groundwater quality standards for 1,1'-biphenyl and diphenyl ether. In their letter dated 24 June 2002, the NJDEP responded to EPI's 17 April 2001 correspondence, and listed Interim Groundwater Standards for these compounds that had been posted on the NJDEP-WM&S web page:

Interim Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	EPI's Proposed IGWQS (ug/L)	NJDEP's IGWQS (ug/L)
1,1'-Biphenyl	1,800	400
Diphenyl Ether	21,000	100

Given the disparity between the alternate groundwater standards proposed by EPI for 1,1'-biphenyl and diphenyl ether and the IGWQS established by the NJDEP, EPI believes further discussions are required before these values are formally adopted for the Kalama Chemical site. Appendix C contains an additional discussion on the IGWQS for 1,1'-biphenyl and diphenyl ether. However, for comparison purposes, the results of the groundwater sampling events discussed in this report have been evaluated using both sets of groundwater quality standards.

6.1.2 Soil Cleanup Criteria

In their 24 August 1998 letter, the NJDEP established the RDCCC for 1,1'-biphenyl and diphenyl ether to be 2,800 ppm, and the NRDCCC for each compound to be 10,000 ppm. During a conference call on 23 September 1998, the NJDEP indicated that they had calculated generic IGWCC of 6.0 to 8.0 (ppm) for 1,1'-biphenyl and diphenyl ether.

In October 1998, discrete soil samples were collected and analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270 (see Section 6.4.2, below). In addition, the USEPA's Synthetic Precipitation Leaching Procedure (SPLP) was conducted on each sample to determine the amount of 1,1'-biphenyl and diphenyl ether that could be leached from the soil. The SPLP is similar to the Toxicity Characteristic Leaching Procedure (TCLP), except that a less acidic solution is used in performing the extractions. Therefore, SPLP results are considered to be more analogous to rainfall or groundwater flushing contaminants from soil.

During the conference call on 23 September 1998, the NJDEP indicated that the results of the SPLP analyses should be multiplied by 20 and then compared to the NJDEP's interim GWQS of 100 ppb. However, during a telephone call on 28 October 1998, the NJDEP clarified how the SPLP results should be evaluated. During this telephone call, Dr. Swati Toppin, after consultation with Mr. Paul Sanders, indicated that it would be acceptable to compare the SPLP results directly to the interim groundwater quality standard.

Since the direct SPLP results were less than 100 ppb, EPI proposed that the IGWCC for 1,1'-biphenyl and diphenyl ether be, at a minimum, the total concentrations present in soil sample SB-2R (i.e., 12.0 ppm for 1,1'-biphenyl and 19.0 ppm for diphenyl ether). The NJDEP approved the proposed IGWCC for 1,1'-biphenyl and diphenyl ether in their letter dated 28 July 1999.

In their letter dated 24 June 2002, the NJDEP indicated that the RDCCC for 1,1'-biphenyl had been increased from 2,800 ppm to 3,900 ppm, but that the RDCCC for diphenyl ether had been decreased from 2,800 ppm to 390 ppm. Although the NRDCCC for 1,1'-biphenyl remained unchanged at 10,000 ppm, the NRDCCC for diphenyl ether had been decreased from 10,000 ppm to 5,100 ppm. The NJDEP indicated that the reduced cleanup criteria for diphenyl ether were based on a recommendation from USEPA's National Center for Environmental Assessment (NCEA) that methoxychlor be used as a surrogate for the toxicity of diphenyl ether. EPI strongly disagrees with this recommendation since methoxychlor is an organochlorine pesticide. Although both chemicals have two phenyl rings, methoxychlor has three chlorine atoms on a carbon atom linking the two phenyl groups. Diphenyl ether has an oxygen atom connecting the two phenyl groups, and has no halogen atoms. The presence of the chlorine atoms makes methoxychlor much more reactive, and provides its toxicity in the form typical of organochlorine pesticides. This activity is not similar to the much lower reactivity of diphenyl ether, which has no leaving groups (such as the chlorine atoms). The metabolism of methoxychlor has been well studied, and the majority of toxic metabolites are directly related to reactions involving the halogen atoms and/or the methoxy groups located on each phenyl ring (these methoxy groups are also not present in the diphenyl ether structure). This issue is discussed further in Appendix C.

As indicated above, the initial IGWCC for 1,1'-biphenyl and diphenyl ether were based on the highest total concentrations found in a sample on which an SPLP test had been conducted. In August 2003, as part of the delineation of AEC-36 (see Section 6.7, below), EPI performed SPLP tests on three soil samples containing higher concentrations of these compounds to determine if a higher IGWCC could be achieved. The following Table summarizes the results of these analyses.

Compound	BLD16-9A		BLD16-12A		BLD16-14A	
	Total (mg/Kg)	SPLP (ug/L)	Total (mg/Kg)	SPLP (ug/L)	Total (mg/Kg)	SPLP (ug/L)
1,1'-Biphenyl	139	0.92	5,540	2,810	99.9	143
Diphenyl Ether	476	339	19,100	7,990	382	542

Since the SPLP results for 1,1'-biphenyl and diphenyl ether in sample BLD16-9A were both below the current NJDEP IGWQS of 400 ppb for 1,1'-biphenyl, EPI proposes that the total concentrations in this sample become the new IGWCC for these compounds (i.e., 139 ppm for 1,1'-biphenyl and 476 ppm for diphenyl ether). The current diphenyl ether IGWQS of 100 ppb was not used in this evaluation since EPI believes this number to be overly conservative, as it appears to have been calculated (at least in part) using methoxychlor as a surrogate for the toxicity of diphenyl ether. As was indicated above, EPI strongly disagrees with this approach since methoxychlor is an organochlorine pesticide. Since the final IGWCC for 1,1'-biphenyl and diphenyl ether has not yet been established, the results of the soil sampling events discussed in this report have been evaluated using both sets of cleanup criteria.

6.2 AEC-14 - June 1996 Investigation

During the 1 May 1996 meeting between EPI, *SECOR*, and the NJDEP, the Department expressed their concern that a source of DNAPL may be present in the southeast corner of the site. In order to address the NJDEP's concern, while not delaying the installation of the air sparging/soil vapor extraction (AS/SVE) system, EPI agreed to perform an investigation in AEC-14 to determine the possible presence of DNAPL. The results of this investigation (and all supporting documentation and analytical data packages) were previously submitted to the NJDEP in the *Results of the Soil and Groundwater Investigation in the Area of Building 23* report dated 22 April 1998.

6.2.1 Phase I Sampling Methodology

The DNAPL investigation was to have consisted of visually inspecting soil samples collected from 10.0-12.0 feet, 15.0-17.0 feet, and continuously from 20.0 to 30.0 feet during the installation of air sparge points AS-1, AS-6, AS-7, AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, AS-20, and AS-22 (see Figure 35). Each sparge point was installed to the top of the till layer, which averaged approximately 28 feet below grade. However, due to the presence of running sands[5], soil samples could not be collected below 17 feet, and in two locations (AS-7 and AS-10), no soil samples could be collected. During the installation of the remaining sparge points, samples were collected from 10.0-12.0 feet and 15.0-17.0 feet below grade.

The methods used to enhance the visual inspection of soil samples for DNAPL were consistent with the guidance included in the USEPA's January 1992, *Quick Reference Fact Sheet: Estimating Potential for DNAPL at Superfund Sites*. Approximately 2 oz. of soil were placed in a 4 oz. jar and a similar amount was placed in a paint filter. A sufficient amount of water was added to the jar to saturate the soil, and the jar was then shaken for 15 to 20 seconds. The sediment was allowed to settle and the contents were checked for the presence of separate phases (i.e., a sheen or discrete drops of product). Water was also added to the soil in the paint filter and allowed to drain into an 8 oz. jar. The paint filter and the water collected in the 8 oz. jar were then checked for separate phases.

If the DNAPL screening suggested the possible presence of product, duplicate samples (not the soil which was screened in the field) were retained for laboratory analysis. Samples were submitted to RECRA Environmental, Inc. in Amherst, New York (RECRA; New Jersey Certification No. 73455) and analyzed for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8240)

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[5] The presence of running sands had not been anticipated since they had rarely been reported by Geraghty & Miller. This can be attributed to the fact that the vast majority of the borings drilled in the southeast corner of the site by Geraghty & Miller were shallower than the depth at which the running sands were encountered.

and base neutral acid extractable compounds (including benzoic acid and benzaldehyde) plus an NBS library search (BNA+20; USEPA Method 8270). A total of 17 soil samples from nine sparge points (AS-1, AS-6, AS-11, AS-12, AS-16, AS-18, AS-19, AS-20, and AS-22) were submitted for laboratory analysis. The DNAPL screening was negative on samples from AS-14 and AS-15; as indicated above, no samples could be collected from AS-7 and AS-10. The analytical results for the samples collected for laboratory analysis are summarized on Table 55.

6.2.2 Soil Lithology

The lithology of the investigation area is characterized as consisting of 5.0 to 10 feet of coarse sand and fine gravel fill material, underlain primarily by fine to medium sand containing trace amounts of silt and clay. However, discontinuous lenses of finer grained material (silty sand, sandy silt, and sandy silty clay) were noted throughout the area.

6.2.3 Phase I Investigation Results

As shown on Table 55, nine targeted and 38 nontargeted VOCs, and 26 targeted and 20 nontargeted BNAs were detected in the soil samples. However, only two VOCs (toluene at 960 ppm in sample AS-1B and chlorobenzene at 1.7 ppm in AS-22B) exceeded their respective IGWCC of 500 ppm and 1.0 ppm. Benzo(a)anthracene exceeded its RDCCC of 0.90 ppm, but was below its NRDCCC of 4.0 ppm, in samples AS-11B (0.92 ppm), AS-12C (1.7 ppm), and AS-20C (2.1 ppm). Benzo(b)fluoranthene was detected at 1.4 ppm in AS-20C, which exceeded its RDCCC of 0.90 ppm, but was below its NRDCCC of 4.0 ppm. Benzo(a)pyrene exceeded its RDCCC and NRDCCC of 0.66 ppm in samples AS-11B (0.81 ppm) and AS-20C (1.2 ppm).

Toluene was detected in all of the soil samples, although generally at low concentrations; in 10 samples toluene was detected at less than 1.0 ppm. Excluding toluene, the total concentration of targeted VOCs was generally less than or equal to 1.0 ppm, with individual compounds being detected at levels well below their respective remediation criteria. The most common nontargeted VOCs were biphenyl and diphenyl compounds. Identical types of compounds were also detected in the BNA analyses, although at significantly higher concentrations. Given the nature of the DNAPL, the concentrations reported from the BNA analyses for the biphenyl and diphenyl compounds are considered more representative of site conditions.

The results of the BNA analyses indicate that targeted BNAs are not of concern in this area. Previous sampling has documented that benzo(a)anthracene, benzo(b)fluoranthene, and benzo(a)pyrene are related to the fill material and is not related to operations at the site. The concentrations of targeted and nontargeted BNAs ranged from 0.024 ppm in AS-18C to 4,657 ppm in AS-20C, with an average concentration of 456 ppm; nontargeted compounds comprised the majority of the total concentrations. The distribution of total targeted and nontargeted BNAs are shown in Figure 36. The most wide-spread nontargeted BNAs were biphenyl, diphenyl ether, methylbiphenyl isomers, and an unknown compound, which were detected at the following frequency:

Compound & CAS No.	No. Samples Detected	Percentage of Samples	Concentration Range (ppm)	Sample with Highest Concentration
Biphenyl (92-52-4)	14	82%	2.0 - 570	AS-20C
Diphenyl Ether (101-84-8)	13	76%	0.19 - 530	AS-22B
Methylbiphenyl Isomers (N/A)	16	94%	0.71 - 2,370	AS-20C
Unknown (N/A)	15	88%	0.21 - 242	AS-20C
No. of Samples = 17 N/A = Not Applicable				

Numerous other biphenyl and diphenyl compounds were detected in these samples, but their concentrations and distributions were much lower than the ones listed above. These compounds are of particular interest since the suspected DNAPL at the site (Dowtherm) is comprised of biphenyl (27%) and diphenyl ether (73%)[6].

Two data gaps remained at the completion of the initial round of soil sampling:

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[6] Dowtherm Material Safety Data Sheet, Dow Chemical Co., 10 June 1994.

- No soil samples had been collected from below 17 feet, so the vertical extent of the Dowtherm had not been defined.

- The historical groundwater data for AEC-14 was inconclusive as to the concentrations of biphenyl and diphenyl ether present in the shallow and deep overburden zones. The concentrations of these two compounds in groundwater needed to be evaluated to determine if the presence of Dowtherm in soil was impacting groundwater quality.

6.3 AEC-14 - August 1996 Investigation

EPI installed six more soil borings in the area of former Buildings 23 and 10-P5 (see Figure 37). Four of these borings (SB-1, SB-2, SB-3, SB-4) served to satisfy the NJDEP's requirements that samples be collected on 20 foot centers; during the 1 May 1996 meeting, the NJDEP expressed concerns that the 40 to 45 feet spacing between the sparge points was too large to adequately assess the area around former Building 23. The remaining two borings (SB-5, SB-6) were used to delineate the high concentrations of BNAs detected in sample AS-20C. The results of this investigation (and all supporting documentation and analytical data packages) were also submitted to the NJDEP in the *Results of the Soil and Groundwater Investigation in the Area of Building 23* report dated 22 April 1998.

Each boring was advanced using a hollow stem auger drill rig, and samples were collected using split spoon samplers. Soil samples were collected and screened for DNAPL following the procedures discussed in Section 6.2.1, above. Based on the results of the Phase I investigation, the Phase II soil samples were only analyzed for biphenyl and diphenyl ether by USEPA Method 8270.

In order to indirectly evaluate soil quality from immediately above the till layer (and to determine if groundwater quality has been impacted by Dowtherm), each boring was advanced to approximately 28 feet below grade and an *in situ* groundwater sample was collected using HydroPunch methodology. The HydroPunch is a stainless steel and Teflon sampling tool which has been approved by the NJDEP for use in site characterization. The hollow stem augers were advanced to approximately 23 feet below grade and then the HydroPunch was driven like a split spoon until refusal (assumed to be the top of the till layer). Due to the volume of water required (up to two liters), samples were collected using the

Hydrocarbon Mode (HP-II). In this sampling mode, a five feet long section of PVC screen is exposed when the HydroPunch is opened; water and hydrocarbons (if present) can then enter the sampling chamber. A Teflon bailer was then lowered through the drill stem to the sampling chamber to collect the necessary groundwater sample; it is not necessary to purge the HydroPunch prior to sample collection. Each groundwater sample was analyzed for BNA+20 by USEPA Method 8270 (including calibrations for biphenyl, diphenyl ether, benzoic acid, and benzaldehyde).

The Phase II DNAPL investigation was completed by gauging and sampling the nine air sparge points which were installed in and around the foot print of former Building 23 (AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, and AS-20). Since the sparge points extend to the top of the till layer and are constructed with two feet of screen, they serve to monitor the same zone that was sampled by the HydroPunch. Prior to purging, each sparge point was gauged for DNAPL using an interface probe; no measurable amounts of DNAPL were found in any of the sparge points. Groundwater sampling was conducted following the procedures outlined in the NJDEP's May 1992 *Field Sampling Procedures Manual*. Each groundwater sample was analyzed for BNA+20.

6.3.1 Phase II Investigation Results

The Phase II DNAPL investigation consisted of collecting 12 soil samples from six soil borings (SB-1 through SB-6), six HydroPunch groundwater samples (SB-1W through SB-6W), and nine groundwater samples from air sparge points AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, and AS-20. The locations of the Phase II investigation borings and air sparge points are shown on Figure 37.

6.3.1.1 *Soil Results*

The analytical results for the samples from borings SB-1 through SB-6 are summarized on Table 56 and are presented on Figure 38. Detectable concentrations of biphenyl and/or diphenyl ether were detected in all six samples from 10.0-12.0 feet below grade. Biphenyl concentrations ranged from not detected (SB-5A) to 180 ppm (SB-6A), while diphenyl ether concentrations ranged from 0.49 ppm (SB-4A) to 420 ppm (SB-6A). The concentration of biphenyl in samples SB-1A (44.0 ppm), SB-2A (24.0 ppm), and SB-

2B (13.0 ppm) exceeded the current IGWCC of 12.0 ppm, but were below EPI's proposed IGWCC of 139 ppm. Sample SB-6A contained 180 ppm of biphenyl, which exceeded EPI's proposed IGWCC. Diphenyl ether concentrations in SB-1A (94.0 ppm), SB-2A (29.0 ppm), SB-2B (30.0 ppm), SB-5A (49.0 ppm), and SB-6A (420 ppm) exceeded the current IGWCC of 19.0 ppm, but were below EPI's proposed IGWCC of 476 ppm. Concentrations in the deeper samples (15.0-17.0 feet below grade) tended to be two to three orders of magnitude lower than in the shallow samples. The exception to this trend was in sample SB-2B, in which no significant change in concentrations was noted. The decreasing concentrations with depth can be attributed to the presence of a layer of finer grained sand and silt which separated the two sampling intervals; this layer is not present at the location of boring SB-2.

6.3.1.2 *Groundwater Results*

The analytical results for the groundwater samples are summarized on Table 57 (HydroPunch) and Table 58 (air sparge wells) and are presented on Figure 39 (BNAs) and Figure 40 (biphenyl and diphenyl ether). Targeted BNAs were detected in all six HydroPunch samples with total concentrations ranging from 103 ppb (SB-2W) to 1,699 ppb (SB-5W). Sample SB-3W contained 660 ppb of biphenyl, which exceeded the NJDEP's current IGWQS of 400 ppb, but was below EPI's proposed alternate IGWQS of 1,800 ppb. Diphenyl ether was detected at concentrations exceeding the NJDEP's current IGWQS of 100 ppb, but below EPI's proposed alternate IGWQS of 21,000 ppb, in samples SB-1W (230 ppb), SB-3W (180 ppb), SB-4W (290 ppb), and SB-5W (1,100 ppb). Bis(2-ethylhexyl)phthalate exceeded the NJDEP's GWQS of 30.0 ppb in sample SB-1W (150 ppb) and sample SB-3W (110 ppb). Sample SB-5W contained 110 ppb of 2-methylnaphthalene, which is slightly above the GWQS 100 ppb. Benzo(a)anthracene exceeded its IGWQS of 0.20 ppb in samples SB-3W (2.0 ppb) and SB-5W (3.0 ppb). Benzo(a)pyrene also exceeded its IGWQS of 0.20 ppb in sample SB-5W. The concentrations of nontargeted BNAs (primarily methyl biphenyl isomers and unknown compounds) ranged from 472 ppb in SB-2W to 3,959 ppb in SB-5W.

Targeted and nontargeted BNAs were detected in all nine air sparge wells sampled. The concentrations of total targeted BNAs ranged from 19.0 ppb in AS-10 to 14,503 ppb in AS-20. In samples AS-10, AS-14, and AS-18, the concentrations of targeted BNAs were all below their respective groundwater quality criteria. Sparge point AS-15 contained 34.0 ppb of bis(2-ethylhexyl)phthalate, slightly above the GWQS of 30.0 ppb, while the sample from AS-20 contained 6,400 ppb of benzyl alcohol (GWQS of 2,000 ppb). Biphenyl ether concentrations exceeded EPI's and/or the NJDEP's IGWQS in samples AS-12 (2,000 ppb), AS-16 (1,900 ppb), and AS-19 (830 ppb). Diphenyl ether concentrations exceeded the NJDEP's current IGWQS of 100 ppb in samples AS-11 (130 ppb), AS-12 (5,900 ppb), AS-16 (5,000 ppb), AS-19 (1,000 ppb), and AS-20 (900 ppb). The concentrations of nontargeted BNAs (primarily methyl biphenyl isomers and unknown compounds) ranged from 4.0 ppb in AS-10 to 6,372 ppb in AS-20.

6.4 AEC-14 - September 1998 Investigation

In response to the NJDEP's letter dated 24 August 1998, and the subsequent conference call on 23 September 1998, additional soil and groundwater samples were collected in the area of former Building 23. The purpose of collecting the additional samples was to: 1) determine current concentrations of biphenyl and diphenyl ether in soil and groundwater following nine months of operation of the AS/SVE remediation system, and 2) derive an Impact to Groundwater soil remediation criteria for both compounds. The results of the September 1998 investigation (and all supporting documentation and analytical data packages) were submitted to the NJDEP as a letter report dated 11 January 1999.

6.4.1 Groundwater Sampling Methodology

A new round of groundwater samples was collected from the nine air sparge wells (AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, AS-20) that were sampled in August 1996 as part of the initial investigation of Building 23. The air sparging component of the AS/SVE system was turned off on 27 August 1998, approximately two weeks prior to collecting the groundwater samples, to allow the formation to depressurize and re-equilibrate prior to sampling. Groundwater samples were collected on 11 September 1998, following the procedures outlined in the NJDEP's May 1992 *Field Sampling Procedures Manual.* Each well was gauged for both floating and sinking separate phase hydrocarbons (SPH) prior to sampling. None of the nine air sparge wells was found to contain SPH.

The groundwater samples were placed in appropriate laboratory provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. At the end of the day, the samples were shipped via overnight courier to RECRA Environmental Inc. in Amherst, New York. Each groundwater sample plus one field blank was analyzed for biphenyl and diphenyl ether by USEPA Method 8270.

6.4.1.1 *Groundwater Sample Results*

The analytical results for the groundwater samples are summarized on Table 59; the August 1996 results have also been included for comparison purposes. The concentrations of biphenyl and diphenyl ether were below their respective IGWQS' in all nine samples. Biphenyl was only detected in one sample (0.9 ppb in AS-20), while diphenyl ether was only detected in AS -12 (4.0 ppb) and AS-20 (67.0 ppb). These concentrations represent a significant decrease since August 1996, when 1,1'-biphenyl concentrations ranged from 140 ppb (AS-11 and AS-20) to 2,000 ppb (AS-12), and diphenyl ether concentrations ranged from 130 ppb (AS-11) to 5,900 ppb (AS-12).

6.4.2 Soil Sampling Methodology

In their 24 August 1998 letter, the NJDEP established the RDCCC for 1,1'-biphenyl and diphenyl ether to be 2,800 ppm, and the NRDCCC for each compound to be 10,000 ppm. During the 23 September 1998 conference call, the NJDEP indicated that they had calculated generic Impact to Groundwater soil criteria of 6.0 to 8.0 ppm for 1,1'-biphenyl and diphenyl ether.

As part of the process of calculating site specific Impact to Groundwater soil criteria for biphenyl and diphenyl ether, new soil samples were collected from previous boring locations SB-1, SB-2, and SB-6 (see Figure 37). On 1 October 1998, discrete soil samples were collected from 10.0 - 12.0 feet below grade adjacent to borings SB-1, SB-2, and SB-6 using direct push (i.e., Geoprobe) sampling methodology; one composite sample was also prepared from the three soil samples. All four samples were analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. In addition, the USEPA's Synthetic Precipitation Leaching Procedure (SPLP) was conducted on each sample to determine the amount of 1,1'-biphenyl and diphenyl ether that could be leached from the soil. The SPLP is similar to the Toxicity Characteristic Leaching Procedure (TCLP), except that a less acidic solution is used in performing the extractions. Therefore, SPLP results are considered to be more analogous to rainfall or groundwater flushing contaminants from soil.

The soil samples were placed in appropriate laboratory provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. At the end of the day, the samples were shipped via overnight courier to RECRA for analysis.

6.4.2.1 *Soil Sampling Results*

The analytical results for soil samples SB-1R, SB-2R, and SB-6R are summarized on Table 60. The results from the original soil samples are also included on Table 60 for comparison purposes. 1,1'-Biphenyl was detected in SB-1R (0.079 ppm) and SB-2R (12.0 ppm), while diphenyl ether was detected at 0.18 ppm and 19.0 ppm in SB-1R and SB-2R, respectively. No detectable concentrations of 1,1'-biphenyl or diphenyl ether were found in sample SB-6R. The composite sample contained 3.4 ppm of 1,1'-biphenyl and 11.0 ppm of diphenyl ether. All of these concentrations are below the NJDEP's RDCCC and NRDCCC criteria, and they represent a significant (50 to 100%) decrease since August 1996.

The SPLP tests performed on SB-1R and SB-6R generated no leachable concentrations of 1,1'-biphenyl or diphenyl ether. The leachate from sample SB-2R and the composite sample contained 1,1'-biphenyl at 0.011 ppm and 0.019 ppm, respectively. Diphenyl ether was also detected in the leachate from SB-2R (0.072 ppm) and the composite sample (0.086 ppm).

Since the direct SPLP results were less than 100 ppb, EPI proposed that the Impact to Groundwater soil cleanup criteria for 1,1'-biphenyl and diphenyl ether should, at a minimum, be the total concentrations present in soil sample SB-2R (i.e., 12.0 ppm for biphenyl and 19.0 ppm for diphenyl ether). As discussed in Section 6.1.2 of this report, the NJDEP approved the proposed IGWCC for 1,1'-biphenyl and diphenyl ether in their letter dated 28 July 1999.

6.5 AEC-14 - September 2002 Investigation

Following the receipt of the NJDEP's 31 July 2002 letter that allowed the air sparge component of the AS/SVE system to be re-started, and approved the DNAPL investigation program that had been proposed in Section 5.4 of the 1 May 2002 RIRA-2, Sovereign gauged the total depth of each air sparge well to determine which points needed to be re-developed to remove accumulated sediments. On 8 August 2002, an estimated 14.8 feet of DNAPL was measured (using an interface probe) in well AS-12. DNAPL was not detected in any of the other 24 air sparge wells located in the southeast corner of the site. On 14 August 2002, approximately 50 gallons of water were removed from AS-12 during its re-development. On 16 August 2002, the drum containing the development water from AS-12 was gauged and was found to contain approximately 0.37 feet (or approximately 8.0 gallons) of DNAPL; AS-12 was also gauged and was found to contain 0.88 feet of DNAPL.

A sample of the DNAPL was collected and analyzed by Accutest for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260), base neutral/acid extractable compounds (including calibrations for 1,1'-biphenyl, diphenyl ether, benzoic acid, and salicylic acid) plus an NBS library search (BNA+25; USEPA Method 8270), and density. The analytical results for this sample are summarized on Table 61. The DNAPL from AS-12 has a density of 1.07 g/ml (density of water = 1.0 g/ml), and was found to contain 223,000 parts per million (ppm) of 1,1'-biphenyl (approximately 33% of the total concentration) and 420,000 ppm of diphenyl ether (approximately 63% of the total concentration), which is consistent with the composition of Dowtherm. The remaining 4% of the sample was composed primarily of toluene (0.96%), polynuclear aromatic hydrocarbons (PAHs; 0.01 to 0.61% each), nontargeted VOCs (0.33%) and nontargeted BNAs (0.57%).

Between 4 & 6 September 2002, Sovereign conducted the DNAPL investigation groundwater sampling program that had been approved by the NJDEP. This program consisted of three stages, including:

1. Using a transparent, bottom-loading, double check valve bailer to retrieve a water sample from the bottom of monitoring wells MW-4, MW-4D2, MW-5, MW-5D, MW-5D2, MW-D5, MW-17, MW-17D, MW-33, and MW-33D, and air sparge wells AS-6, AS-7, AS-8, AS-9, AS-11, AS-13, AS-15, AS-16, and AS-17 and visually inspecting the recovered fluid for DNAPL;

2. Checking for the presence of DNAPL using Sudan IV, an oleophilic/hydrophobic (i.e., soluble in oil, insoluble in water) dye; and,

3. Collecting and analyzing groundwater samples from each of the above wells for 1,1'-biphenyl and diphenyl ether using low flow purging and sampling methodology. Well purging data for this investigation are included in Appendix F.

The results from Steps 1 & 2 indicated that none of the wells included in the sampling program contained DNAPL. Although the water from MW-4 contained a slight sheen that turned red when the Sudan IV dye was added, this well historically contained light non-aqueous phase liquids (LNAPLs). Therefore, EPI believes the initial screening results from MW-4 are inconclusive.

The analytical results for the DNAPL investigation groundwater samples are summarized on Table 62 and are presented on Figure 41. 1,1'-Biphenyl only exceeded the NJDEP's IGWQS of 400 ppb in MW-4 (770 ppb). Diphenyl ether was detected at concentrations exceeding the NJDEP's IGWQS of 100 ppb in MW-4 (1,690 ppb), MW-D5 (1,040 ppb), MW-17 (728 ppb), and MW-33 (265 ppb). These results are consistent with those from previous quarterly groundwater sampling events. 1,1'-Biphenyl and diphenyl ether were either not detected or were present at concentrations below their respective IGWQS in MW-4D2, MW-5, MW-5D, MW-5D2, MW-17D, MW-33D, AS-6, AS-7, AS-8, AS-9, AS-11, AS-13, AS-15, AS-16, and AS-17. Copies of the analytical data packages and EDD diskette for the September 2002 groundwater samples are included under separate cover as Attachment III.

The results of the well gauging and groundwater sampling program suggest that the DNAPL present in AS-12 is limited to the 90' x 90' box defined by the surrounding air sparge wells.

6.6 AEC-14 - February to July 2003 Investigation

Field screening and soil sampling was conducted in February and April 2003 to define the horizontal and vertical extent of the Dowtherm present around AS-12 in the southeast corner of the site. Additional delineation soil samples were collected in July 2003. The results of these investigations are discussed below.

6.6.1 Sampling Methodology

At the start of the investigation, attempts were made to use Geoprobe's dual-tube sampling methodology in which soil samples are collected through an outer steel casing that serves to keep the borehole from collapsing. However, due to the nature of the unconsolidated sediments at the site, the inner steel sampler repeatedly got stuck within the outer steel casing, resulting in all of the dual tube casing being removed from the borehole while attempting to retrieve the sampler. Since the dual tube system could not be implemented, all of the soil sampling conducted for this investigation was performed by standard direct push methodology. The Geoprobe was operated by a New Jersey licensed driller (Summit Drilling Co., Inc.) under the supervision of an Sovereign geologist. Soil samples were collected into acetate liners within a stainless steel sampler. Each liner was removed from the sampler, slit open, and screened for VOCs using a PID equipped with a 10.6 eV bulb. The descriptions of soil lithologies, results of PID screening, and the depths of the samples collected were recorded in the field. Soil boring logs for this investigation are included in Appendix D.

A Ribbon NAPL Sampler (RNS) manufactured by Flexible Liner Underground Technologies, Ltd. (FLUTe) was used as a field screening technique to expedite the investigation by allowing a rapid determination to be made as to the presence of DNAPL in a soil boring. The following description of the RNS technology has been taken from the Interstate Technology and Regulatory Cooperation (ITRC) Work Group's June 2000 *Dense Non-Aqueous Phase Liquids (DNAPLs): Review of Emerging Characterization and Remediation Technologies* report.

> The RNS is a continuous, direct sampling device that can provide detailed, depth discrete mapping of NAPLs (liquid solvents and/or petroleum products) in a borehole. This NAPL characterization technique uses a flexible membrane system consisting of an impermeable liner and an exterior covering on the liner which reacts with pure product (e.g., NAPL and DNAPL) to form a bright red dye stain on a white background. The pressurized liner forces the reactive cover tightly against the borehole wall. The reactive ribbon is recovered from the hole by inverting/peeling the liner from the hole. In this manner, the reactive ribbon does not touch the hole wall anywhere else as it is removed. The reactive ribbon can then be examined for the presence and extent of layers, and even globules, of NAPL in the subsurface as indicated by red marks on the ribbon. RNS can be deployed with direct push (e.g., Geoprobe) methods for mapping of NAPLs and DNAPLs in both the vadose and saturated zones to identify source regions.

The first phase of field activities was conducted during the first week of February 2003, and was to have involved collecting soil samples in conjunction with the installation and retrieval of the RNS liners. However, due to mechanical problems with the Geoprobe, a family emergency for the driller, and a significant snow fall event, it was only possible to install the RNS liners and collect soil samples from one soil boring near AS-12. Before it was possible to re-mobilize to the site to complete the investigation, a blizzard occurred on 17 February 2003 that left the site covered by over two feet of snow, with drifts of up to eight feet in height. Since it was impossible to locate the RNS borings (or move about the site) under these conditions, soil sampling was not completed April 2003.

For the purposes of characterizing the source area around AS-12, soil samples for laboratory analysis were collected from the depth intervals where DNAPL was indicated by the RNS liner. For the purposes of delineating the extent of the contamination, soil samples for laboratory analysis were also collected from corresponding depth intervals in borings where the RNS did not indicate the presence of DNAPL.

Soil samples were placed directly into laboratory-provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. Each sample was analyzed for total petroleum hydrocarbons (TPH) by USEPA Method 418.1, volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260), and base neutral/acid extractable compounds (including calibrations for 1,1'-biphenyl and diphenyl ether) plus an NBS library search (BNA+25; USEPA Method 8270). Soil samples for VOC analyses were collected from undisturbed soil following the NJDEP's Methanol Preservation Procedures. At the end of the day, the samples were returned to Sovereign's office, where they were picked up the following day by a courier and delivered to Accutest in Dayton, New Jersey (Certification No. 12129) for analysis. For QA/QC purposes, one trip blank sample was also submitted for each day of sampling and analyzed for VOC+10. Copies of the analytical data packages and EDD diskette for these samples are included under separate cover as Attachment IV.

6.6.2 February & April 2003 Field Screening and Sampling Results

As shown on Figure 42, a total of 13 borings were installed as part of the DNAPL investigation around AS-12. RNS liners were installed in borings AS12-1 through AS12-8, while confirmation soil samples were collected from borings B-1, B-4, S-1, B-6, and B-7. Each confirmation soil boring was installed within one foot of the RNS location (AS12-1, AS12-4, AS12-5, AS12-6, and AS12-7) being sampled. Each RNS liner was installed to the top of the glacial till (as estimated based on increased resistance encountered while advancing the Geoprobe rods). The following table summarizes the findings of the RNS liners/borings.

AS-12 Area
Ribbon NAPL Sampler Results

Boring ID	Reaction Time*	Depth to Top of Glacial Till (Feet)	Reaction on Liner	Reaction Intervals (Feet below Grade)
AS12-1	70 minutes	29.0	No	----
AS12-2	43 minutes	34.0	No	----
AS12-3	48 minutes	33.0	No	----
AS12-4	15 hours	34.0	No	----
AS12-5	40 minutes	33.0	Yes	15.5, 16.3, 18.6, 21.8, 24.0
AS12-6	1.0 hour	34.0	No	----
AS12-7	50 minutes	32.0	No	----
AS12-8	55 minutes	33.0	No	----

Notes:
* = The amount of time the RNS liner was allowed to remain in the borehole.

As shown on Figure 42, soil borings B-1, B-4, B-6, and S-1 are all located within 5.5 feet of AS-12, while boring B-7 is located 20.0 feet northwest of AS-12. Given their proximity to each other, the soil lithologies in each boring were relatively similar. The top 5.0 to 7.0 feet of soil consisted of fill material composed of poorly graded sand with little gravel and silt. The fill material was underlain by a lean clay with poorly graded sand that generally extended to 12.0 to 13.0 feet below grade. In boring B-4, a sheen was observed on the soil from approximately 10.0 feet below grade. In addition, stained soil was observed from 7.0 - 7.5 feet below grade in boring B-7. The lean clay layer is underlain by silty sand to the top of the glacial till at 31.0 to 35.0 feet below grade.

No appreciable PID readings were found in borings S-1, B-4, or B-6. The highest PID reading (1,942 ppm) was recorded from the top two feet of fill material in boring B-1. However, no appreciable PID readings were recorded below five feet in boring B-1. In boring B-7, PID readings ranging from 38.0 ppm to 199 ppm were detected in soil from 12.0 to 20.0 feet below grade.

Based on the findings of RNS liner AS12-5, soil samples were collected from boring S-1 at depth intervals of 15.5 - 16.0 feet (S-1A), 23.0 - 24.0 feet (S-1B), 29.5 - 30.0 feet (S-1C), and 33.5 - 34.0 feet (S-1D). The analytical results for the samples from boring S-1 are summarized on Table 63 and are presented on Figure 43. TPH and VOCs were either not detected, or were present at concentrations below their respective remediation criteria. The concentrations of 1,1'-biphenyl were below the current IGWCC of 12.0 ppm in S-1A (0.69 ppm), S-1C (0.80 ppm), and S-1D (1.72 ppm). Diphenyl ether concentrations were also below its current IGWCC of 19.0 ppm in S-1A (1.74 ppm), S-1C (1.81 ppm), and S-1D (3.83 ppm). However, sample S-1B contained 41.7 ppm of 1,1'-biphenyl and 89.5 ppm of diphenyl ether, both of which exceed their current IGWCC but are below EPI's proposed IGWCC of 139 ppm and 476 ppm, respectively. No other BNA compounds exceeded their respective remediation criteria.

Since none of the other RNS liners indicated the presence of DNAPL, the sample intervals for borings B-1, B-4, B-6, and B-7 were selected to delineate the 1,1'-biphenyl and diphenyl ether found in boring S-1. Soil samples were collected at three specific depth intervals: 15.5 - 16.0 feet (designated "A"), 23.0 - 24.0 feet ("B"), and immediately above the glacial till ("C"). Glacial till (based on Geoprobe sampler refusal) was encountered at 31.0 feet below grade in borings B-1 and B-6, so samples were collected from 30.5 - 31.0 feet. In borings B-4 and B-7, glacial till was encountered at 33.5 feet below grade, so samples from the bottom of the borehole were collected from 33.0 - 33.5 feet.

The differences in the depth to the top of the glacial till noted in the RNS borings and the soil sample borings can be attributed to the equipment used to advance each bore hole. The borings for the RNS liners were advanced using steel rods with an approximately 2.0-inch diameter pointed steel tip. In this configuration, no soil samples could be collected, but the rods would be better able to penetrate more resistant material. It should be noted that the RNS borings were not advanced until refusal was encountered, but rather to the point where increased resistance to the drill rods was detected (at which point it was assumed that the top of glacial till had been reached). The soil sample borings were advanced using the same rods, but a 2.0-inch diameter, 4.0 feet long macrocore sampler was used instead of a pointed steel tip. Due to its broader face and longer length, the sampler is harder to advance through the unconsolidated sediments, and is therefore less able to penetrate the glacial till. Therefore, the top of glacial till (as defined by sampler refusal) was always encountered at a shallower depth in the soil sample borings than in the RNS borings.

The analytical results for the samples from borings B-1, B-4, B-6, and B-7 are also summarized on Table 63, and are presented on Figure 43. As with the samples from boring S-1, TPH and VOCs were either not detected or were present at concentrations below their respective remediation criterion in all of the samples. 1,1'-Biphenyl concentrations were below the IGWCC of 12.0 ppm in all samples except B-4A (14.7 ppm) and B-4B (20.8 ppm). Similarly, diphenyl ether concentrations were below the IGWCC of 19.0 ppm in all samples except B-4A (29.5 ppm) and B-4B (26.9 ppm). The 1,1'-biphenyl and diphenyl ether concentrations in samples B-4A and B-4B were below EPI's proposed IGWCC of 139 ppm and 476 ppm, respectively. No other BNA compounds exceeded their respective remediation criteria.

6.6.3 August 2003 Sampling Results

In August 2003, additional soil sampling was conducted to complete the horizontal delineation of the 1,1-biphenyl and diphenyl ether detected in the samples from boring B-4. As shown on Figure 42, soil borings B-8 and B-9 were installed 15.0 feet south and 35.0 feet east of boring B-4, respectively. The presence of the air lines and equipment pads for the air sparge system immediately to the east of boring B-4 prevent sampling closer to this location in this direction. Each boring was advanced to 24.0 feet below grade so that soil samples could be collected to delineate the 1,1'-biphenyl and diphenyl ether that were detected in samples B-4A (15.5 - 16.0 feet below grade) and B-4B (23.0 - 24.0 feet below grade). All sampling was conducted using Geoprobe methodology following the procedures discussed above. Each sample was analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

In boring B-8, the top six feet of soil consisted of fill material composed of poorly graded sand and gravel. The fill material was underlain by two feet of lean clay, followed by clayey sand from 8.0 - 12.0 feet below grade. Poorly graded sand was encountered from 12.0 feet below grade to the completion depth of the boring at 24.0 feet below grade. No organic vapors were detected while screening the soil with a PID, and no sheens or staining were observed. Soil samples B-8A and B-8B were collected from within the poorly graded sand at 15.5 - 16.0 feet below grade and 23.25 - 23.75 feet below grade, respectively.

In boring B-9, the top four feet of soil consisted of fill material composed of poorly graded sand and gravel. The fill material was underlain by six feet of lean clay, followed by poorly graded sand from 10.0 - 16.0 feet below grade. Well graded sand was encountered from 16.0 - 22.0 feet below grade, with the bottom two feet of the boring consisting of poorly graded sand. A sheen was observed on the soil from within the clay layer, and PID readings within the clay ranged from 18.3 ppm to 2,334 ppm. No organic vapors were detected in the soil either above or below the clay layer, and no sheens or staining were observed. Soil samples B-9A and B-9B were collected from within the poorly graded sand at 15.5 - 16.0 feet below grade and 23.25 - 23.75 feet below grade, respectively.

The analytical results for the samples from borings B-8 and B-9 are also summarized on Table 63, and are presented on Figure 43. Trace amounts (less than 1.0 ppm) of 1,1'-biphenyl and diphenyl ether were detected in samples B-8A, B-8B, and B-9A. Sample B-9B contained 110 ppm of 1,1'-biphenyl and 396 ppm of diphenyl ether. Although these concentrations exceed the current IGWCC of 12.0 ppm and 19.0 ppm, they are below the proposed new IGWCC of 139 and 476 ppm.

6.6.4 Interim Remedial Measures

Following the discovery of DNAPL in AS-12, EPI implemented a manual recovery program as an interim remedial measure. During each weekly operation & maintenance (O&M) visit for the SVE system and thermal oxidizer, AS-12 was gauged to determine the presence of DNAPL, and a surface mounted centrifugal pump was used to remove any accumulated product. Approximately 30.1 gallons of DNAPL were recovered from AS-12 during this program. The results of the recovery program are summarized on Table 64.

The last DNAPL recovery event from AS-12 was conducted on 30 January 2003. While sealing the borings associated with the DNAPL investigation that was conducted during the first week of February 2003, grout from one or more of the boreholes migrated into AS-12, and effectively sealed the well to a depth of 18.0 feet below grade. Attempts to remove the grout were unsuccessful, since it was not discovered until several days after it had entered the sparge well.

6.6.4.1 *Well Abandonment & Replacement*

Between 16 & 17 October 2003, AS-12 was abandoned by a licensed New Jersey well driller by filling the remaining 18.0 feet of casing with a bentonite/cement grout. In addition, replacement monitoring well MW-63 was installed to allow the DNAPL recovery program to be continued. The location of MW-63 is shown on Figure 42. Soil lithologies were first logged on 16 October 2003 using Geoprobe methodology. The top 12.0 feet of soil consisted of fill material comprised of poorly graded gravel with sand. Groundwater was encountered in the soil boring at approximately 4.0 feet below grade. Lean clay was encountered from 12.0 - 14.0 feet below grade, followed by well graded sand with clay to 16.5 feet below grade. Lean clay was encountered again from 16.5 - 20.0 feet below grade, which was in turn underlain by poorly graded sand (20.0 - 22.5 feet below grade), well graded sand (22.5 - 25.0 feet below grade), and well graded sand with clay (25.0 - 30.0 feet below grade). A sheen was observed on the groundwater from the lean clay layer at 16.5 - 20.0 feet below grade. Clayey sand was present from 30.0 - 37.0 feet below grade, followed by clayey sand with gravel to the completion depth of the boring at 40.0 feet below grade. The presence of gravel at 37.0 feet below grade is believed to represent the top of the glacial till lithologic unit in this area of the site. With the exception of PID readings of 631 ppm and 472 ppm in the top two feet of fill material, no organic vapors were detected in the remainder of the soil samples. The soil boring for MW-63 was sealed with a cement/bentonite grout at the completion of sampling.

On 17 October 2003, hollow stem auger drilling methodology was used to installed MW-63 at the same location as the soil boring. MW-63 has a total depth of approximately 37.0 feet (the top of the glacial till), and is constructed with 25.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 12.0 feet of PVC casing. The screened portion of the well overlaps the intervals where staining was observed on the RNS liners (i.e., those intervals where DNAPL is suspected to be present in the soil). The wellhead for MW-63 was completed with a flush-mount, water tight manhole with a locking cap. A copy of the well log for MW-63 is included in Appendix B.

The location and elevation of MW-63 was measured by a New Jersey licensed surveyor; Certification Forms A & B are also included in Appendix B. Since the purpose of installing MW-63 is to replace AS-12 and facilitate the recovery of DNAPL, EPI does not propose to collect groundwater samples from this well at this time. As of 18 December 2003 (the last time the well was gauged), no DNAPL has been detected in MW-63.

6.7 AEC-36 - Building 16 Dowtherm Area

On 17 September 2002, EPI began excavating the former process waste sewer line that runs parallel to Hudson Street on the south side of the site. A full discussion of these activities was included in the 26 February 2003 *Remedial Investigation and Remedial Actions Report - Building 17 & Former Sewer Lines*. The excavation of the sewer line began in the southwest corner of the site. When the excavation reached approximately 11.5 - 12.0 feet below grade adjacent to the southwest corner of Building 16, a dark fluid entered the trench from beneath the building. Sovereign collected samples of the product and determined in the field that the material was heavier than water. It appears that this product could possibly have come from a small section of pipe that connected a bathroom in Building 16 to the Hudson Street sewer line. Based upon information from Figure J-1 of Geraghty & Miller's December 1993 *ECRA Investigation Report and Proposed Remedial Action Plan*, this line had been plugged at the junction with the Hudson Street line in February 1981.

A sample of the apparent dense non-aqueous phase liquid (DNAPL) was analyzed by Accutest for VOC+10 by USEPA Method 8260, BNA+25 by USEPA Method 8270, and density. The analytical results for this sample are summarized on Table 65. The Building 16 DNAPL has a density of 1.11 g/ml, and was found to contain 288,000 ppm of 1,1'-biphenyl (approximately 30% of the total concentration) and 612,000 ppm of diphenyl ether (approximately 64% of the total concentration), which is consistent with the composition of Dowtherm. The remaining 6% of the sample was composed primarily of toluene (0.36%), nontargeted VOCs (2.9%) and nontargeted BNAs (2.0%).

Due to the instability of the sidewalls, it was not feasible to leave the excavation open. Therefore, a temporary sump consisting of 5.0 feet of 2.0-inch diameter 20-slot well screen and 10 feet of PVC casing was installed in the area where the DNAPL entered the excavation; the screened interval was surrounded by crushed stone, with the remainder of the excavation filled with quarry process material.

On 18 September 2002, a vacuum truck from EISCO-NJ was mobilized to the site to begin total fluids extraction from the sump. Prior to beginning the total fluids extraction, the sump was gauged and found to contain approximately two feet of water, but no measurable amounts of either light non-aqueous phase liquid (LNAPL) or DNAPL. After two extraction periods totaling 2.5 hours, approximately 30.0 gallons of water (but no measurable amounts of product) were recovered.

On 24 September 2002, the sump near Building 16 was removed and a 10' x 15' area was excavated an additional 3.0 feet in depth (to approximately 15.0 feet below grade) in the vicinity of where the DNAPL entered the trench. During the removal of the sump, it was observed that the materials used to backfill the initial excavation on 17 September 2002 from below the water table appeared to be stained. However, the soils excavated from approximately 12.0 to 15.0 feet below grade on 24 September 2002 did not appear to be stained. Since the excavation extended several feet below the water table, it was not possible to visually inspect the soils remaining in place.

In order to document the concentrations of 1,1'-biphenyl and diphenyl ether that remained at the base of the excavation, one soil sample was collected and analyzed for base neutral compounds plus an NBS library search (BNC+15; USEPA Method 8270). Post-excavation sample SL-HS-2A contained 549 ppm of 1,1'-biphenyl and 1,270 ppm of diphenyl ether, both of which exceed the current and proposed IGWCC for these compounds.

6.7.1 AEC-36 - April and August 2003 Investigation

On 9 April 2003, six borings (BLD16-1 through BLD16-6) were installed through the floor and immediately outside the southwest corner of the building. Each boring was advanced to the top of the silty clay layer that is present in the southwest corner of the site. Borings BLD16-1 through BLD16-5 were advanced to 16.0 feet below grade, while boring BLD16-6 (located inside Building 16) was advanced to 24.0 feet. The greater depth of BLD16-6 was required to correct for the 6.0 feet difference between the floor of the building and the outside ground surface. In order to accurately compare the findings from boring BLD16-6 to the other five borings in this area, all depth intervals for boring BLD16-6 have been corrected to reflect depth below ground surface instead of depth below the floor of the building. On 11 August 2003, an additional 10 soil borings (BLD16-7 through BLD16-16) were installed outside the southwest corner of Building 16 to delineate the 1,1'-biphenyl and diphenyl ether detected in the April 2003 samples. The results of the April and August 2003 sampling events are discussed below.

6.7.1.1 *Sampling Methodology*

All of the soil sampling conducted for this investigation was performed by standard direct push methodology. The Geoprobe was operated by a New Jersey licensed driller (Summit Drilling Co., Inc.) under the supervision of an Sovereign geologist. Soil samples were collected into acetate liners within a stainless steel sampler. Each liner was removed from the sampler, slit open, and screened for VOCs using a PID equipped with a 10.6 eV bulb. The descriptions of soil lithologies, results of PID screening, and the depths of the samples collected were recorded in the field. Soil boring logs for this investigation are included in Appendix D.

If stained soil was encountered, a sample was field screened for the presence of DNAPL by placing soil in a polyethylene tube with a few milligrams of Sudan IV dye. A sufficient amount of water was then added to saturate the sample, and the tube was shaken for 10 to 20 seconds to create a soil/water suspension. The contents of the tube was then inspected for the presence of DNAPL. At the completion of sampling, each boring was Tremie grouted to grade using a cement/bentonite grout.

6.7.1.2 *Field Screening & Soil Sampling Results - April 2003*

The locations of borings BLD16-1 through BLD16-6 are shown on Figure 44. The top 12.0 to 14.0 feet of soil in each boring consisted of a sandy fill material with little gravel and silt. The fill material in borings BLD16-1, BLD16-3, BLD16-4, and BLD16-6 is underlain by clay or clayey sand. In boring

BLD16-2, well graded sand with silt was encountered from below the fill material to the completion depth of the boring at 16.0 feet below grade. In boring BLD16-5, silty sand was encountered from 14.0 - 16.0 feet below grade. Stained soil was only encountered near the bottom of the fill material in borings BLD16-1 and BLD16-3. No appreciable PID readings were recorded from depths above 11.0 to 12.0 feet below grade. In boring BLD16-1, PID readings of 59.0 ppm were found in the sandy clay layer at 14.0 - 16.0 feet below grade. In boring BLD16-3, PID readings of 59.0 to 199 ppm were found within the fill material from 12.5 to 13.5 feet below grade. PID readings of approximately 20.0 ppm were found in the fill material from 11.5 to 14.0 feet below grade in BLD16-4, but increased to 348 ppm in the top six inches of the clayey sand (14.0 - 14.5 feet below grade) before decreasing to 14.1 ppm at 15.5 - 16.0 feet below grade. None of the stained soil yielded positive results when screened for the presence of DNAPL using the Sudan IV dye test.

Soil samples from borings BLD16-1 through BLD16-6 were to be collected from the following depth intervals: 1) 13.5 - 14.0 feet, which corresponded to the depth of post-excavation sample SL-HS-2A; 2) the bottom of each boring for the purposes of vertically defining the extent of the Dowtherm contamination; and 3) the interval within each boring that exhibited the highest field screening results or obvious signs of contamination. All three samples were collected from each boring, with the exception of BLD16-3, in which only two samples could be collected from above the clay layer due to poor sample recoveries. The following table summarizes the designations and depth intervals for the samples collected from these borings.

Building 16 Area
Summary of April 2003 Sample Designations & Depth Intervals

Boring ID	Sample Designations & Depth Intervals (Feet below Grade)		
	A	B	C
BLD16-1	9.5 - 10.0	13.5 - 14.0	15.5 - 16.0
BLD16-2	11.0 - 12.0	13.5 - 14.0	15.5 - 16.0
BLD16-3	12.5 - 13.0	13.5 - 14.0	Not Sampled
BLD16-4	10.5 - 11.0	13.5 - 14.0	15.5 - 16.0
BLD16-5	10.5 - 11.0	13.5 - 14.0	15.5 - 16.0

Building 16 Area Summary of April 2003 Sample Designations & Depth Intervals			
Boring ID	Sample Designations & Depth Intervals (Feet below Grade)		
	A	B	C
BLD16-6	13.5 - 14.0 (19.5 - 20.0)*	16.5 - 17.0 (22.5 - 23.0)*	17.0 - 17.5 (23.0 - 23.5)*

Notes:
* - Depth interval in feet below the floor of the building.

The analytical results for the samples from borings BLD16-1 through BLD16-6 are summarized on Table 66, and are presented on Figure 45. TPH and VOCs were either not detected or were present at concentrations below their respective remediation criteria. The concentrations of 1,1'-biphenyl and diphenyl ether were below their respective remediation criteria of 12.0 ppm and 19.0 ppm in all of the samples from borings BLD16-2, BLD16-5, and BLD16-6, which completes the horizontal delineation of these compounds to the east and north of post-excavation sample SL-HS-2. 1,1'-Biphenyl concentrations exceeded the IGWCC of 12.0 ppm in samples BLD16-1B (494 ppm), BLD16-3B (456 ppm), and BLD16-4B (332 ppm). Diphenyl ether concentrations exceeded the IGWCC of 19.0 ppm in samples BLD16-1B (1,640 ppm), BLD16-3A (32.7 ppm), BLD16-3B (1,330 ppm), and BLD16-4B (945 ppm). With the exception of 0.74 ppm of benzo(a)pyrene in sample BLD16-2A, no other BNA compounds exceeded their respective remediation criteria; the RDCCC and NRDCCC for benzo(a)pyrene is 0.66 ppm. It should be noted that benzo(a)pyrene and other polynuclear aromatic hydrocarbons (PAHs) are present in the fill material across the site. Therefore, EPI believes that the presence of benzo(a)pyrene in sample BLD16-2A is not related to the Dowtherm release and does not require further investigation. The analytical results suggest that the Dowtherm impacted soil is limited to the base of the Hudson Street sewer line excavation trench.

6.7.1.3 - *Field Screening & Soil Sampling Results - August 2003*

Additional soil sampling was required to complete the horizontal delineation of the 1,1'-biphenyl and diphenyl ether detected in sample BLD16-4B (13.5 - 14.0 feet below grade), and the horizontal and vertical delineation of the 1,1'-biphenyl and diphenyl ether detected in sample BLD16-3 (12.5 - 13.0 feet and 13.5 - 14.0 feet below grade). The locations of soil borings BLD16-7 through BLD16-16 are shown on Figure 44. Each boring was advanced to 16.0 feet below grade using Geoprobe methodology.

The top 2.0 to 12.0 feet of soil in each boring consisted of a sandy fill material containing coarse gravel. The amount of fill material was dependent on whether the boring was located in undisturbed soil or within the sewer line excavation trench. In BLD16-7, the top 3.5 feet of fill material was underlain by 8.5 feet of poorly graded sand, followed by well graded sand from 12.0 - 15.0 feet below grade. Silty sand was encountered at 15.0 - 16.0 feet below grade. No staining was observed on the soil; due to a malfunctioning PID, it was not possible to screen soil for VOCs. Soil sample BLD16-7A was collected at 13.5 - 14.0 feet below grade from the well graded sand.

In boring BLD16-8, 8.0 feet of fill material was underlain by 4.0 feet of well graded sand and gravel to 12.0 feet below grade, followed by silty sand to the completion depth of the boring at 16.0 feet below grade. No staining was observed on the soil; due to a malfunctioning PID, it was not possible to screen soil for VOCs. Soil sample BLD16-8A was collected at 13.5 - 14.0 feet below grade from the silty sand.

In BLD16-9, the top 4.0 feet of fill material was underlain by 4.0 feet of poorly graded sand, followed by well graded sand to the completion depth of the boring at 16.0 feet below grade. No staining was observed on the soil; due to a malfunctioning PID, it was not possible to screen soil for VOCs. Soil sample BLD16-9A was collected at 13.5 - 14.0 feet below grade from the well graded sand.

In boring BLD16-10, 2.0 feet of fill material was underlain by 3.0 feet of silty sand, followed by poorly graded sand from 5.0 - 11.0 feet below grade. From 11.0 - 16.0 feet below grade, the soil consisted of well graded gravel and sand. No staining was observed on the soil, and no VOCs were detected while screening with a PID. Soil sample BLD16-10A was collected at 13.5 - 14.0 feet below grade from the well graded gravel and sand.

The soil in boring BLD16-11 consisted of 4.0 feet of fill material underlain by 10.0 feet of poorly graded sand to 14.0 feet below grade. The interval from 14.0 - 16.0 feet below grade consisted of lean clay. No staining was observed on the soil, and no VOCs were detected by the PID. Soil samples BLD16-11A and BLD16-11B were collected from the poorly graded sand at 12.5 - 13.0 and 13.5 - 14.0 feet below grade, respectively, while sample BLD16-11C was collected from the lean clay at the bottom of the boring at 15.5 - 16.0 feet below grade.

In BLD16-12, the top 8.0 feet of fill material was underlain by well graded sand with clay from 8.0 - 14.0 feet below grade. As in boring BLD16-11, lean clay was present from 14.0 - 16.0 feet below grade. Stained soil was observed in both the sand and clay and lean clay intervals. In the sand and clay interval, PID readings ranged from 99.0 ppm to 1,420 ppm, while in the lean clay interval, PID readings of 374 ppm and 510 ppm were detected. Soil samples BLD16-12A and BLD16-12B were collected from the sand and clay interval at 12.5 - 13.0 feet (PID reading of 99.0 ppm) and 13.5 - 14.0 feet (PID reading of 1,420 ppm), respectively, while sample BLD16-12C was collected from the lean clay at the bottom of the boring at 15.5 - 16.0 feet below grade.

Boring BLD16-13 was installed adjacent to boring BLD16-3 for the purposes of collecting a vertical delineation sample at this location; a sample from within the clay layer could not be obtained from boring BLD16-3. Given that boring BLD16-13 was located within the former sewer line excavation trench, the top 12.0 feet of soil consisted of fill material. Silty sand was encountered from 12.0 - 14.0 feet below grade, followed by lean clay from 14.0 - 16.0 feet below grade. No staining was observed on the soil, and no VOCs were detected by the PID. Soil sample BLD16-13 was collected from the lean clay at the bottom of the boring at 15.5 - 16.0 feet below grade.

The soil in boring BLD16-14 consisted of 8.0 feet of fill material underlain by 6.0 feet of sandy lean clay to 14.0 feet below grade.. The interval from 14.0 - 16.0 feet below grade consisted of lean clay. No staining was observed on the soil, and no VOCs were detected while screening with the PID. Soil samples BLD16-14A and BLD16-14B were collected at 12.5 - 13.0 and 13.5 - 14.0 feet below grade, respectively from the sandy lean clay, while sample BLD16-14C was collected from the lean clay at the bottom of the boring at 15.5 - 16.0 feet below grade.

In BLD16-15, the top 4.0 feet of fill material was underlain by 12.0 feet of poorly graded sand to the completion depth of the boring at 16.0 feet below grade. No staining was observed on the soil, and no VOCs were detected while screening with the PID. Soil sample BLD16-15A (12.5 - 13.0 feet below grade) and BLD16-15B (13.5 - 14.0 feet below grade) were collected from the poorly graded sand interval.

In boring BLD16-16, 4.0 feet of fill material was underlain by 10.0 feet of poorly graded sand to 14.0 feet below grade. From 14.0 - 16.0 feet below grade, the soil consisted of silty sand. No staining was observed on the soil, and no VOCs by the PID.

The analytical results for the samples collected from borings BLD16-7 through BLD16-15 are summarized on Table 66 and are presented on Figure 45; no samples were required to be analyzed from boring BLD16-16. The concentrations of 1,1'-biphenyl and diphenyl ether were below their current IGWCC of 12.0 ppm and 19.0 ppm, respectively, in samples BLD16-7A, BLD16-8A, BLD16-13, BLD16-14C, BLD16-15A, and BLD16-15B. 1,1'-Biphenyl concentrations were also below the current IGWCC of 12.0 ppm in samples BLD16-11C (6.28 ppm) and BLD16-14B (5.03 ppm). Concentrations of 1,1'-biphenyl exceeded the current IGWCC of 12.0 ppm, but did not exceed EPI's proposed IGWCC of 139 ppm, in samples BLD16-9A (139 ppm) and BLD16-14A (99.0 ppm). Samples BLD16-10A (232 ppm), BLD16-11A (440 ppm), BLD16-11B (1,040 ppm), BLD16-12A (5,540 ppm), BLD16-12B (501 ppm), and BLD16-12C (175 ppm) all contained 1,1'-biphenyl concentrations that exceed EPI's proposed IGWCC. Concentrations of diphenyl ether exceeded the current IGWCC of 19.0 ppm, but did not exceed EPI's proposed IGWCC of 476 ppm, in samples BLD16-9A (476 ppm), BLD16-11C (21.0 ppm), BLD16-14A (382 ppm), and BLD16-14B (20.2 ppm). Diphenyl ether was detected in samples BLD16-10A (819 ppm), BLD16-11A (1,440 ppm), BLD16-11B (3,320 ppm), BLD16-12A (19,100 ppm), BLD16-12B (1,640 ppm), and BLD16-12C (525 ppm) at concentrations exceeding EPI's proposed IGWCC.

As was discussed in Section 6.1.2 of this report, the initial IGWCC for 1,1'-biphenyl and diphenyl ether were based on the highest total concentrations found in a sample on which an SPLP test had been conducted. In order to determine if higher IGWCC were possible, EPI performed SPLP tests on three of the Building 16 investigation soil samples (BLD16-9A, BLD16-12A, and BLD16-14A) that contained higher concentrations of 1,1'-biphenyl and diphenyl ether than the samples on which the original SPLP tests were performed in October 1998.

The analytical results for the SPLP tests on BLD16-9A, BLD16-12A, and BLD16-14A are summarized on Table 67. The SPLP test performed on sample BLD16-9A generated 0.92 ppb and 339 ppb of 1,1'-biphenyl and diphenyl ether, respectively. The SPLP test on BLD16-12A generated 2,810 ppb of 1,1'-

biphenyl and 7,990 ppb of diphenyl ether. The leachate from the SPLP test on BLD16-14A contained 143 ppb of 1,1'-biphenyl and 542 ppb of diphenyl ether.

Since the SPLP test on sample BLD16-9A resulted in 1,1'-biphenyl and diphenyl ether concentrations that were below the NJDEP's current IGWQS of 400 ppb for 1,1'-biphenyl, EPI proposes that the total concentrations in sample BLD16-9A become the new IGWCC for these compounds (i.e., 139 ppm for 1,1'-biphenyl and 476 ppm for diphenyl ether).

7.0 BIOSPARGING BENCH SCALE TREATABILITY TESTING

As indicated in Section 2.6, soil and groundwater samples were collected from the ORC-4D area for the purposes of conducting bench scale treatability testing to determine if biosparging would be viable for remediating the Northern Phenol area. A copy of the treatability study report is included in Appendix G. A total of four saturated soil columns were used in the treatability study: two columns were static and two had air injected at the bottom of the column. The soil used in the columns was collected from the drill cuttings from soil boring ORC4DSB-2. The groundwater used in the study was collected from ORC-4D. The physical, chemical, and biological properties of the soil (after homogenization) and groundwater are summarized on the following Table.

Characteristics of the Soil & Groundwater used in the Treatability Study

Parameter	Soil	Groundwater
pH	7.83	8.28
Inorganic Nitrogen NH_4 - N NO_3 - N	 4.4 mg/Kg 5.7 mg/Kg	 1.0 mg/L 0.4 mg/L
Inorganic Phosphorus Orthophosphate - P	 6.3 mg/Kg	 1.15 mg/L
Total Heterotrophs	8.53×10^6 cfu	2.52×10^4 cfu
Phenol Degraders	4.67×10^4 mpn	2.28×10^3 mpn
Salicylic Acid Degraders	7.12×10^4 mpn	4.40×10^3 mpn
Methanol Degraders	5.55×10^4 mpn	3.46×10^3 mpn

Note:
cfu = Colony Forming Units/gram of soil or milliliter of water
mpn = Most Probable Number/gram of soil or milliliter of water

The pH of the soil and groundwater were within the optimum range (6.5 - 8.5) for biodegradation and should be capable of supporting a diversified microbial community.

Air was injected at a rate of 5.0 ml/minute, and diffused upward through the columns to simulate a biosparging scenario. The column study was conducted for eight weeks, with samples being collected at intervals of 0, 2, 4, 6, and 8 weeks into the study to monitor the degradation of phenol, salicylic acid, and methanol. Throughout the eight week study, the columns were incubated at 20°C (68°F). The average starting concentrations of phenol, salicylic acid, and methanol are summarized below:

Average Starting Groundwater Concentrations for the Treatability Study

Parameter	Static Columns	Biosparge Columns
Phenol	43,000	42,500
Salicylic Acid	146,500	152,500
Methanol	5,750	6,000

Note:
All concentrations in ppb.

The results of the treatability study are summarized on the tables and graphs included in Appendix G. Of the three compounds in the study, methanol degraded most rapidly, followed by phenol and then salicylic acid. In both the static and biosparge columns, no detectable concentrations of methanol were found after the first two weeks of the study. After two weeks, phenol concentrations decreased 35% in the static columns, and 81% in the biosparge columns. After six weeks, the static columns still contained an average concentration of 8,750 ppb of phenol, but no detectable concentrations were found in the biosparge columns. Salicylic acid concentrations decreased 33% in the static columns and 71% in the biosparge columns after two weeks. After six weeks, the static columns contained an average salicylic acid concentration of 12,500 ppb, while the biosparge columns contained an average concentration of 1,000 ppb. By the completion of the study, salicylic acid was not detected in the biosparge columns, but was present at an average concentration of 3,750 ppb in the static columns.

By the end of the treatability study, no detectable concentrations of phenol, salicylic acid, and methanol were found in the biosparge columns. However, concentrations also decreased significantly in the static columns, which would suggest that very rapid degradation was already occurring in the deep overburden zone. However, since the concentrations of phenol, salicylic acid, and methanol in ORC-4D have not been decreasing with time, it is likely that the conditions in the static columns were not an accurate simulation of *in situ* conditions. The degradation rates seen in the static columns are most likely related to the homogenization of the soil used in the columns, which increases the oxygen available to the microorganisms present in the soil and results in artificially improved conditions and increased degradation rates.

For all three compounds, the greatest decrease in concentrations in the sparging columns occurred during the first two weeks of the study. Given the physical properties of each compound (i.e., their high solubilities in water and their high Henry's Law constants), the amount of methanol, phenol, and salicylic acid lost to volatilization due to sparging was not quantified during the treatability study. EPI believes the decreased concentrations observed were primarily due to biodegradation, and that the losses due to volatilization, if any, were minimal[7].

The treatability study indicated that aeration (i.e., an oxygen source) is the most limiting factor needed to enhance biodegradation of the phenol, salicylic acid, and methanol present in the deep overburden zone groundwater. As shown on the tables and graphs in Appendix G, when air was injected into the columns, the microbial populations capable of degrading phenol, salicylic acid, and methanol showed a greater increase in the biosparge columns relative to the static columns. Therefore, the results of the treatability study confirm that biosparging would be a viable technology for remediating the phenol, salicylic acid, and methanol present in the deep overburden zone of the Northern Phenol Area to below the applicable remedial standards. Although formaldehyde was not included in this treatability test, a previous test conducted in 1995 during the design of the air curtain biosparging system in the southwest corner of the site indicated that formaldehyde would rapidly degrade under aerobic conditions. A copy of the report for this earlier treatability test is also included in Appendix G.

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[7] Air sparging and air stripping are not recommended treatments for phenol, salicylic acid, and methanol due to the very high air-to-water ratios required to remove these compounds from groundwater.

8.0 CHEMICAL OXIDATION BENCH SCALE TREATABILITY TESTING

Between December 2002 and April 2003, PRIMA Environmental (PRIMA) in Sacramento, California conducted bench-scale treatability testing for the purposes of determining if the Dowtherm DNAPL could be remediated by *in situ* chemical oxidation. Treatability tests were conducted using three oxidants, including potassium permanganate ($KMnO_4$), Fenton's reagent, and ozone. $KMnO_4$ is a moderately strong oxidant that has been used extensively to treat chlorinated solvents in groundwater. Chemical reactions for the potential conversion of 1,1'-biphenyl and diphenyl ether into carbon dioxide (CO_2) using $KMnO_4$ as an oxidant are:

$$\underset{\text{1,1'-Biphenyl}}{3C_{12}H_{10}} + 58KMnO_4 + 58H^+ \text{------->} 58MnO_2 + 36CO_2 + 44H_2O + 58K^+ \quad (1)$$

$$\underset{\text{Diphenyl Ether}}{3C_{12}H_{10}O} + 56KMnO_4 + 56H^+ \text{------->} 56MnO_2 + 36CO_2 + 43H_2O + 56K^+ \quad (2)$$

Based on these equations, the stoichiometric dose requirements for each COC would be 20g of $KMnO_4$ per gram of 1,1'-biphenyl, and 17g of $KMnO_4$ per gram of diphenyl ether.

Fenton's reagent is an acidified mixture of hydrogen peroxide (H_2O_2) and ferrous iron catalyst. It is a strong oxidant that is known to react with a wide range of organic compounds including aromatics such as benzene and toluene, and ethers such as methyl tertiary butyl ether (MTBE). Because oxidation by Fenton's reagent is a catalytic process, chemical reactions cannot easily be written, and stoichiometric doses cannot be determined without testing.

Ozone, a gas that can be sparged into groundwater, is also a strong oxidant that can destroy a wide range of organic compounds. Ozone may react directly with the COCs, or it may react with transition metals in the soil and groundwater to create hydroxyl radicals. Possible chemical reactions for the direct oxidation of 1,1'-biphenyl and diphenyl ether by ozone are:

$$\underset{\text{1,1'-Biphenyl}}{C_{12}H_{10}} + 29O_3 \text{------->} 29O_2 + 12CO_2 + 5H_2O \quad (3)$$

$$\underset{\text{Diphenyl Ether}}{C_{12}H_{10}O} + 28O_3 \text{------->} 28O_2 + 12CO_2 + 5H_2O \quad (4)$$

Because of the uncertainty of the effectiveness of these oxidants on the compounds of concern (COCs), the bench-scale testing was conducted in two phases. In Phase I, batch tests were conducted on impacted groundwater to determine whether each of the oxidants was capable of destroying the COCs. In Phase II, testing was conducted on soil and groundwater to determine whether *in situ* implementation was practicable and to develop design parameters. The results of these tests are summarized in the following Sections. A full description of the bench-scale testing conducted is included in the treatability testing report in Appendix H.

8.1 Phase I Tests

For $KMnO_4$ and Fenton's reagent, batch tests were conducted in which the oxidant was added to groundwater collected from air sparge well AS-12; a small amount of DNAPL was also present in the groundwater sample. After about 24 hours, the water was analyzed for 1,1'-biphenyl and diphenyl ether. Control tests in which de-ionized water rather than the oxidant was added were also run in order to estimate losses due to sample handling. For ozone, contaminated groundwater was sparged with ozone, while the control test was sparged with nitrogen gas. The control allowed estimates to be made of losses due to oxidation versus losses due to sparging.

8.1.1 Phase I Test Results

Although none of the oxidants completely removed all of the 1,1'-biphenyl or diphenyl ether, each was able to significantly reduce the dissolved concentrations of each compound. As summarized on the following Table, ozone removed over 99% of the dissolved 1,1'-biphenyl and diphenyl ether, Fenton's reagent removed over 84%, and $KMnO_4$ removed about 69%.

Phase I Chemical Oxidation Bench Scale Treatability Test Results								
	Ozone Test			Fenton's & $KMnO_4$ Tests				
Compound	Nitrogen (Control)	Ozone	% Removed	Control	Fenton's	% Removed	$KMnO_4$	% Removed
1,1'-Biphenyl	131,000	988	99.2	45,200	7,120	84.2	14,300	68.4
Diphenyl Ether	293,000	1,480	99.2	101,000	12,700	87.4	31,000	69.3
Notes: All concentrations in ug/L.								

The initial concentration of $KMnO_4$ in the tests was 4.7 g/L, which is almost 2 times the stoichiometric dose needed to convert the 1,1'-biphenyl and diphenyl ether to carbon dioxide. The amount of $KMnO_4$ consumed in the test (1,400 mg/L) correlated well to the amount needed to treat the portion of COCs that were actually removed (1,808 mg/L). This suggests that complete removal might be achieved with either a longer reaction time or with a higher $KMnO_4$ dose, which could increase the rate of reaction.

Based on the stoichiometries of Equations 3 and 4, and the concentration of COCs in the nitrogen-sparged control, 3.5 g of ozone were required to completely oxidize 1,1'-biphenyl and diphenyl ether in the Dowtherm ozone tests. About 20 g of ozone was sparged into each column over the course of the test, yet complete removal of COCs was not achieved. This indicates that there may be physical factors limiting the rate of COC oxidation by ozone - for example, inefficient dissolution of ozone from the gas phase into the aqueous phase (and/or COC transfer from the aqueous phase into the gas phase) or slow dissolution of COCs from the NAPL phase into the aqueous or gas phase. These factors could be overcome in the field by treating for a longer period of time.

8.2 Phase II Tests

Based on the Phase I test results, all three oxidants were further evaluated during Phase II testing. The procedures used were similar to those of the Phase I tests, but included soil as well as groundwater. In addition, other parameters such as $KMnO_4$ soil oxidant demand and rate of off-gas formation during Fenton's reagent oxidation were evaluated during Phase II testing. Soil for the tests was collected during the February 2003 soil sampling program around AS-12 (Section 6.6, above). Once the soil samples for laboratory analysis had been collected, the unused soil from each sample liner was composited into a five gallon pail and shipped to PRIMA. Since AS-12 had been accidentally sealed with grout, groundwater for the Phase II tests was collected from MW-D5, which was known to contain elevated dissolved concentrations of 1,1'-biphenyl and diphenyl ether.

8.2.1 Phase II Test Results

In the Phase II $KMnO_4$ tests, no COCs were observed in the aqueous phase of the Control test at concentrations above the detection limits of 2.2 μg/L for 1,1'-biphenyl and diphenyl ether. In addition, the concentrations in the soil were low compared to the $KMnO_4$-treated soils and to the Fenton's Control. Discussions with Accutest Laboratories and review of PRIMA's notes yielded no obvious explanation for these results. Because the results of the Control test were low, interpretation of the remaining data related to the $KMnO_4$ tests is limited.

$KMnO_4$ did not completely remove COCs from either the aqueous or soil phases within seven days. It is unclear whether any COCs were destroyed since the Control data are ambiguous. However, some COCs in the soil phase were apparently solubilized: increasing the concentration of $KMnO_4$ from 5 g/L to 12 g/L increased the COC concentrations in the aqueous phase and decreased the concentrations in the soil phase. The total mass of each COC in the system was approximately the same, however. It is possible that sorbed COCs were released into the aqueous phase as soil organic matter was preferentially oxidized. At the end of the test, the concentration of $KMnO_4$ was still high (the water was nearly black in both tests), indicating that $KMnO_4$ was not a limiting reagent. Greater removal could have possibly been achieved given longer contact times.

Fenton's reagent was very effective in treating the 1,1'-biphenyl and diphenyl ether. Aqueous concentrations of 1,1'-biphenyl and diphenyl ether were reduced by up to 100% when 5% H_2O_2 was used and up to 87% when 10% H_2O_2 was used. Similarly, soil concentrations were decreased up to 98% with 5% H_2O_2 and up to 54% with 10% H_2O_2. Over all, 96-98% of the COCs were removed from the soil and water using 5% H_2O_2, but only 57-58% were removed using 10% H_2O_2. Poorer performance with higher concentrations of H_2O_2 is possible because excess H_2O_2 can react with the hydroxyl radicals preventing reaction of the hydroxyl radical with COCs.

Ozone did not completely remove COCs from either the soil or aqueous phases in the Dowtherm tests. Aqueous COC concentrations were lower at 24 hours than at 6 hours, indicating some removal. Although this removal is most likely due to oxidation, this is difficult to confirm, especially for 1,1'-biphenyl, which had much lower concentrations in the nitrogen-sparged system (the control) than in the ozone-sparged system. The reason for this is not known, since Phase I testing indicated that COCs were not readily lost by sparging with nitrogen. The concentrations of COCs in the soil were higher in the ozone treated system than in the nitrogen-sparged system; it is possible that the soil used was not well-homogenized.

8.3 Conclusions

All three oxidants removed a portion of the 1,1'-biphenyl and diphenyl ether from the aqueous phase during Phase I testing, though ozone and Fenton's reagent were more effective than $KMnO_4$. Incomplete removal was probably due, in part, to insufficient contact, which could be addressed in full scale treatment design. In Phase II testing, which incorporated soil, Fenton's reagent was most effective, though this may have been due, in part, to better mixing among soil, water, and added oxidants. None of the oxidants evaluated completely removed all COCs from both the soil and water phases. Ozone effectively treated aqueous phase COCs, but not soil-phase COCs, apparently because it did not disperse well in the soil. A full-scale *in situ* treatment system would likely be effective if the issues of dispersion could be addressed.

9.0 REMEDIAL ACTION SELECTION

In accordance with N.J.A.C. 7:26E-5.1, the remedial actions selected for the Kalama Chemical site will ensure that there is a reduction or elimination of potential exposure to compounds of concern at concentrations above the applicable remediation standards. The selection of the remedial actions for the Kalama site considered the following:

- The short and long-term protection of public health and safety and the environment;
- The implementability of the proposed remedial action;
- The reliability of the remediation technology;
- The ability to reduce toxicity, mobility, and volume of the contaminants;
- The ability to expedite the remediation effort; and,
- The consistency of the proposed remedial action with other applicable Federal, State, and local laws and regulations.

The groundwater and soil remediation standards for the Northern Phenol Area are presented in Section 2.0 of this report. For the Dowtherm DNAPL Areas, the soil and groundwater remediation standards are provided in Section 6.0 of this report.

The remedial action selection for the Northern Phenol Area and the Dowtherm DNAPL areas are presented below. For both areas, a description of each selected technology and a discussion of how the remedial action satisfies the requirements of N.J.A.C. 7:26E-5 (c) are discussed.

9.1 Northern Phenol Area– Remedial Action Selection

A review of available information and data for the Northern Phenol Area suggest that the extent of impact in the deep and shallow overburden zones are restricted to the site, but distributed over a wide area. Because of the extent and volume of impacted soil and groundwater in Northern Phenol Area, only *in situ* treatment technologies were considered in the remedial action selection. The evaluated technologies would not be disruptive to the existing remediation and monitoring infrastructure currently available at the site.

The following remedial action alternatives were evaluated for the Northern Phenol Area:

- Air Sparging;
- Biosparging;
- Chemical Oxidation
- Pump and Treat; and,
- Containment.

A discussion of each of the potential technologies for remediating the Northern Phenol Area is presented in the following subsections.

9.1.1 Air Sparging

Air sparging is an *in situ* technology in which air is injected through a contaminated saturated zone. The injected air moves through the saturated zone and removes contamination by volatilization. During air sparging, volatilized contaminants are commonly flushed upwards and into the unsaturated zone in the vapor phase. A soil vapor extraction system is typically installed in conjunction with air sparging to remove the generated vapor phase contamination.

The target contaminant groups for air sparging are volatile organic compounds and fuels. Air sparging is not generally a recommended remedial action for phenol, salicylic acid, methanol, and formaldehyde because of the high air-to-water ratios required to successfully remove these compounds from groundwater. As a result, air sparging was not selected as the remediation technology for addressing the Northern Phenol Area.

9.1.2 Biosparging

Biosparging is similar to air sparging in that air is injected into the saturated zone to remediate groundwater. However, in a biosparging system, biodegradation is the primary remedial process. A biosparge system introduces oxygen (and sometime nutrients) into a contaminated saturated zone. The provided oxygen and/or nutrients promote the biodegradation of contaminants by existing bacteria. The technology can be applied through conventional vertical wells or horizontal wells. The results of the bench-scale treatability tests discussed in Section 7.0 indicate that phenol, salicylic acid, methanol, and formaldehyde can all be degraded by the indigenous bacterial population under aerobic conditions. Therefore, biosparging would be a suitable technology for remediating the Northern Phenol Area.

9.1.3 Chemical Oxidation

In situ chemical oxidation (including Fenton's reagent, ozone, and permanganate) involves injecting chemical oxidants into contaminated saturated or unsaturated zones. The objective of this technology is the complete mineralization of contaminants to carbon dioxide and water. Chemical oxidation technologies can generally be applied to sites contaminated with high concentrations of chlorinated volatile organics, fuels, semi-volatile contaminants or pesticides. Drawbacks to chemical oxidation include the probable need for re-circulation wells at the site to compensate for soil heterogeneities and resultant uneven injection of oxidants. Often times, more than one injection dose is required. In addition, native organic matter can compete for the injected oxidants, causing an increase in the volume of chemicals required. Chemical oxidation is most effective in treating relatively small source areas. Due to the volume of oxidizing solutions that would be required, treating large dissolved phase plumes with this technology is typically not cost effective. As a result of the limitations stated above, the chemical oxidation technology was not a selected remedial alternative for the Northern Phenol Area.

9.1.4 Pump & Treat

Pump and treat technology removes contaminated water from the saturated zone through single or multiple pumping wells. The extracted groundwater typically requires treatment prior to discharge to a sewer or surface water body, or prior to re-injection to the subsurface. Treatment may include air stripping or granular activated carbon. Pump and treat systems typically require extended periods of time (10+ years) to achieve the remediation standards. During pumping, drawdown occurs and contaminants commonly become adsorbed to the soils. When pumping is discontinued, adsorbed contaminants can be re-dissolved creating a rebound effect.

Pump and treat technology has commonly been used for the containment of groundwater plumes contaminated by volatile and semi-volatile organic compounds and metals. Where high concentrations of iron or calcium are present in the groundwater (as is the case at the Kalama site), fouling of the system is common. The slow rate of remediation, the uncertainties in how the treated groundwater would be able to be discharged, and the costly operation and maintenance that would be required to insure optimum performance of the system are the primary reasons pump and treat was not selected as the remedial technology for the Northern Phenol Area.

9.1.5 Containment

Containment technologies include the use of slurry walls or grout walls to prevent the horizontal migration of contaminants. The use of these technologies require vertically excavated trenches which are backfilled with the slurry, grout or reactive agent. The trenches may extend to 30.0 feet in depth and are generally two to four feet thick. Optimum use of a containment wall technology would allow for the base of the wall to vertically key two to three feet into a low permeability layer (e.g. clay, bedrock). This technology is typically used in conjunction with capping.

Containment technology can be used with any contaminant. However, some contaminants may deteriorate a slurry or grout wall over time. Although there is a low permeability glacial till unit available at the site to key a containment wall into, the glacial till unit is deeper than 30.0 feet. Long term monitoring is required to monitor the containment wall integrity. Because this technology would not serve to reduce the concentrations of the compounds of concern in the shallow and deep overburden groundwater zones, and would not be a permanent remediation effort, containment was not a selected remedial alternative for the Northern Phenol Area.

9.1.6 Selected Remedial Technology

A summary of the evaluated criteria for the selection of the groundwater and soil remedial actions in the deep overburden zone of Northern Phenol Area is presented in the Table below.

Evaluation of Remedial Technologies for the Northern Phenol Area					
	Biosparging	Air Sparging	Chemical Oxidation	Pump & Treat	Containment
Ability to Achieve Remediation Standards	High	Low	Low - Moderate	Low	Low
Reliability of Technology	High	High	High	High	Moderate - High
Ability to Reduce Toxicity, Mobility, and Volume	High	Low	Moderate	Low - Moderate	Moderate - High
Ability to Minimize Risks & Short Term Impacts	High	Low	Moderate	High	High
Ability to Provide Long Term Protection	High	Low	Moderate	Moderate	Moderate - High
Ability to Mitigate or Eliminate Off-site Migration	High	Low	Moderate	Moderate	High
Ability to Expedite Remediation	High	Low	Moderate	Low	Low
Ability to be Protective of Public Health, Safety, and the Environment	High	Low	Moderate - High	Low - Moderate	High

Biosparging has been selected to remediate the Northern Phenol Area. This technology will avoid costly pumping technologies and should prove to be very effective for the treatment of the large Northern Phenol Area. It should be noted that this technology has already been proven to be effective in remediating groundwater in the southwest corner of the site, where the air curtain has been in operation since 1998. The conceptual design of the biosparge system for the Northern Phenol Area is presented in Section 10.0 of this report.

9.2 Dowtherm DNAPL Areas – Remedial Action Selection

A review of available information and data for the Dowtherm DNAPL Areas suggests that the contamination is limited to discrete identified zones within the subsurface. Because the impacted soils are restricted to limited areas of the Dowtherm DNAPL Areas and residual and free product are anticipated, soil removal was considered in addition to other *in situ* treatment technologies in the remedial action selection.

The following remedial action alternatives were evaluated for the Dowtherm DNAPL Areas:

- Air Sparging/Soil Vapor Extraction (AS/SVE);
- Biosparging;
- Chemical Oxidation;
- Pump and Treat;
- Containment; and,
- Soil Excavation & Off Site Disposal

A discussion of each of the potential technologies for remediating the Dowtherm DNAPL Areas is presented in the following subsections.

9.2.1 Air Sparging/Soil Vapor Extraction

As was discussed above, air sparging is an *in situ* technology in which air is injected through a contaminated saturated zone. The injected air moves through the saturated zone and removes contamination by volatilization. During air sparging, volatilized contaminants are commonly flushed upwards and into the unsaturated zone in the vapor phase. A soil vapor extraction system is typically installed in conjunction with air sparging to remove the generated vapor phase contamination.

The use of air sparging is not generally a recommended remedial action when DNAPL is present in the saturated zone since it may reduce interfacial tensions and promote downward migration of previously trapped DNAPL. In addition, the presence of DNAPL within the area of an existing AS/SVE system (which had operated for 3.5 years prior to its shut down in August 2001) indicates that this technology is not suitable for the remediation of Dowtherm. Therefore, AS/SVE was not a selected remedial alternative for the Dowtherm DNAPL Areas.

9.2.2 Biosparge

Like air sparging, biosparging involves the injection of air into the saturated zone, although the goal of this technology is biodegradation rather than volatilization. Therefore, the potential exists that the injection of air could liberate trapped DNAPL and promote downward migration of the material. Although there is some evidence to suggest that the components of Dowtherm (1,1'-biphenyl and diphenyl ether) can be biodegraded, the DNAPL itself would not be addressed by this technology (since the concentrations in the Dowtherm would be toxic to the indigenous bacteria). Due to the uncertainties in the ability of the technology to achieve the required remediation goals, biosparging was not selected as the remedial alternative for the Dowtherm DNAPL areas.

9.2.3 Chemical Oxidation

In situ chemical oxidation (including Fenton's reagent, ozone, and permanganate) involves injecting chemical oxidants into contaminated saturated or unsaturated zones. The objective of this technology is the complete mineralization of contaminants to carbon dioxide and water. As was discussed in Section 8.0 of this report, bench scale tests indicated that chemical oxidation may be applicable to conditions at the site; and that the use of ozone may be more effective than Fenton's reagent. However, heterogeneities in the soil may require multiple injections of oxidizing solution, or the protracted operation of an ozone sparging system. As a result of these limitations, and concerns that the remediation standards may not be achieved in an acceptable time frame, chemical oxidation was not selected as the remedial alternative for the Dowtherm DNAPL Areas.

9.2.4 Pump and Treat

Pump and treat technology removes contaminated water from the saturated zone through a single or multiple pumping wells. For the removal of DNAPLs, the injection of a surfactant is typically required to enhance its solubility and to reduce the pore volumes of groundwater that would need to be extracted during a pump and treat remediation. The extracted groundwater typically requires treatment prior to discharge to a sewer or surface water body, or prior to re-injection to the subsurface. Treatment may include air stripping or granular activated carbon. Pump and treat systems typically require extended periods of time (10+ years) to achieve the remediation standards. During pumping, drawdown occurs and contaminants commonly become adsorbed to the soils. When pumping is discontinued, adsorbed contaminants can be re-dissolved creating a rebound effect.

Pump and treat technology has commonly been used for the removal of groundwater contaminated by volatile and semi-volatile organic compounds and metals. Where high concentrations of iron or calcium are present in the groundwater (as is the case at the Kalama site), fouling of the system is common. The slow rate of remediation, the uncertainties in how the treated groundwater would be able to be discharged, and the costly operation and maintenance that would be required to insure optimum performance of the system are the primary reasons pump and treat was not selected as the remedial technology for the Dowtherm DNAPL Areas.

9.2.5 Containment

Containment technologies include the use of slurry walls or grout walls to prevent the horizontal migration of contaminants. The use of these technologies require vertically excavated trenches which are backfilled with the slurry, grout or reactive agent. The trenches may extend to 30.0 feet in depth and are generally two to four feet thick. Optimum use of a containment wall technology would allow for the base of the wall to vertically key two to three feet into a low permeability layer (e.g. clay, bedrock). This technology is typically used in conjunction with capping.

Containment technology can be used with any contaminant. However, some contaminants may deteriorate a slurry or grout wall over time. Although there is a low permeability glacial till unit available at the site to key a containment wall into, the glacial till unit is deeper than 30.0 feet. Long term monitoring is required to monitor the containment wall integrity. Because this technology would not serve to reduce the concentrations of the compounds of concern in the shallow and deep overburden groundwater zones, containment was not a selected remedial alternative for the Dowtherm DNAPL areas.

9.2.6 Soil Excavation & Off-Site Disposal

The excavation, removal, and hauling of contaminated soils from the site can be accomplished with conventional equipment commonly used for construction purposes. This remediation alternative can almost totally eliminate the presence of contamination at a site and the potential need for long-term monitoring. Once excavation is initiated, the time to achieve beneficial results can be short relative to alternatives such as *in situ* treatment. Due to the limited areal extent of each Dowtherm DNAPL area, excavation and off-site disposal of soil would be a viable remediation technology at the Kalama site.

9.2.7 Selected Remedial Technology

A summary of the evaluated criteria for the selection of the Soil remedial actions in the Dowtherm DNAPL Areas around AS-12 and the southwest corner of Building 16 is presented in the Table below.

Evaluation of Remedial Technologies for the Dowtherm DNAPL Areas

	Excavation/ Off Site Disposal	Biosparging	Air Sparging	Chemical Oxidation	Pump & Treat	Containment
Ability to Achieve Remediation Standards	High	Low	Low	Low - Moderate	Low	Low
Reliability of Technology	High	High	High	High	High	Moderate - High
Ability to Reduce Toxicity, Mobility, and Volume	High	Low - Moderate	Low - Moderate	Low - Moderate	Moderate - High	Moderate - High
Ability to Minimize Risks & Short Term Impacts	High	Low	Low	Low - Moderate	Low - Moderate	High
Ability to Provide Long Term Protection	High	Low	Low	Low - Moderate	Moderate - High	Moderate - High
Ability to Mitigate or Eliminate Off-site Migration	High	Low	Low	Low - Moderate	Low - Moderate	High
Ability to Expedite Remediation	High	Low	Low	Low - Moderate	Low	Low

Evaluation of Remedial Technologies for the Dowtherm DNAPL Areas						
	Excavation/ Off Site Disposal	Biosparging	Air Sparging	Chemical Oxidation	Pump & Treat	Containment
Ability to be Protective of Public Health, Safety, and the Environment	High	Low	Low	Low - Moderate	Low - Moderate	High

Soil excavation and off-site disposal was the technology selected for the remediation of the Dowtherm DNAPL Areas. Soil excavation will serve to remove residual or free product that could potentially be a continued localized source of groundwater contamination, and would provide the optimum probability for attaining the required remediation objectives. Excavation of the residual and/or free product source soils would also meet site objectives for public health, safety, and the environment in the shortest time frame. The details of the excavation activities to be conducted around AS-12 and the southwest corner of Building 16 are discussed in Section 11.0 of this report.

10.0 N. PHENOL AREA - CONCEPTUAL BIOSPARGE SYSTEM DESIGN

Based on the results of the treatability tests discussed in Section 7.0, and based on the effectiveness of the existing air curtain/biosparge system in remediating groundwater in the southwest corner of the site, EPI proposes to install a second biosparge system to remediate groundwater in the shallow and deep overburden zones in the Northern Phenol Area. The conceptual design for this biosparge system is discussed below.

10.1 Conceptual System Design

The preliminary biosparge system design is based on previous pilot testing conducted in the subject area, including:

- ORC pilot testing;
- Air sparge pilot testing[8]; and,
- Biosparge bench scale treatability testing.

The testing confirmed the effectiveness of oxidation in various forms in degrading the phenol, salicylic acid, formaldehyde, and methanol present in soil and groundwater in the shallow and deep overburden zones. The proposed biosparge system is designed to affect the defined area of remediation by enhancing the natural degradation of the identified compounds by the indigenous bacteria. The enhanced biodegradation would be achieved by injecting air into the saturated zone at low flow rates. The injected air would migrate horizontally and vertically away from the injection point, which would result in an increase in dissolved oxygen concentration of the groundwater. This increase in dissolved oxygen would stimulate biological activity and promote the natural biodegradation of the phenol, salicylic acid, formaldehyde and methanol. Since the availability of oxygen has been identified as the primary factor limiting the aerobic biological degradation of the compounds in the saturated zone, the addition of nutrients (i.e., nitrogen, phosphorous, etc.) is not proposed.

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[8] The results of the air sparging pilot test conducted in the Northern Phenol Area were included in the 31 March 1995 *Revised Remedial Action Work Plan.*

Two horizontal wells designated as HW-3 and HW-4 would be installed from the west end of the Northern Phenol Area to the east end of the area. The approximate locations of HW-3 and HW-4 are shown on Figure 46. Each horizontal biosparge well is designed to yield a radial influence, using injected air, extending 60.0 feet along the horizontal axis of the well. The two horizontal wells are configured with overlapping areas of influence to insure treatment of the source area around MW-47D, MW-48D, and ORC-4D (Figure 47). The basis for this design was the results of the air sparge pilot test, in which increased well head pressures and decreased depths to water were observed 30.0 to 90.0 feet away from the sparge well. It should be noted that even if the radius of influence around the injection wells is less than 60.0 feet, the system would still be effective in remediating groundwater in the deep overburden zone. As oxygen enriched groundwater migrates away from the air injection wells, it will serve to stimulate biodegradation downgradient from the area of active remediation. Any groundwater migrating through the treatment zone would be remediated by the enhanced biodegradation processes.

The design basis of the horizontal well system yields the following specifications:

- Header length = 160'
- Depth of well below grade = 30'
- Water level above the horizontal screen = 20' average
- Tail length = 160'
- Well Diameter = 4" nominal
- Well material = SDR-11 HDPE
- Lithology = silty sand
- Screen length = 200'

The air distribution along the screen length was designed at 0.5 standard cubic feet per minute (scfm) for the 200' length. Shortening the length of screen in HW-4 may be necessary to fit the well within the confines of the site, however the air distribution volume would remain unchanged, yielding a 0.7 scfm/ft of screen. An air delivery system capable of delivering a maximum of 100 scfm to each well would be installed on-site within the existing equipment building. The blower system would have a maximum capacity of 200 scfm. The system would have the flexibility to operate in a pulse fashion, one well at a time, or both wells simultaneously.

A rotary lobe or rotary screw air compressor would be used to inject atmospheric air into the horizontal wells at a required pressure of approximately 17.0 psi as estimated from previous performance test data. The air would be delivered to the wells through individual conveyance pipes run below grade from the equipment building to the head of the horizontal pipe. The head of each horizontal well would be set below grade in a 2.0 foot by 2.0 foot traffic-rated road box. The opposite end of each horizontal well would be completed and fitted with a ball valve, also set below grade in a similar road box.

The air compressor would be fitted with piping and instrumentation to control the flow and pressure of air into the formation and with alarm instrumentation to shut down the system in the event of equipment failure or operation out of set parameters (Figure 48). Discharge from the air compressor would go through a pressure regulator, air filter, 3-way solenoid valve, and a flow meter on a manifold set up in the equipment building. The flow rate to each well would be regulated to operate between 0 and 100 scfm.

The shallow overburden zone in the area of former Buildings 33-A and 33-B in the northwest corner of the site would be addressed through the installation of three passive aeration wells (PAWs) at the locations shown on Figure 46. The purpose of the PAWs is to allow the air being injected into the deep overburden zone to migrate through the clay layer to the shallow overburden zone. Each PAW would be 4.0-inches in diameter, and would be constructed with a screened interval that extended from 33.0 feet below grade, to approximately 3.0 feet above the clay layer. Solid Sch. 80 PVC casing would extend to the surface, and a threaded cap would be used to seal the top of the well. The annulus of the boring would be filled with well gravel to 1.0 foot above the top of the screen, followed by a cement/bentonite grout to grade. By capping each well, air that migrates through the well would not be able to vent to the atmosphere, but would be forced to diffuse into the shallow overburden groundwater zone, thereby stimulating biodegradation above the clay layer.

10.2 Air Emissions

The following table summarizes the physical and chemical properties of the primary compounds of concern present in the shallow and deep overburden groundwater zones:

Compound	Vapor Pressure (mm Hg)	Aqueous Solubility (mg/L)	Henry's Constant (atm x m^3/mol)
Formaldehyde	93.6 @ 38°C	400,000	$3.37x10^{-7}$
Methanol	97.6 @ 20°C	Miscible	$4.55x10^{-6}$
Phenol	20.0 @ 20°C	82,000	$3.33x10^{-7}$
Salicylic Acid	$8.2x10^{-5}$ @ 25°C	2,240	$7.34x10^{-9}$

The chemical and physical characteristics common to formaldehyde, methanol, phenol, and salicylic acid, in conjunction with results from the biodegradation treatability study, indicate that volatilization was not a significant factor in the removal of those compounds from the saturated air sparge column used in bench scale testing.

The dissolved concentrations of phenol showed significantly different rates of decline during the initial test period (two weeks) when comparing the actively sparged test column to the passively vented test column. The actively sparged test column showed an initial decline in concentration of approximately 83% compared with 34% for the static column over the same period. Conversion/degradation rates for phenol approach similar values for each test column as the incubation test time is terminated (eight weeks). Salicylic acid constituent data in the test columns yielded results similar to that of phenol.

The dissolved concentrations of methanol showed indiscernible differences in removal/degradation between incubation of the sparged columns and the static columns over the initial, two week, test period.

The more rapid rate of decline in constituent concentrations yielded by the sparged test column is attributed to accelerated biodegradation afforded by the excess oxygen to support natural processes in the low vapor pressure compounds. The conversion/removal rates of each test reach similar values as the additional oxygen furnished in the air sparge column exceeds that which can be utilized by the remaining biodegradable products.

Increased biodegradation is attributed to the initial excess organics and the additional air (oxygen) supplied. Each constituent is characterized by a high aqueous solubility; concentrations of these components were well below aqueous saturation capacity in the site specific samples submitted for testing. Each constituent also has a very low Henry's Constant where its affinity for water outweighs the effects of their inherent vapor pressures (97.6 mm Hg for methanol and 20 mm Hg for phenol). The air-to-water ratio that would be required to strip/sparge the subject components from groundwater is not feasibly achieved as an in-situ process. It should also be noted that methanol, due to its high vapor pressure, is not commonly retained in the vadose zone as it is rapidly volatilized to the atmosphere under ambient conditions. Formaldehyde exhibits properties common to both methanol and phenol, and has the second highest aqueous solubility of the subject compounds.

Based on the test results, a finite organic content, and the inherent properties of the chemicals of concern, biosparging will enhance the biodegradation of the target compounds with little effect on volatilization and subsequent air emissions. The maximum air sparge rate over the treatment area and the total estimated mass of contaminants in the saturated zone will yield emissions below the NJDEP Reportable Limits. Quantifiable emission rates and supporting calculations will be submitted with permit application documents to the NJDEP Air Permitting Program, Bureau of New Source Review (BNSR). It is anticipated that vapor monitoring points (VMPs) will be required for emission monitoring during the operation of this biosparging system. The number and locations of these VMPs would be included with the final design specifications submitted during the air permitting process.

11.0 DOWTHERM DNAPL AREAS REMEDIAL ACTIONS

Based on the results of the soil sampling conducted to date, a remediation program has been developed to address the Dowtherm impacted soils that have been identified in AEC-14 (the area around AS-12) and AEC-36 (the southwest corner of Building 16). The remediation program for each of these AECs is discussed in the following Sections.

11.1 AEC-14 - Area Around AS-12

Due to the presence of DNAPL in former air sparge well AS-12, EPI proposes to remediate the area around the former well through excavation and off-site disposal. Excavation in this area would serve to remove product saturated soils that may exist in the area, which should help to eliminate the source of the DNAPL that had been present in AS-12 (but is not currently present in MW-63), plus help reduce the dissolved concentrations of 1,1'-biphenyl and diphenyl ether in groundwater. As indicated in Section 9.2, excavation was selected as the remedial option for this area of the site due to the limited areal extent of the area, and the expedited time frame in which the remediation objectives could be attained.

As shown on Figure 49, an area measuring 35' x 20' feet would be excavated to a depth of 30.0 feet below grade (the approximate top of the glacial till). The limits of the excavation are defined to the east and west by soil borings B-4 and B-6, and to the north and south by borings B-7 and B-8. Approximately 780 yards of soil would be excavated for off-site disposal. Prior to initiating excavation activities, MW-63 would be abandoned by a licensed New Jersey well driller. Once the excavation has been completed, a replacement well would be installed to confirm that the DNAPL has been successfully remediated (see Section 11.1.2, below). In addition, the natural gas and electric service to the air sparge/soil vapor extraction (AS/SVE) system would be disconnected, and all of the equipment associated with this system would be removed.

11.1.1 Post-Excavation Sampling

Since the initial limits of the excavation are defined by the soil samples from borings B-4, B-6, B-7, and B-8, EPI does not propose to collect post-excavation samples. However, if the size of the excavation increases due to the need to remove additional soil, EPI would collect post-excavation samples from the expanded area(s) in accordance with N.J.A.C. 7:26E-6.4 *et seq*. Any post-excavation sample(s) collected would be analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

11.1.2 Area Restoration

Once the excavation has been completed and post-excavation samples collected (if warranted), it would be backfilled with certified clean material, compacted, and re-surfaced with asphalt. The horizontal SVE line that ran partially through the excavation and any other PVC piping associated with the AS/SVE system would be repaired/replaced prior to re-paving the area. Replacement monitoring well MW-63R would be installed adjacent to the original well location. MW-63R would have an approximate total depth of 37.0 feet, and would be constructed with 25.0 feet of 4.0-inch diameter, Sch. 40 PVC screen and 12.0 feet of PVC casing (i.e., the same construction as MW-63). The well head would be protected with a flush mount, water tight manhole and locking cap. The location and elevation of MW-63R would be measured by a licensed New Jersey Professional Land Surveyor.

11.2 AEC-36 - Building 16 Area

Due to the presence of Dowtherm in the soil around the southwest corner of Building 16, EPI proposes to remediate this area of the site through excavation and off-site disposal. Excavation in this area would serve to remove product saturated soils that may exist in the area, thereby eliminating a source of 1,1'-biphenyl and diphenyl ether in groundwater. As indicated in Section 9.2, excavation was selected as the remedial option for this area of the site due to the limited areal extent of the area, and the expedited time frame in which the remediation objectives could be attained.

As shown on Figure 50, an area measuring approximately 940 square feet will be excavated to a depth of 18.0 feet below grade (the estimated vertical extent of the Dowtherm based on the analytical results from borings BLD16-11, BLD16-13, and BLD16-14). The limits of the excavation are defined to the north by soil borings BLD16-5, BLD16-7, and BLD16-8, and to the east by soil borings BLD16-2 and BLD16-15. The western and southern extent of the excavation would be determined in the field through visual observations, field screening with a PID, and post-excavation sampling. Most of the soil in this area consists of clean fill material that was used to backfill the excavation trench of the Hudson Street process waste sewer line. Based on the analytical results for the shallow samples collected from borings in this area, the top 12.0 feet of soil would first be removed and staged for use as backfill material. Therefore, EPI's initially estimates that approximately 210 yards of soil would be excavated for off-site disposal. Due to the proximity of Hudson Street to the southern sidewall of the excavation, soil in this direction will only be excavated to the extent practicable as determined by an on-site licensed New Jersey Professional Engineer. EPI would demolish Building 16 prior to excavating this area due to the proximity of the building to the excavation area, and due to the need to remove soil from along the footings of the building. Removal of Building 16 would also facilitate access to the area, and would allow the excavation equipment to be kept on-site, thereby minimizing impacts to traffic along Hudson Street and River Drive.

Prior to initiating excavation activities, air curtain well ACW-12 would be abandoned by a licensed New Jersey well driller. Once the excavation has been completed, a replacement air curtain well would be installed (see Section 11.2.2, below). Every effort will be made to preserve monitoring well MW-14R, which would be on the western end of the excavation. If it is determined that this monitoring well cannot be retained, it would be abandoned by a licensed New Jersey well driller.

11.2.1 Post-Excavation Sampling

In accordance with N.J.A.C. 7:26E-6.4 *et seq.*, post-excavation soil samples would be collected from the southern and western side walls to document the effectiveness of the remediation program. Samples would be collected from 12.5 - 13.0 feet, 13.5 - 14.0 feet, and 15.5 - 16.0 feet below grade at the approximate locations shown on Figure 50. Samples from the northern and eastern sidewalls would not be required based on the analytical results from borings BLD16-2, BLD16-5, BLD16-8, and BLD16-15.

In addition, at least two post-excavation samples would be collected from the base of the excavation (including one at the location of boring BLD16-12). Each post-excavation sample would be analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

11.2.2 Area Restoration

Once the excavation has been completed and post-excavation samples collected (if warranted), it would be backfilled with the clean soil and fill material removed at the start of the excavation, plus additional certified clean material to bring the excavation up to grade. All fill material would be compacted, and the surface grade would be restored. Replacement air curtain well ACW-12R would be installed adjacent to the original well location. ACW-12R would have a total depth of 30.0 feet, and would be constructed with 2.0 feet of 2.0-inch diameter, Sch. 40 PVC screen and 28.0 feet of PVC casing (i.e., the same construction as ACW-12). The sub-grade air conveyance line would be connected to the well, and the well head would be protected with a flush mount, water tight manhole.

12.0 SAMPLING & MONITORING PLAN

EPI proposes to continue the groundwater monitoring program that is currently being implemented to document the effectiveness of the remedial actions proposed for the Northern Phenol Area and the Dowtherm DNAPL Areas (i.e., the AS-12 area and the southwest corner of Building 16). In response to the NJDEP's letter dated 26 June 2000, a groundwater monitoring program for wells addressing the Toluene Spill Area was submitted as part of the 3 August 2001 *Remedial Investigation Report Addendum* (RIRA); the wells included in the Toluene Spill Area monitoring program encompass both Dowtherm DNAPL areas. The NJDEP approved this monitoring program in their letter dated 15 October 2001. A groundwater monitoring program for the Northern Phenol Area was provided to the NJDEP as part of the 1 May 2002 *Remedial Investigation Report Addendum No. 2* (RIRA-2); the NJDEP approved this program in their letter dated 30 July 2002.

12.1 Quarterly Groundwater Monitoring

The wells to be sampled in the Toluene Spill Area and the Northern Phenol Area, and the compounds for which the samples will be analyzed, are discussed below.

Toluene Spill Area/Dowtherm DNAPL Areas

In order to monitor the effectiveness of the soil excavation activities proposed for the Dowtherm DNAPL Areas, plus the operation of the air curtain and the off-site SVE systems, groundwater samples would be collected from the following wells:

Source Area Wells:	MW-4, MW-5, MW-D5, MW-E5, MW-9R, MW-17, MW-33, MW-45, OW-3
Fringe Wells:	MW-1, MW-10, MW-11, MW-14R, MW-23, MW-25, MW-31, MW-36, MW-40, MW-41, MW-42, MW-46, MW-56, OW-1, OW-2, OW-4, OW-5
Sentinel Wells:	MW-6, MW-22, MW-30, MW-37, MW-38, MW-61
Background Wells:	MW-16, MW-60

Groundwater samples would be collected quarterly from all wells that do not contain separate phase hydrocarbons (SPH) for the following parameters:

- January, July, and October - Benzene and toluene by USEPA Method 624, and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

- April - Volatile organic compounds (VOCs) by USEPA Method 624 and base neutral/acid extractable compounds (BNAs) including 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. The library search component of each analysis would not be performed.

Northern Phenol Area

In order to monitor the effectiveness of the biosparge system in remediating the phenol, salicylic acid, methanol, and formaldehyde present in the shallow (i.e. above the clay layer) and deep (i.e., below the clay layer) overburden zones in the northern half of the site, groundwater samples would be collected from the following wells:

Shallow Overburden Zone

Source Area Wells:	WP-2R, WP-2D
Monitoring Points:	MW-21, MW-51, MW-58, MW-59, MW-62, WP-1R

Deep Overburden Zone

Source Area Wells	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, MW-57D, ORC-4D, WP-3R
Monitoring Points	MW-2DR, MW-3D, MW-12D, MW-21D, MW-32D, MW-52D, MW-53D, MW-54D, MW-58D, MW-59D

Sovereign proposes to collect groundwater samples from these wells as per the following schedule:

- January, July, and October - Phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015-Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315.

- April - VOCs by USEPA Method 624, BNAs (including salicylic acid) by USEPA Method 8270, methanol, and formaldehyde. The library search component of the VOC and BNA analysis would not be performed.

The groundwater samples from MW-21D and MW-51D would also be analyzed for methyl salicylate by USEPA Method 8270 during each sampling event.

12.2 Background Groundwater Quality Monitoring

EPI proposes to monitor background groundwater quality around the site on an annual basis. Groundwater samples would be collected from monitoring wells MW-19 and MW-19D (located on the corner of Cambridge Avenue and Monroe Street), MW-20 and MW-20D (located on Commerce Street), MW-35 and MW-35D (located on Hudson Street), and MW-8 (located to the east of former Building 10-T on Cambridge Street). Groundwater samples would be collected as part of the April monitoring event, and would be analyzed for VOCs by USEPA Method 624, BNAs (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate) by USEPA Method 8270, methanol by USEPA Method 8015-DAI, and formaldehyde by USEPA Method 8315.

12.3 Groundwater Sampling and QA/QC Procedures

All groundwater sampling would be conducted as per the procedures discussed in Section 2.5 of this report.

12.4 Post-Excavation Soil Sampling

Post-excavation soil samples will be collected to document the effectiveness of the remediation program in the area of the southwest corner of Building 16 (AEC-36). A total of nine samples would be collected from three sidewall locations, and two base samples would be collected. The sidewall samples would be collected from 12.5 - 13.0 feet, 13.5 - 14.0 feet, and 15.5 - 16.0 feet below grade to correspond to the samples from boring BLD16-12. Each sample would be analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

Post-excavation samples may be required to be collected following the excavation of AS-12 (AEC-14). If necessary, the depths and locations of these samples would be determined in the field. Each sample would be analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

All samples would be placed in appropriate, laboratory provided bottleware, labeled, logged onto a chain of custody form, and placed on ice in a cooler. At the end of the day, the samples would either be delivered directly to the analytical laboratory, or would be returned to the office where they would be picked up by a laboratory courier the next day.

12.5 Reporting

EPI will prepare semi-annual Remedial Action Progress Reports (RAPRs) for submission to the NJDEP. Each report will include a discussion of sampling activities, analytical data tables, groundwater elevation data, updated groundwater contour maps, distribution maps for the compounds of concern, and separate phase hydrocarbon distribution maps (if applicable).

State of New Jersey
Department of Environmental Protection

DONALD T. DIFRANCESCO
Acting Governor

Robert C. Shinn, Jr.
Commissioner

AUG 6 2001

Thomas LoBue
BF Goodrich Kalama, Inc.
290 River Drive
Garfield, NJ 07026

Re: Administrative Consent Order (ACO) In The Matter of
Former Kalama Chemical Facility
Ordered Party: El Paso Corporation (EPI)
290 River Drive, Garfield City, Bergen County
ISRA Case #E86B73
Remedial Investigation Reports (RIR) Dated:
1) December 1, 2000 – Quarterly Ground Water Sampling Report for October 2000;
2) April 17, 2001 – Request for Alternate Soil & Ground Water Criteria;
3) May 17, 2001 – Quarterly Ground Water Sampling Report for January 2001.

Dear Mr. LoBue:

The New Jersey Department of Environmental Protection (NJDEP) has completed its review of the above referenced RIRs. The NJDEP's comments regarding the RIRs are noted below:

The December 2000 and May 2001 Quarterly Ground Water Sampling Reports are not acceptable until EPI has addressed all outstanding issues raised in this letter and the NJDEP letter of June 26, 2000.

I. GROUND WATER.

Ground water samples collected from both shallow overburden monitor wells (screened 10-30 feet bgs) and deep overburden monitor wells (screened 25-40 feet bgs) indicate widespread ground water contamination consisting of some or all of the following: VOCs (benzene, toluene, chlorinated solvents), BNs (various PAHs, phenols), and NAPL (both DNAPL and LNAPL). NAPL is only present in the shallow overburden monitor wells.

SUPPLEMENTARY REVIEW OF APRIL 22, 1998 RIR.

Six inches of DNAPL were historically detected in monitoring well MW-5 in November 1991; this monitoring well is located in the southeast corner of the facility. The DNAPL was removed in December 1991 and did not reappear. In order to determine whether DNAPL was still present in this area of the site, EPI investigated both soils and ground water during the installation of sparge points in this area of the site in June to August 1996.

In the January 11, 1999 report, EPI states that additional investigation for DNAPL should not be required in this area, based on the following: (a) absence of DNAPL in any sparge wells, (b) reduction in dissolved phase 1,1'-biphenyl and diphenyl ether below the interim generic ground water quality criteria of 100 ppb, and (c) reduction in concentrations of 1,1'-biphenyl and diphenyl ether in soils to concentrations that will not impact ground water quality.

NJDEP Comments

The NJDEP believes that the information provided by EPI indicates that additional investigation for DNAPL is required in this area of the site. Requirements regarding the need for additional DNAPL investigation are included below (NJDEP Comments/Requirements).

QUARTERLY GROUND WATER SAMPLING RESULTS REPORT, DATED DECEMBER 1, 2000

Ground water samples were collected October 10 - 12, 2000. EPI states that three areas of the site require remediation and/or monitoring:

1. Northeast Phenol Hot-Spot: former Building 10/36
2. Northwest Phenol Hot-Spot: former Building 3-B
3. Benzoic Acid/Benzaldehyde Plant, Toluene Spill Area: AOC-14

CONTAMINANTS OF CONCERN

EPI states that the primary contaminants of concern originally determined to be present in ground water are benzene, toluene, phenol, benzoic acid, methanol, and formaldehyde. Based on ground water samples collected in the area of Building 10/26, salicylic acid was added to the list of parameters for the monitoring wells addressing the Northeast Phenol Hot-Spot. EPI also states that based on quarterly ground water sampling results from June 1997 through October 1998, phenol and benzoic acid are no longer considered contaminants of concern in the Toluene Spill Area and have been eliminated from the monitoring program for the wells addressing this area of concern. EPI states that 1,1'-biphenyl and diphenyl ether were added to the monitoring program for the wells addressing the Toluene Spill Area starting with the July 2000 ground water sampling event.

REMEDIATION CRITERIA

EPI states that the results from the 13 previous quarters of ground water sampling will be included in the response to the June 26, 2000 NJDEP letter. As noted above, EPI still has not submitted this response.

EPI states that the NJDEP has approved the following ground water remediation criteria:

Benzene: 1 ppb (source: N.J.A.C. 7:9-6 et seq.)
Toluene: 1000 ppb (source: N.J.A.C. 7:9-6 et seq.)
Phenol: 4000 ppb (source: N.J.A.C. 7:9-6 et seq.)
Benzoic Acid: 30000 ppb (source: September 6, 1995 NJDEP letter)
Methanol: 3500 ppb (source: August 30, 1996 NJDEP letter)
Formaldehyde: 110 ppb (source: August 30, 1996 NJDEP letter)

EPI also states that 30,000 ppb is being used as the ground water quality standard for salicylic acid, based on the fact that the NJDEP approved this standard for benzoic acid, and the fact that general information for salicylates indicates that ingestion of up to 150 ppm does not cause adverse health effects in children.

EPI states that the 100 ppb interim generic criteria required by the NJDEP for 1,1'-biphenyl and diphenyl ether are being used in this report.

MONITORING WELL ABANDONMENT/REPLACEMENT

Well point WP-3, located in the basement of Building 36, was abandoned on June 29, 1998, because the building was being demolished. Because this was a source area well, a replacement well was installed (WP-3R). It is stated that auger refusal was encountered at the first drilling location. It is stated that the replacement well was successfully installed approximately three feet further away from the original well location. The actual distance from the original WP-3 well location to the replacement well location is not stated. The final depth of the well is 17 feet bgs, with 10 feet of two-inch diameter PVC screen. Monitoring Well Certification Form A was not included in this submittal; however, a monitoring well construction log was included. Based on the construction log, it can not be determined whether this well point is constructed properly, with the top of screen set above the ground water table. Based upon depth to ground water information included in this report, it appears that the well point is constructed properly, with the top of screen set above the ground water table. This issue requires clarification.

Well points WP-1 and WP-2, located in the basements of Building 33 and Building 33-B, respectively, were abandoned on January 6, 2000, because the buildings were being demolished. Because WP-2 was a source area well for phenol in the northwest corner of the site, and WP-1 was the closest down gradient well, replacement wells were installed (WP-1R, WP-2R). It is stated that each replacement well was installed immediately adjacent to the original well location. The final depth of WP-1R is stated as 20 feet bgs, with 10 feet of two-inch diameter PVC screen. The final depth of WP-2R is stated as 16 feet bgs, with five feet of two-inch diameter PVC screen. EPI notes that the screen lengths are identical to those of the original well points. Monitoring Well Certification Forms A were not included in this submittal; however, monitoring well construction logs were included. Based on the construction logs, it can not be determined whether these well points are constructed properly, with the top of screen set above the ground water table. Based upon depth to ground water information included in this report, it appears that the well points are constructed properly, with the top of screen set above the ground water table. This issue requires clarification.

EPI states that monitoring well MW-2D was damaged during the demolition of Building 1, and soil and debris filled in the bottom 10 feet of the well. Removal of the obstruction was not possible, so the monitoring well was abandoned. A replacement well (MW-2DR) was installed October 26, 2000, approximately three feet from the location of the original monitoring well. It is stated that the final depth of the well is 34 feet bgs, with 10 feet of four-inch diameter PVC screen. EPI notes that the screen length is identical to that of the original monitoring well. Monitoring Well Certification Form A was not included in this submittal; however, a monitoring well construction log was included.

GROUND WATER SAMPLING PROCEDURE

EPI states that prior to sampling, each well was gauged to determine the depth to water, and inspected with an interface probe in order to determine whether separate phase hydrocarbons were present. It is not stated whether all wells were inspected for DNAPL as well as LNAPL. It is stated that after water level measurements were collected, three to five well volumes were purged from each monitoring well; it is stated that if three well volumes could not be purged due to poor recharge, the water level in the well was allowed to recover to within two feet of static conditions (or sufficiently to allow for sample collection). Ground water samples were then collected subsequent to purging.

It is stated that field parameter purging information was collected pursuant to the "Field Sampling Procedures Manual," and included as Appendix B of this report. The following discrepancies were noted in the information provided:

Dissolved oxygen: negative values reported
Temperature: elevated values reported (i.e., 21.4°C to 22.0°C MW-D5)
Wells purged to dryness: MW-2, -4, -12D, -19D, -22, -25, -28, -32, -37, -47D, ORC-2, ORC-4D, WP-2R, -3R, -5
Top of screen at or below water table: MW-11, MW-46, OW-4, OW-5
"Surging water in well": MW-1, MW-10, MW-11, MW-41, OW-2, OW-3, O-4, OW-5

GROUND WATER ELEVATIONS

Ground water elevations were collected and used to construct ground water contour maps. It is stated that the gauging data from MW-1, MW-11, MW-41, OW-2, OW-4, and OW-5 were not used in preparing the contour maps due to "surging ground water" from operation of the air curtain injection wells. No explanation of "surging ground water" was provided, nor was any information provided regarding the effects of the "surging ground water."

Based on the ground water elevation data, EPI states that the overall ground water flow direction in the shallow overburden continues to be towards the south-southwest, and that a ground water mound is still present in the northeast corner of the site. EPI states that the overall ground water flow direction in the deep overburden continues to be westward.

NORTHEAST PHENOL HOT SPOT (FORMER BUILDING 10/36)

Ground water samples were collected from the following wells:

Source area:	Shallow:	WP-5, WP-6, ORC-2
	Deep:	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, ORC-4D, WP-3R
Monitoring points:	Shallow:	MW-2, MW-3, MW-18, MW-28, MW-32
	Deep:	MW-2D/2DR, MW-3D, MW-12D, MW-32D

It is stated that MW-47D, MW-48D, MW-49D, and MW-50D were installed in July 2000, to address elevated concentrations of phenol, salicylic acid, and methanol detected in ORC-4D. It is stated that each well is 33.0 feet deep, and screened entirely within the deep overburden zone. It is further stated that results of this investigation will be submitted as part of a remedial action workplan addendum. It should be noted that well construction logs and Monitoring Well Certification Forms A and B were not submitted for any of these wells.

Ground water samples were analyzed for phenol, salicylic acid, methanol, and formaldehyde.

Results: Shallow Overburden Zone

It is stated that a ground water sample could not be collected from WP-6, as this well did not recharge after purging.

It is stated that concentrations of phenol, methanol, formaldehyde, and salicylic acid were either not detectable or below their ground water quality criteria in both WP-5 and ORC-2 during this sampling event.

It is stated that none of the ground water samples collected from the downgradient monitoring points had detectable concentrations of any of the contaminants, with the exception of 2.3 ppb phenol and 8.9 ppb salicylic acid in MW-18.

Results: Deep Overburden Zone

Phenol concentrations ranged from non-detect (several wells) to 7,170 ppb (MW-28D) to 330,000 ppb (MW-47D). Methanol concentrations ranged from non-detect (several wells) to 2,470 ppb (ORC-4D) to 7,550,000 (MW-47D). Formaldehyde concentrations ranged from non-detect (several wells) to 52.0 ppb (ORC-4D) to 1,600 ppb (MW-47D). Salicylic acid ranged from non-detect (several wells) to 6.2 ppb (estimated, MW-3D) to 573,000 ppb (MW-47D).

EPI notes that the worst-case concentrations of phenol, methanol, and salicylic acid were detected in MW-47D. The suspected source area is the former Building 10/36 complex. ORC-4D is located approximately 60 feet downgradient of the downgradient extent of the former Building 10/36 complex, and MW-47D is located approximately 90 feet downgradient of the downgradient extent of the former Building 10/36 complex. EPI also notes that elevated concentrations of phenol and methanol were also detected in MW-50D, located upgradient of ORC-4D, and at the immediate downgradient extent of the former Building 10/36 complex, but that the concentrations in MW-50D are below the concentrations in both ORC-4D and MW-47D. EPI concludes that the contaminant distribution is indicative of a migrating contaminant plume, and that MW-47D represents the leading edge of this contaminant plume.

EPI notes that MW-2D is located approximately 65 feet downgradient of MW-47D, and that methanol has never been detected in ground water samples collected from MW-2D, and concentrations of phenol and salicylic acid have generally been below their respective ground water quality standards. Lastly, EPI notes that the source material has been eliminated (facility is no longer operating and the process line has been removed). EPI concludes that the plume may have achieved a steady-state and may no longer be migrating.

NORTHWEST PHENOL HOT SPOT (FORMER BUILDING 33-B)

EPI notes that contaminant concentrations in ground water in this area of the site have not decreased with time. EPI states that WP-2 may have been installed "within a honeycomb of footings," which created isolated pockets of contaminated ground water. EPI then states that the demolition of Building 4/33/33-A/33-B complex and removal of the building footings should create more favorable conditions for biodegradation to occur.

Ground water samples were collected from the following wells. It is stated that each ground water sample was analyzed for phenol by USEPA Method 8270:

Source area: WP-2R

Monitoring points: WP-1R, MW-21

Results:

Phenol was detected at 180,000 ppb in WP-2R; EPI states that this concentration is consistent with historical concentrations in MW-2. EPI notes that this is the greatest concentration since January 1999, and may reflect flushing of contaminants into ground water subsequent to the building demolition.

Phenol was detected at 1,120 ppb in downgradient well WP-1R (narrative states 71.4 ppb, table lists 1,120 ppb), and was ~~non~~-detect in downgradient well MW-21.

BENZOIC ACID/BENZALDEHYDE PLANT AND TOLUENE SPILL AREA (AEC-14).

This area is the source of the benzene and toluene contamination in the ground water, and is being remediated by the onsite air sparging/vapor extraction systems and the air curtain system (horizontal and vertical air injection wells), as well as the offsite soil vapor extraction system located beneath portions of Hudson Street and Bloomingdale Avenue.

It is stated that three offsite soil vapor extraction (SVE) wells were installed in the vicinity of monitoring well MW-33 on December 15, 1999 (OSSVE-6, OSSVE-7, OSSVE-8). EPI proposed these SVE wells in their July 16, 1999 report, and the NJDEP approved the installation in the June 26, 2000 letter to EPI.

It is stated that each vertical SVE well is 20 feet deep, and extends several feet into ground water. The wells were brought online at the end of December 1999. It is stated that on March 17, 2000, 0.61 feet of separate phase product (SPH) were detected in OSSVE-8; it is noted that 0.22 feet of SPH were detected in MW-33 on this same date. EPI states that the existing well network delineated the extent of the SPH to the north, east, and west, but that an additional well was required to delineate SPH to the south. Therefore, EPI installed MW-45 on the south side of Hudson Street, approximately 40 feet from MW-33 and 30 feet from OSSVE-8. In addition, EPI installed MW-46 in Cambridge Street, approximately 100 feet south of Hudson Street. MW-45 is 25 feet in depth, with 15 feet of screen, and MW-46 is 30 feet in depth, with 20 feet of screen. It should be noted that Monitoring Well Certification Forms A and B were not submitted for either MW-45 or MW-46. In addition, based on the information provided in Table 1 ("Well Gauging Data"), the top of screen for both of these monitoring wells is at the depth of the water table. However, Appendix B ("Groundwater Sampling Field Data Summary") indicates that the top of screen in MW-45 is eight feet above the ground water table. EPI shall be aware that the NJDEP will consider the wells to be improperly constructed if the top of screen is set at or below the ground water table; the purpose of these wells is to delineate and monitor for product, and if the top of screen is set at or below the ground water table, product may not enter the well and therefore would not be detected.

Source area:	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, MW-33
Monitoring points:	MW-16, MW-22, MW-31, MW-36, MW-27, MW-38, MW-40, MW-41, MW-42, MW-45, MW-46, OW-1, OW-2, OW-3, OW-4, OW-5

Results:

It is stated that a "heavy sheen" was detected in MW-9, and therefore a ground water sample was not collected from this monitoring well.

Ground water samples were collected and analyzed for benzene, toluene, 1,1'-biphenyl, and diphenyl ether. It is noted that due to excessive sediment, the ground water sample from MW-1 was not analyzed for 1,1'-biphenyl, and diphenyl ether.

Benzene was detected in onsite monitoring wells at concentrations up to 1,110 ppb (MW-D5), and in offsite monitoring wells at concentrations up to 4,440 ppb (MW-33). Benzene was detected in downgradient monitoring well MW-36 at 10.5 ppb. Benzene was also detected in newly installed monitoring well MW-45 at 3730 ppb. Benzene was not detected in MW-46 above the method detection limit. However, the MDL was elevated above the 1 ppb benzene ground water quality standard, at 6.7 ppb.

Toluene was detected in onsite monitoring wells at concentrations up to 54,800 ppb (MW-D5), and in offsite monitoring wells at concentrations up to 350,000 ppb (MW-33). Toluene was detected in newly installed monitoring wells MW-45 at 263,000 ppb, and MW-46 at 4,800 ppb.

1,1'-biphenyl was detected in onsite monitoring wells at concentrations up to 5,720 ppb (MW-4), and in offsite monitoring wells at concentrations up to 1,930 ppb (MW-33). 1,1'-biphenyl was also detected in newly installed offsite monitoring wells MW-45 (278 ppb) and MW-46 (377 ppb).

Diphenyl ether was detected in onsite monitoring wells at concentrations up to 19,800 ppb (MW-4), and in offsite monitoring wells at concentrations up to 3,010 ppb (MW-33). Diphenyl ether was also detected in newly installed offsite monitoring wells MW-45 (555 ppb) and MW-46 (697 ppb).

EPI notes that it appears that the distribution of both 1,1'-biphenyl and diphenyl ether is related to the migration of benzene and toluene.

BACKGROUND GROUND WATER QUALITY

Ground water samples were collected from background monitoring wells MW-19 and MW-19D, MW-20 and MW-20D, and MW-35 and MW-35D. Contaminants were not detected in any of these ground water samples.

CONTAMINANT DISTRIBUTION

EPI states that worst-case toluene contamination within the shallow overburden is limited to the southern side of the site, in three distinct areas: the area around MW-33 and MW-45, the area around MW-40, and the area around MW-14.

EPI states that worst-case benzene contamination within the shallow overburden approximates the worst-case toluene contamination: the area around MW-4, MW-33, and MW-45, the area around MW-40, MW-25, and MW-42, and the area around MW-14 and MW-23 (benzene above 10 ppb was also detected at downgradient well MW-26 (10.5 ppb)).

EPI states that worst-case 1,1'-biphenyl contamination within the shallow overburden is in the southeast and southwest corners of the site, in the area around MW-4, MW-33, and MW-46, and in the area around MW-14.

EPI states that worst-case diphenyl ether contamination within the shallow overburden is in the southeast and southwest corners of the site, and to the south of the site, in the area around MW-4, MW-D5, MW-33, MW-45, and MW-46, in the area around MW-14 and MW-23, and the area of MW-25 and MW-40, respectively.

EPI states that worst-case phenol contamination within the shallow overburden is beneath former Building 33-B, at WP-2R. EPI states that worst-case phenol contamination within the deeper overburden is north (upgradient) of former Building 33-B, extending from the area of WP-5 to the area of MW-2D.

EPI states that formaldehyde was only detected in the deeper overburden, in the vicinity of MW-47D.

EPI states that salicylic acid was detected above the arbitrary 30,000 ppb standard only in the deeper overburden, in the area of ORC-4D, MW-47D, and MW-48D.

EPI states that methanol was detected above the 3,500 ppb ground water quality standard only in the deeper overburden, in the area of MW-47D.

ALTERNATE GROUND WATER QUALITY CRITERIA REQUEST, DATED APRIL 17, 2001.

EPI has submitted a formal request for alternate ground water quality criteria for 1,1'-biphenyl (1,800 ppb), diphenyl ether (21,000 ppb), salicylic acid (5,600 ppb), and methyl salicylate (5,900 ppb). EPI has also submitted a request for alternate soil criteria.

NJDEP Response:

Until such time that the NJDEP determines interim specific criteria for these contaminants, EPI shall implement the following criteria:

1,1'-biphenyl	100 ppb (interim generic criterion)
Diphenyl ether	100 ppb (interim generic criterion)
Salicylic acid	80 ppb (interim specific criterion)
Methyl salicylate	100 ppb (interim generic criterion)

QUARTERLY GROUND WATER SAMPLING RESULTS REPORT, DATED MAY 17, 2001.

Ground water samples were collected January 23 through January 26, 2001. As in the previous quarterly ground water report (Section D, above), EPI states that three areas of the site require remediation and/or monitoring:

1. Northeast Phenol Hot-Spot: former Building 10/36
2. Northwest Phenol Hot-Spot: former Building 3-B
3. Benzoic Acid/Benzaldehyde Plant, Toluene Spill Area: AOC-14

GROUND WATER SAMPLING PROCEDURE.

The ground water sampling procedures were similar to those employed during the previous ground water sampling event, and are detailed above (Quarterly Ground Water Sampling Results Report, Dated December 1, 2000).

It is stated that field parameter purging information was collected pursuant to the "Field Sampling Procedures Manual," and included as Appendix A of this report. The following discrepancies were noted in the information provided:

Dissolved oxygen: Elevated values reported (i.e., 11.72 mg/L MW-2)

Wells purged to dryness: MW-6, MW-14, MW-22, MW-25, MW-28, MW-28D, MW-31, MW- 32, OW-3, WP-2R, WP-5, WP-6)

Insufficient volume purged: MW-4 (7.5 gallons water in well, only 18 gallons purged)

"Surging water in well": MW-1, MW-10, MW-11, OW-2

GROUND WATER ELEVATIONS

Ground water elevations were collected and used to construct ground water contour maps. It is stated that the gauging data from MW-1, MW-10, MW-11, OW-2, and OW-5 were not used in preparing the contour maps due to "surging ground water" from operation of the air curtain injection wells. No explanation of "surging ground water" was provided, nor was any information provided regarding the effects of the "surging ground water." In addition, it is noted that 0.41 feet of product were detected in MW-9.

Based on the ground water elevation data, EPI states that the overall ground water flow direction in the shallow overburden continues to be towards the south-southwest, and that a ground water mound is still present in the northeast corner of the site. EPI states that the overall ground water flow direction in the deep overburden continues to be westward.

NORTHEAST PHENOL HOT SPOT (FORMER BUILDING 10/36)

Ground water samples were collected from the following wells:

Source area:	Shallow:	WP-5, WP-6, ORC-2
	Deep:	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, ORC-4D, WP-3R
Monitoring points:	Shallow:	MW-2, MW-3, MW-18, MW-28, MW-32
	Deep:	MW-2D/2DR, MW-3D, MW-12D, MW-32D

It is stated that MW-52D, MW-53D, MW-54D, and MW-55D were installed in November 2000, to address elevated concentrations of phenol, salicylic acid, and methanol detected in MW-47D and ORC-4D (MW-47D was installed in July 2000, to address the contamination detected in ORC-4D). It is stated that each well is 33.0 feet deep, and screened entirely within the deep overburden zone. It is further stated that results of this investigation will be submitted as part of a remedial action workplan addendum (as noted above, a similar statement was made in the December 2000 remedial investigation report, that information regarding the MW-47D investigation would be submitted; this information remains outstanding). It should be noted that, as with monitoring wells MW-47D through MW-50D, installed in July 2000, well construction logs and Monitoring Well Certification Forms A and B were not submitted for any of these wells.

Ground water samples were analyzed for phenol, salicylic acid, methanol, and formaldehyde.

Results: Shallow Overburden Zone

It is stated that concentrations of phenol, methanol, formaldehyde, and salicylic acid were either not detectable or below their ground water quality criteria in both WP-5 and ORC-2 during this sampling event.

Methanol was not detected in the sample from WP-6, but formaldehyde was detected at a concentration of 58 ppb. It is stated that the well did not sufficiently recharge after purging to allow for collection of a sample for phenol and salicylic acid analyses.

It is stated that none of the ground water samples collected from the down gradient monitoring points had detectable concentrations of any of the contaminants, with the exception of 62 ppb formaldehyde in MW-28.

EPI states that since January 1998, concentrations of phenol and methanol in the shallow overburden have been below their respective ground water quality standards, with few (three) exceptions: 5,000 ppb phenol in MW-3 in October 1998, 5,750 ppb phenol in WP-5 in April 1999, and 7,940 ppb methanol in ORC-2 in January 1999. EPI further states that formaldehyde was either not detected or below its ground water quality standard for the ninth consecutive quarter, and that salicylic acid was below the applied ground water quality standards for the tenth consecutive quarter.

Results: Deep Overburden Zone

Phenol concentrations ranged from non-detect (WP-3R) to 17,700 ppb (MW-28D) to 693,000 ppb (MW-55D). Methanol concentrations ranged from non-detect (several wells) to 1,890 ppb (MW-50D) to 6,280,000 (MW-47D). Formaldehyde concentrations ranged from non-detect (several wells) to 160.0 ppb (ORC-4D) to 1,500 ppb (MW-47D). Salicylic acid ranged from 23,000 ppb (MW-28D) to 1,200,000 ppb (MW-48D).

NORTHWEST PHENOL HOT SPOT (FORMER BUILDING 33-B).

As noted in the previous (December 2000) report, EPI notes that contaminant concentrations in ground water in this area of the site have not decreased with time. EPI states that WP-2 may have been installed "within a honeycomb of footings," which created isolated pockets of contaminated ground water. EPI then states that the demolition of Building 4/33/33-A/33-B complex and removal of the building footings should create more favorable conditions for biodegradation to occur.

Ground water samples were collected from the following wells. It is stated that each ground water sample was analyzed for phenol by USEPA Method 8270:

Source area: WP-2R

Monitoring points: WP-1R, MW-21

Phenol was detected at 166, 000 ppb in WP-2R; EPI states that this concentration is again consistent with historical concentrations in MW-2. EPI notes that this is the greatest concentration since January 1999, and may reflect flushing of contaminants into ground water subsequent to the building demolition. Salicylic acid was detected at 59,800 ppb in WP-2R.

Phenol was detected at 2,810 ppb in downgradient well WP-1R, and was non-detect in downgradient well MW-21. Salicylic acid was detected at 354 ppb in MW-1R. EPI states that these concentrations are consistent with historical concentrations.

BENZOIC ACID/BENZALDEHYDE PLANT AND TOLUENE SPILL AREA (AEC-14).

This area is the source of the benzene and toluene contamination in the ground water, and is being remediated by the onsite air sparging/vapor extraction systems and the air curtain system (horizontal and vertical air injection wells), as well as the offsite soil vapor extraction system located beneath portions of Hudson Street and Bloomingdale Avenue.

Source area: MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, MW-33

Monitoring points: MW-16, MW-22, MW-31, MW-36, MW-27, MW-38, MW-40, MW-41, MW-42, MW-45, MW-46, OW-1, OW-2, OW-3, OW-4, OW-5

As noted above, 0.41' feet of SPH were detected in MW-9, and therefore a ground water sample was not collected from this monitoring well. EPI also states that OW-4 was buried beneath plowed snow, and a ground water sample was not collected from this monitoring well, either.

Ground water samples were collected and analyzed for benzene, toluene, 1,1'-biphenyl, and diphenyl ether.

Benzene was detected in onsite monitoring wells at concentrations up to 1,710 ppb (MW-D5), and in offsite monitoring wells at concentrations up to 6,230 ppb (MW-45; narrative states 3730, tables and figures indicate 6,230 ppb). Benzene was detected in downgradient monitoring well MW-36 at 1.9 ppb (narrative states 10.5 ppb, tables and figures indicate 1.9 ppb). Benzene was not detected in MW-46 above the method detection limit.

Toluene was detected in onsite monitoring wells at concentrations up to 70,000 ppb (MW-D5), and in offsite monitoring wells at concentrations up to 322,000 ppb (MW-45) and 326,000 ppb (MW-33). Toluene was detected in MW-46 at 580 ppb.

1,1'-biphenyl was detected in onsite monitoring wells at concentrations up to 1,660 ppb (MW-E5) and in offsite monitoring wells at concentrations up to 790 ppb (MW-33). 1,1'-biphenyl was also detected in offsite monitoring wells MW-45 (106 ppb) and MW-46 (429 ppb).

Diphenyl ether was detected in onsite monitoring wells at concentrations up to 5,610 ppb (MW-4), and in offsite monitoring wells at concentrations up to 1,710 ppb (MW-33). 1,1'-biphenyl was also detected in offsite monitoring wells MW-45 (209 ppb) and MW-46 (671 ppb).

BACKGROUND GROUND WATER QUALITY.

Ground water samples were collected from background monitoring wells MW-19 and MW-19D, MW-20 and MW-20D, and MW-35 and MW-35D. Contaminants were not detected in any of these ground water samples.

CONTAMINANT DISTRIBUTION.

EPI states that worst-case toluene contamination within the shallow overburden is limited to the southern side of the site, in the area around MW-33 and MW-45 and the area around MW-14.

EPI states that worst-case benzene contamination within the shallow overburden approximates the worst-case toluene contamination, in the areas around MW-D5, MW-33, and MW-45.

EPI states that worst-case phenol contamination within the shallow overburden is beneath former Building 33-B, at WP-2R. EPI states that worst-case phenol contamination within the deeper overburden is north (upgradient) of former Building 33-B, extending from the area of WP-5 to the area of MW-2D. EPI states that concentrations decrease rapidly to below the 4,000 ppb ground water quality, as evidenced by the concentrations detected in MW-2DR, MW-49D, and MW-54D.

EPI states that formaldehyde was only detected in the deeper overburden.

EPI states that salicylic acid was detected above the proposed 5,600 ppb standard only in the deeper overburden, in the area of ORC-4D, MW-47D, MW-48D, and MW-55D.

EPI states that methanol was detected above the 3,500 ppb ground water quality standard only in the deeper overburden, in the area of MW-47D (6,280,000 ppb).

PROPOSALS

Other than the proposals for alternate Ground Water Quality and Soil Criteria in the report Dated April 17, 2001, EPI has included no proposals in any of the other reports.

NJDEP COMMENTS/REQUIREMENTS.

SUPPLEMENTARY REVIEW OF APRIL 22, 1998 RIR

The information provided by EPI indicates that additional investigation for DNAPL is still required in the area of former Bldg #23 which is located near MW-5.

Additional investigation is required regarding the product saturated soils detected during the demolition of Building #23. As stated by EPI, the likely sources of this product were the two boilers housed in Building #23. EPI shall submit a remedial investigation work plan that includes investigation below the groundwater table for the presence of additional DNAPL. As stated at N.J.A.C. 7:26E-6.1(d), product shall be either treated, removed, or contained, and natural remediation of free and/or residual product shall not be allowed.

1. DNAPL was identified in 17 of the original soil samples (nine of 11 borings). Therefore, the NJDEP concludes that DNAPL is present in this area of the site (saturated soils are already known to exist). In addition, the dissolved phase concentrations detected in ground water are also indicative of the presence of DNAPL.

2. Clarification is required regarding the calculation of the effective solubilities of 1,1'-biphenyl and diphenyl ether. It is imperative that EPI determine whether product is present by comparing one percent of the effective solubility of both 1,1'-biphenyl and diphenyl ether to the contamination present.

EPI shall present all calculations used to determine the effective solubility of both 1,1'-biphenyl and diphenyl ether, and whether product is present in a specific sample based on concentrations greater than one percent of the effective solubility of the specific contaminant.

a. The NJDEP understands that Dowtherm contains MCBs (monochlorinated biphenyls). EPI shall use the exact chemical composition when determining the effective solubilities of the various constituents.

In addition, as noted by EPI, effective solubility is calculated based on the mole fraction of the contaminant. If the chemical composition of the original product is known, this chemical composition should be used to determine the mole fraction for each contaminant, rather than back-calculating from dissolved phase contamination results. Therefore, assuming that the product is in fact Dowtherm, EPI shall use the MSDS sheets to properly determine the mole fraction of each contaminant, and to then calculate the effective solubility of each contaminant.

b. EPI states that the calculated effective solubilities for biphenyl and diphenyl ether are significantly higher than one percent of the pure phase solubility for each contaminant (0.075 mg/L for biphenyl and 0.21 mg/L for diphenyl ether). This is irrelevant. The "one percent" rule for DNAPL applies regardless of whether it is a pure phase contaminant solubility or a mixed phase effective solubility. Therefore, EPI shall determine whether product is likely present by comparing one percent of the effective solubility of both biphenyl and diphenyl ether to the contamination present.

c. The NJDEP concludes that DNAPL is present in this area of the site, based on the soil and ground water data submitted. EPI shall recalculate the effective solubilities of biphenyl and diphenyl ether so that DNAPL remediation criteria can be determined for these contaminants. Pursuant to N.J.A.C. 7:26E-2.1(a)11, at a minimum, the NJDEP will consider DNAPL product to be present until such time as all contaminant concentrations decrease to below one percent of their effective solubilities. A final decision regarding completion of the remediation of the DNAPL will be based on: all DNAPL source material is removed/contained, contaminant concentrations continue to decrease. If contaminant concentrations increase or remain stable at elevated concentrations, it will be assumed that DNAPL remains and that the DNAPL is impacting ground water. This remaining DNAPL will need to be remediated (either removed or contained).

3. EPI shall submit a proposal to actively remediate the DNAPL detected in the area of Building #23. Remediation shall include removal/containment of all DNAPL present in this area. In addition, EPI shall submit a proposal for remediation of all dissolved phase ground water contamination present above the interim specific ground water remediation criterion of 100 ppb for both biphenyl and diphenyl ether. If EPI proposes to allow the dissolved phase ground water contamination to naturally remediate, a proposal pursuant to N.J.A.C. 7:26E-6.3(d) and (e) shall be submitted.

QUARTERLY GROUND WATER SAMPLING RESULTS REPORTS

Contaminants of Concern

1. Unless approved by NJDEP, EPI shall not delete any contaminant for analyses from ground water samples at any area of concern. Therefore, EPI shall include phenol and benzoic acid as contaminant of concern at the Toluene Spill Area.

For all future Ground Water Sampling Results reports, EPI shall include tables of historical ground water analytical results for all contaminants at all monitoring wells. Conclusions regarding case progress and direction cannot be reached without this information.

Remediation Criteria.

1. As noted above, until other ground water remediation criteria are approved, EPI shall utilize the criteria included in N.J.A.C. 7:9-6, New Jersey Ground Water Quality Standards, when interpreting ground water analytical results. This shall include utilizing 100 ppb as the interim generic criterion for any contaminant not included in either N.J.A.C. 7:9-6 or any case-specific letters from the NJDEP. This 100 ppb interim generic criterion shall apply to salicylic acid, 1,1'-biphenyl, and diphenyl ether at this time.

Monitoring Well Abandonment/Replacement.

1. EPI shall specify the location of replacement well WP-3R relative to the location of the original monitoring well, WP-3.

2. Based on the construction log and the depth to ground water information included in the Ground Water Sampling Results report, it appears that well points WP-1, WP-2, and WP-3R are constructed properly, with the top of screen set above the ground water table.

3. EPI shall submit Monitoring Well Certification Forms A and B for well points WP-1, WP-2, and WP-3R, and monitoring well MW-2DR.

Ground Water Sampling Procedure.

1. EPI shall further explain what is meant by the "surging water in well." The NJDEP is extremely concerned that the remediation system in the toluene spill area is ineffective, and is in fact causing the contaminant plume to migrate, as evidenced by offsite contaminant concentrations. The NJDEP believes that the "surging water" observed in MW-1, MW-10, MW-11, MW-41, OW-2, OW-3, O-4, and OW-5 is further evidence of the ineffectiveness of the remediation system, as well as plume migration. This issue is discussed in detail in the section "Benzoic Acid/Benzaldehyde Plant And Toluene Spill Area," below.

2. As detailed above, numerous discrepancies were noted in the well purging data sheets included in the two Ground Water Sampling Results reports. The NJDEP is concerned that these discrepancies indicate that the monitoring wells were not properly purged and sampled. The NJDEP therefore has concerns regarding the quality of the data, as well as concerns that some of the ground water analytical results may be biased low.

3. For all future ground water sampling events, EPI shall inspect all monitoring wells, onsite and offsite, for the presence of LNAPL.

4. For all future ground water sampling events, EPI shall inspect all onsite monitoring wells in the southeastern portion of the site ("Benzoic Acid/Benzaldehyde Plant And Toluene Spill Area") for the presence of DNAPL.

5. EPI shall purge poorly recharging wells at rates that will not cause drawdown to exceed 0.3 feet during purging and sampling. Purge rates for poorly recharging wells shall not exceed 500 ml/min.

6. For all future reports, EPI shall include a section in the narrative detailing anomalies noted during the purging and sampling of the wells (i.e., elevated or depressed temperatures, elevated dissolved oxygen, wells purged to dryness, etc.), as well as conclusions regarding the anomalies.

Northeast Phenol Hot Spot (Former Building 10/36).

Shallow overburden zone

1. The NJDEP has no comments at this time regarding the results of the ground water sampling results from the shallow overburden monitoring wells in the northeast phenol hot spot.

Deep overburden zone

1. The NJDEP is extremely concerned with the contaminant concentrations observed in the deep overburden ground water samples. Specifically, the contaminant concentrations observed in MW-47D in both the October 2000 and January 2001 ground water sampling events (330,000 ppb and 517,000 ppb phenol, 7,550,000 ppb and 6,280,000 methanol, 1,600 ppb and 1,500 ppb formaldehyde, and 573,000 ppb and 980,000 ppb salicylic acid), and in MW-55D during the January 2001 ground water sampling event (693,000 ppb phenol and 356,000 ppb salicylic acid).

a. EPI shall submit a proposal for additional horizontal and vertical delineation of the ground water contamination detected in MW-47D and MW-55D. This shall include delineation of phenol, methanol, formaldehyde, and salicylic acid.

b. EPI shall be aware that based on the results of the vertical delineation of the overburden aquifer, investigation of the bedrock aquifer may be required.

c. Subsequent to completing the horizontal and vertical delineation, EPI shall submit a proposal for actively remediating the contamination detected in the areas of MW-47D and MW-55D.

2a. EPI shall submit monitoring well construction logs and Monitoring Well Certification Forms A and B for monitoring wells MW-47D through MW-50D (installed July 2000) and monitoring wells MW-52D through MW-55D (installed November 2000). If this information is not provided, the NJDEP will consider these monitoring wells improperly constructed, the monitoring wells will be required to be decommissioned, and replacement monitoring wells installed. In addition, EPI shall provide copies of the NJDEP Monitoring Well Permits for each of these monitoring wells.

2b. EPI shall clarify whether a monitoring well designated MW-51 was installed at the site. If so, EPI shall indicate the location of this monitoring well, and shall submit Monitoring Well Certification Forms A and B and construction logs.

3) EPI shall submit copies of the NJDEP Monitoring Well Permits and Monitoring Well Certification Forms A and B for all monitoring wells installed during future investigation phases. The Permits and the Forms shall be submitted in the first report submitted after the wells are installed. Monitoring well construction is an integral part of determining progress of this case, and therefore decisions cannot be made without submittal of this information.

Northwest Phenol Hot Spot (Former Building 33-B).

1. EPI shall submit a proposal for vertical delineation of the contamination detected in WP-2R (180,000 ppb phenol October 2000, 166,000 ppb phenol January 2001). This vertical delineation is required based on the fact that the deeper overburden is contaminated in the area of the northeast phenol hot spot.

2. EPI shall horizontally delineate the 59,800 ppb salicylic acid detected in the January 2001 ground water sample collected from WP-2R.

Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AOC-14).

1. The current remediation system, consisting of the onsite air sparging/vapor extraction Systems, air curtain system (horizontal and vertical air injection wells), and offsite soil vapor extraction system, appears to be ineffective at either removing or containing the ground water contamination and may be causing the contaminant plume to migrate further offsite from this AOC.

This is substantiated by the fact that significant decreases in contaminant concentrations have not been observed in any monitoring wells at this AOC, the fact that contaminant concentrations have increased in several of the offsite monitoring wells, and the fact that "surging ground water" was observed in several of the offsite monitoring wells. As noted, EPI states that worst-case toluene, benzene, 1,1'-biphenyl, and diphenyl ether contamination is present in the area of MW-33, MW-45, and MW-46.

a. EPI shall immediately shut down the air sparging/air injection portions of the active ground water remediation system. The system will remain off line until the NJDEP issues approval to restart the system. As noted, the NJDEP is concerned that these portions of the active ground water remediation system may be causing the contaminant plume to further migrate offsite.

b. EPI shall submit a synopsis of the ground water remediation system. This shall include analysis of both increasing and decreasing contaminant trends for all contaminants in all monitoring wells. The narratives included in the Ground Water Sampling Results reports were biased towards improvements in contaminant concentrations, and tended to ignore or downplay increases in contaminant concentrations.

c. EPI shall submit all historical ground water sampling analytical results for all monitoring wells. In addition, EPI shall submit all hydraulic data collected from all monitoring wells since commencement of the active remediation system. EPI shall submit a narrative detailing the hydraulic effects of the active ground water remediation system.

d. EPI shall submit a proposal for modifying the ground water remediation system. This shall include active efforts to prevent additional migration of the contaminant plume, as well as capture and containment of the contaminant plume that has already migrated offsite.

e. Based on the contamination detected in offsite monitoring wells (refer to table, below), EPI shall delineate ground water contamination that is likely migrating in the area between Cambridge Avenue and Bloomingdale Avenue. <u>The delineation shall be conducted within 120 days of receipt of this letter.</u>

		Benzene	Toluene	1,1'-Biphenyl	Diphenyl Ether
MW-33	October 2000	4440	350000	1930	3010
	January 2001	4210	326000	790	1710
MW-45	October 2000	3730	263000	278	555
	January 2001	6230	322000	106	209
MW-46	October 2000	6.7	4800	377	697
	January 2001	0.54	580	429	671

Indoor vapor monitoring may be required if high concentrations of benzene and toluene in ground water are migrating beneath residential homes that have basements.

f. EPI shall install a monitoring well on the eastern corner of the intersection of Cambridge Avenue and Hudson Street.

g. Subsequent to delineation of the contaminant plume in the area of MW-45 and MW-46, EPI shall submit a proposal to remediate this contaminant plume.

2. EPI was required to address the product detected in offsite monitoring well MW-41 (located in Hudson Street, near the intersection with Bloomingdale Avenue). No information regarding this issue was included in the reports.

EPI shall submit Monitoring Well Certification Forms A and B for monitoring wells MW-45 and MW-46. As noted, based on the information provided in the "Well Gauging Data" tables from both Ground Water Sampling Results reports, the top of screen for both of these monitoring wells is at the depth of the water table. EPI shall be aware that the NJDEP will consider the wells to be improperly constructed if the top of screen is set at or below the ground water table. The purpose of these wells is to delineate and monitor for product, and if the top of screen is set at or below the ground water table, product may not enter the well and therefore would not be detected. Installation of replacement monitoring wells may be required, pending review of the required information.

3. EPI shall submit Monitoring Well Certification Forms A and B for all monitoring wells installed during future investigation phases. The Forms shall be submitted in the first report submitted after the wells are installed. Monitoring well construction is an integral part of determining progress of this case, and therefore decisions cannot be made without submittal of this information.

4. EPI shall delineate the separate phase hydrocarbons (SPH) detected in MW-9 ("heavy sheen" October 2000, 0.41 feet January 2001).

5. Monitoring well MW-1 shall be redeveloped, to remove the excess sediment observed during the October 2000 ground water sampling event. It is imperative that ground water samples from all monitoring wells be analyzed for 1,1'-biphenyl, and diphenyl ether.

6. As part of the original remediation proposals, EPI was to actively recover and treat the ground water contaminant plume present beneath Bloomingdale Avenue, and migrating towards and Riverside Avenue. The treated ground water was to be discharged via onsite injection. This remediation system never became active, since EPI was unable to complete satisfactory recovery or injection tests.

EPI shall inform the NJDEP regarding the status of the remediation for the offsite ground water contaminant plume.

II. SOIL.

EPI has requested alternate soil cleanup criteria for four compounds at the referenced facility. The four compounds are: biphenyl, diphenyl ether, salicylic acid and methyl salicylate. EPI proposes the following (all ppm):

	RDCSCC	NRDCSCC	IGWSCC	GWQS
Salicylic Acid	10,000	10,000	1,300	5.6
Methyl Salicylate	10,000	10,000	1,400	5.9
1,1'-Biphenyl	2,800	10,000	12	1.8
Diphenyl Ether	2,800	10,000	19	21

The NJDEP disagrees with the methodology used by Sovereign Consulting to generate the criteria. The NJDEP has calculated criteria for three of the compounds. Due to a lack of pertinent toxicity data, the NJDEP was not able to calculate criteria for methyl salicylate.

Generation of an alternate cleanup criteria for methyl salicylate will require considerable time and effort. Therefore, EPI shall provide the distribution and concentrations for this and other contaminants at the site. If other compounds will drive a cleanup then development of an alternate cleanup criteria for methyl salicylate may not be necessary.

NJDEP GENERATED ALTERNATE CLEANUP CRITERIA (ppm)

	RDCSCC	NRDCSCC
Biphenyl	3,900	10,000
Diphenyl Ether	390	5,100
Salicylic Acid	980	10,000

ANALYTICAL DATA QA/QC.

The analytical data are acceptable.

ELECTRONIC DATA SUBMITTAL.

The electronic data submittal is acceptable.

REMEDIAL SCHEDULE.

The NJDEP previously approved EPI's Remedial Schedule dated June 1, 1999.

The NJDEP acknowledges receipt of the Remedial Investigation Report Addendum dated August 3, 2001. The NJDEP will comment on this report once the review is completed.

If you have any questions, please contact the Case Manager, Andrew Dillman, at (609) 633-1447.

Sincerely,

Lois Arbegast

Lois Arbegast, Supervisor
Bureau of Environmental Evaluation,
Cleanup and Responsibility Assessment

c: David Haymes, NJDEP
Kris Geller, NJDEP
Roger Towe, EPI
Ravi Gupta, Sovereign
Garfield Health Dept.
Bergen County Dept. of Health Services

SOVEREIGN CONSULTING INC.

REMEDIAL INVESTIGATION REPORT ADDENDUM

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County New Jersey
ISRA Case No. 86B73

3 August 2001

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ATTACHMENTS (under separate cover)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (SCI) has prepared this response to the New Jersey Department of Environmental Protection's (NJDEP's) letter dated 26 June 2000, which provided comments on EPI's *Remedial Investigation Report* (RIR) dated 16 July 1999. The RIR presented the results of aquifer testing and groundwater sampling conducted between June 1997 and May 1999 at the Kalama Chemical Inc. facility in Garfield, Bergen County, New Jersey (Figure 1). EPI had proposed a new remediation program to address the benzene and toluene present in groundwater to the south of the Kalama site. Under this new remediation program, the air sparge/soil vapor extraction (AS/SVE) system, the air curtain, and the off-site SVE system would continue to be operated. In addition, EPI proposed to add three off-site SVE wells in the vicinity of MW-33 to enhance the remediation in the area of this well. To address the off-site area affected by dissolved concentrations of benzene and toluene, EPI proposed to initiate an enhanced form of "monitored natural attenuation".

The term "monitored natural attenuation", as defined by the USEPA, refers to the reliance on natural processes (i.e., biodegradation, dispersion, dilution, sorption, and/or volatilization) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by more active methods (USEPA, 1999). The USEPA has approved monitored natural attenuation as an appropriate option to be considered when reviewing possible remediation strategies. In recent years, the NJDEP has also modified their environmental statutes and regulations to allow natural attenuation to be used as a remedial alternative (NJDEP, 1996). Given the remediation systems that are currently operating at the site (i.e., the AS/SVE system, the air curtain system, and the off-site SVE system), EPI's proposal was actually an enhanced natural attenuation program.

In their 26 June 2000 response, the NJDEP indicated that additional information needed to be submitted in order to evaluate EPI's proposal. In addition, additional investigative work was required to address existing and potential off-site contamination. This RIR Addendum discusses the aquifer test and degradation rate information requested by the NJDEP, presents a work plan for investigating the potential "smear zone" beneath Hudson Street and Bloomingdale Avenue, proposes a groundwater monitoring program for the wells that address the toluene spill area, and includes the information required by the NJDEP for establishing a Classification Exception Area (CEA).

2.0 GROUNDWATER RECOVERY SYSTEM

The 31 March 1995 *Revised Remedial Action Workplan* (Revised RAW) included an off-site groundwater recovery and treatment system as part of the overall remediation program for the site. Given that the sources contributing to the off-site groundwater impact would be addressed by the on-site AS/SVE and enhanced in-situ biodegradation (i.e. air curtain) systems, the groundwater recovery system was designed to maximize off-site benzene and toluene mass removal. Based on computer modeling performed at that time (see Section 9.4 and Appendix J of the Revised RAW), the four proposed pumping wells were placed to maximize contaminant removal. It was recognized at the time that the groundwater recovery system would only be effective for approximately four years, after which mass removal rates would be minimal.

The off-site groundwater recovery system was installed in 1996 and the treatment system was installed in 1998. Although EPI submitted an application for a New Jersey Pollutant Discharge Elimination System - Discharge to Groundwater (NJPDES-DGW) permit in August 1997 for re-injection of the treated groundwater, the NJDEP has not issued a permit due to concerns regarding recovery system capture and decreased residence time of groundwater as it flowed through the air curtain downgradient of the proposed re-injection system. Supplemental information was submitted to the NJDEP in 1998 and 1999, and additional information on aquifer test interpretations and groundwater recovery and re-injection system modeling is being provided in this report.

In the meantime, the on-site remediation systems and an additional off-site SVE system have been operational since 1997/1998. Through June 2001, the AS/SVE system and the off-site SVE system had recovered over 21,000 pounds and 4,000 pounds of non-methane hydrocarbons, respectively. The on-site air curtains have also been operational, although these systems are intended to enhance in-situ contaminant degradation rather than achieve mass removal, making it difficult to quantify the hydrocarbon mass degraded. Based on the results of quarterly groundwater monitoring conducted since June 1997 (which are discussed in Sections 3.0 and 4.0 of this report), operation of the remediation systems has had a profound effect on groundwater concentrations both on-site and off-site. Based on the significant decrease in size (areal extent, concentration, and mass) of the benzene and toluene plumes, EPI requests that the NJDEP reconsider its requirement for the operation of the off-site groundwater recovery system, and approve EPI's proposal for off-site sampling and remediation outlined in Section 5.0 of this document.

2.1 Comments on Aquifer Tests

The groundwater level data collected for the entirety of the pumping tests conducted on PW-1 and PW-3 in December 1998 are provided in Appendix A and Appendix B, respectively. Regarding the observed water level fluctuations, EPI cannot provide an explanation for this phenomenon. First, the magnitude of the fluctuations observed vary considerably from well to well, but not as would be expected if they were caused by tidal influence of the Passaic River (i.e. they do not decrease with distance from the river). For example, wells MW-41 and OW-2 exhibited approximately 2.5 feet of fluctuation, wells OW-1 and OW-3 exhibited approximately 1.0 foot of fluctuation, while other wells closer to the river exhibited less than 0.25 feet of fluctuation or none at all. Secondly, only well MW-1D exhibited the classic sinusoidal fluctuation typical of tidally influenced groundwater and the fluctuation was approximately 0.75 feet; the other wells in which the fluctuations were observed exhibited a strongly asymmetrical shape more typical of the on/off of a regularly scheduled pumping well and fluctuated by as much as 2.5 feet. Thirdly, the pattern of the fluctuations stopped abruptly one day prior to the start of pumping at PW-1 (see hydrographs for MW-41, OW-1, OW-2, OW-3) and resumed prior to the cessation of pumping, yet the fluctuation continued during the PW-3 pumping test (see same wells).

It should be noted that the exhaustive well search conducted by Geraghty & Miller (included in the July 1992 *SPAN-2 Investigation Report* and in Appendix K of the December 1993 *ECRA Investigation Report and Proposed Remedial Action Plan*) determined that there are six industrial supply wells, one private supply well for a sprinkler system, and one public supply well within a 0.5-mile radius of the Kalama site. Of the six industrial supply wells, two are located 0.5-miles to the northeast and east of the site, three are located 0.5 miles west of the site (across the Passaic River), and one is located approximately 1,000 feet south of the site. All six wells are installed in the bedrock aquifer and range in depth from 230 feet to 505 feet. The one private sprinkler system supply well is located 0.25 miles east of the site and has a total depth of 130 feet. The one public supply well (owned by the City of Garfield) is located 0.3

miles southeast of the site and has a total depth of 400 feet. As reported by G&M, the City of Garfield has indicated that this supply well has never been used since the water in the well is too hard.

Given the locations and depths of the production wells identified in the vicinity of the site, it is unlikely that the operation of these wells could have caused the water level fluctuations observed during the aquifer tests on PW-1 and PW-3.

2.2 Comments on Modeling of Groundwater Recovery System Capture

The groundwater recovery (and injection) system modeling was performed using WinFlow (Environmental Simulations Inc., 1995), an analytical model that simulates two-dimensional groundwater flow in a uniform regional flow field. The model is similar to Geraghty & Miller's QuickFlow model, which was developed by the primary author of WinFlow. A summary of the main input parameters was provided in the 16 July 1999 RIR. As requested by the NJDEP, all of the input (and output) parameters are provided in the form of the model summary output file (Appendix C). Given that WinFlow is a flow model and does not incorporate solute transport, contaminant degradation was not included in the evaluation of groundwater capture.

Initially, the capture was simulated using the four existing wells and actual pumping rates determined for each well. As discussed in the July 1999 RIR, a hydraulic conductivity of 5 ft/day was used as a representative value for the site based on numerous estimates by Geraghty & Miller, SECOR, and Sovereign. The model simulations indicated that the four pumping wells did not achieve capture of the benzene and toluene plumes. Therefore, additional model simulations were run by adding pumping wells until adequate plume capture was observed. The end result was a total of seven pumping wells operating at an estimated total rate of 5 gallons per minute (gpm).

Given that the WinFlow model is an analytical model, a uniform hydraulic conductivity value must be used for the entire model area. Therefore, varying the hydraulic conductivity in different portions of the site to account for heterogeneities would require the use of a numerical flow model, such as the United States Geological Survey's (USGS's) MODFLOW program. Although numerical models such as

MODFLOW are substantially more robust than WinFlow, they are also much more difficult to setup and calibrate and are more susceptible to numerical errors, especially given the small area to be modeled. Additionally, since the hydraulic conductivity at the site is relatively uniform (estimated to range from 1.0 to 39 ft/day) as opposed to varying over several orders of magnitude, a model of that complexity is not warranted. Finally, detailed studies are needed to justify varying the hydraulic conductivity across a model domain.

Although it is possible to perform a sensitivity analysis on the model input parameters, specifically hydraulic conductivity, it is not warranted since the benzene and toluene plumes have decreased significantly in size due to the combined effects of operating the existing remediation systems and natural attenuation processes. Given that the plumes have continued to shrink in size over the past several years (as discussed in later Sections), further evaluation of the groundwater recovery and re-injection system is not necessary.

3.0 GROUNDWATER SAMPLING RESULTS

The 16 July 1999 RIR included a discussion of the changes that have occurred in groundwater quality in the area of the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area between June 1997 (prior to the onset of active remediation) and April/May 1999. The RIR only included detailed discussions on the June 1997 and April/May 1999 sampling events, although the benzene and toluene data from all of the sampling events were included on the concentration vs. time graphs. On Page 12 of their 26 June 2000 letter, the NJDEP required that EPI submit a discussion of the results from all of the quarterly groundwater sampling events. The benzene, toluene, and groundwater elevation data for all 13 sampling events are summarized on the concentration vs. time graphs included in Appendix D.

3.1 Groundwater Quality Standards

A groundwater monitoring program was originally proposed to the NJDEP in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan (and the proposed monitoring program) had not yet been approved by the NJDEP, quarterly groundwater sampling was implemented in June 1997 to establish a base-line against which remediation progress could be compared. The groundwater quality standards (GWQS) for the five compounds of concern that were included in the monitoring program for the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area are summarized below.

Site Specific Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Benzene	1.0
Toluene	1,000
Phenol	4,000
Benzoic Acid	30,000
Formaldehyde	110

The benzene, toluene, and phenol standards are from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The values for benzoic acid and formaldehyde were established by the NJDEP in their 30 August 1996 letter following the submission of proposed standards in the 29 February 1996 *Revised RAW Addendum.*

As is discussed in the following Section, samples from all of the wells addressing the toluene spill area were analyzed for benzene and toluene. However, only samples from select wells (based on historical data) were analyzed for benzoic acid. The phenol analyses were performed on wells that historically contained elevated concentrations of this compound, although the presence of phenol in these wells was unrelated to the toluene spill. Therefore, phenol was not considered to be a compound of concern for the toluene spill area. Finally, two rounds of samples were analyzed for formaldehyde as part of a program to determine if formaldehyde was a site-wide compound of concern.

Benzoic acid, phenol, and formaldehyde were all subsequently eliminated from the monitoring program for the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area as accumulated groundwater data indicated that these compounds were not present at concentrations exceeding their respective groundwater quality standards.

Starting with the July 2000 groundwater monitoring event, samples were also analyzed for 1,1'-biphenyl and diphenyl ether. However, since the NJDEP does not have any established groundwater quality standards for these compounds, a generic value of 100 parts per billion (ppb) would be applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believes the generic 100 ppb criterion is too conservative, since it does not incorporate toxicological data specific to each compound. Since neither 1,1'-biphenyl or diphenyl ether are volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the NJDEP's 100 ppb criterion is based, acceptable groundwater concentrations at the site should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request for the following alternate groundwater quality standards for 1,1'-biphenyl, and diphenyl ether.

Proposed Alternate Groundwater Quality Standards Kalama Chemical Inc. Facility Garfield, Bergen County, New Jersey	
Compound of Concern	GWQS (in ug/L)
1,1'-Biphenyl	1,800
Diphenyl Ether	21,000

The results of the July 2000 groundwater sampling event have been evaluated using the proposed alternate GWQS.

3.2 Groundwater Sampling Procedures

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of separate phase hydrocarbons (SPH) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones. If three well volumes could not be purged due to poor recharge, the water level in the well was allowed to recover to within two feet of static conditions (or sufficiently to allow sample collection) prior to sampling.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rate was kept below five gallons per minute (gpm). The flow rate for purging the final well volume did not exceed one gpm. In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

<u>Before Purging</u>

- Date, time, and weather conditions
- Well number

- Head space reading immediately after well cap is removed
- Product thickness, if any
- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

A total of 13 quarterly groundwater sampling events are discussed in this report, including June 1997, September 1997, January 1998, April 1998, July 1998, October 1998, January 1999, April/May 1999, July 1999, October 1999, January 2000, April 2000, and July 2000. Results from the October 2000 and January 2001 sampling events have been submitted to the NJDEP as separate reports. The results from the April 2001 and July 2001 sampling events will also be submitted to the NJDEP as separate reports. The well purging information for the 13 sampling events included in this report are summarized on the groundwater sampling data forms included under separate cover as Attachment I. Item "d" on Page 12 of the NJDEP's 26 June 2000 letter states that "...the NJDEP has requested this information [well purging data] historically, as EPEC has usually not included it in any of their reports." EPI was surprised at this comment since it is obviously incorrect. Since 1994, when Tenneco Polymers Inc. (now EPEC Polymers Inc.) assumed responsibility for the Kalama Chemical project, only four reports have been submitted that contained a significant discussion of groundwater quality: 1) the 31 March 1995 Revised RAW; 2) the 22 April 1998 *Results of the Soil and Groundwater Investigation in the Area of Building 23*;

3) the 11 January 1999 remedial investigation report summarizing additional soil and groundwater sampling conducted in the area of Building 23; and, 4) the 16 July 1999 *Remedial Investigation Report*. With the exception of the July 1999 RIR, all of these reports included the well purging data the NJDEP says has not been submitted. It is also worth noting that prior to EPI's involvement, well purging data was included with Geraghty & Miller's September 1991 *Revised ECRA Sampling Plan Investigation Report*, their July 1992 *Sampling Plan Addendum No. 2 Investigation Report*, and their December 1993 *ECRA Investigation Report and Proposed Remedial Action Plan.*

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for VOC analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was generally collected for each day of sampling.

Between June 1997 and October 1998, the groundwater samples for benzene, toluene, benzoic acid, and phenol were shipped via overnight courier to RECRA Environmental, Inc. in Amherst, New York (NJ Certification No. 73455). Since the January 1999 sampling event, the samples for benzene and toluene were either delivered to the analytical laboratory (Accutest in Dayton, New Jersey; Certification No. 12129) or returned to the office where they were picked up by an Accutest courier the following morning. The formaldehyde samples were shipped via overnight courier to Savannah Laboratories & Environmental Services, Inc. (SLES) in Savannah, Georgia (NJ Certification No. 50769) or Tallahassee, Florida (NJ Certification No. 49517). Copies of the analytical data packages for 12 sampling events (including the electronic data disk deliverables) are being provided under separate cover as Attachments II through XIII. The analytical data packages for the April/May 1999 sampling event were submitted to the NJDEP as part of the 16 July 1999 RIR.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

3.3 June 1997 Sampling Event

In order to establish base-line conditions prior to operating the air sparge/soil vapor extraction (AS/SVE) system and the air curtain system, groundwater samples were to be collected from the following wells:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, and MW-41

Measurable amounts of SPH were detected in MW-4 (0.01 feet), MW-D5 (0.24 feet), MW-9 (0.04 feet), and MW-41 (0.30 feet) and therefore, groundwater samples were not collected from these wells. The groundwater samples from the remaining 18 wells were analyzed for benzene and toluene by USEPA Method 602. In addition, samples from MW-10, MW-11, and MW-17 were analyzed for benzoic acid by USEPA Method 8270, and samples from MW-6, MW-22, MW-30, and MW-31 were analyzed for phenol by USEPA Method 8270. Each well was also analyzed for formaldehyde by USEPA Method 8315 to determine if this compound is of environmental concern in this area of the site. The analytical results for the June 1997 sampling event are summarized on Table 1 and are presented on Figure 2.

Formaldehyde, phenol, and benzoic acid did not exceed their respective GWQS in any of the wells sampled for these parameters. Benzene was detected at concentrations above the GWQS of 1.0 ppb in 14 of the 18 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in seven wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 16.0 ppb in MW-5 to 770 ppb in MW-17. Benzene was detected in all of the wells sampled along the southern property line (Hudson Street) and along the southwestern property line (River Drive). In the off-site wells, benzene concentrations ranged from 26.0 ppb in MW-36 to 9,300 ppb in MW-33.

Toluene exceeded the GWQS in on-site wells MW-14 (90,000 ppb) and MW-30 (44,000 ppb). In the off-site wells, toluene exceeded the GWQS in MW-23 (3,600 ppb), MW-25 (94,000 ppb), MW-31 (4,300 ppb), MW-33 (610,000 ppb) and MW-40 (480,000 ppb).

In general, benzene and toluene concentrations in June 1997 did not reflect any significant changes from previous sampling events. One exception is the toluene concentration in MW-17, which dropped from 240,000 ppb in May 1993 (the last time the well was sampled) to 170 ppb in June 1997. Benzoic acid concentrations also decreased in MW-17, dropping from 74,000 ppb in May 1993 to not detected (at a detection limit of 50.0 ppb) in June 1997. A significant decrease in phenol was also observed in MW-6, dropping to 3.0 ppb from 56,000 ppb in January 1995.

A sample of the SPH found in MW-41 was collected and analyzed for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8240) and base neutral/acid extractable compounds (including calibrations for benzoic acid and benzaldehyde) plus an NBS library search (BNA+25; USEPA Method 8270). The analytical results for this sample are summarized on Table 2. Toluene was detected at 660,000 parts per million (ppm) or 66.0% and benzene was detected at 1,700 ppm. Other compounds detected at significant concentrations in the SPH sample include ethylbenzene (230 ppm), xylenes (400 ppm), benzoic acid (350 ppm), and dibenzofuran (670 ppm).

The distributions of toluene and benzene in the shallow overburden zone using the June 1997 groundwater sampling results are shown on Figure 3 and Figure 4, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are found in a lenticular shaped plume which originates from the toluene spill area (MW-33) and extends westward along Hudson Street. Upon reaching River Drive, the toluene plume extends to the north to MW-30. This distribution is consistent with those from previous sampling events. The benzene plume roughly mirrors the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in a lenticular shaped plume extending from MW-33 westward to MW-40. The benzene plume has two lobes which extend to the north, one in the toluene spill area and one along the southwestern property line. The benzene plume also extends further to the south, although at significantly lower concentrations than seen in the wells within Hudson Street.

3.4 September 1997 Sampling Event

Groundwater samples were to be collected from the following wells during this sampling event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, and MW-41

At the time of this sampling event, the SVE component of the AS/SVE system had been in operation since July 1997.

Measurable amounts of SPH were detected in MW-D5 (0.05 feet), MW-9 (0.03 feet), and MW-41 (1.34 feet) and therefore, groundwater samples were not collected from these wells. Although no measurable amounts of SPH were detected in MW-4, a sample was not collected from this well due to the presence of globules of SPH in the bailer. The groundwater samples from the remaining 18 wells were analyzed for benzene and toluene. In addition, samples from MW-10 and MW-17 were analyzed for benzoic acid[1], and samples from MW-6, MW-22, MW-30, and MW-31 were analyzed for phenol. Each well was also analyzed for formaldehyde to determine if this compound is of environmental concern in this area of the site. The analytical results for these samples are summarized on Table 3 and are presented on Figure 5.

Formaldehyde, phenol, and benzoic acid did not exceed their respective GWQS in any of the wells sampled for these parameters. Since at least two rounds of samples have been analyzed for formaldehyde by USEPA Method 8315, and since none of the wells sampled contained this compound at a concentration exceeding the GWQS, formaldehyde was eliminated from future samples from wells addressing this area of the Kalama site. Benzene was detected at concentrations above the GWQS of 1.0 ppb in 13 of the 18 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in six wells.

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[1] The sample from MW-11 was also to be analyzed for benzoic acid. However, both amber bottles broke during shipment to RECRA.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 30.0 ppb in MW-10 to 580 ppb in MW-17. Benzene was detected in all of the wells sampled along the southern property line (Hudson Street) and along the southwestern property line (River Drive). In general, benzene concentrations did not exhibit a significant change when compared to the June 1997 sampling event. One change of note was in MW-30, in which the benzene concentration dropped from 230 ppb in June 1997 to 0.85 ppb. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 75.0 ppb in MW-36 to 9,200 ppb in MW-33.

Toluene exceeded the GWQS in on-site wells MW-5 (4,100 ppb) and MW-14 (71,000 ppb). The toluene concentration in MW-30 (20.0 ppb) was significantly lower during this sampling event, having dropped from 44,000 ppb in June 1997. In the off-site wells, toluene exceeded the GWQS in MW-23 (2,600 ppb), MW-25 (210,000 ppb), MW-33 (840,000 ppb), and MW-40 (320,000 ppb). The toluene concentration in MW-31 (180 ppb) also exhibited a significant decrease relative to the June 1997 sampling event (4,300 ppb).

The results of this sampling event confirmed the decreased concentrations of toluene and benzoic acid observed in MW-17 during the June 1997 event, and the decreased concentration of phenol seen in MW-6.

The distributions of toluene and benzene in the shallow overburden zone using the September 1997 groundwater sampling results are shown on Figure 6 and Figure 7, respectively. No significant changes in the distribution of benzene and toluene were observed during this sampling event. The highest concentrations of toluene (greater than 100,000 ppb) are found in a lenticular shaped plume which originates from the toluene spill area (MW-33) and extends westward along Hudson Street. The benzene plume roughly mirrors the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in a lenticular shaped plume extending from MW-33 westward to MW-40. The benzene plume has one lobe which extend to the north in the toluene spill area. The benzene plume also extends further to the south, although at significantly lower concentrations than seen in the wells within Hudson Street.

3.5 January 1998 Sampling Event

Groundwater samples were to be collected from the following wells during the January 1998 monitoring event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, and MW-41

At the time of this sampling event, in addition to the on-site SVE system, the off-site SVE system in Hudson Street and Bloomingdale Avenue was in operation (having been brought on-line in December 1997).

Measurable amounts of SPH were detected in MW-9 (0.19 feet), MW-33 (0.06 feet), and MW-41 (0.07 feet) and therefore, groundwater samples were not collected from these wells. For the first time since quarterly sampling was initiated, no measurable amounts (or visible evidence) of SPH were detected in MW-4 and MW-D5. This represents the first time these wells have been sampled since April 1991 (MW-4) and April 1992 (MW-D5). The groundwater samples from the remaining 19 wells were analyzed for benzene and toluene. In addition, samples from MW-4, MW-10, MW-11, and MW-17 were analyzed for benzoic acid, and samples from MW-6, MW-22, MW-30, and MW-31 were analyzed for phenol. As indicated in the previous Sections of this report, the analytical results from the June and September 1997 sampling events indicated that formaldehyde is no longer a compound of concern in this area of the site. The analytical results for these samples are summarized on Table 4 and are presented on Figure 8.

Phenol and benzoic acid did not exceed their respective GWQS in any of the wells sampled for these parameters. Benzene was detected at concentrations above the GWQS of 1.0 ppb in 14 of the 19 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in seven wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 14.0 ppb in MW-6 to 2,500 ppb in MW-D5. Benzene was detected in all of the wells sampled along the southern property line (Hudson Street) and along the southwestern property line (River Drive). In general, benzene concentrations did not exhibit a significant change when compared to the September 1997 sampling event. The benzene concentrations in MW-4 and MW-D5 were also similar to April 1991 and April 1992 sampling results. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.7 ppb in MW-36 to 3,000 ppb in MW-40. Although benzene was not detected in MW-14 and MW-25, both samples had elevated practical quantitation limits (PQLs) of 400 ppb and 800 ppb, respectively. Therefore, these results were not considered to be representative of groundwater quality in each well.

Toluene exceeded the GWQS in three on-site wells including MW-4 (160,000), MW-D5 (200,000 ppb), and MW-14 (32,000 ppb). In the off-site wells, toluene exceeded the GWQS in MW-23 (3,000 ppb), MW-25 (130,000 ppb), MW-31 (4,800 ppb), and MW-40 (210,000 ppb). No significant changes in toluene concentrations were observed relative to the September 1997 sampling event.

The distributions of toluene and benzene in the shallow overburden zone using the January 1998 groundwater sampling results are shown on Figure 9 and Figure 10, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are found in a lenticular shaped plume which originates from the toluene spill area (MW-4, MW-D5) and extends westward along Hudson Street. The benzene plume roughly mirrors the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in a lenticular shaped plume extending from MW-4 and MW-D5 westward to MW-40. No significant changes in the distribution of benzene or toluene were observed during the January 1998 sampling event.

3.6 April 1998 Sampling Event

Groundwater samples were to be collected from the following wells during the April 1998 sampling event.

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, and MW-41

At the time of this sampling event, the AS/SVE system, the off-site SVE system, and the vertical component of the air curtain were in operation. The air sparging component of the AS/SVE system was brought on-line in January 1998 (after groundwater sampling event). The vertical injection wells for the air curtain were brought on-line in March 1998.

No measurable amounts of SPH were found during this sampling event. Groundwater samples were collected from all wells addressing this area of environmental concern (AEC) except MW-1, which had almost completely silted up due to the operation of the air curtain. The groundwater samples for the remaining 21 wells were analyzed for benzene and toluene. In addition, samples from MW-4, MW-10, MW-11, and MW-17 were analyzed for benzoic acid, and samples from MW-6, MW-22, MW-30, and MW-31 were analyzed for phenol. The analytical results for these samples are summarized on Table 5 and are presented on Figure 11.

Phenol and benzoic acid did not exceed their respective GWQS in any of the wells sampled for these parameters. Benzene was detected at concentrations above the GWQS of 1.0 ppb in 14 of the 22 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in eight wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 1.6 ppb in MW-10 to 2,200 ppb in MW-D5. Benzene was detected in all of the wells sampled along the southern property line (Hudson Street) and in MW-31 along the western property line (River Drive). In the off-site wells, benzene concentrations exceeding the GWQS ranged from 6.6 ppb in MW-36 to 6,400 ppb in MW-25. Benzene concentrations decreased in most wells when compared to the January 1998 sampling event. The most significant changes were seen in the following wells:

- MW-10 - 1.6 ppb (lowest concentration since April 1991)
- MW-11 - not detected for the first time since February 1993
- MW-17 - 5.9 ppb (lowest concentration since May 1993)
- MW-22 - not detected for the first time since January 1992
- MW-31 - 8.3 ppb (lowest concentration since January 1992)

The benzene concentration in one well increased significantly when compared to previous sampling events. MW-25 contained 6,400 ppb of benzene, an increase from 1,100 ppb in September 1997 and the highest concentration seen in this well since January 1992 (7,300 ppb). None of the concentration changes seen in these wells appears to be related to fluctuations in the water table since groundwater elevations did not change significantly relative to the last few sampling events.

Toluene exceeded the GWQS in four on-site wells including MW-4 (68,000 ppb), MW-D5 (86,000 ppb), MW-14 (63,000 ppb), and MW-33 (450,000 ppb). In the off-site wells, toluene exceeded the GWQS in MW-23 (15,000 ppb), MW-25 (410,000 ppb), MW-40 (260,000 ppb), and MW-41 (320,000 ppb).

The toluene concentrations in MW-4 and MW-D5 represent a 58% and 57% decrease, respectively, when compared to the January 1998 results. The toluene concentrations seen in MW-23 and MW-25 represent the highest levels seen in these wells since January 1995. However, the results from the April 1998 sampling event are still below the highest concentrations ever detected in these wells (50,000 ppb in MW-23 and 880,000 ppb in MW-25).

The distributions of toluene and benzene in the shallow overburden zone using the April 1998 groundwater sampling results are shown on Figure 12 and Figure 13, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are found in a lenticular shaped plume which originates from the toluene spill area (MW-4, MW-D5, MW-33) and extends westward along Hudson Street. The benzene plume roughly mirrors the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in a lenticular shaped plume extending from MW-4 and MW-D5 westward to MW-40. No significant changes in the distribution of benzene or toluene were observed during the April 1998 sampling event.

3.7 July 1998 Sampling Event

Groundwater samples were to be collected from the following wells during the July 1998 monitoring event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, and MW-41

At the time of this sampling event, the AS/SVE system, the off-site SVE system, and the vertical and horizontal components of the air curtain were in operation. The horizontal injection wells for the air curtain were brought on-line in May 1998.

None of the wells addressing this area of the site contained measurable amounts of SPH. Groundwater samples were collected from all wells except MW-1, which had silted up due to the operation of the air curtain. The groundwater samples for the remaining 21 wells were analyzed for benzene and toluene. In addition, samples from MW-4, MW-10, MW-11, and MW-17 were analyzed for benzoic acid, and samples from MW-6, MW-22, MW-30, and MW-31 were analyzed for phenol. The analytical results for these samples are summarized on Table 6 and are presented on Figure 14.

Phenol and benzoic acid did not exceed their respective GWQS in any of the wells sampled for these parameters. Benzene was detected at concentrations above the GWQS of 1.0 ppb in 10 of the 21 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in seven wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 1.2 ppb in MW-11 to 1,800 ppb in MW-D5. Benzene was detected in all of the wells sampled along the southern property line (Hudson Street) and in MW-31 along the western property line (River Drive). In the off-site wells, benzene concentrations exceeding the GWQS ranged from 10.0 ppb in MW-36 to 5,000 ppb in MW-33. Benzene concentrations decreased in most wells when compared to the April 1998 sampling event. The most significant changes were seen in the following wells:

- MW-10 - 0.49 ppb (lowest concentration since April 1991; first time below GWQS)
- MW-17 - 0.86 ppb (lowest concentration since May 1993)
- MW-22 - not detected for second consecutive quarter
- MW-23 - 41.0 ppb (lowest concentration since January 1992)
- MW-30 - not detected for second consecutive quarter

- MW-31 - 2.9 ppb (lowest concentration since January 1992)
- MW-33 - 5,000 ppb (lowest concentration since January 1995)

Benzene concentrations decreased in all wells except MW-11 (1.2 ppb), MW-14 (640 ppb), and MW-36 (10.0 ppb). These increases were slight (1.2 ppb in MW-11, 3.4 ppb in MW-36, and 40.0 ppb in MW-14) and the July 1998 levels are consistent with historic analytical results.

Toluene exceeded the GWQS in three on-site wells including MW-4 (2,700 ppb), MW-D5 (70,000 ppb), and MW-14 (74,000 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (360,000 ppb), MW-33 (400,000 ppb), MW-40 (180,000 ppb), and MW-41 (140,000 ppb).

The toluene concentrations in MW-4 and MW-D5 represent a 96% and 19% decrease, respectively, when compared to the April 1998 results. The toluene concentration seen in MW-23 (84.0 ppb) represents the lowest level ever seen in this well (dating back to January 1992). When compared to the April 1998 results, the toluene concentrations in MW-40 and MW-41 decreased 31% and 56%, respectively, and continue the overall decreasing trend seen in these wells since June 1997.

Since there was no significant change in groundwater elevation between the April 1998 and July 1998 sampling events, EPI believes the lower benzene and toluene concentrations observed in July 1998 can be attributed to the full scale operation of the AS/SVE system, the off-site SVE system, and the air curtain system.

The distribution of toluene and benzene in the shallow overburden zone using the July 1998 groundwater sampling results are shown on Figure 15 and Figure 16, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are found in a lenticular shaped plume which originates from the toluene spill area (MW-D5, MW-33) and extends westward along Hudson Street (MW-25, MW-40, MW-41). The benzene plume roughly mirrors the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in a lenticular shaped plume extending from MW-D5 westward to MW-40.

Since June 1997, when the groundwater monitoring program commenced, the most significant change in the shape of the toluene plume has been the elimination of the portion of the plume that extended northward from MW-14 to MW-30 along the western property line. The shape of the benzene plume has also changed slightly since June 1997. The most significant change is the reduction in size of the 100 ppb isoconcentration line, which used to encompass MW-14, MW-22, MW-23, MW-30, and MW-31 along the western end of the plume. The 100 ppb isoconcentration line now only extends to MW-14, and the benzene concentrations in MW-22, MW-30, and MW-31 have dropped to near or below 1.0 ppb.

3.8 October 1998 Sampling Event

In accordance with the NJDEP's letter dated 19 August 1998, EPI had installed five off-site observation wells (OW-1 through OW-5) and one monitoring well (MW-42) in Hudson Street and Bloomingdale Avenue prior to this sampling event. All of these wells were included in this monitoring event but, as per the NJDEP's 19 August 1998 letter, only MW-42 was required to be incorporated into future sampling events.

In order to monitor the effectiveness of the AS/SVE, off-site SVE, air curtain systems, groundwater samples were to be collected from the following wells:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, and MW-42, OW-1, OW-2, OW-3, OW-4, and OW-5

At the time of this sampling event, the air sparging system in the southeast corner of the site and the vertical and horizontal injection wells of the air curtain in the southwest corner of the site were not in operation. These systems had been shut down to allow the formation to re-equilibrate prior to conducting the aquifer tests on PW-1 and PW-3.

Measurable amounts of SPH were not detected during the initial gauging of the wells in this area. However, SPH was drawn into MW-9 during purging, so a sample was not collected from this well.

Groundwater samples were collected from all other wells except MW-11, which contained an insufficient volume of water due to sediment clogging the filter pack material. MW-1 had been re-developed several weeks before this sampling event, allowing a groundwater sample to be collected from this well for the first time since January 1998. The 27 groundwater samples from this area were analyzed for benzene and toluene. In addition, samples from MW-4, MW-10, and MW-17 were analyzed for benzoic acid, and samples from MW-6, MW-22, MW-30, and MW-31 were analyzed for phenol. The analytical results for these samples are summarized on Table 7 and are presented on Figure 17.

Phenol and benzoic acid did not exceed their respective GWQS in any of the wells sampled for these parameters. Benzene was detected at concentrations above the GWQS of 1.0 ppb in 19 of the 27 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in 11 wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 4.5 ppb in MW-6 to 4,000 ppb in MW-D5. Benzene was detected in all of the wells sampled along the southern property line except MW-1, and in MW-31 along the western property line. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 18.0 ppb in OW-1 to 9,300 ppb in OW-3. Benzene concentrations increased in most wells when compared to the April 1998 sampling event. This rebound is most likely due to the fact that the air sparging and air curtain remediation systems were not in operation for several weeks leading up to the October 1998 sampling event. Although benzene concentrations in most wells rebounded, the concentrations seen during this sampling event were still lower than those seen prior to initiating active groundwater remediation. Benzene concentrations in several off-site wells continued to decline, including:

- MW-23 - 30.0 ppb (5th consecutive quarter with declining concentration)
- MW-25 -1,000 ppb (lowest concentration since January 1992)
- MW-36 - 1.0 ppb (lowest concentration since May 1993)
- MW-40 - 960 ppb (lowest concentration since June 1997)

Toluene exceeded the GWQS in three on-site wells including MW-4 (25,000 ppb), MW-D5 (190,000 ppb), and MW-14 (82,000 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (110,000 ppb), MW-33 (410,000 ppb), MW-40 (54,000 ppb), and MW-41 (3,400 ppb), and in OW-2 (93,000 ppb), OW-3 (12,000 ppb), OW-4 (190,000 ppb), and OW-5 (75,000 ppb).

As was seen with benzene, the toluene concentrations in MW-4, MW-D5, MW-14, and MW-33 all rebounded relative to the July 1998 sampling results. However, the October 1998 concentrations were still lower than those seen in groundwater from before the remediation systems were started. The toluene concentration seen in MW-23 (14.0 ppb) represented the lowest level ever seen in this well (dating back to January 1992). When compared to the July 1998 results, the toluene concentrations in MW-40 and MW-41 decreased 70% and 98%, respectively, and continued the overall decreasing trend seen in these wells since June 1997.

The distribution of toluene and benzene in the shallow overburden zone using the October 1998 groundwater sampling results are shown on Figure 18 and Figure 19, respectively. The shapes of the benzene and toluene plumes have been refined using the data from observation wells OW-1 through OW-5 and monitoring well MW-42. The highest concentrations of toluene (greater than 100,000 ppb) were found in two small lenses centered around MW-33 and MW-D5, and around MW-25 and OW-4. The concentrations of toluene exceeding the GWQS of 1,000 ppb are found in a lenticular shaped plume originating from the toluene spill area (MW-D5, MW-33) and extending westward along Hudson Street to MW-14. Although it had been inferred in the past, the groundwater data from OW-1 and MW-42 confirmed that the toluene plume does not extend more than 80 feet down Bloomingdale Avenue.

The benzene plume roughly mirrors the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in two lenses centered around MW-D5, MW-33, and OW-3, and around MW-25 and OW-4. Based on the analytical results from MW-42, the benzene plume extended approximately 150 feet down Bloomingdale Avenue, which was consistent with the extent that had previously been inferred using 1996 data from PW-2.

3.9 January 1999 Sampling Event

Groundwater samples were to be collected from the following wells during the January 1999 sampling event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, and MW-42

The AS/SVE system, the off-site SVE system, and the air curtain were all in operation at the time of this sampling event. None of the wells to be sampled contained measurable amounts of SPH. Groundwater samples were collected from all wells addressing this AEC except MW-1 and MW-22. Due to the operation of the air curtain, both of these wells had filled with sediment which prevented proper purging and sampling. The 21 groundwater samples from this area were analyzed for benzene and toluene by USEPA Method 624. Based on the last six quarters of sampling, phenol and benzoic acid were no longer considered to be compounds of concern in the Toluene Spill Area and were eliminated from the monitoring program for the wells addressing this AEC. The analytical results for these samples are summarized on Table 8 and are presented on Figure 20.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in six of the 21 wells sampled. Toluene was detected at concentrations above the GWQS of 1,000 ppb in seven wells. Over the last six quarters of sampling, benzene exceeded 1.0 ppb in an average of 69% of the wells, while toluene exceeded 1,000 ppb in 37% of the wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 342 ppb in MW-14 to 2,350 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 143 ppb in MW-40 to 6,730 ppb in MW-33. When compared to the October 1998 sampling event, benzene concentrations decreased in every well except MW-23. The benzene concentration in MW-23 increased to 316 ppb from 30.0 ppb in October 1998. This represented the first increase in benzene in MW-23 since June 1997, when 520 ppb was detected. This increase did not appear to be related to a fluctuation in the water table since the groundwater elevation in MW-23 only increased 0.09 feet between October 1998 and January 1999. Benzene concentrations in several other off-site wells continued to decline, including:

- MW-25 - 304 ppb (lowest concentration since January 1992)
- MW-31 - Not detected for the first time since the well was originally sampled (May 1993)
- MW-36 - Not detected for the first time since the well was originally sampled (May 1993)
- MW-40 - 143 ppb (lowest concentration since June 1997)
- MW-41 - Not detected for the first time since the well was originally sampled (June 1997)

Toluene exceeded the GWQS in on-site wells MW-4 (5,980 ppb), MW-D5 (84,400 ppb), and MW-14 (40,800 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (36,700 ppb), MW-33 (438,000 ppb), and MW-40 (6,400 ppb).

As was seen with benzene, the toluene concentrations in MW-4, MW-D5, and MW-14 decreased relative to the October 1998 sampling results. The toluene concentration in MW-23 increased to 5,820 ppb, which is the highest level seen in this well since April 1998 (when 15,000 ppb was detected). When compared to the October 1998 results, the toluene concentrations in MW-40 and MW-41 decreased 88% and 95%, respectively, and continued the overall decreasing trend seen in these wells since June 1997.

The distribution of toluene and benzene in the shallow overburden zone using the January 1999 groundwater sampling results are shown on Figure 21 and Figure 22, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to a small lens centered around MW-33. The concentrations of toluene exceeding the GWQS of 1,000 ppb are found in two separate areas centered around MW-25 and MW-33; during previous sampling events, the 1,000 ppb plume was continuous and extended from MW-33 westward to MW-14.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found near MW-D5 and MW-33. The size of the benzene affected area is significantly smaller than in October 1998, mainly due to the reduced concentrations seen in the wells on the perimeter of the plume (i.e., MW-6, MW-10, MW-11, MW-31, and MW-36).

3.10 April/May 1999 Sampling Event

Groundwater samples were to be collected from the following wells during the April/May 1999 sampling event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, and OW-1, OW-2, OW-3, OW-4, and OW-5

The AS/SVE system, the off-site SVE system, and the air curtain were all in operation at the time of this sampling event.

Groundwater samples were collected from 26 wells in April and May 1999. Monitoring well MW-9 was not sampled due to the presence of SPH. Observation wells OW-1 through OW-4 were sampled in May 1999 to help further define the shape of the benzene and toluene plumes. OW-5 was silted up and could not be sampled. The analytical results for the April 1999 sampling event are summarized on Table 9 and are presented on Figure 23.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 12 of the 26 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 4.7 ppb in MW-17 to 2,100 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.3 ppb in MW-42 to 1,600 ppb in OW-3.

When compared to the January 1999 sampling event, benzene concentrations remained below the GWQS is 12 wells and decreased in five wells (MW-D5, MW-14, MW-22, MW-23, and MW-33). Benzene concentrations increased slightly in MW-4 (from ND to 7.9 ppb), MW-17 (ND to 4.7 ppb), and MW-42 (ND to 1.3 ppb), and more significantly in MW-25 (304 ppb to 851 ppb) and MW-40 (143 ppb to 1,170 ppb).

Toluene was detected at concentrations above the GWQS of 1,000 ppb in three on-site wells including MW-4 (1,480 ppb), MW-D5 (112,000 ppb), and MW-14 (48,600 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (89,800 ppb), MW-33 (228,000 ppb), MW-40 (128,000 ppb), OW-2 (4,740 ppb) and OW-3 (3,040 ppb).

Relative to the January 1999 sampling results, toluene concentrations remained below the GWQS in 15 wells and decreased in three wells (MW-4, MW-23, and MW-33). Toluene concentrations increased in MW-D5, MW-14, MW-25, and MW-40, although with the exception of MW-40, the January 1999 results were still lower than those from October 1998.

The distribution of toluene and benzene in the shallow overburden zone using the January 1999 groundwater sampling results are shown on Figure 24 and Figure 25, respectively. The highest concentrations of toluene (greater than 100,000 ppb) were found in two areas centered around MW-D5 and MW-33, and MW-40. The concentrations of toluene exceeding the GWQS of 1,000 ppb are found in three areas encompassing MW-4, MW-D5, MW-33, and OW-3, MW-25, MW-40, and OW-2, and MW-14. The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found near MW-D5 and MW-33, and MW-40.

3.11 July 1999 Sampling Event

Groundwater samples were to be collected from the following wells during the July 1999 sampling event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33,
Monitoring Points	MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, OW-1, OW-2, OW-3, OW-4, and OW-5

All three of the remediation systems were in operation at the time of this groundwater monitoring event. No samples could be collected from MW-9 and MW-33 due to the presence of 0.08 feet and 0.10 feet of SPH, respectively. Due to the wells being filled with sediment, no samples could be collected from OW-4 and OW-5. Groundwater elevations during this sampling event were generally lower (by almost one foot) than in April 1999. The groundwater samples collected from the remaining wells addressing this

AEC were analyzed for benzene and toluene. The analytical results for these samples are summarized on Table 10 and are presented on Figure 26.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in nine of the 24 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 1.3 ppb in MW-5 to 4,240 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.5 ppb in MW-42 to 2,200 ppb in OW-3. The benzene concentration in MW-23 decreased slightly from 72.8 ppb in April 1999 to 68.8 ppb. This continues the trend of decreasing benzene concentrations dating back to June 1997 that was interrupted by the January 1999 results.

Benzene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW-1 - Not detected for the third consecutive quarter.
- MW-6 - Not detected for the third consecutive quarter.
- MW-10 - Not detected for the third consecutive quarter.
- MW-11 - Not detected for the third consecutive quarter.
- MW-30 - Not detected for the sixth consecutive quarter.
- MW-31 - Not detected (below the GWQS for the third consecutive quarter).
- MW-36 - Not detected for the third consecutive quarter.
- MW-41 - 0.87 ppb (below the GWQS for the third consecutive quarter).

Although benzene concentrations increased in three wells (MW-D5, MW-22, and MW-42) relative to April 1999, the July 1999 results are still less than or comparable to the January 1999 data.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in two on-site wells (MW-D5 at 159,000 ppb and MW-14 at 40,800 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (105,000 ppb), MW-40 (8,200 ppb), OW-2 (2,590 ppb), and OW-3 (3,040 ppb). The toluene concentration in MW-40 decreased from 128,000 ppb in April 1999. This continues the trend of decreasing toluene concentrations dating back to June 1997 that was interrupted by the April 1999 results. The other toluene concentrations are consistent with the historical data for each well.

The distribution of toluene and benzene in the shallow overburden zone using the July 1999 groundwater sampling results are shown on Figure 27 and Figure 28, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to two small lenses in the vicinity of MW-33 and MW-25. The concentrations of toluene exceeding the GWQS of 1,000 ppb are found in three separate areas around MW-14, MW-25 and MW-33; prior to January 1999, the 1,000 ppb plume was continuous and extended from MW-33 westward to MW-14.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found near MW-33. The size of the benzene affected area is relatively smaller than in April 1999, mainly due to the reduced concentrations seen in wells MW-25 and MW-40.

3.12 October 1999 Sampling Event

During the October 1999 monitoring event, groundwater samples were to be collected from the following wells:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33,
Monitoring Points	MW-16, MW-22, MW-31, MW-34, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, OW-1, OW-2, OW-3, OW-4, and OW-5

The AS/SVE system, the off-site SVE system, and the air curtain were all in operation at the time of this sampling event. In order to better define the eastern (i.e., upgradient) edge of the benzene and toluene plume, monitoring wells MW-16 and MW-34 (both located in Cambridge Avenue) were added to this quarter's sampling program. SPH was detected in MW-9 (0.36 feet) and MW-33 (0.46 feet) and therefore, groundwater samples were not collected from these wells. No samples could be collected from OW-4 and OW-5 due to the wells being filled with sediment. Relative to the July 1999 sampling event, groundwater elevations tended to be 1.0 - 1.5 feet higher in October 1999. The groundwater samples collected from the remaining wells addressing this area of the site were analyzed for benzene and toluene. The analytical results for these samples are summarized on Table 11 and are presented on Figure 29.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in six of the 26 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 89.6 ppb in MW-14 to 3,120 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 5.0 ppb in MW-23 to 1,250 ppb in OW-3. The benzene concentration in MW-23 represented a significant decrease from July 1999 when 68.8 ppb was detected. The benzene concentration in MW-14 (89.9 ppb) was the lowest ever detected in this well, and was significantly lower than in July 1999 (263 ppb). However, the concentration of benzene in MW-42 (6.1 ppb) had increased for the third consecutive quarter.

Benzene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW-1 - Not detected for the 4th consecutive quarter.
- MW-6 - Not detected for the 4th consecutive quarter.
- MW-10 - Not detected for the 4th consecutive quarter.
- MW-11 - Not detected for the 4th consecutive quarter.
- MW-30 - Not detected for the 7th consecutive quarter.
- MW-31 - Not detected (below the GWQS for the 4th consecutive quarter).
- MW-36 - Not detected for the 4th consecutive quarter.
- MW-41 - Not detected (below the GWQS for the 4th consecutive quarter).

Benzene concentrations only increased in two wells (MW-40 and MW-42) relative to July 1999. However, the October 1999 results are still less than or comparable to the April 1999 data.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in on-site wells MW-D5 (108,000 ppb), MW-14 (19,100 ppb), and MW-4 (1,230 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (59,600 ppb) and MW-40 (40,700 ppb). Although the toluene concentration in MW-40 increased from 8,200 ppb in July 1999, the level is still below that seen in April 1999 (128,000 ppb). The concentrations of toluene in OW-2 (157 ppb) and OW-3 (778 ppb) decreased 94% and 74%, respectively, relative to July 1999, and were below the GWQS for the first time.

Toluene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW- 1- Not detected for the 4th consecutive quarter; below GWQS for the 7th consecutive quarter.
- MW- 5- 2.1 ppb; below GWQS for the 8th consecutive quarter.
- MW- 6- Not detected for the 4th consecutive quarter; below GWQS for the 10th consecutive quarter.
- MW-10- Not detected for the 4th consecutive quarter; below GWQS for the 10th consecutive quarter.
- MW-11- Not detected for the 5th consecutive quarter; below GWQS for the 9th consecutive quarter.
- MW-17- Not detected; below the GWQS for the 10th consecutive quarter.
- MW-23- 26.9 ppb; below GWQS for five of the last six quarters.
- MW-30- Not detected; below the GWQS for the 9th consecutive quarter.
- MW-31- Not detected; below the GWQS for the 6th consecutive quarter.
- MW-41- 2.6 ppb; Not detected; below the GWQS for the 4th consecutive quarter.

The distribution of toluene and benzene in the shallow overburden zone using the October 1999 groundwater sampling results are shown on Figure 30 and Figure 31, respectively. The highest concentration of toluene (greater than 100,000 ppb) is limited to the vicinity of MW-D5 and MW-33. The concentrations of toluene exceeding the GWQS of 1,000 ppb are found in two additional areas around MW-14, and MW-25 and MW-40. This distribution is consistent with April and July 1999, although the hot-spot areas around MW-14 and MW-25/MW-40 are smaller due to the lower concentrations found in MW-14, MW-25, and OW-2.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb).being found around MW-D5, MW-33, and OW-3. Benzene concentrations exceeding 100 ppb were found around MW-40, while concentrations exceeding 10.0 ppb were found around MW-14.

No detectable concentrations of benzene, and low (4.6 ppb to 15.7 ppb) concentrations of toluene were found in upgradient wells MW-16 and MW-34. These results confirm previous analytical data which indicated that the benzene and toluene affected area did not extend off-site to the east. Due to their proximity to each other, only MW-16 was incorporated into future monitoring events.

3.13 January 2000 Sampling Event

Groundwater samples were to be collected from the following wells during the January 2000 sampling event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33,
Monitoring Points	MW-16, MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, OW-1, OW-2, OW-3, OW-4, and OW-5

All three of the remediation systems were in operation at the time of this sampling event. MW-9 and MW-33 contained 0.60 feet and 0.11 feet of SPH, respectively, and were not sampled. Groundwater elevations tended to be 0.5- 1.5 feet lower than during the October 1999 sampling event. The groundwater samples collected from the remaining wells addressing this area of the site were analyzed for benzene and toluene. The analytical results for these samples are summarized on Table 12 and are presented on Figure 32.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in eight of the 27 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 6.9 ppb in MW-4 to 1,920 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.5 ppb in MW-36 to 285 ppb in OW-3. The benzene concentration in OW-3 represents a significant decrease from October 1999 when 1,250 ppb was detected. Although no detectable concentrations of benzene have been found in MW-25 for three consecutive quarters, this was the first time the detection limits were also below the GWQS of 1.0 ppb.

The benzene concentration in MW-40 (40.2 ppb) was the lowest ever detected in this well, and was significantly lower than in October 1999 (656 ppb). The concentration of benzene in MW-42 (2.1 ppb) decreased from 6.1 ppb in October 1999 after increasing for three consecutive quarters. MW-36 contained a detectable concentration of benzene (1.5 ppb) for the first time since October 1998. Benzene was not detected in the samples from OW-4 and OW-5.

Benzene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW-1 - Not detected for the 5th consecutive quarter.
- MW-6 - Not detected for the 5th consecutive quarter.
- MW-10 - Not detected for the 5th consecutive quarter.
- MW-11 - Not detected for the 5th consecutive quarter.
- MW-30 - Not detected for the 5th consecutive quarter.
- MW-31 - 1.0 ppb (at or below the GWQS for the 5th consecutive quarter).
- MW-41 - Not detected (below the GWQS for the 5th consecutive quarter).

Benzene concentrations increased slightly in four wells from not detected to 1.0 - 1.5 ppb (MW-31, MW-36, OW-1) and 6.9 ppb (MW-4). Benzene concentrations increased to a greater extent in MW-14 and MW-23 relative to October 1999, but the January 2000 results are still less than the July 1999 data.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in on-site wells MW-D5 (76,600 ppb) and MW-14 (28,100 ppb). For the second time in the last three quarters, the toluene concentration in MW-4 (478 ppb) was below the GWQS. For the first time since groundwater monitoring started, none of the off-site wells contained toluene at concentrations exceeding the GWQS. In October 1999, MW-25 and MW-40 still contained 59,600 ppb and 40,700 ppb of toluene, respectively. In the January 2000 samples, the concentrations had dropped to not detected in MW-25 and 703 ppb in MW-40.

Although the dissolved concentrations of toluene were below the GWQS, it should be noted that MW-33, which is located just off-site in the southeast corner of the property, still contained SPH during this sampling event.

Toluene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW- 1- Not detected for the 5th consecutive quarter; below GWQS for the 8th consecutive quarter.
- MW- 5- 1.9 ppb; below GWQS for the 9th consecutive quarter.
- MW- 6- Not detected for the 5th consecutive quarter; below GWQS for the 11th consecutive quarter.

- MW-10- Not detected for the 5th consecutive quarter; below GWQS for the 11th consecutive quarter.
- MW-11- Not detected for the 6th consecutive quarter; below GWQS for the 10th consecutive quarter.
- MW-17- 0.40 ppb; below the GWQS for the 11th consecutive quarter.
- MW-23- 39.1 ppb; below GWQS for six of the last seven quarters.
- MW-30- Not detected; below the GWQS for the 10th consecutive quarter.
- MW-31- 2.8 ppb; below the GWQS for the 8th consecutive quarter.
- MW-41- 3.1 ppb; below the GWQS for the 5th consecutive quarter.
- OW-2- 157 ppb; below the GWQS for the 2nd consecutive quarter.
- OW-3- 219 ppb; below the GWQS for the 2nd consecutive quarter.
- OW-4- 0.62 ppb; below the GWQS for the 2nd consecutive quarter.

The distribution of toluene and benzene in the shallow overburden zone using the January 2000 groundwater sampling results are shown on Figure 33 and Figure 34, respectively. The highest concentrations of toluene (greater than 10,000 ppb) were limited to the area around MW-14, and to the vicinity of MW-D5 and MW-33. The concentrations of toluene exceeding the GWQS of 1,000 ppb were also found around these three wells. This was the smallest areal extent of the toluene affected area observed to date.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found around MW-D5 and MW-33. Benzene concentrations exceeding 100 ppb were also found around OW-3 and MW-14, while concentrations exceeding 10.0 ppb were found around MW-23 and MW-40.

No detectable concentrations of benzene or toluene were found in upgradient well MW-16. These results confirm previous analytical data which indicated that the benzene and toluene affected area did not extend off-site to the east.

3.14 April 2000 Sampling Event

Groundwater samples were to be collected from the following wells during the April 2000 sampling event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-16, MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, OW-1, OW-2, OW-3, OW-4, and OW-5

All three remediation systems were in operation at the time of this sampling event. MW-9 and MW-33 contained 0.02 feet and 0.26 feet of SPH, respectively, and were not sampled. Groundwater elevations tended to be 0.5 to 1.0 feet higher in April 2000 relative to January 2000. The groundwater samples collected from the remaining wells addressing this AEC were analyzed for benzene and toluene. The analytical results for these samples are summarized on Table 13 and are presented on Figure 35.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 11 of the 27 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 8.1 ppb in MW-17 to 4,520 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 2.7 ppb in OW-2 to 401 ppb in MW-40. Benzene was detected in MW-25 (47.0 ppb) for the first time in four quarters. However, the April 2000 benzene concentration is still significantly less than in April 1999 when 851 ppb was detected. Benzene concentrations also rebounded relative to the January 2000 sampling event in MW-D5, MW-23 (119 ppb), and MW-40.

Benzene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW-1 - Not detected for the 6th consecutive quarter.
- MW-6 - Not detected for the 6th consecutive quarter.
- MW-10 - Not detected for the 6th consecutive quarter.
- MW-11 - Not detected for the 6th consecutive quarter.
- MW-30 - Not detected for the 6th consecutive quarter.
- MW-31 - Not detected (at or below the GWQS for the 6th consecutive quarter).

- MW-41 - Not detected (below the GWQS for the 6th consecutive quarter).
- OW-1 - Not detected (at or below the GWQS for the 4th consecutive quarter).

The benzene concentration in MW-14 (71.2 ppb) was the lowest ever detected in this well, and continued the overall decreasing trend observed dating back to October 1998. In addition, the concentration of benzene in OW-3 (75.8 ppb) decreased for the third consecutive quarter.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in on-site wells MW-D5 (173,000 ppb) and MW-14 (11,400 ppb). For the third time in the last four quarters, the toluene concentration in MW-4 (581 ppb) was below the GWQS. Unlike in January 2000 when none of the off-site wells contained toluene at concentrations exceeding the GWQS, MW-25 and MW-40 contained 8,010 ppb and 11,800 ppb of toluene, respectively. These values are still below the October 1999 results, when toluene was detected at 59,600 ppb in MW-25 and 40,700 ppb in MW-40.

The benzene and toluene concentrations in several of the off-site wells appear to be influenced by changes in groundwater elevations. As can be seen on the concentration vs. time graphs included in Appendix D, dissolved concentrations have increased when the water table rises, and decreased when it has fallen. This effect is most noticeable over the last six quarters in the graphs for MW-23, MW-40, MW-42 and OW-3.

Toluene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW- 1- Not detected for the 6th consecutive quarter; below GWQS for the 9th consecutive quarter.
- MW- 5- 0.40 ppb; below GWQS for the 10th consecutive quarter.
- MW- 6- Not detected for the 6th consecutive quarter; below GWQS for the 12th consecutive quarter.
- MW-10- Not detected for the 6th consecutive quarter; below GWQS for the 12th consecutive quarter.
- MW-11- Not detected for the 7th consecutive quarter; below GWQS for the 11th consecutive quarter.
- MW-17- 2.3 ppb; below the GWQS for the 12th consecutive quarter.

- MW-23- 142 ppb; below GWQS for the 5th consecutive quarter.
- MW-30- Not detected; below the GWQS for the 11th consecutive quarter.
- MW-31- Not detected; below the GWQS for the 8th consecutive quarter.
- MW-41- 0.78 ppb; below the GWQS for the 6th consecutive quarter.
- OW-2- 248 ppb; below the GWQS for the 3rd consecutive quarter.
- OW-3- 273 ppb; below the GWQS for the 3rd consecutive quarter.
- OW-4- Not detected; below the GWQS for the 3rd consecutive quarter.

The distribution of toluene and benzene in the shallow overburden zone using the April 2000 groundwater sampling results is shown on Figure 36 and Figure 37, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to the area around MW-D5 and MW-33. The concentrations of toluene exceeding the GWQS of 1,000 ppb are also found in the vicinity of MW-25 and MW-40, and around MW-14.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found around MW-D5 and MW-33. Benzene concentrations exceeding 100 ppb were also found around MW-40 and MW-23, while concentrations exceeding 10.0 ppb were found around MW-14 and MW-25.

No detectable concentrations of benzene or toluene were found in upgradient well MW-16.

3.15 July 2000 Sampling Event

In response to comments in the NJDEP's letter dated 26 June 2000, 1,1'-biphenyl and diphenyl ether were added to the monitoring program for wells addressing the toluene spill area during the July 2000 sampling event. As discussed in Section 3.1, the analytical results for these compounds were compared to the alternate GWQS proposed by EPI in their 17 April 2001 letter to the NJDEP.

Groundwater samples were to be collected from the following wells during the July 2000 monitoring event:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-16, MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, OW-1, OW-2, OW-3, OW-4, and OW-5

All three remediation systems were operating at the time of this sampling events. MW-9 did not contain measurable amounts of SPH during the initial gauging event. However, after purging, 0.02 feet of SPH was drawn into the well. MW-33 did not contain SPH for the first time since April 1999. The groundwater samples collected from the remaining wells were analyzed for benzene and toluene by USEPA Method 624, and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. The analytical results for these samples are summarized on Table 14 and are presented on Figure 38.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 10 of the 28 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 10.2 ppb in MW-4 to 1,380 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.2 ppb in MW-42 to 4,700 ppb in MW-33. The benzene concentration detected in MW-25 (16.4 ppb) was significantly less than in April 2000, and continues the overall decreasing trend that has been observed in this well since April 1998. Benzene concentrations also decreased relative to the April 2000 sampling event in MW-D5, MW-23 (44.6 ppb), and MW-40 (342 ppb).

Benzene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW-1 - Not detected for the 7th consecutive quarter.
- MW-5 - Not detected for the 4th consecutive quarter.
- MW-6 - Not detected for the 7th consecutive quarter.
- MW-10 - Not detected for the 7th consecutive quarter.
- MW-11 - Not detected for the 7th consecutive quarter.
- MW-22 - Not detected for the 4th consecutive quarter.
- MW-30 - Not detected for the 7th consecutive quarter.
- MW-31 - Not detected (at or below the GWQS for the 7th consecutive quarter).
- MW-41 - Not detected (below the GWQS for the 7th consecutive quarter).
- OW-1 - Not detected (at or below the GWQS for the 5th consecutive quarter).
- OW-4 - Not detected for the 4th consecutive sampling event.
- OW-5 - Not detected for the 3rd consecutive quarter.

Low concentrations of benzene continue to be found in off-site wells MW-36 (7.3 ppb) and MW-42.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in on-site wells MW-D5 (66,300 ppb) and MW-14 (7,490 ppb). These are the lowest concentrations ever detected in these wells. Toluene concentrations exceeded the GWQS in off-site wells MW-25 (2,310 ppb), OW-3 (2,750 ppb), MW-40 (18,900 ppb), and MW-33 (334,000 ppb). The concentrations in MW-40 and OW-3 increased relative to the April 2000 sampling results, while the toluene concentration in MW-25 decreased to the second lowest level ever seen in this well. The toluene concentration in MW-33 is consistent with the historic levels for this well.

Toluene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW- 1- Not detected for the 7th consecutive quarter; below GWQS for the 10th consecutive quarter.
- MW-4 - 412 ppb; below GWQS for the 3rd consecutive quarter.
- MW-5 - Not detected; below GWQS for the 11th consecutive quarter.
- MW- 6- Not detected for the 7th consecutive quarter; below GWQS for the 13th consecutive quarter.
- MW-10- Not detected for the 7th consecutive quarter; below GWQS for the 13th consecutive quarter.
- MW-11- Not detected for the 8th consecutive quarter; below GWQS for the 12th consecutive quarter.
- MW-17- 4.9 ppb; below the GWQS for the 13th consecutive quarter.
- MW-23- 30.0 ppb; below GWQS for the 6th consecutive quarter.
- MW-30- Not detected; below the GWQS for the 12th consecutive quarter.
- MW-31- 37.5 ppb; below the GWQS for the 9th consecutive quarter.
- MW-41- Not detected; below the GWQS for the 7th consecutive quarter.
- OW-2- 85.7 ppb; below the GWQS for the 4th consecutive quarter.
- OW-4- Not detected; below the GWQS for the 4th consecutive sampling event.
- OW-5- Not detected; below the GWQS for the 3rd consecutive quarter.

The benzene and toluene concentrations in several of the off-site wells appear to be influenced by changes in groundwater elevations. This effect is most noticeable over the last seven quarters in the graphs for MW-23, MW-40, MW-42, and OW-3 (see Appendix D).

1,1'-biphenyl was detected at concentrations above the proposed alternate GWQS of 1,800 ppb in on-site wells MW-4 (4,490 ppb) and MW-10 (1,860 ppb). In the off-site wells, 1,1'-biphenyl was detected at 2,040 ppb in MW-33. Diphenyl ether was detected at concentrations exceeding the proposed alternate GWQS of 21,000 ppb in MW-4 (23,900 ppb).

The distribution of toluene and benzene in the shallow overburden zone using the July 2000 groundwater sampling results is shown on Figure 39 and Figure 40, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to the area around MW-33. The concentrations of toluene exceeding the GWQS of 1,000 ppb are also found in the vicinity of MW-25 and MW-40, and around MW-14.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found around MW-D5 and MW-33. Benzene concentrations exceeding 100 ppb were also found around MW-40, while concentrations exceeding 10 ppb were found around MW-14 and MW-25.

The distribution of 1,1'-biphenyl in the shallow overburden zone is shown on Figure 41. Concentrations exceeding the alternate GWQS of 1,800 ppb exist in the southeast corner of the site (between MW-4, MW-10, and MW-33). The distribution of diphenyl ether is shown on Figure 42. The highest concentrations (above the alternate GWQS of 21,000 ppb), are limited to the vicinity of MW-4.

No detectable concentrations of benzene, toluene, 1,1'-biphenyl, or diphenyl ether were found in upgradient well MW-16.

3.16 October 2000 Sampling Event

Groundwater samples were collected from the wells addressing the toluene spill area between 10 and 12 October 2000. The results of the groundwater sampling event were submitted to the NJDEP in the *Quarterly Groundwater Sampling Results* report dated 1 December 2000.

3.17 January 2001 Sampling Event

Groundwater samples were collected from the wells addressing the toluene spill area between 23 and 26 January 2001. The results of the groundwater sampling event were submitted to the NJDEP in the *Quarterly Groundwater Sampling Results* report dated 17 May 2001.

4.0 FATE OF OFF-SITE BENZENE & TOLUENE PLUMES

Based on declining concentrations of benzene and toluene between June 1997 and April 1999, as discussed in detail in the 16 July 1999 RIR, EPI re-evaluated the need for a groundwater recovery system to aid in remediating the off-site groundwater impacts. Given the reductions in plume size observed through April 1999, EPI proposed to defer completion of the groundwater recovery system and to continue monitoring the observed decreasing concentration trends in off-site monitoring wells. The NJDEP responded that EPI's proposal was not acceptable because the NJDEP was concerned with continued off-site plume migration and, therefore, required a groundwater recovery system to contain the plume. The NJDEP cited many reasons for their disapproval of EPI's proposal, including EPI's evaluation of concentration trends and predictive methods to demonstrate that groundwater recovery was not warranted.

In the July 1999 RIR, EPI attempted to predict the fate of the benzene and toluene plumes by two methods: 1) extrapolation of observed trends in actual groundwater data, and 2) groundwater flow and solute transport modeling using WinTran. The NJDEP stated that EPI's evaluation did not address the issue of plume migration. However, EPI contends that the evaluation did in fact account for plume migration. Since the first method used actual groundwater concentration data, groundwater flow was inherent in the evaluation since the concentrations observed are based on groundwater flow. The second method utilized a <u>solute transport model</u> to predict future concentrations.

Since no reliable methods are available for predicting the effectiveness of the remediation systems in use at the site, it is not possible to predict future concentrations resulting from the remediation efforts. Therefore, actual site data collected during active remediation is likely the most reliable method for prediction. However, given the NJDEP response to EPI's previous attempt to predict the fate of the benzene and toluene plumes, EPI will not attempt to predict future groundwater concentrations. Instead, EPI will rely on actual groundwater results to demonstrate that the active remediation systems, along with natural attenuation processes, have remediated the off-site groundwater plume over the past several years such that there is virtually no groundwater plume needing containment. The concentrations have been reduced so dramatically that any concentrations remaining above the groundwater quality standards after completion of the active remediation should easily be addressed by natural attenuation.

4.1 Concentration Trend Analysis

One of the main issues/concerns of the NJDEP was EPI's evaluation of concentration trend plots prepared using data through April 1999. It appears that there was some confusion by the NJDEP regarding the intention of the plots and the interpretations made by EPI. The purpose of the plots was to illustrate graphically that concentrations in the off-site wells were declining over time and to attempt to quantify the rate of decline. EPI then used the observed rates of decline to predict future concentrations. However, the NJDEP expressed concerns regarding the plots and, therefore, the predictions of future concentrations. Since April 1999, nine additional quarterly groundwater sampling events have been conducted (seven of which are included in this discussion). Therefore, EPI has updated the trend plots with the recent data and has made changes to the evaluation to address the NJDEP's concerns.

The updated concentration trend plots are provided in Appendix E. Separate plots for benzene and toluene were prepared to avoid overlapping data and curve-fits. Also, to aid in illustrating concentration trends, the data were plotted using both linear and logarithmic scales. The linear scale plots help to illustrate if declining trends are apparent and whether the changes appear to be following a linear (straight line) or exponential (curved) decline. However, if concentrations range over several orders of magnitude, the lower concentration data tends to "bunch up" on linear scale plots and logarithmic plots are more useful. Also, if a first-order exponential decay describes the apparent contaminant concentration decline, the data plot as a straight line on logarithmic plots. As requested by the NJDEP, EPI performed separate regressions for data prior to June 1997 (initial pre-remediation baseline), data since June 1997 when active remediation began, and all data, where appropriate.

If the slope of the straight line on a logarithmic plot is negative (the value of k is negative), then the plume is considered to be shrinking. The steeper the slope, the greater the rate of attenuation of the plume. This technique can be used to evaluate the natural attenuation rate. However, when concentrations are declining and active remediation is being conducted, as at the Kalama site, the observed attenuation rate is a combination of both natural attenuation and remediation processes. As discussed above, the purpose of the plots in the July 1999 RIR was to illustrate graphically that concentrations in the off-site wells were declining over time and to attempt to quantify the rate of decline. Qualitatively, the slope of the exponential regression provides an indication that the concentrations are declining. Quantitatively, the value of k provides the rate at which concentrations are declining.

EPI acknowledges that the remediation systems are directly or indirectly contributing to the declining trends. The remediation systems are directly contributing to the decreasing concentrations in wells within their zone of influence by actively remediating groundwater, while they are indirectly contributing at other locations by removing the source of groundwater contamination. Regardless of the mechanism responsible for the decreasing trends (natural attenuation, direct remediation, or indirect remediation), it is undeniable that concentrations are declining. Although the exponential regressions are not always very good fits to the data, they still indicate overall declining trends. In some cases, however, the regression fit the data quite well and are more reliable for predicting future concentrations. However, given the observed decreases in concentration through January 2001, it is not necessary to predict future concentrations. At many of the off-site wells, the concentrations have declined several orders of magnitude and are currently near or below the ground water quality standards.

In the previous submittal, EPI converted the attenuation rates obtained from the graphs into half-lives, as is common practice for radioactive or biological decay. The purpose was to put the k values in terms of a more understandable decay rate (i.e. months or years). The half-lives were mis-interpreted by the NJDEP as being biological degradation rates. They were merely observed attenuation rates which were used to predict future concentrations based on observed decreasing trends at individual well locations (Section 4.1 of July 1999 RIR). These half-lives were not used as biological half-lives in the solute transport modeling discussed in Section 5.0 of the July 1999 RIR. As stated in the July 1999 RIR, and again in this report, EPI acknowledges that the remediation systems are contributing to the decreasing concentrations observed in on-site and off-site wells. However, the decreasing trends cannot be ignored.

4.2 Distribution of Benzene and Toluene in Groundwater

To further illustrate the change in concentrations that have occurred since June 1997, maps depicting the distribution of benzene and toluene were prepared using the 15 quarters of groundwater sample results through January 2001 (Figures 43 and 44). The contour maps were prepared using Surfer, a grid-based contouring program. In addition to depicting the extent of the plumes, the maps were used to estimate the mass of dissolved and adsorbed phase benzene and toluene assuming equilibrium conditions. Based on assumed representative values for porosity (30% or 0.3), bulk density (1.86 gm/cm^3), organic carbon content (0.5% or 0.005), and partition coefficients for benzene (84 ml/gm) and toluene (115 ml/gm), retardation factors of 3.6 for benzene and 4.6 for toluene were used in the mass calculations. The retardation factor of 3.6 for benzene corresponds to 28% of the mass dissolved in groundwater and 72% adsorbed to soil. The retardation factor of 4.6 for toluene corresponds to 22% of the mass dissolved in groundwater and 78% adsorbed to soil. Although these values may vary, they provide a reasonable means to account for the greater mass adsorbed to soil under typical conditions.

It is apparent from visual inspection of Figures 43 and 44 that the benzene and toluene plumes have shrunk in size considerably during the 15 quarters since June 1997. For visualization purposes, the 1.0 ug/l benzene contour does not include color. However, the area and mass within the 1.0 ug/l contour are accounted for and are discussed below. Also, the area and mass of toluene in excess of 100 ug/l (1/10 the groundwater quality standard of 1,000 ug/l) were estimated to illustrate the mass distribution even below the NJDEP standard.

Table 15 provides summary statistics and graphs representing the change in distribution of benzene from June 1997 through January 2001. As shown, the benzene plume above 1.0 ug/l has been reduced in size from 450,112 ft^2 (10 acres) in June 1997 to 141,348 ft^2 (3 acres) in January 2001. The total dissolved and adsorbed mass of benzene is also estimated to have been reduced from 201 pounds in June 1997 to 19 pounds in 2001. As shown on Table 15 and the associated graphs, the area and mass within each contour interval (i.e. 1, 10, 100, and 1,000 ug/l) have all steadily declined during that time period. The summary also illustrates that although the benzene plume above 1.0 ug/l was 141,348 ft^2 (3 acres) in January 2001, the area of the benzene plume in excess of 10 ug/l is only 28,560 ft^2 (0.65 acres). The data also show that the vast majority of the benzene mass is concentrated within the 4,075 ft^2 (0.1 acre) where concentrations exceed 1,000 ug/l. This 4,075 ft^2 area is centered around wells MW-33 and MW-45 where new SVE wells OSSVE-6, 7, & 8 were installed in January 2000 to address this off-site source area.

Table 16 provides summary statistics and graphs representing the change in distribution of toluene from June 1997 through January 2001. As shown, the toluene plume above 1,000 ug/l has been reduced in size from 134,648 ft^2 (3 acres) in June 1997 to 19,271 ft^2 (0.4 acres) in January 2001. The total dissolved and adsorbed mass of toluene (within the 100 ug/l contour) is also estimated to have been reduced from 18,313 pounds in June 1997 to 993 pounds in 2001. As shown on Table 16 and the associated graphs, the area and mass within each contour interval (i.e. 100, 1,000, 10,000 and 100,000 ug/l) have all steadily declined during that time period. The data also show that the vast majority of the toluene mass is concentrated within the 8,442 ft^2 (0.2 acres) where concentrations exceed 10,000 ug/l. Similar to the benzene plume, this 8,442 ft^2 area is centered around wells MW-33 and MW-45 where new SVE wells OSSVE-6, 7, & 8 were installed in January 2000 to address this off-site source area.

5.0 OFF-SITE INVESTIGATION

The NJDEP's 26 June 2000 letter required EPI to perform an investigation into the presence of a possible "smear zone" that may exist beneath Hudson Street and Bloomingdale Avenue. The NJDEP is requiring that the presence or absence of this "smear zone" be confirmed and actively remediated, if necessary. The NJDEP indicated that the existing soil vapor extraction (SVE) system that is currently operating in Hudson Street and Bloomingdale Avenue would not be acceptable by itself, since it cannot remediate contaminated soil existing below the water table. The NJDEP is also requiring that an additional off-site monitoring well be installed to determine if benzene and/or toluene are migrating from MW-25 (located in Bloomingdale Avenue) towards MW-36 (located downgradient from MW-25 in Riverside Drive).

EPI intends to conduct the smear zone investigation using a phased approach. The first phase of the investigation, which has already been completed, involved performing an advanced geophysical survey of Hudson Street and Bloomingdale Avenue to determine the location(s) of the possible smear zone. The findings of the geophysical survey indicated that the concentrations of toluene in soil to the south of the Kalama site are below the NJDEP's Impact to Groundwater remediation criterion of 500 ppm. The second phase of the investigation will involve confirming the geophysical survey results by collecting soil samples biased towards locations and depths where a smear zone would most likely be expected. The third phase would be contingent on the results of the soil sampling, and would involve performing pilot tests to design an appropriate remediation system, if warranted. All three phases of the investigation are discussed in the following Sections.

5.1 Geophysical Survey

In order to determine the depth and location of the possible smear zone non-intrusively, Pollution Prevention Associates (P2A) performed a Passive Magnetic Resonance Anomaly Mapping (PMRAM) geophysical survey. PMRAM is a patented process based on the fundamental principle that every elemental atom or molecule has a unique electromagnetic resonance. The PMRAM technology is a passive method for measuring these frequencies. The magnetic resonance signals associated with subsurface anomalies are compared to a known magnetic resonance signal generated and maintained within the surface instrumentation. Therefore, only the magnetic resonance frequency and signal strength associated with a specific anomaly (i.e., the toluene smear zone) is detected, measured, and recorded.

The PMRAM survey was performed between 29 January 2001 and 2 February 2001. The survey area consisted of a sidewalk grid pattern along Hudson Street (from Cambridge Avenue to River Drive), Bloomingdale Avenue (from Hudson Street to approximately 80 feet south of monitoring well MW-42), and Cambridge Avenue (from Hudson Street to approximately 70 feet south of MW-46). The survey also extended on-site from the toluene spill area in the southeast corner of the property to the southwest corner near MW-14. Readings were collected at five foot intervals along the sidewalks and centerline of each street to map the areal extent of the possible smear zone. In addition, vertical profiles (consisting of continuous readings collected at a fixed location at sequentially deeper intervals) were performed at eight points within the survey area. The survey area and the locations of the vertical profiles are shown on Figure 2 in Appendix F.

A total of two surveys were conducted over the same grid pattern. During the first survey, the resonator was calibrated using a sample of reagent grade toluene that was purchased from a chemical supply company. Since it has been 20+ years since the toluene spill occurred in the southeast corner of the site, and since active soil and groundwater remediation has been occurring since 1997, a second survey was also conducted using a sample of SPH from MW-33 to calibrate the resonator. The second survey would serve to account for any changes that would have occurred to the toluene over time (i.e., weathering or physical alteration due to the operation of the remediation systems).

According to the PMRAM survey, the distribution of toluene is limited to the southern half of the site and does not extend east of Cambridge Avenue (see Figure 2 in Appendix F). Toluene was not detected in a large area along the south-central portion of site. This area coincides with the location of the vertical component of the air curtain and the off-site SVE system. The highest relative concentration of toluene was found in the southwest corner of site near monitoring well MW-43, and off-site to the west (i.e., upgradient) of monitoring well MW-23.

The distribution of the weathered SPH based on the PMRAM survey is shown on Figure 3 in Appendix F. It should be noted that the PMRAM survey was not detecting actual SPH, but rather the mixture of chemicals that comprised the product sample. The distribution of these chemicals is similar to that of toluene, with most detections limited to the southern half of the site. No detectable readings were found along Cambridge Avenue, or in the south-central portion of the site. Once again, the highest relative concentrations of the chemical mixture were found between MW-43 and MW-23.

As shown on the vertical profiles, most of the toluene and/or chemical mixture was detected in the vadose zone soils. In most instances, detectable concentrations were found from 5.0 to 7.0 feet above the water table (as identified by the PMRAM technology). At the locations of vertical profiles PS#4 and PS#5, detectable concentrations were found from 3.0 to 4.0 feet above the water table. At the locations of vertical profiles PS#1, PS#3, PS#4, PS#5, PS#6, and PS#7, no detectable to trace amounts of toluene and/or chemical mixture were found below the water table. In vertical profile PS#2 and PS#8, apparent adsorbed contamination was found to extend approximately 3.0 feet and 4.0 feet, respectively, below the water table.

On 19 April 2001, soil samples were collected for the purpose of verifying the results of the PMRAM survey. The following table summarizes the distribution of toluene as identified by P2A in vertical profiles PS#3 (adjacent to MW-D5), and PS#8 (adjacent to MW-43).

Profile No.	Depth Interval Containing Toluene (feet)	Intervals with Highest Relative Concentrations of Toluene (feet)
PS#3	3.4 - 8.6	8.2 - 8.4
PS#8	6.8 - 13.6	7.4 - 7.8
	15.0 - 17.4	16.6 - 17.0

These locations were selected for confirmation sampling since they were both located on-site, and were located in areas of high (PS#8) and low (PS#3) relative concentrations of toluene. In order to develop an accurate profile of the distribution of toluene through the intervals identified above, soil samples were collected at one foot increments, starting at one foot above the identified interval and extending to one foot below the interval. Soil samples were specifically collected from the interval(s) at each location exhibiting the highest relative concentrations of toluene. The remaining samples were collected from the six-inch interval within each one foot increment that exhibited the highest VOC concentration when screened with a PID.

The soil sampling was performed using Geoprobe methodology. The Geoprobe was operated by a New Jersey licensed driller from Summit Drilling Co. under the supervision of an Sovereign geologist. Soil samples from the required depths were collected into acetate liners within a stainless steel sampler. Each liner was removed from the sampler, slit open, and screened for VOCs using PID equipped with a 10.6 eV bulb. Soil samples for toluene analysis by USEPA Method 8260 were collected from undisturbed soil following the NJDEP's Methanol Preservation Procedures. The descriptions of soil lithologies, results of PID screening, and the depths of the samples collected were recorded in the field (and are included on the boring logs in Appendix F).

Soil samples were placed directly into laboratory-provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. At the end of the day, the samples were returned to Sovereign's office, where they were picked up the following day by a courier and delivered to Accutest for analysis. For QA/QC purposes, one trip blank sample was also submitted and analyzed for toluene. The analytical results for the confirmation soil samples are summarized on Table F-1 in Appendix F. A copy of the analytical data package (along with the electronic data deliverables) for the confirmation soil samples is included under separate cover as Attachment XIV.

At vertical profile PS#3 (located adjacent to MW-D5 in the southeast corner of the site), the detectable concentrations of toluene in soil ranged from 0.25 ppm at 4.5 - 5.0 feet below grade to 3.31 ppm at 9.5 - 10.0 feet below grade. Between 3.4 - 8.6 feet below grade, the highest toluene concentration detected in soil was 0.57 ppm in the 8.2 - 8.4 feet interval (which the PMRAM survey indicated had the highest relative estimated concentration).

At vertical profile PS#8 (located adjacent to MW-43 in the southwest corner of the site), the detectable concentrations of toluene in soil ranged from 0.32 ppm at 16.6 - 17.0 feet below grade, to 0.85 ppm at 12.5 - 13.0 feet below grade. No detectable concentration of toluene was found at 7.4 - 7.8 feet below grade.

Using the analytical results for the confirmation soil samples, P2A performed a statistical evaluation to determine the ability to predict toluene concentrations in soil based on the PMRAM readings. Using the Gauss-Newton (N-1) method, correlation equations were derived that had a minimum 95% confidence interval. As shown on the following Table, three correlation equations were developed: two for the locations of PS#3 and PS#8 where actual soil samples were collected, and one for the remaining six vertical profiles.

Correlation Equations for Calculating Estimated Toluene Concentrations in Soil			
Vertical Profile PS#3 (MW-43)			
Gauss-Newton	b_0	b_1	Confidence Interval (%)
(N-1)	0.4242	0.3065	95
Correlation Equation: T = 0.4242EXP(0.3065*h)			
Vertical Profile PS#8 (MW-D5)			
Gauss-Newton	b_0	b_1	Confidence Interval (%)
(N-1)	0.4667	0.3134	95
Correlation Equation: T = 0.4667EXP(0.3134*h)			
Vertical Profiles PS#1, 2, 4, 5, 6, & 7			
Gauss-Newton	b_0	b_1	Confidence Interval (%)
(N-1)	0.4491	0.3192	95
Correlation Equation: T = 0.4491EXP(0.3192*h)			
Notes: b_0 = Lower detection limit b_1 = Operator factor (constant of proportionality) T = Toluene concentration in ppm. h = peak intensity (millivolts).			

The geophysical data collected at vertical profiles PS#1 through PS#8, along with the calculated toluene concentrations, are summarized on Tables F-2 through F-9 in Appendix F. As can be seen on these Tables, the calculated toluene concentrations in soil within the PMRAM survey area are all below 1.0 ppm. This data suggests that a smear zone <u>does not</u> exist beneath Hudson Street and Bloomingdale

Avenue. In order to confirm the findings of the PMRAM survey, EPI has developed the following soil sampling program that targets the most likely areas where a smear zone could possibly exist.

5.2 Proposed Soil Sampling Program

EPI proposes to investigate the possible presence of a smear zone beneath Hudson Street and Bloomingdale Avenue by collecting soil samples adjacent to monitoring wells that have previously contained SPH, or that have recently exhibited changes in dissolved concentrations that mirrored fluctuations in the water table (i.e., concentrations increased when the water table rose and decreased when the water table fell). As shown on Figure 45, soil samples would be collected adjacent to monitoring wells MW-23, MW-33, MW-40, MW-41, and OW-3 in Hudson Street, and adjacent to MW-25, MW-42, OW-1, and OW-2 in Bloomingdale Avenue. An additional soil boring would be located near vertical profile PS#5 to close the gap between MW-23 and MW-40. As summarized on the following Table, the sampling intervals at each location will be based on historical water table fluctuations that have been observed in each well.

Depth to Water Summary and Proposed Investigation Intervals

Well ID / Sample Location	Shallowest DTW (feet)	Deepest DTW (feet)	Investigation Interval* (feet)
MW-23	6.21	8.88	5.0 - 11.0
MW-25	8.81	13.34	7.5 - 15.5
MW-33	15.28	19.14	14.0 - 21.0
MW-40	10.98	14.17	10.0 - 16.0
MW-41	10.70	16.88	9.5 - 19.0
MW-42	11.56	14.12	10.5 - 16.0
OW-1	13.26	14.48	12.0 - 16.5
OW-2	9.08	14.08	8.0 - 16.0

Depth to Water Summary and Proposed Investigation Intervals			
Well ID / Sample Location	Shallowest DTW (feet)	Deepest DTW (feet)	Investigation Interval* (feet)
OW-3	15.32	16.77	14.0 - 19.0
PS#5			12.0 - 19.0**

Notes:
DTW = Depth to water from ground surface.
* = To be adjusted based on the DTW in the well on the day of sampling, if necessary.
** = Based on intervals identified in PMRAM survey.
Depth intervals are in feet below grade.

The smear zone investigation would begin at approximately one foot above the highest recorded water table (i.e., the shallowest depth to water), and extend to approximately two feet below the lowest recorded water table (i.e, the deepest depth to water). The depth to water in each well would be measured prior to soil sampling. If the depth to water is deeper or shallower than the historical values, the sampling intervals would be adjusted accordingly. Since there are no monitoring wells in the vicinity of PS#5, the investigation interval has been selected based on the findings from the vertical profile.

The soil sampling discussed above would be performed using Geoprobe methodology. The Geoprobe would be operated by a New Jersey licensed driller under the supervision of an Sovereign geologist. Soil samples from the required depths would be collected into acetate liners within a stainless steel sampler. Each liner would be removed from the sampler, slit open, and screened for VOCs using a photo-ionization detector (PID) equipped with a 10.6 eV bulb. The descriptions of soil lithologies, results of PID screening, and the depths of the samples collected would be recorded in the field.

If stained soil is encountered, the sample will be field screened for the presence of SPH. Approximately 2 oz. of soil would be placed in a jar and a similar amount would be placed in a paint filter. A sufficient amount of water would be added to the jar to saturate the soil, and the jar would then be shaken for 15 to 20 seconds. The sediment would be allowed to settle and the contents would be checked for the presence of separate phases (i.e., a sheen or discrete drops of product). Water would also be added to the soil in the paint filter and allowed to drain into a jar. The paint filter and the water collected in the jar would then be checked for separate phases.

At least one soil sample from above and one sample from below the water table would be collected for laboratory analyses from each boring. Samples for analysis would be collected from the interval exhibiting the highest field screening results or obvious signs of staining. If the interval to be analyzed is the same as the one that was used to screen for SPH, duplicate samples (not the soil which was screened in the field) would be retained for laboratory analysis. Soil samples for VOC analyses would be collected from undisturbed soil following the NJDEP's Methanol Preservation Procedures.

Soil samples would be placed directly into laboratory-provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. Each sample would be analyzed for total petroleum hydrocarbons (TPH) by USEPA Method 418.1, volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260) and base neutral acid extractable compounds (including calibrations for 1,1'-biphenyl and diphenyl ether) plus an NBS library search (BNA+25; USEPA Method 8270). At the end of the day, the samples would be returned to Sovereign's office, where they would be picked up the following day by a courier and delivered to Accutest for analysis. For QA/QC purposes, one trip blank sample would also be submitted for each day of sampling and analyzed for VOC+10.

5.3 DPVE Pilot Testing

If the analytical results for the confirmation soil samples discussed above indicate that site related compounds of concern are present in soil beneath Hudson Street and/or Bloomingdale Avenue at concentrations requiring remediation, EPI would conduct pilot tests to evaluate an alternate remediation technology.

Dual phase vacuum extraction (DPVE) is an unsaturated and saturated zone remedial technology, which is used to address soil and groundwater impacted by vapor, adsorbed, dissolved, and/or separate phase hydrocarbons. DPVE combines groundwater recovery and treatment and soil vapor extraction technologies. Additionally, groundwater and soil vapor recovery rates are enhanced by the application of a moderate to high vacuum (approximately 10 to 20 inches of mercury) at the DPVE wells. The DPVE wells are screened to, or below, the depth of impact. Groundwater containing dissolved and separate phase hydrocarbons are extracted from the DPVE wells, which lowers the water table exposing impacted soil. The vacuum at the DPVE well also induces air flow through the unsaturated soil, which volatilizes adsorbed phase VOCs and collects vapor phase VOCs for subsequent treatment. The induced air flow through the unsaturated zone has the additional benefit of enhancing the biodegradation of aerobically degradable compounds. Dual phase extraction may be achieved by using a high vacuum blower (18 to 25 inches of mercury) to extract both groundwater and soil vapor or by using a submersible or pneumatic pump to extract groundwater and a low to high vacuum blower (3 to 25 inches of mercury) to extract soil vapor. Additionally, for pilot tests or short-term applications, a vacuum truck can be utilized to extract both soil vapor and groundwater.

Temporary Air Discharge Authorization

The DPVE pilot test will require the submission of a temporary air discharge permit to the NJDEP - Bureau of New Source Review (BNSR) for the extraction and discharge of soil vapor. The required information and the application fee will be submitted to the BNSR, and will typically take 30 to 60 days to receive approval.

Performance of Pilot Testing

EPI proposes to perform two days of pilot testing using MW-25 as the extraction well. Based upon a review of the location and construction of existing monitoring wells at the site, EPI does not anticipate the need to install additional wells to perform the pilot test. A vacuum truck will be used to extract both soil vapor and groundwater from MW-25. The vacuum will be applied to the test well through a drop tube set at a depth below the smear zone as determined by the soil sampling discussed in Section 5.2. The drop tube will exit the top of the well through an air-tight seal and will be connected to a wellhead assembly, which will be fitted with a vacuum gauge and a port to enable gauging of the well. The air and water will then be routed through a hose to a manifold located just prior to the vacuum truck. The manifold will be fitted with valves to throttle flow and a port to collect air samples. The amount of groundwater recovered, which will settle out in the tank of the vacuum truck, will be measured at the end of testing. On the discharge side of the vacuum truck, the air will be routed through an oil removal coalescing filter, an air flow meter, and then through two, 180 pound, granular activated carbon (GAC) adsorbers plumbed in series prior to discharge to the atmosphere.

The first day of testing will consist of setting up the necessary equipment, collecting baseline data, and performing step-tests to determine the optimum operating conditions for the long-term DPVE test. The baseline data for the first day of testing will include gauging water levels and recording pre-test vacuum levels in all wells in the vicinity of MW-25, including OW-1, OW-2, PW-2, and MW-42 (see Figure 46).

On the second day of testing, groundwater and soil vapor will be extracted from MW-25 at the flow rates determined during the step-tests. The applied vacuum (in inches of mercury), extraction air flow rate (in standard cubic feet per minute), extraction air VOC concentration (in ppm), and pre-GAC, between GAC, and post-GAC VOC concentrations (in ppm) will be measured periodically during testing. The measurement of groundwater recovered (in gallons) will be recorded at the end of the day. The depth to water (in feet) and the induced vacuum (in inches of water) will be measured approximately once per hour of testing at nearby monitoring wells. Additionally, samples of the extracted air and water will be collected at the start, mid-way, and end of the test. Each sample will be analyzed for VOCs by USEPA Methods TO-14 (for air) and 601 (for groundwater). Field VOC measurements will be made using a calibrated photo-ionization detector (PID).

At the completion of the pilot tests, the recovered groundwater will be transported from the site in the vacuum truck for disposal. The vapor phase GAC units will be staged on-site in the area of Building 29 pending off-site disposal.

5.4 Installation of Off-Site Monitoring Well

The NJDEP is requiring that EPI address the "data gap" between MW-25 (located in Bloomingdale Avenue) and MW-36 (located in Riverside Drive). Much of the area between these two wells consists of residential properties. Due to the proximity of the houses with each other, this area is not accessible for a drill rig. Therefore, EPI proposes to install one monitoring well (to be designated MW-56) in Riverside Avenue at the approximate location shown on Figure 47.

The installation of MW-56 would be performed by a licensed New Jersey well driller under the supervision of a Sovereign geologist. A hollow-stem auger drill rig will be used, and split spoon samplers will be advanced through the augers to collect samples of undisturbed soil for lithologic description. The soil recovered by the split spoons will be screened for VOCs using a PID. Based on the depth to water data from MW-36, MW-56 will have a total depth of approximately 15.0 feet and will be constructed with 10.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 5.0 feet of PVC casing. The well will be completed with a flush-mount, water tight manhole with a locking cap. The location and elevation of MW-56 will be measured by a New Jersey licensed surveyor.

Groundwater samples from MW-56 wold be collected and analyzed following the monitoring program proposed for the site in Section 6.0.

6.0 GROUNDWATER MONITORING PROGRAM

In accordance with the NJDEP's 26 June 2000 letter, EPI has developed a groundwater monitoring program for the toluene spill area of the site. A groundwater monitoring program for the entire site was originally proposed to the NJDEP in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan had not been approved by the NJDEP by the time the remediation systems were ready to be brought on-line, a monitoring program was voluntarily implemented by EPI in June 1997 to establish a base-line against which remediation progress could be compared. Please note that the monitoring program discussed in this Section applies ONLY to the toluene spill source area and downgradient monitoring wells. A groundwater monitoring program for the other areas of the site is outside the scope of this document, but will be submitted to the NJDEP as part of the Revised RAW Addendum No. 2.

The toluene spill area is located in the southeast corner of the site and represents the source area for the benzene and toluene in groundwater. Soil and groundwater is being actively remediated by the operation of an AS/SVE system, an air curtain system comprised of both vertical and horizontal air injection wells, and an off-site SVE system located beneath portions of Hudson Street and Bloomingdale Avenue to the south of the site.

In order to monitor the effectiveness of the AS/SVE, air curtain, and the off-site SVE systems, EPI proposes to collect groundwater samples from the following wells:

Source Area Wells	MW-4, MW-5, MW-D5, MW-E5, MW-9, MW-17, MW-33, MW-45, and OW-3
Monitoring Points	MW-1, MW-6, MW-10, MW-11, MW-14, MW-16, MW-22, MW-23, MW-25, MW-30, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, MW-46, MW-56, OW-1, OW-2, OW-4, and OW-5

Groundwater samples would be collected quarterly from all wells that do not contain SPH for the following parameters:

- January, July, and October - Benzene and toluene by USEPA Method 624 and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

- April - Volatile organic compounds (VOCs) by USEPA Method 8260 and base neutral/acid extractable compounds including 1,1'-biphenyl and diphenyl ether (BNAs) by USEPA Method 8270. The library search component of each analyses would not be performed.

6.1 Groundwater Sampling Procedures

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling will be performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". Prior to sampling, each well will be gauged to measure the depth to groundwater and determine the presence/absence of SPH using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Three well volumes will then be purged from each monitoring well to remove stagnant water and ensure that the sample collected will be representative of the water quality in the aquifer. If three well volumes cannot be purged due to poor recharge, the water level in the well will be allowed to recover to within two feet of static conditions prior to sampling (or sufficiently to allow sample collection).

Well purging will be performed using submersible electric pumps. During purging, the flow rate will be kept below 5 gpm. Disposable Teflon bailers and dedicated nylon string will be used to sample each monitoring well after purging. The interface probe and pH/dissolved oxygen/specific conductivity/temperature meter will be decontaminated between measurements and well locations using a non-phosphate detergent wash followed by a tap water rinse. The submersible pumps used during groundwater sampling will be decontaminated between each well. The pump and electric cord will first be placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump will also be removed during this stage. The pump will then be transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump will be rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing will be disposed between well locations, it will not be necessary to decontaminate this material.

Groundwater samples would be placed directly into laboratory-provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. At the end of the day, the samples would be returned to Sovereign's office, where they would be picked up by a courier the next day and delivered to Accutest for analysis. For QA/QC purposes, one trip blank and one field blank (rinsate of an un-used Teflon bailer) would also be submitted for analysis for each day of sampling. The trip blank would only be analyzed for VOCs, while the field blank would be analyzed for VOCs and BNAs.

6.2 Reporting

EPI would continue to submit quarterly remedial action progress reports (RAPRs) to the NJDEP. The RAPR would include the results of the most recent round of groundwater sampling, representative groundwater elevation contours, and a discussion of remedial activities.

7.0 REMEDIATION SYSTEMS PERFORMANCE DATA

The NJDEP is requiring that the performance data for the AS/SVE system, the air curtain system, and the off-site SVE system be submitted.

7.1 AS/SVE System

The AS/SVE system covers an area slightly greater than one acre, and consists of 25 vertical air sparge wells, and three vertical and 12 horizontal SVE wells (see Figure G-1 in Appendix G). Since start-up in July 1997, the SVE system has averaged an extraction flow rate of approximately 1,100 cubic feet per minute (CFM) of air, which is treated with a thermal oxidizer prior to discharge to the atmosphere. The AS system has averaged an injection flow rate of approximately 96.0 CFM of air into the saturated zone via the vertical wells. Between 10 July 1997 and 28 June 2001, over 21,500 pounds of non-methane hydrocarbons have been removed by the AS/SVE system. The performance data for the AS/SVE system is provided in Appendix G. The increased mass removal rates that occurred in January 2000 are a direct result of bringing the off-site SVE wells that were proposed by EPI in the 16 July RIR (OSSVE-6, OSSVE-7, and OSSVE-8) on-line.

7.2 Air Curtain System

The enhanced *in-situ* biodegradation system (the "air curtain") is comprised of 12 vertical and two horizontal air injection wells (see Figure H-1 in Appendix H). The horizontal wells are approximately 410 feet long with the screened interval set at 20 feet below grade. Each well was curved at the southern end to keep the exit hole within the property line. The 12 vertical and two horizontal wells have averaged a combined air injection rate of 103 CFM since both components of the air curtain were brought on-line in May 1998. The performance data for the air curtain system is provided in Appendix H.

7.3 Off-Site SVE System

The off-site SVE system was designed to address benzene and toluene vapors in the vadose zone above the portion of the off-site plume containing the highest concentrations of these compounds. The off-site SVE system consists of five horizontal wells located beneath Hudson Street and Bloomingdale Avenue (see Figure I-1 in Appendix I), and has averaged an extraction air flow rate of approximately 360 CFM since start-up in December 1997. The recovered air stream is routed through four vapor phase carbon units prior to discharge to the atmosphere. Since December 1997, approximately 4,200 pounds of non-methane hydrocarbons have been removed by the off-site SVE system. No significant concentrations of VOCs have been detected in the influent air stream since mid-October 2000. The performance data for the off-site SVE system is provided in Appendix I.

8.0 CLASSIFICATION EXCEPTION AREA

A completed Classification Exception Area and Well Restriction Area (CEA/WRA) Fact Sheet is provided in Appendix J. Active remediation of the benzene and toluene groundwater plumes has been on-going since 1997/1998. As previously mentioned, no reliable methods are available for predicting the effectiveness of the remediation system in use (AS/SVE and enhanced biological degradation air curtains). However, quarterly groundwater sample results indicate the remediation systems have reduced concentrations significantly and that the plumes have retreated back towards the small remaining source areas. At this time, EPI plans to continue to aggressively address the remaining sources through active remediation. Based on past performance of the existing systems and the current status of the groundwater plumes, EPI anticipates that active remediation will continue for one to three years. When the active remediation is terminated, some isolated areas with concentrations in excess of the ground water quality standards will likely remain and EPI will implement a natural remediation compliance program. However, given the substantial reduction in size already observed, it is reasonable to assume that the historical plume limits can serve as the CEA/WRA. This is based on the fact that the size of the plume had effectively stabilized prior to remediation with the on-site sources unabated for decades. Given the tremendous reduction in size and mass of the source areas, it is unlikely that any remaining impacts would migrate beyond the historical limits of the plumes. Therefore, EPI proposes the boundary of the CEA/WRA be defined by a polygon connecting the following monitoring wells, as shown on Exhibit C in Appendix J: MW-35 - MW-38 - MW-37 - MW-22 - MW-21 - MW-8 - MW-35.

As a way of checking the limits of the CEA/WRA boundary, EPI also performed fate and transport calculations as per the model in the NJDEP's November 1998 *Final Guidance on Designation of Classification Exception Areas*. As a worst case scenario, the calculations were performed using the benzene (4,210 ppb) and toluene (326,000 ppb) concentrations detected in MW-33 during the January 2001 groundwater sampling event. The conservative half-life of two years for benzene (Howard, 1991) was also used for toluene in the CEA calculations. Using the same values for porosity (30% or 0.3), bulk density (1.86 gm/cm^3), organic carbon content (0.5% or 0.005), and partition coefficients for benzene (84 ml/gm) and toluene (115 ml/gm) that were discussed in Section 4.2 of this report, the time required for benzene and toluene to degrade to below their GWQS of 1.0 ppb and 1,000 ppb, respectively, and the distance the dissolved phase plumes would migrate in that time are:

Constituent	Duration (years)	Distance (feet)
Benzene	24.1	407
Toluene	16.7	223

Application of the NJDEP's model indicates that under a worst case scenario (i.e., all remediation activities would have ceased in January 2001) the maximum travel distance for benzene in groundwater would be 407 feet from monitoring well MW-33, and that degradation to the GWQS of 1.0 ppb would take approximately 24 years. This travel distance is well within the CEA/WRA boundary discussed above and shown on Exhibit C in Appendix J.

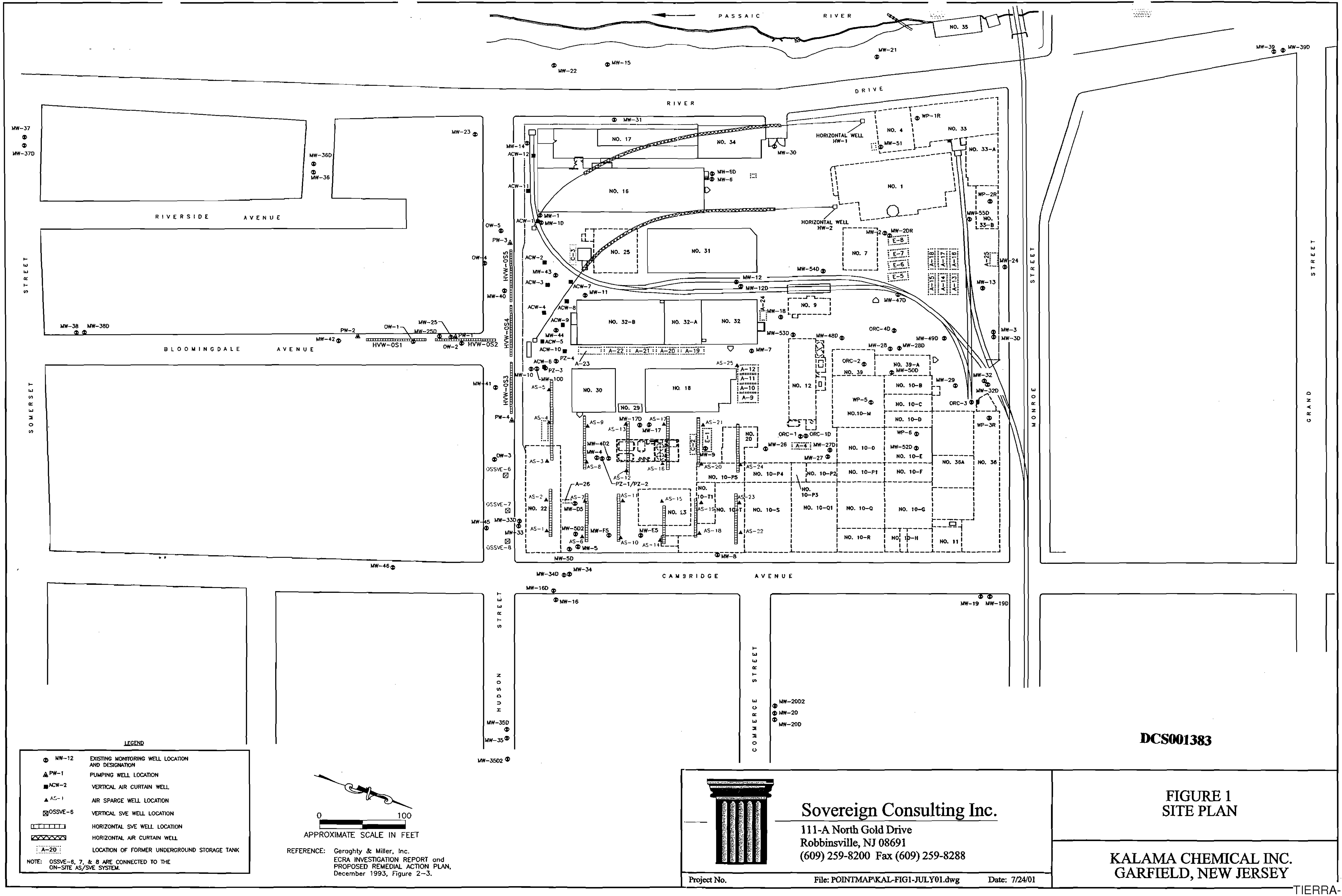
9.0 REFERENCES

Howard, Phillip H., 1991. *Handbook of Environmental Degradation Rates*. CRC Press, Boca Raton, Florida.

New Jersey Department of Environmental Protection. March, 1996. *Evaluating Sites for Natural Remediation of Contaminated Aquifers*, Site Remediation News. Trenton, New Jersey.

United States Environmental Protection Agency. April, 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*, OSWER Directive 9200.4-17P. Washington, D.C.

Figures



REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2–3.

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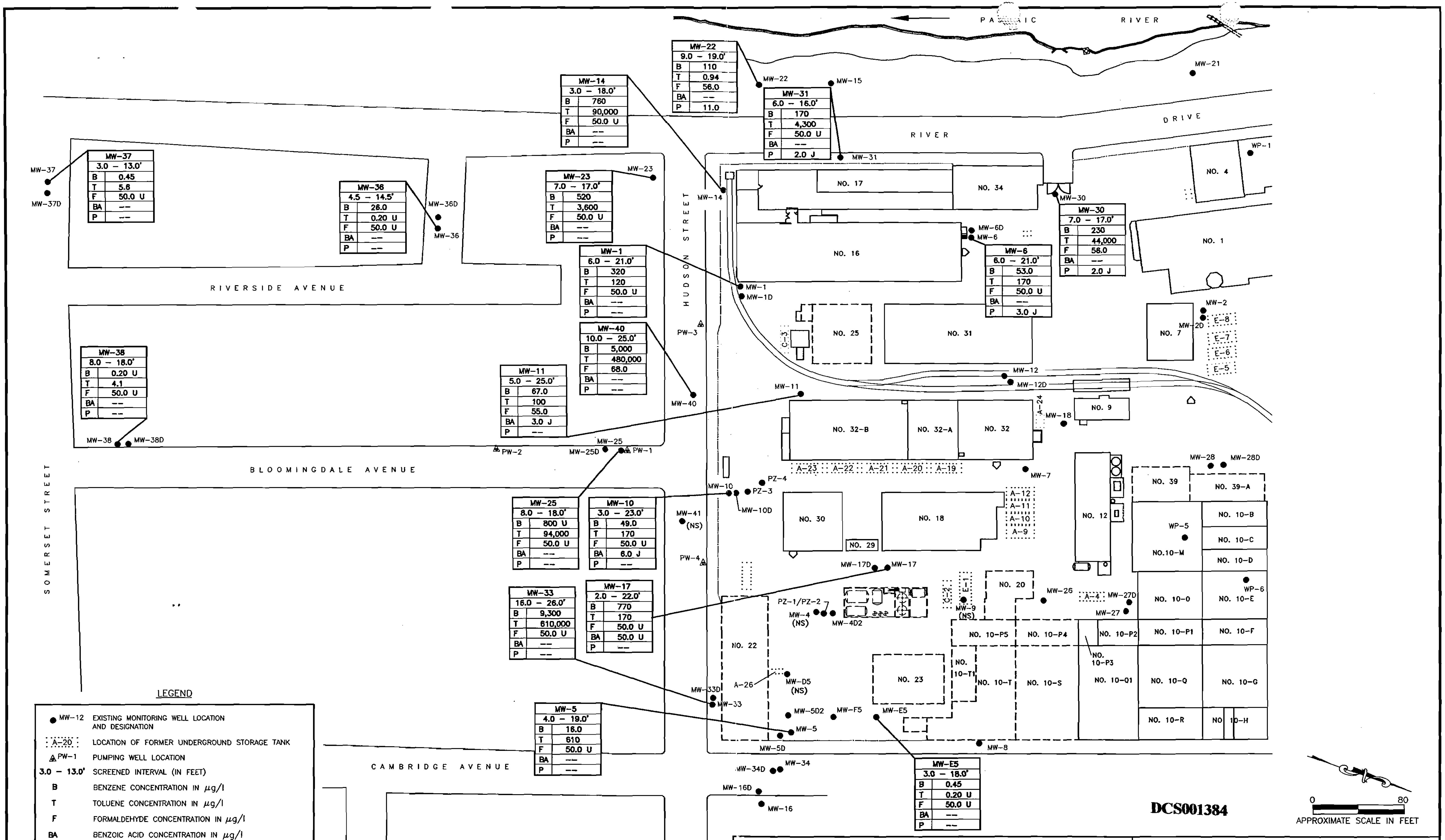
FIGURE 1
SITE PLAN

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No.
File: POINTMAP\KAL-FIG1-JULY01.dwg
Date: 7/24/01



MW-22	
9.0 – 19.0'	
B	110
T	0.94
F	56.0
BA	--
P	11.0

MW-14	
3.0 – 18.0'	
B	760
T	90,000
F	50.0 U
BA	--
P	--

MW-31	
6.0 – 16.0'	
B	170
T	4,300
F	50.0 U
BA	--
P	2.0 J

MW-37	
3.0 – 13.0'	
B	0.45
T	5.6
F	50.0 U
BA	--
P	--

MW-36	
4.5 – 14.5'	
B	26.0
T	0.20 U
F	50.0 U
BA	--
P	--

MW-23	
7.0 – 17.0'	
B	520
T	3,600
F	50.0 U
BA	--
P	--

MW-30	
7.0 – 17.0'	
B	230
T	44,000
F	56.0
BA	--
P	2.0 J

MW-6	
6.0 – 21.0'	
B	53.0
T	170
F	50.0 U
BA	--
P	3.0 J

MW-1	
6.0 – 21.0'	
B	320
T	120
F	50.0 U
BA	--
P	--

MW-40	
10.0 – 25.0'	
B	5,000
T	480,000
F	68.0
BA	--
P	--

MW-38	
8.0 – 18.0'	
B	0.20 U
T	4.1
F	50.0 U
BA	--
P	--

MW-11	
5.0 – 25.0'	
B	67.0
T	100
F	55.0
BA	3.0 J
P	--

MW-25	
8.0 – 18.0'	
B	800 U
T	94,000
F	50.0 U
BA	--
P	--

MW-10	
3.0 – 23.0'	
B	49.0
T	170
F	50.0 U
BA	6.0 J
P	--

MW-33	
16.0 – 26.0'	
B	9,300
T	610,000
F	50.0 U
BA	--
P	--

MW-17	
2.0 – 22.0'	
B	770
T	170
F	50.0 U
BA	50.0 U
P	--

MW-5	
4.0 – 19.0'	
B	16.0
T	610
F	50.0 U
BA	--
P	--

MW-E5	
3.0 – 18.0'	
B	0.45
T	0.20 U
F	50.0 U
BA	--
P	--

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN $\mu g/l$
T	TOLUENE CONCENTRATION IN $\mu g/l$
F	FORMALDEHYDE CONCENTRATION IN $\mu g/l$
BA	BENZOIC ACID CONCENTRATION IN $\mu g/l$
P	PHENOL CONCENTRATION IN $\mu g/l$
J	ESTIMATED CONCENTRATION
U	NOT DETECTED
--	NOT SAMPLED DUE TO SEPARATE PHASE HYDROCARBONS

DCS001384

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

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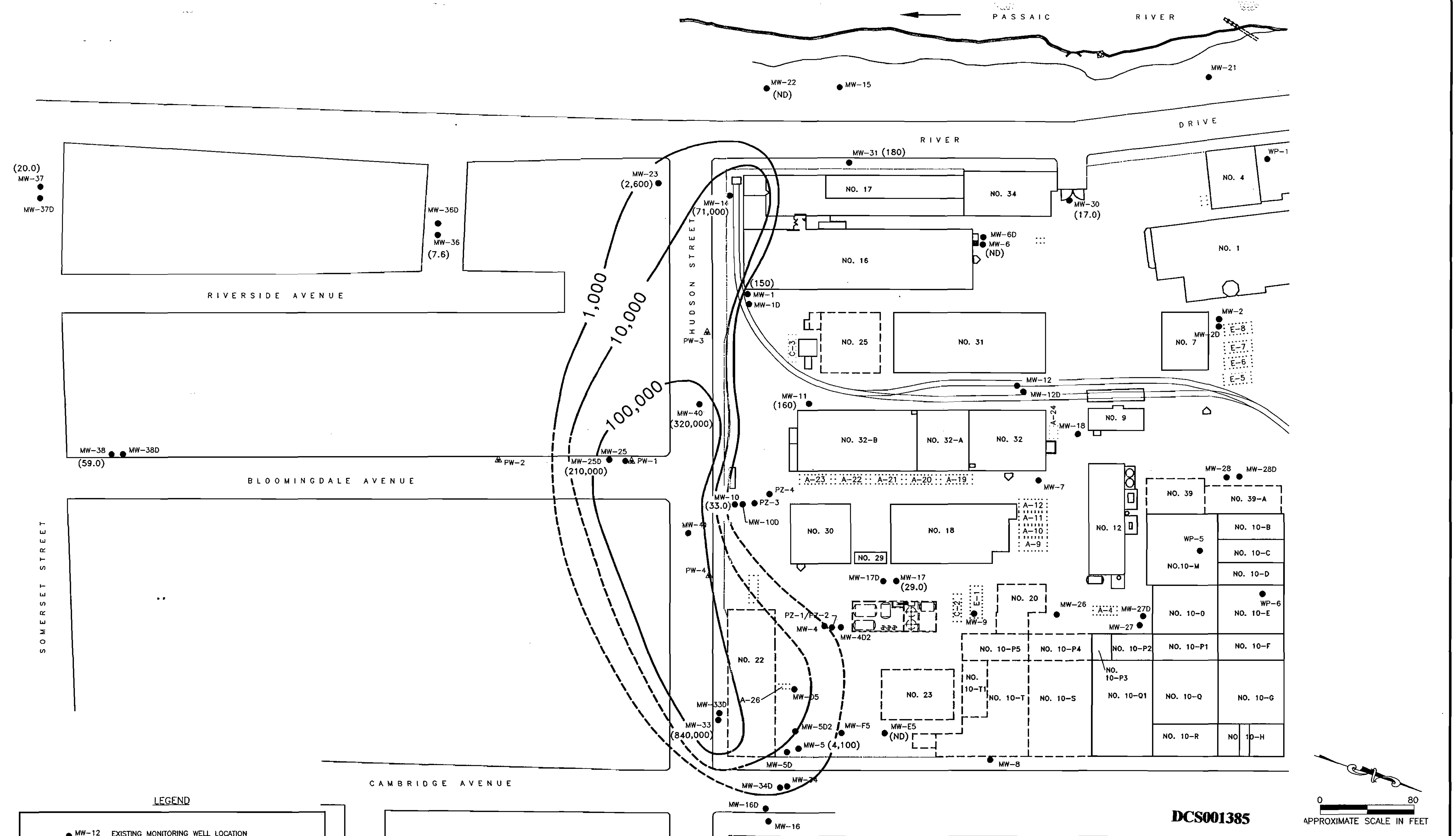
Project No. File: POINTMAP\KAL-FIG2-JULY01.dwg Date: 7/23/01

FIGURE 2
TOLUENE SPILL AREA
BENZENE, TOLUENE, BENZOIC ACID,
PHENOL & FORMALDEHYDE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JUNE 1997

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



DCS001385

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(71,000)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Date: 7/23/01

FIGURE 6
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
SEPTEMBER 1997

KALAMA CHEMICAL INC.
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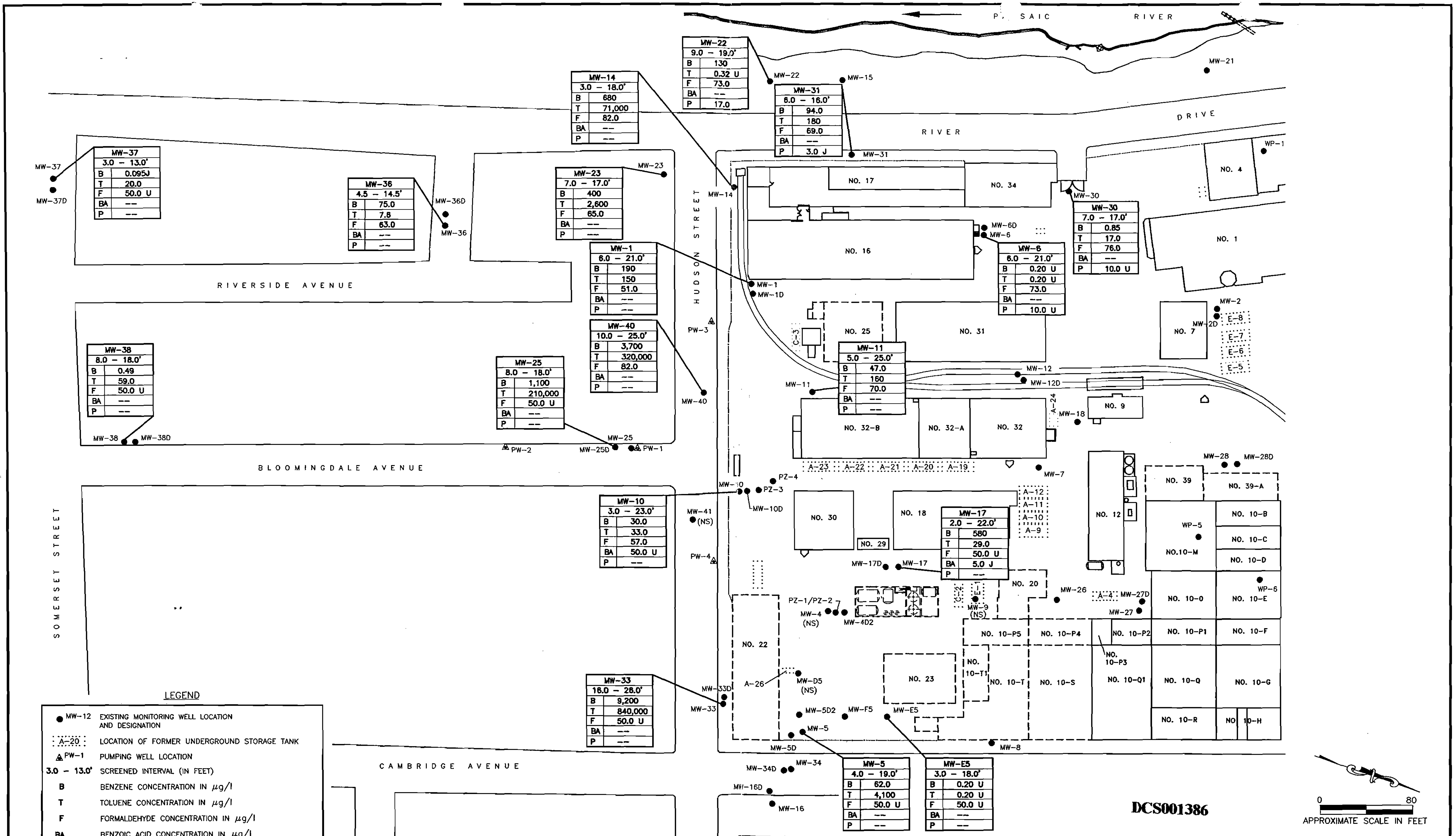

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
F	FORMALDEHYDE CONCENTRATION IN μg/l
BA	BENZOIC ACID CONCENTRATION IN μg/l
P	PHENOL CONCENTRATION IN μg/l
J	ESTIMATED CONCENTRATION
U	NOT DETECTED
NS	NOT SAMPLED DUE TO SEPARATE PHASE HYDROCARBONS
--	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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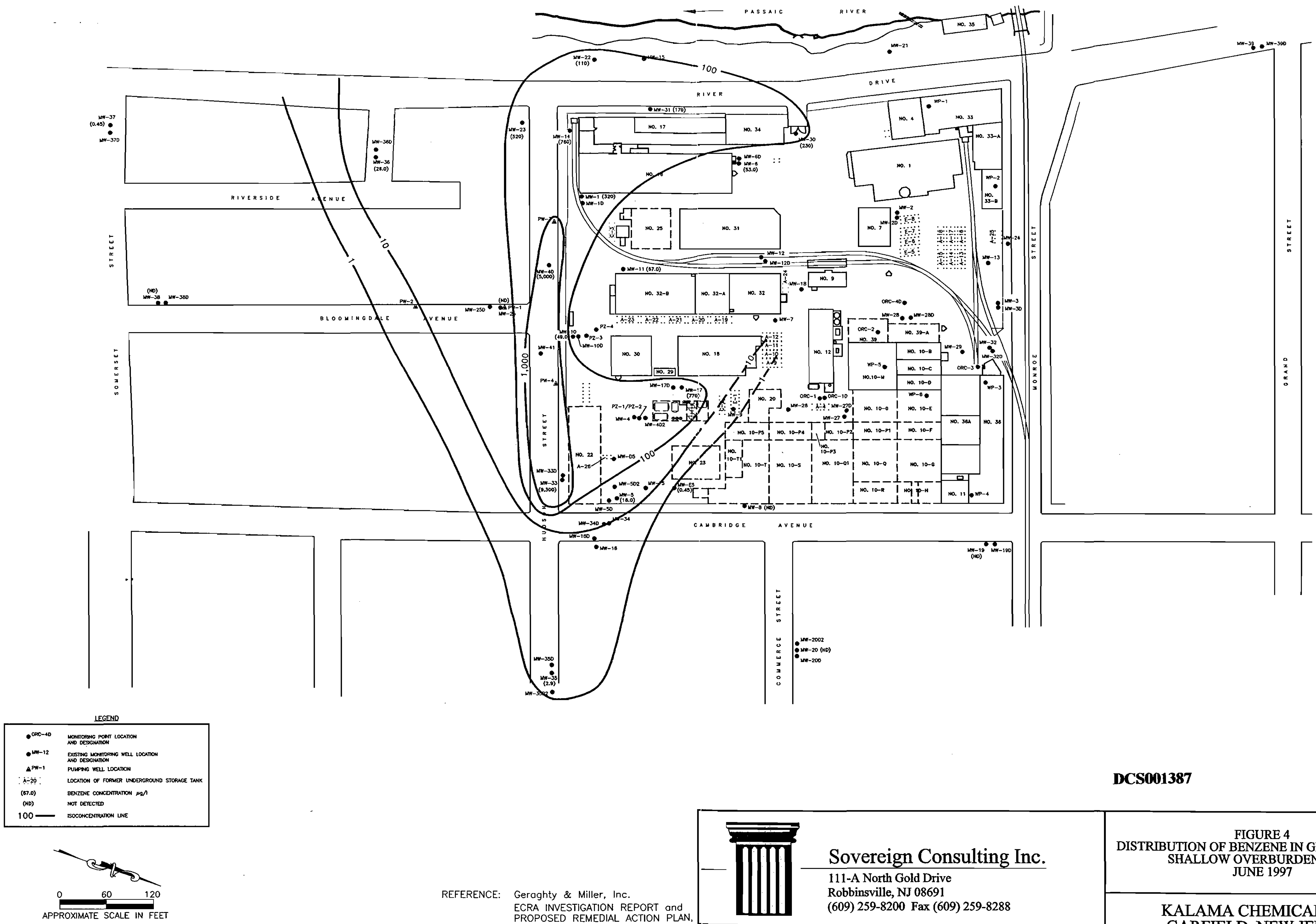
Date: 7/23/01

FIGURE 5
TOLUENE SPILL AREA
BENZENE, TOLUENE, BENZOIC ACID,
PHENOL & FORMALDEHYDE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
SEPTEMBER 1997

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
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FIGURE 4
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JUNE 1997

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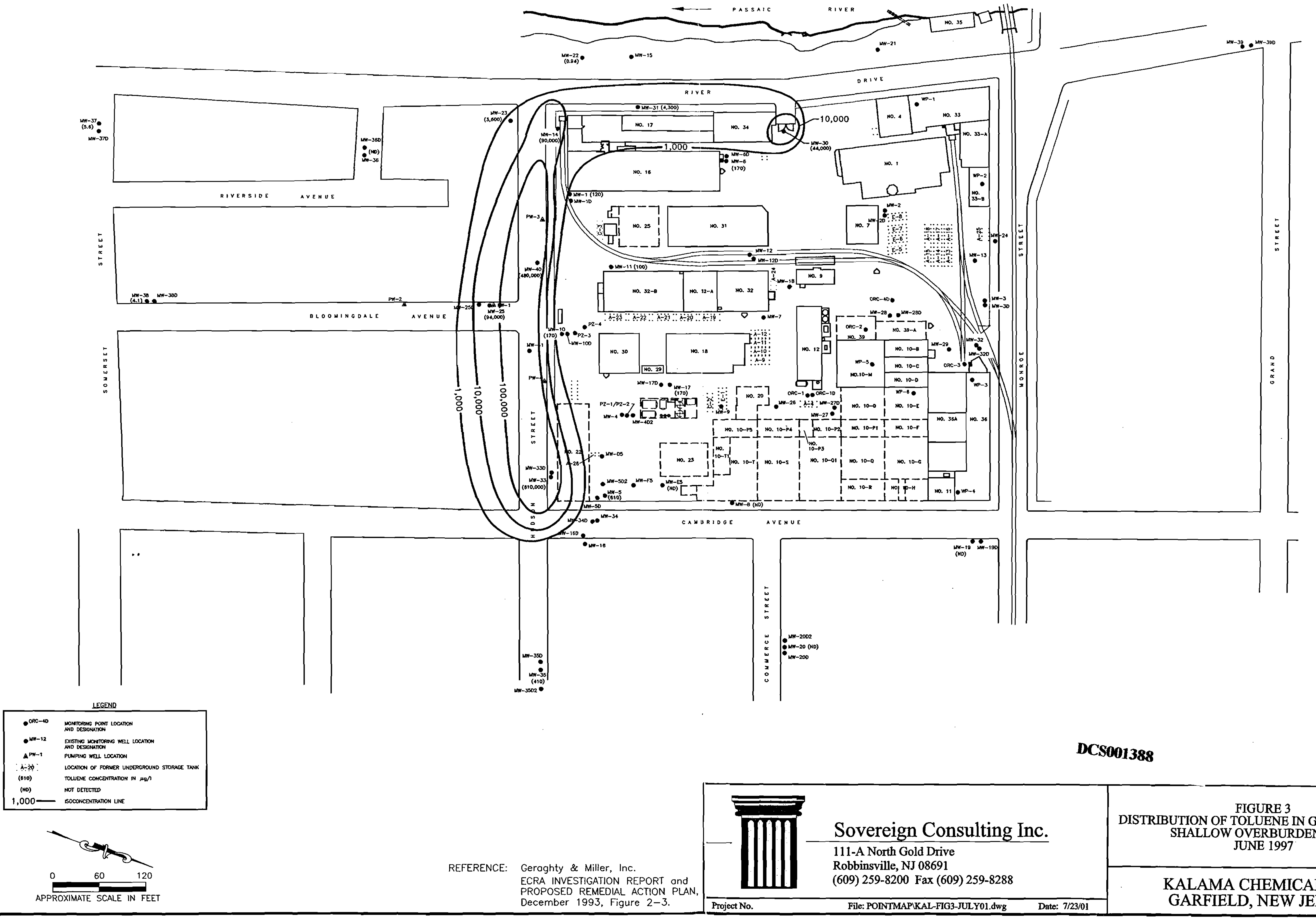
Project No.	File: POINTMAP\KAL-FIG4-JULY01.dwg	Date: 7/23/01



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REFERENCE: Geraghty & Miller, Inc.
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PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

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Project No. File: POINTMAP\KAL-FIG3-JULY01.dwg Date: 7/23/01

FIGURE 3
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JUNE 1997

KALAMA CHEMICAL INC.
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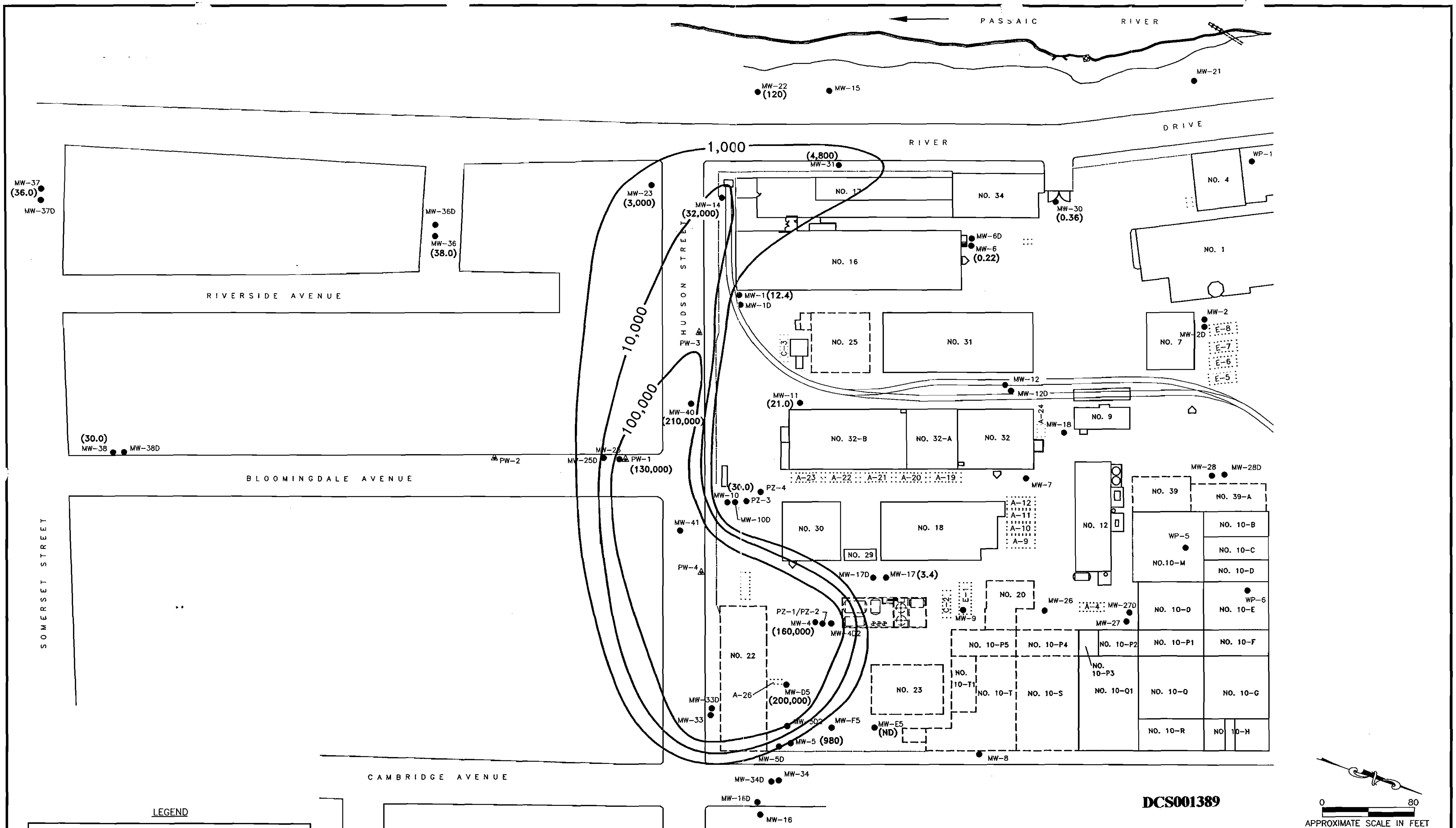

DCS001389

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(38.0)	TOLUENE CONCENTRATION IN μg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Project No. File: POINTMAP\KAL-FIG9-JULY01.dwg Date: 7/23/01

FIGURE 9
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 1998

KALAMA CHEMICAL INC.
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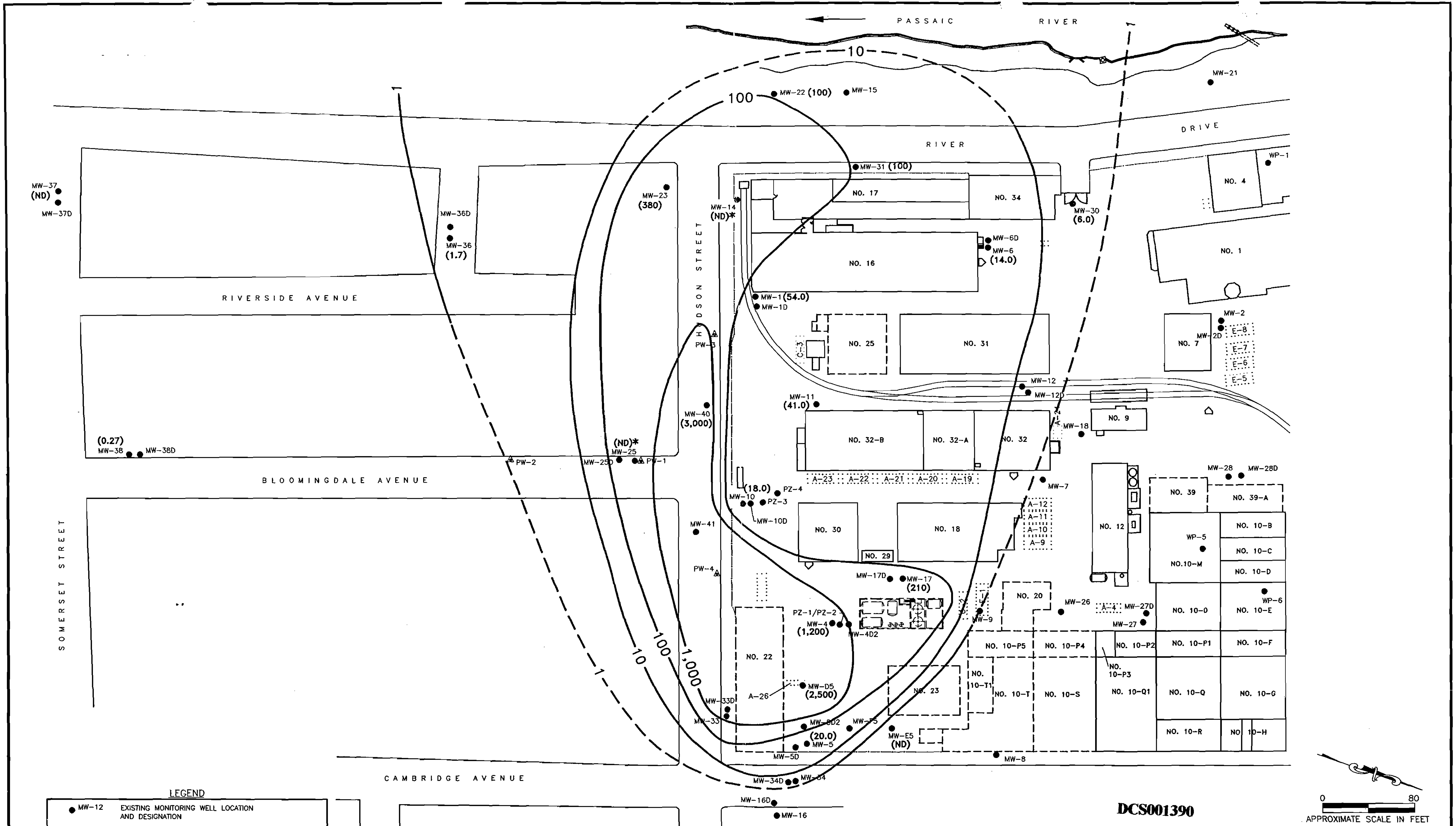

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(210)	BENZENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
*	ELEVATED DETECTION LIMIT DUE TO SAMPLE DILUTION
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Date: 7/23/01

FIGURE 10
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 1998

KALAMA CHEMICAL INC.
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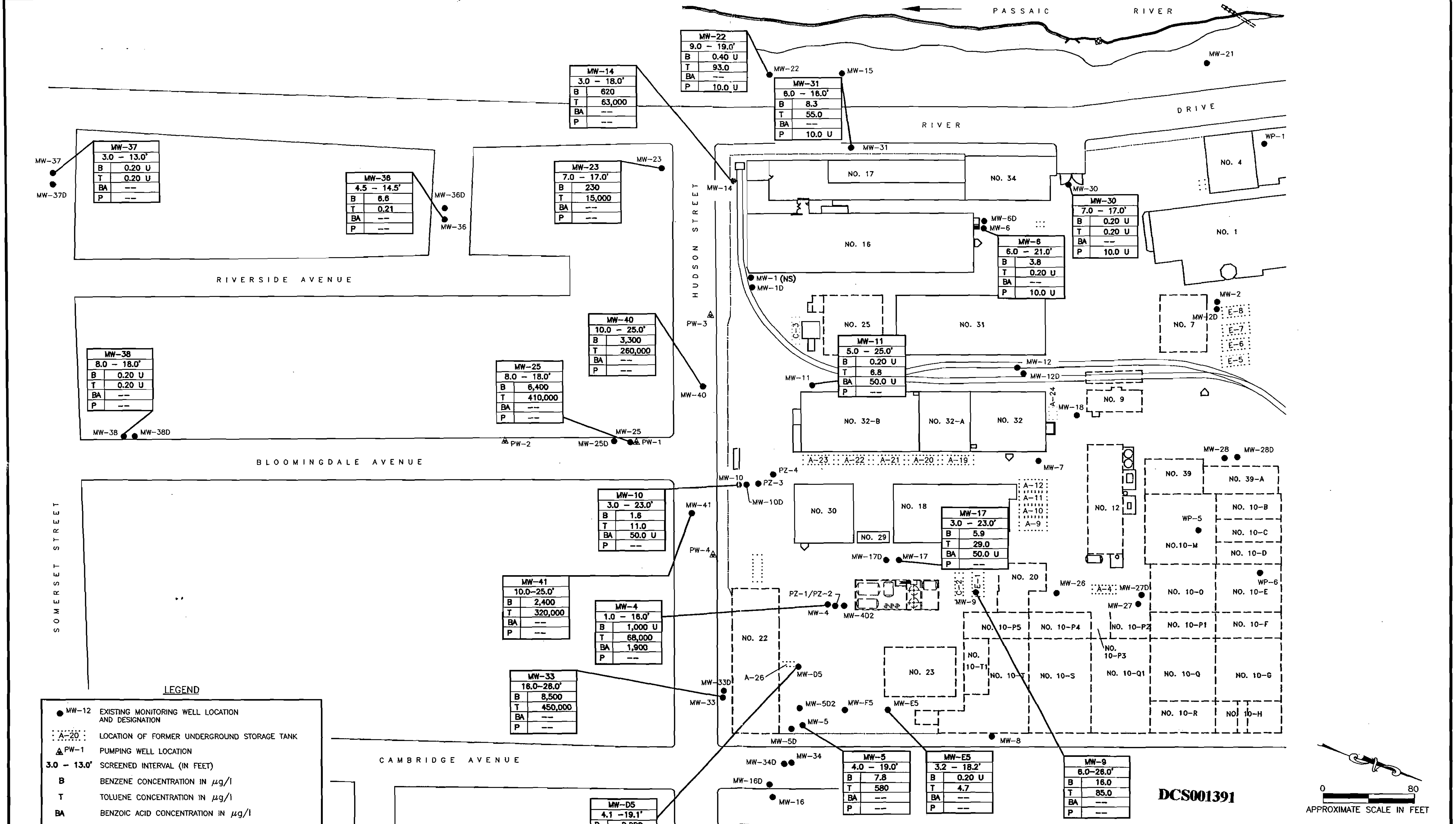

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LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN µg/l
T	TOLUENE CONCENTRATION IN µg/l
BA	BENZOIC ACID CONCENTRATION IN µg/l
P	PHENOL CONCENTRATION IN µg/l
U	NOT DETECTED
NS	NOT SAMPLED DUE TO EXCESSIVE SEDIMENT
--	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Project No. File: POINTMAP\KAL-FIG11-JULY01.dwg Date: 7/23/01

FIGURE 11
TOLUENE SPILL AREA
BENZENE, TOLUENE, BENZOIC ACID, & PHENOL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 1998

KALAMA CHEMICAL INC.
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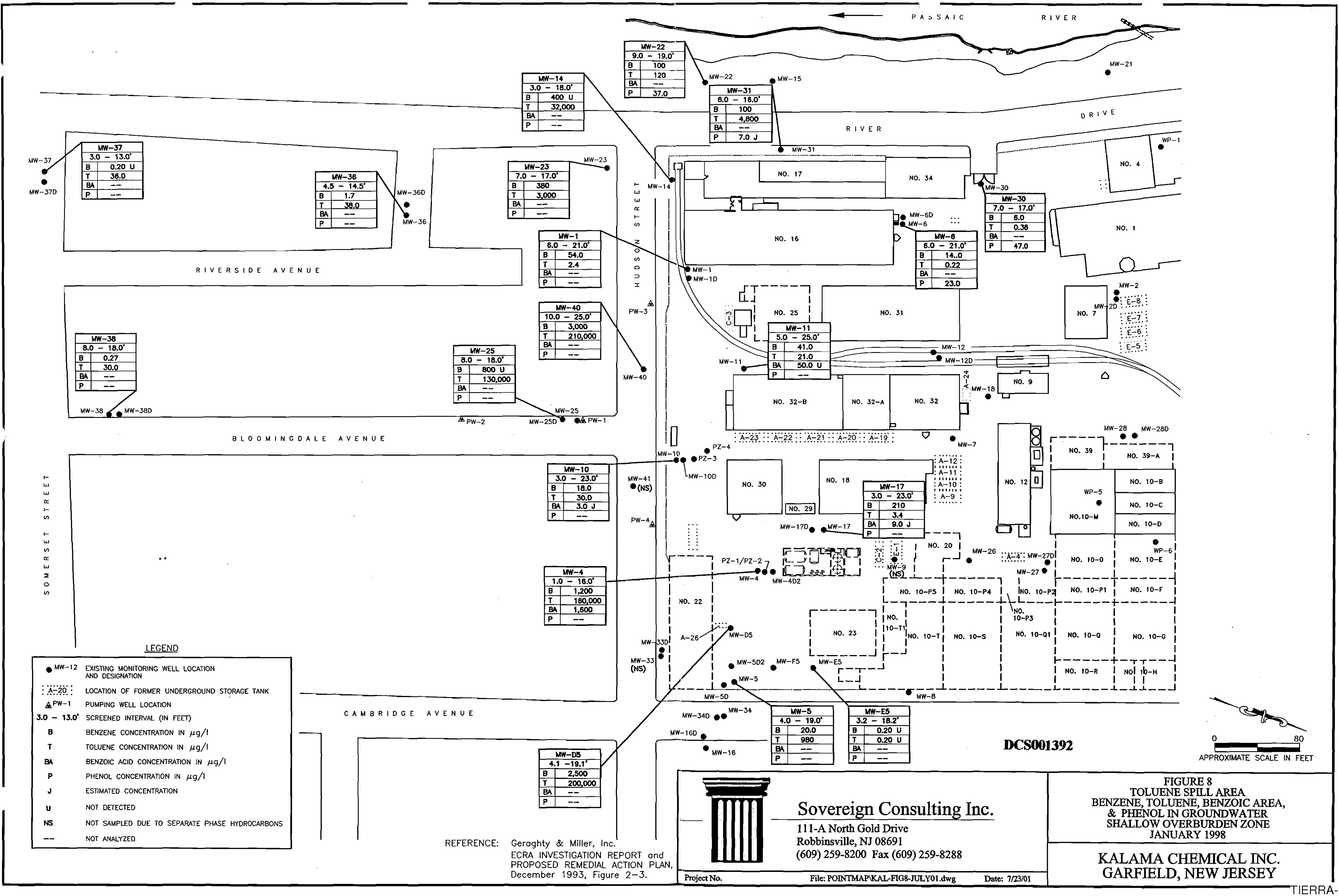

MW-22	
9.0 – 19.0'	
B	100
T	120
BA	--
P	37.0

MW-14	
3.0 – 18.0'	
B	400 U
T	32,000
BA	--
P	--

MW-31	
6.0 – 16.0'	
B	100
T	4,800
BA	--
P	7.0 J

MW-37	
3.0 – 13.0'	
B	0.20 U
T	36.0
BA	--
P	--

MW-36	
4.5 – 14.5'	
B	1.7
T	38.0
BA	--
P	--

MW-23	
7.0 – 17.0'	
B	380
T	3,000
BA	--
P	--

MW-30	
7.0 – 17.0'	
B	6.0
T	0.36
BA	--
P	47.0

MW-1	
6.0 – 21.0'	
B	54.0
T	2.4
BA	--
P	--

MW-6	
6.0 – 21.0'	
B	14..0
T	0.22
BA	--
P	23.0

MW-40	
10.0 – 25.0'	
B	3,000
T	210,000
BA	--
P	--

MW-11	
5.0 – 25.0'	
B	41.0
T	21.0
BA	50.0 U
P	--

MW-38	
8.0 – 18.0'	
B	0.27
T	30.0
BA	--
P	--

MW-25	
8.0 – 18.0'	
B	800 U
T	130,000
BA	--
P	--

MW-10	
3.0 – 23.0'	
B	18.0
T	30.0
BA	3.0 J
P	--

MW-17	
3.0 – 23.0'	
B	210
T	3.4
BA	9.0 J
P	--

MW-4	
1.0 – 16.0'	
B	1,200
T	160,000
BA	1,600
P	--

MW-5	
4.0 – 19.0'	
B	20.0
T	980
BA	--
P	--

MW-E5	
3.2 – 18.2'	
B	0.20 U
T	0.20 U
BA	--
P	--

MW-D5	
4.1 –19.1'	
B	2,500
T	200,000
BA	--
P	--

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN $\mu g/l$
T	TOLUENE CONCENTRATION IN $\mu g/l$
BA	BENZOIC ACID CONCENTRATION IN $\mu g/l$
P	PHENOL CONCENTRATION IN $\mu g/l$
J	ESTIMATED CONCENTRATION
U	NOT DETECTED
NS	NOT SAMPLED DUE TO SEPARATE PHASE HYDROCARBONS
--	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Date: 7/23/01

FIGURE 8
TOLUENE SPILL AREA
BENZENE, TOLUENE, BENZOIC AREA,
& PHENOL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 1998

KALAMA CHEMICAL INC.
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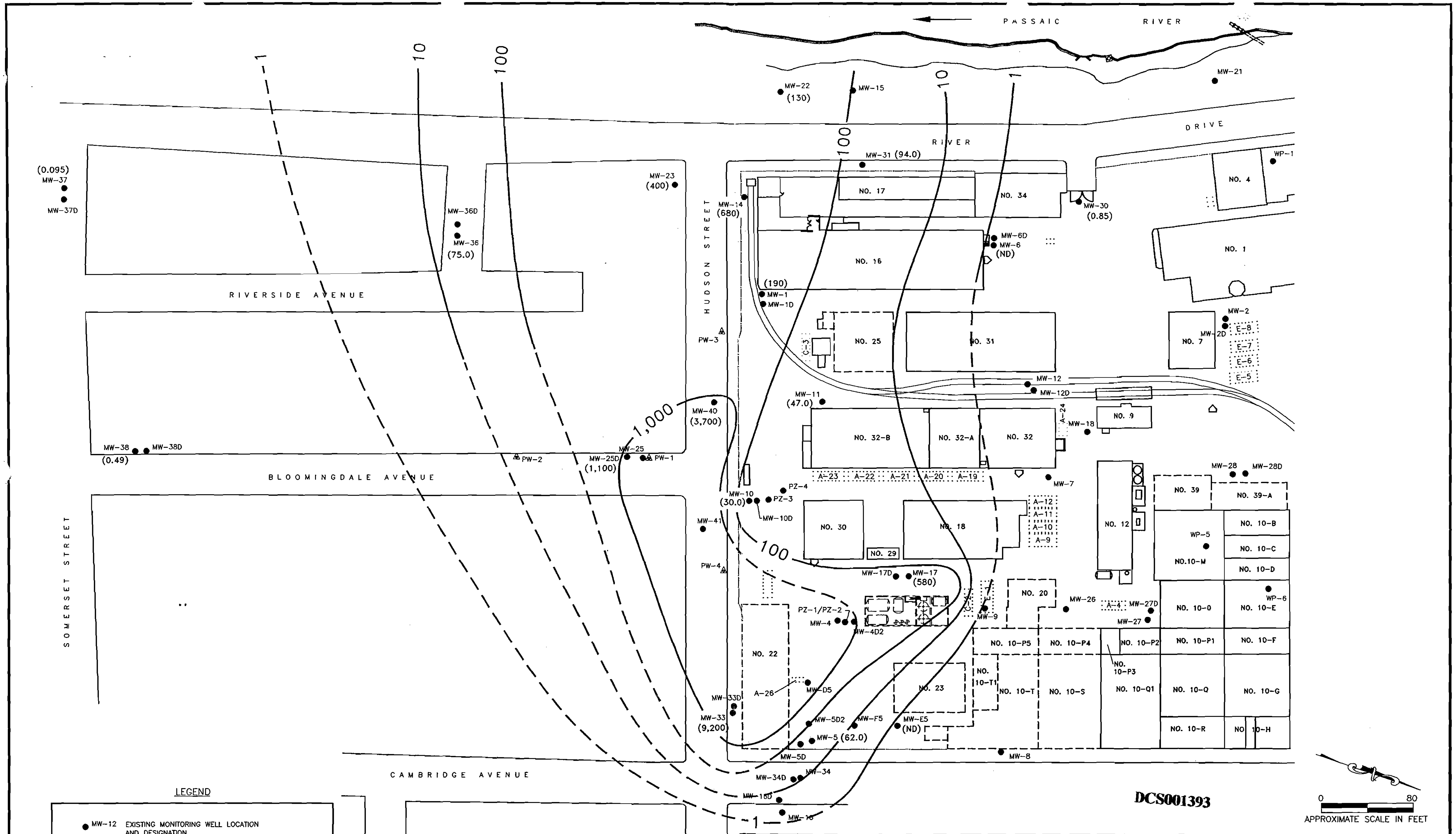

DCS001393

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(400)	BENZENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
10 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Date: 7/23/01

FIGURE 7
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
SEPTEMBER 1997

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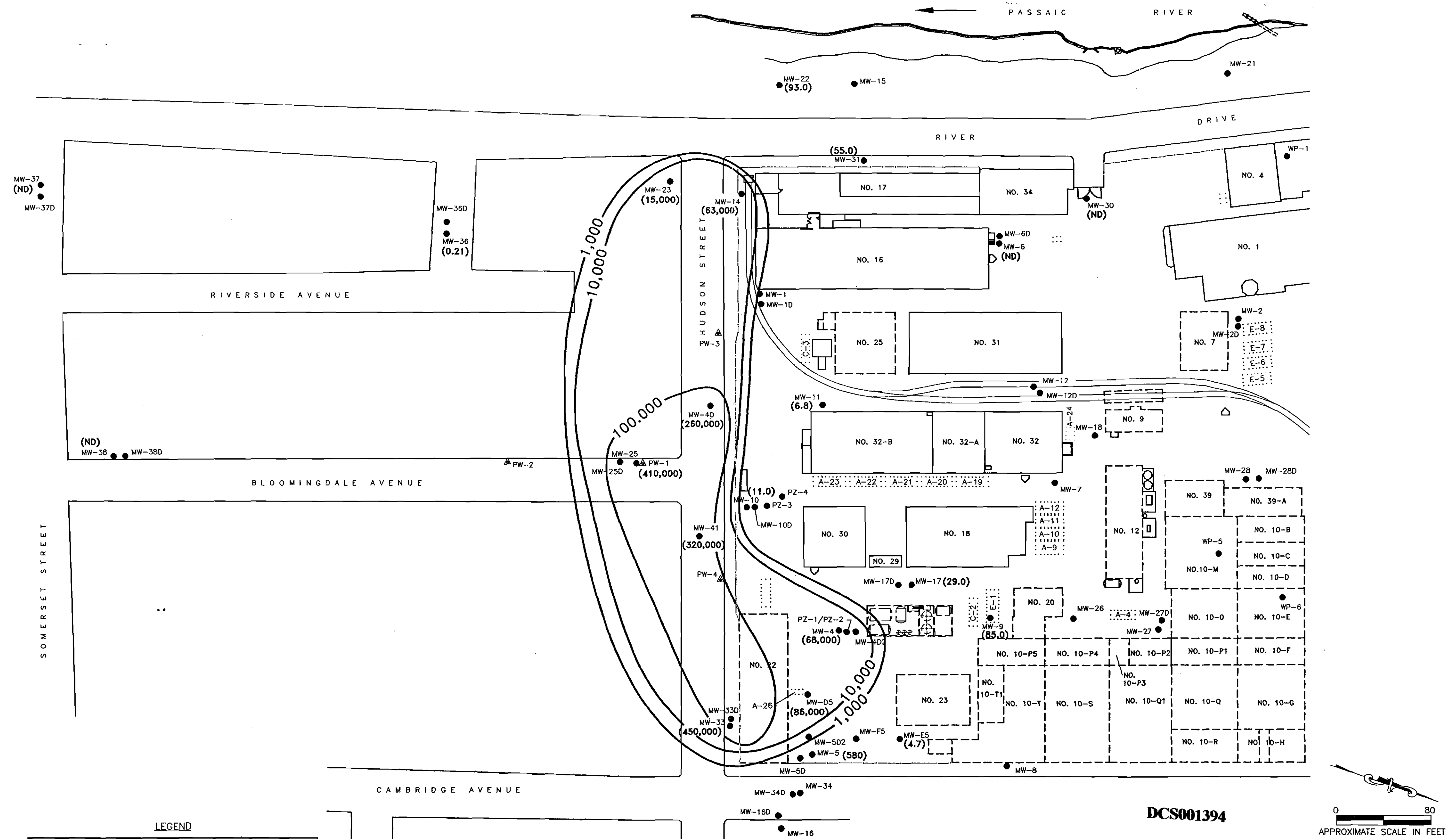

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(580)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
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Date: 7/23/01

FIGURE 12
DISTRIBUTION OF TOLUENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE
APRIL 1998

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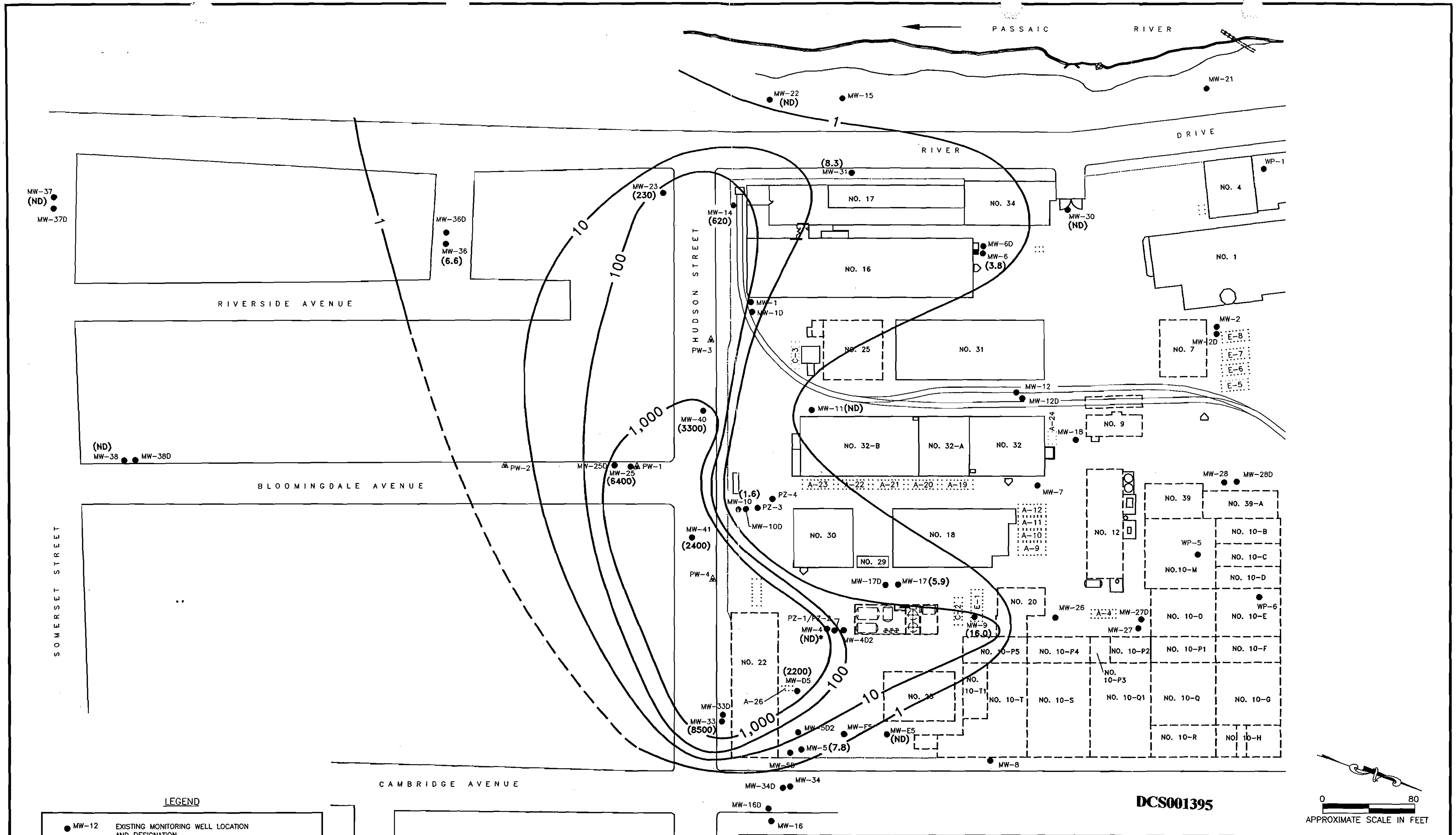

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(230)	BENZENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
*	ELEVATED DETECTION LIMIT DUE TO SAMPLE DILUTION
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 13
DISTRIBUTION OF BENZENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE APRIL 1998

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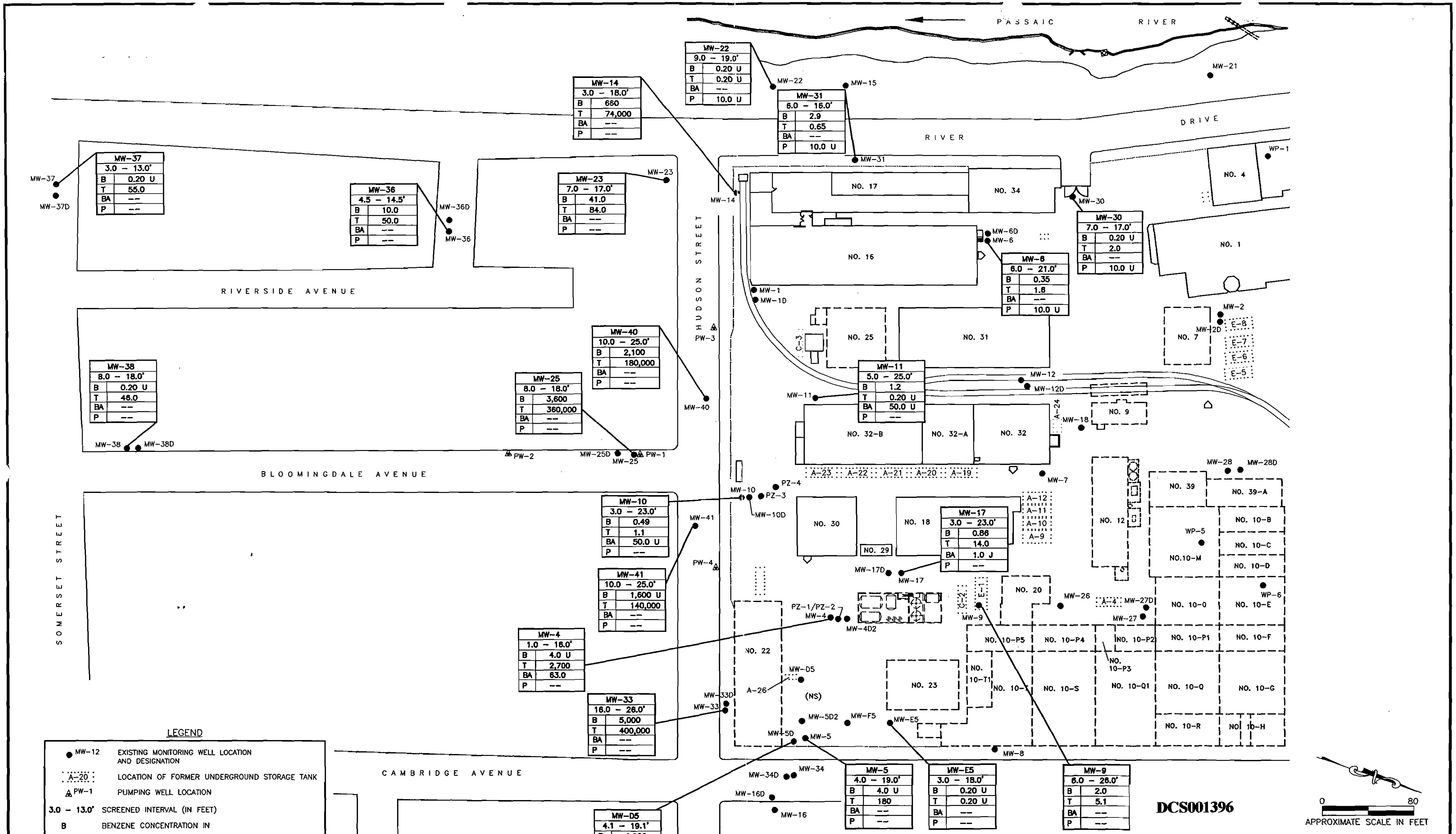
Project No.
File: POINTMAP\KAL-FIG13-JULY01.dwg
Date: 7/23/01



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN
T	TOLUENE CONCENTRATION IN
BA	BENZOIC ACID CONCENTRATION IN
P	PHENOL CONCENTRATION IN
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
––	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
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Project No. File: POINTMAP\KAL-FIG14-JULY01.dwg Date: 7/23/01

FIGURE 14
TOLUENE SPILL AREA
BENZENE, TOLUENE, BENZOIC ACID,
& PHENOL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 1998

KALAMA CHEMICAL INC.
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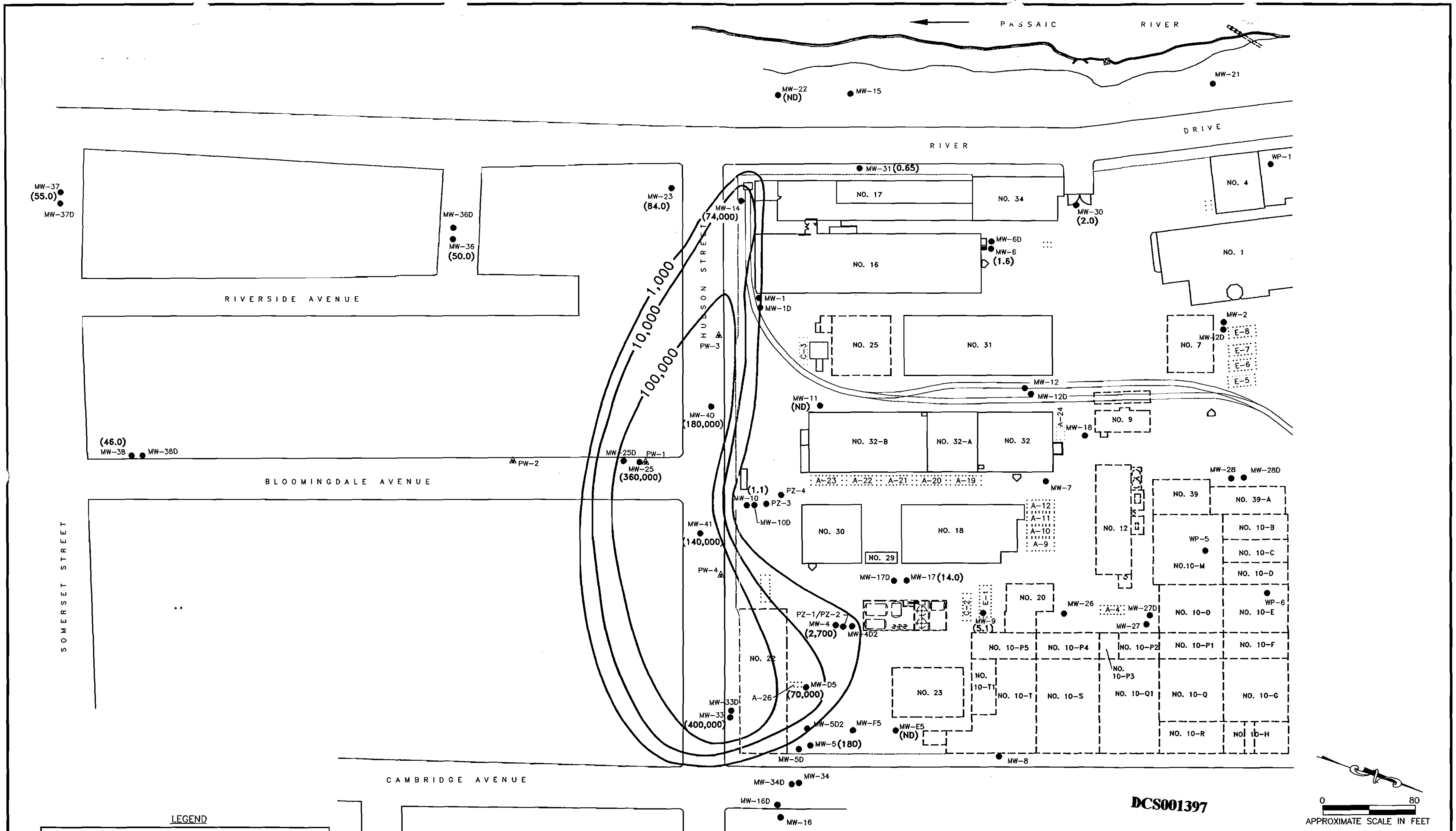

DCS001397

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(84.0)	TOLUENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Project No.
File: POINTMAP\KAL-FIG15-JULY01.dwg
Date: 7/23/01

FIGURE 15
DISTRIBUTION OF TOLUENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE JULY 1998

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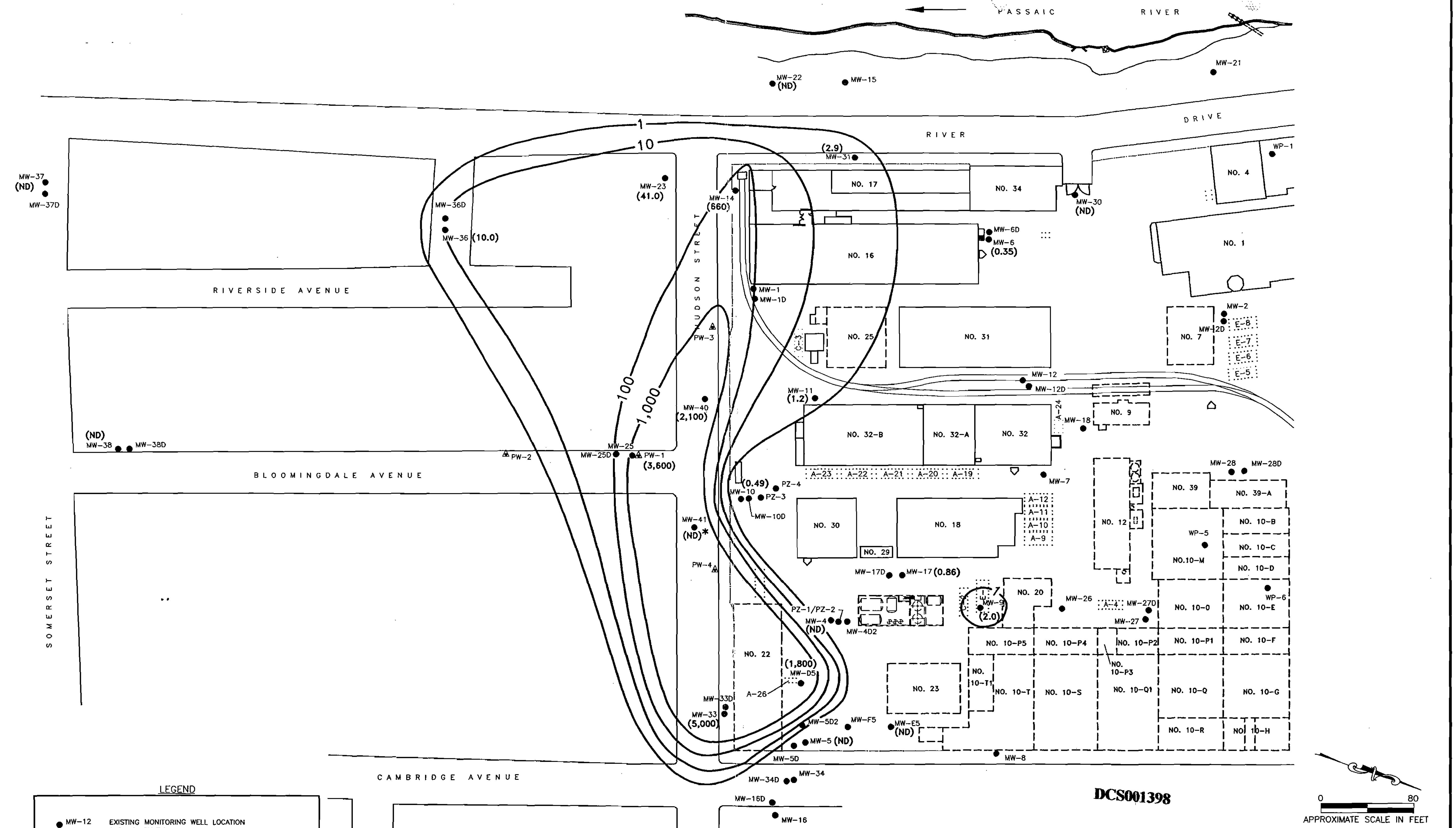

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LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(41.0)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
*	ELEVATED DETECTION LIMIT DUE TO SAMPLE DILUTION
1,000——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Project No. File: POINTMAP\KAL-FIG16-JULY01.dwg Date: 7/23/01

FIGURE 16
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 1998

KALAMA CHEMICAL INC.
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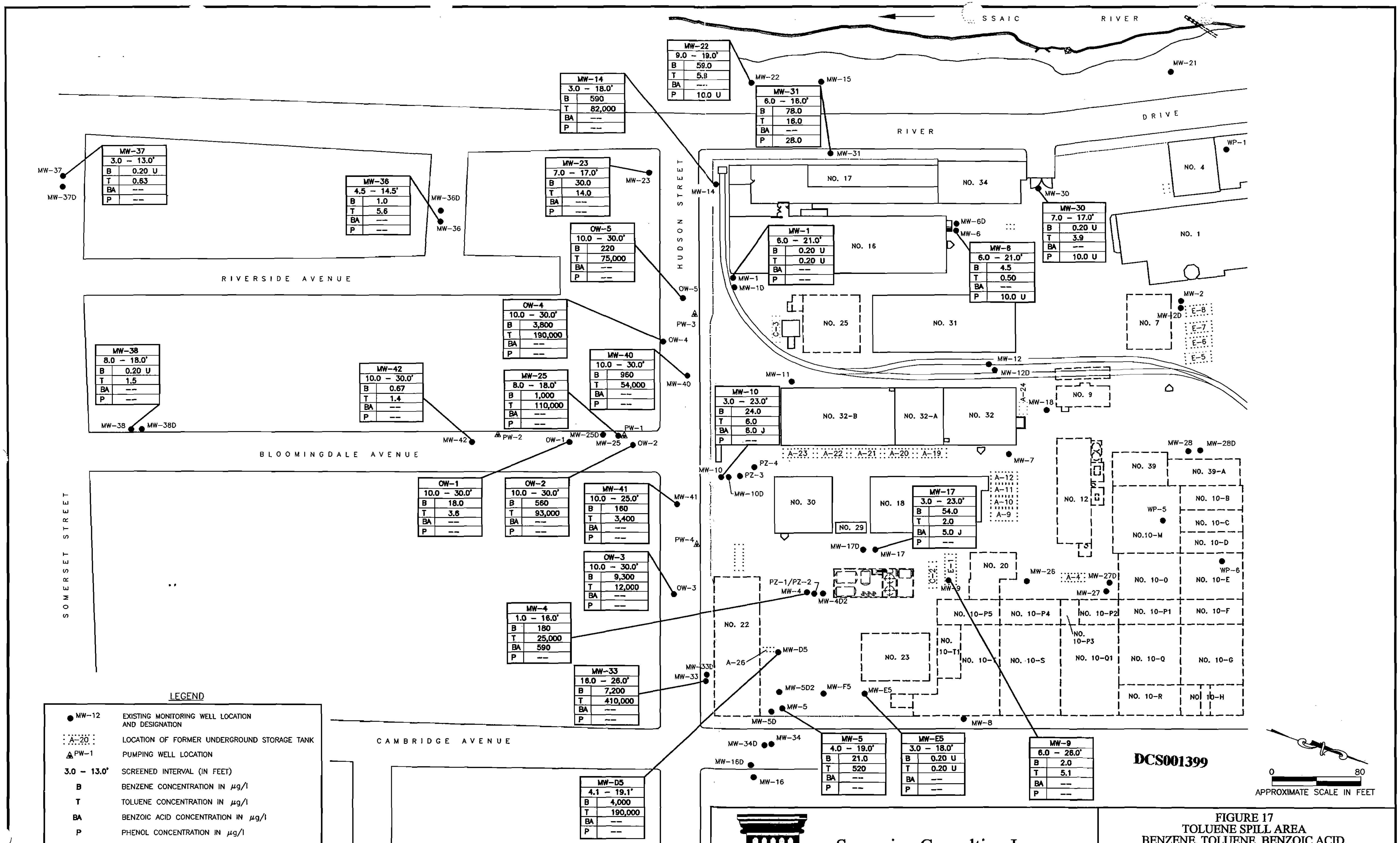

MW-22	
9.0 – 19.0'	
B	59.0
T	5.8
BA	--
P	10.0 U

MW-14	
3.0 – 18.0'	
B	590
T	82,000
BA	--
P	--

MW-31	
6.0 – 16.0'	
B	78.0
T	16.0
BA	--
P	28.0

MW-37	
3.0 – 13.0'	
B	0.20 U
T	0.63
BA	--
P	--

MW-36	
4.5 – 14.5'	
B	1.0
T	5.6
BA	--
P	--

MW-23	
7.0 – 17.0'	
B	30.0
T	14.0
BA	--
P	--

OW-5	
10.0 – 30.0'	
B	220
T	75,000
BA	--
P	--

MW-1	
6.0 – 21.0'	
B	0.20 U
T	0.20 U
BA	--
P	--

MW-6	
6.0 – 21.0'	
B	4.5
T	0.50
BA	--
P	10.0 U

MW-30	
7.0 – 17.0'	
B	0.20 U
T	3.9
BA	--
P	10.0 U

OW-4	
10.0 – 30.0'	
B	3,800
T	190,000
BA	--
P	--

MW-38	
8.0 – 18.0'	
B	0.20 U
T	1.5
BA	--
P	--

MW-42	
10.0 – 30.0'	
B	0.67
T	1.4
BA	--
P	--

MW-25	
8.0 – 18.0'	
B	1,000
T	110,000
BA	--
P	--

MW-40	
10.0 – 30.0'	
B	960
T	54,000
BA	--
P	--

MW-10	
3.0 – 23.0'	
B	24.0
T	6.0
BA	8.0 J
P	--

OW-1	
10.0 – 30.0'	
B	18.0
T	3.6
BA	--
P	--

OW-2	
10.0 – 30.0'	
B	560
T	93,000
BA	--
P	--

MW-41	
10.0 – 25.0'	
B	160
T	3,400
BA	--
P	--

MW-17	
3.0 – 23.0'	
B	54.0
T	2.0
BA	5.0 J
P	--

OW-3	
10.0 – 30.0'	
B	9,300
T	12,000
BA	--
P	--

MW-4	
1.0 – 16.0'	
B	180
T	25,000
BA	590
P	--

MW-33	
16.0 – 26.0'	
B	7,200
T	410,000
BA	--
P	--

MW-5	
4.0 – 19.0'	
B	21.0
T	520
BA	--
P	--

MW-E5	
3.0 – 18.0'	
B	0.20 U
T	0.20 U
BA	--
P	--

MW-9	
6.0 – 26.0'	
B	2.0
T	5.1
BA	--
P	--

MW-D5	
4.1 – 19.1'	
B	4,000
T	190,000
BA	--
P	--

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN µg/l
T	TOLUENE CONCENTRATION IN µg/l
BA	BENZOIC ACID CONCENTRATION IN µg/l
P	PHENOL CONCENTRATION IN µg/l
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
--	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
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December 1993, Figure 2-3.

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FIGURE 17
TOLUENE SPILL AREA
BENZENE, TOLUENE, BENZOIC ACID,
& PHENOL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 1998

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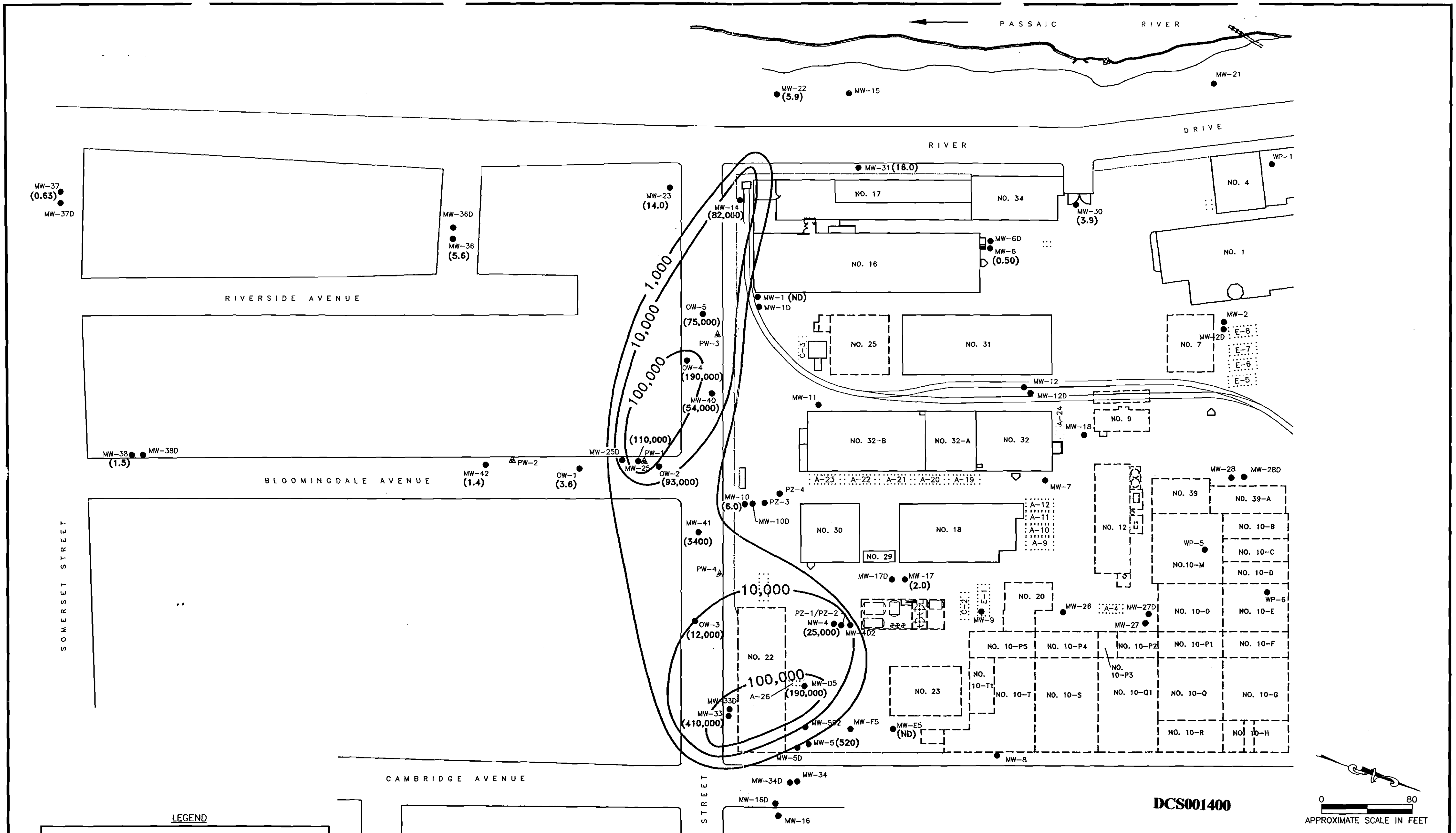
GARFIELD, NEW JERSEY



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(520)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
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PROPOSED REMEDIAL ACTION PLAN,
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FIGURE 18
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 1998

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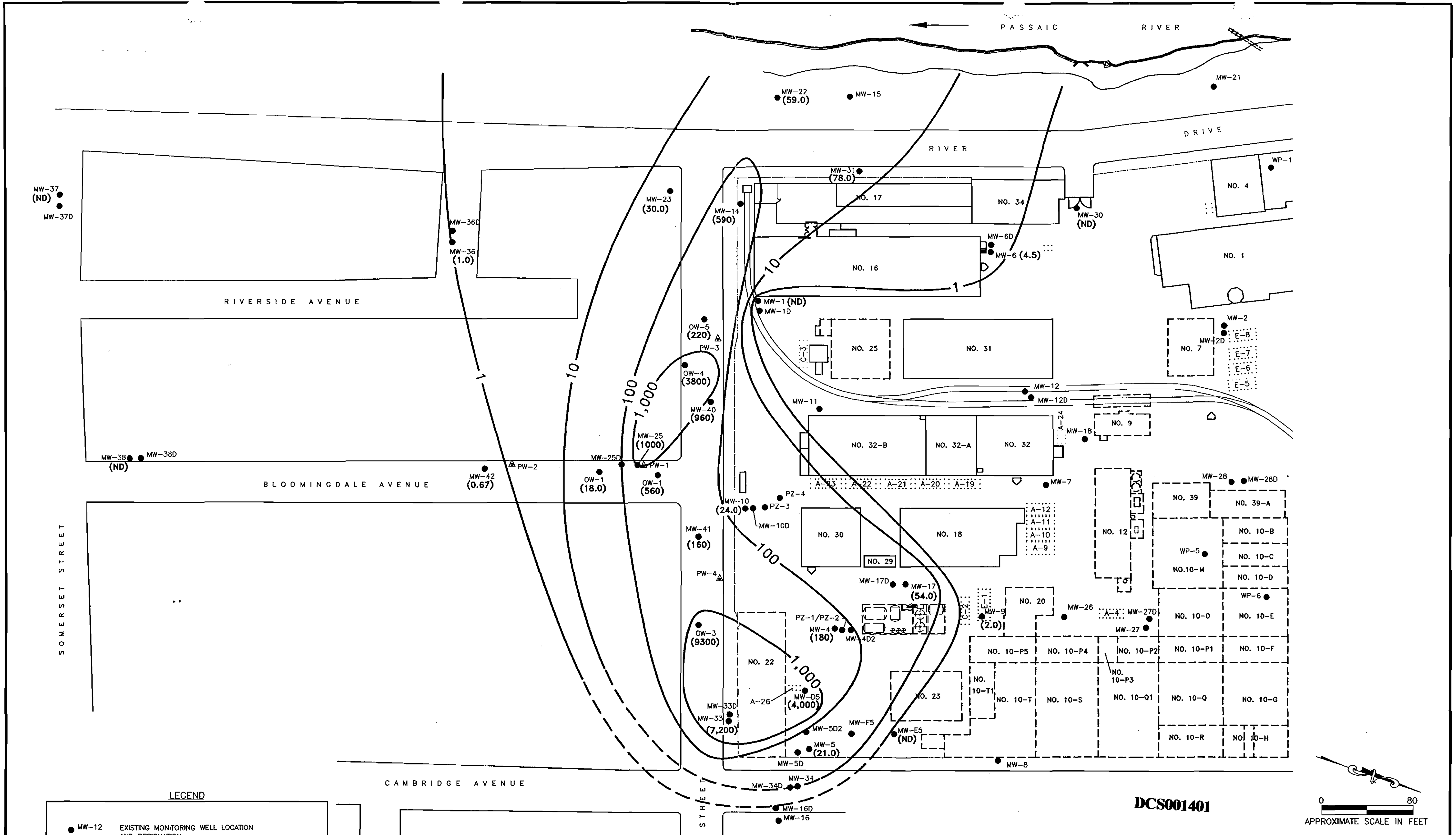

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(54.0)	TOLUENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 19
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 1998

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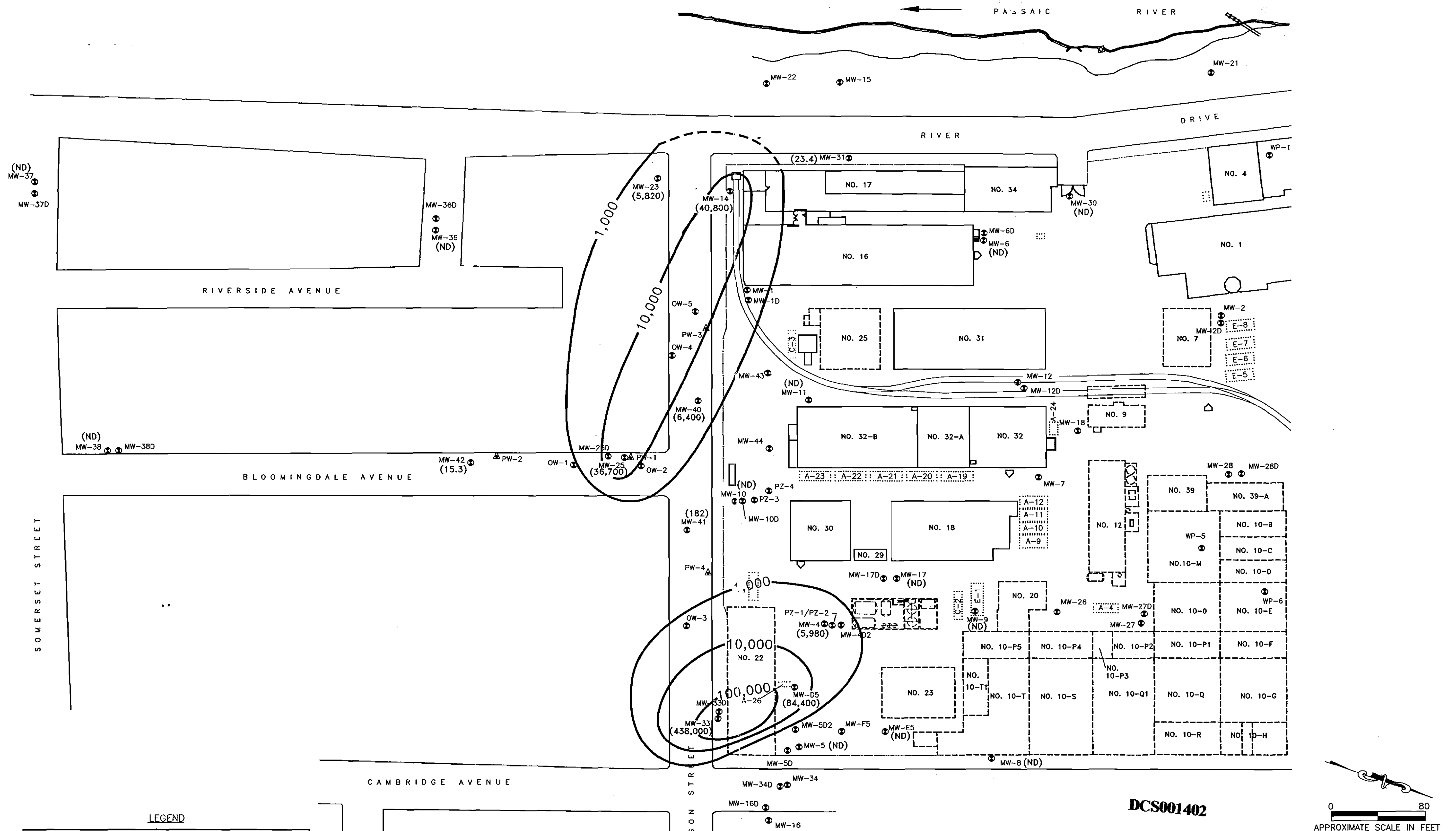

DCS001402

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(182)	TOLUENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE (DASHED WHERE INFERRED)

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 21
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 1999

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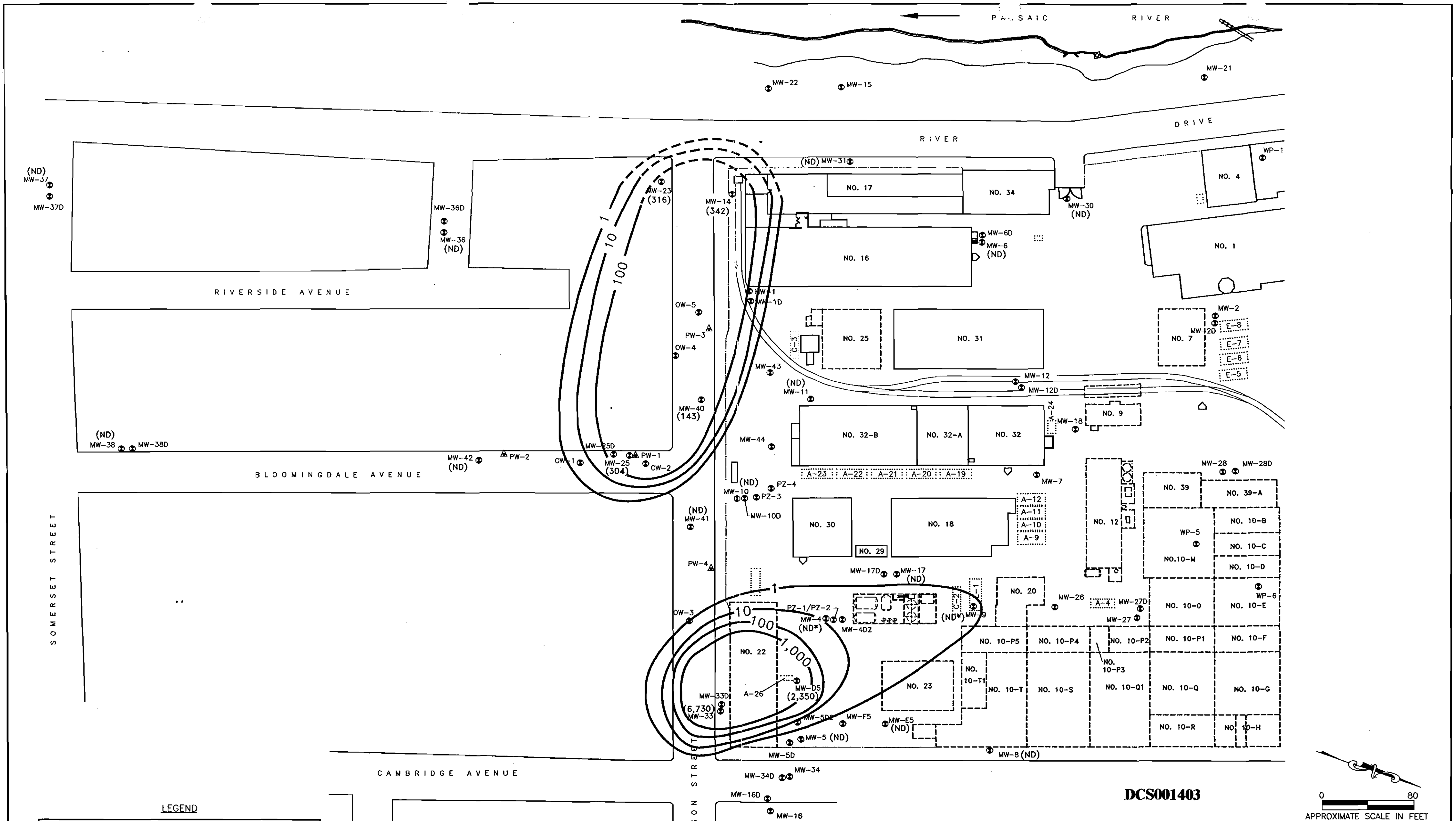

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(143)	BENZENE CONCENTRATION IN μg/l
(ND)	NOT DETECTED
(ND*)	NOT DETECTED WITH AN ELEVATED DETECTION LIMIT
100 ——	ISOCONCENTRATION LINE (DASHED WHERE INFERRED)

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 22
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 1999

KALAMA CHEMICAL INC.
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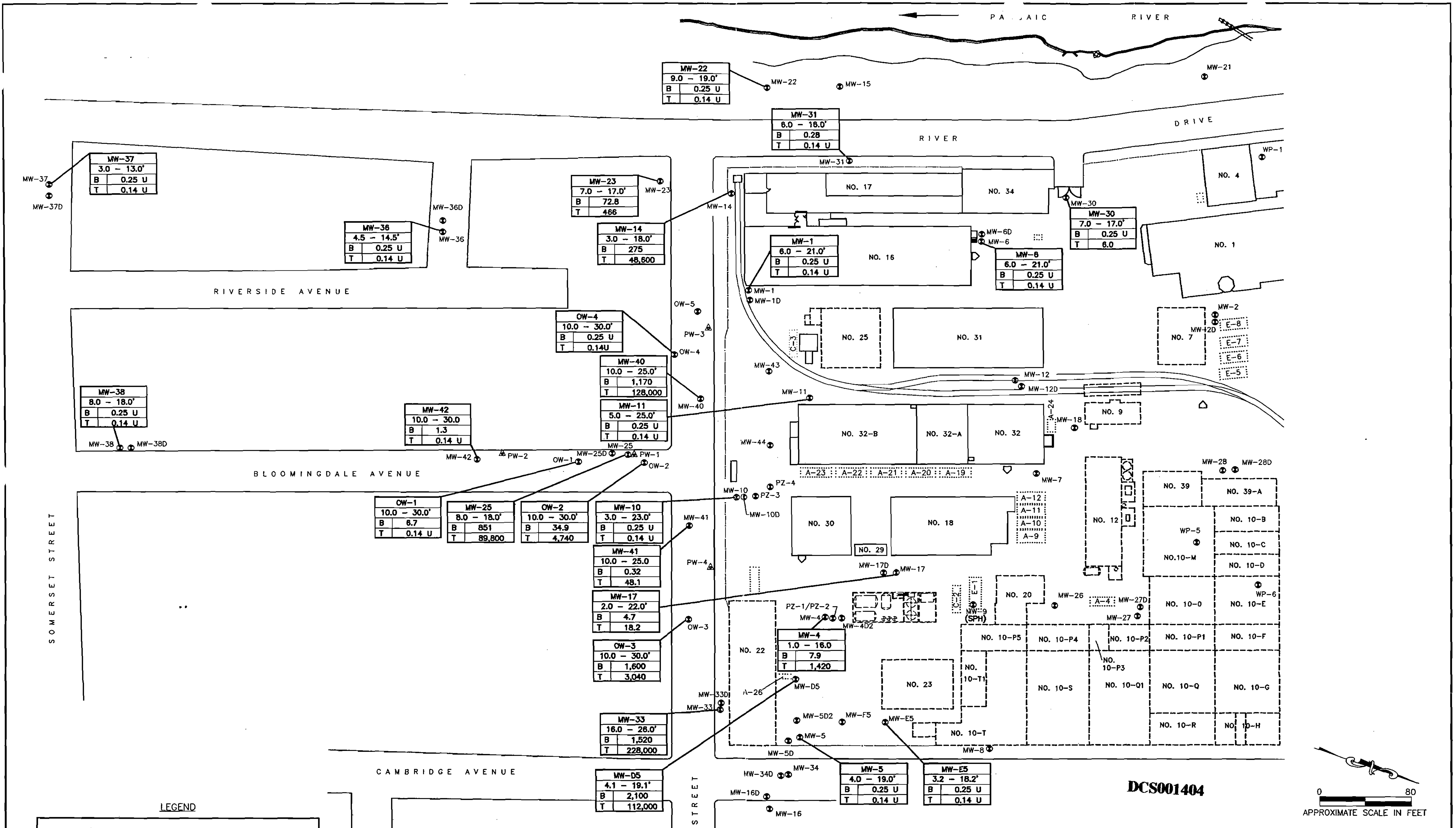

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
U	NOT DETECTED
SPH	SEPARATE PHASE HYDROCARBONS

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 23
BENZENE AND TOLUENE CONCENTRATIONS IN GROUNDWATER
APRIL/MAY 1999

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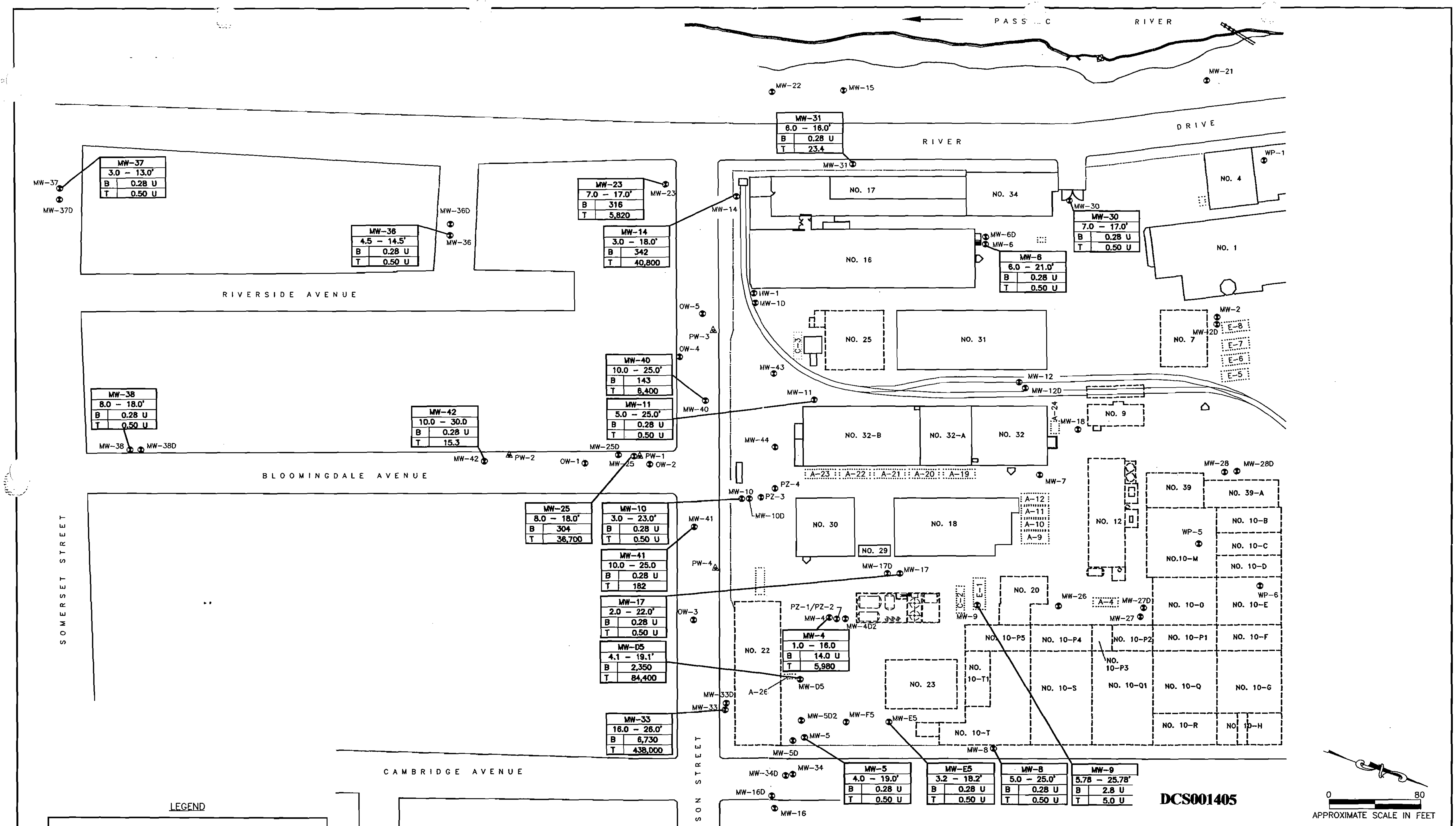

DCS001405

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
U	NOT DETECTED
—	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 20
TOLUENE SPILL AREA
BENZENE AND TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 1999

KALAMA CHEMICAL INC.
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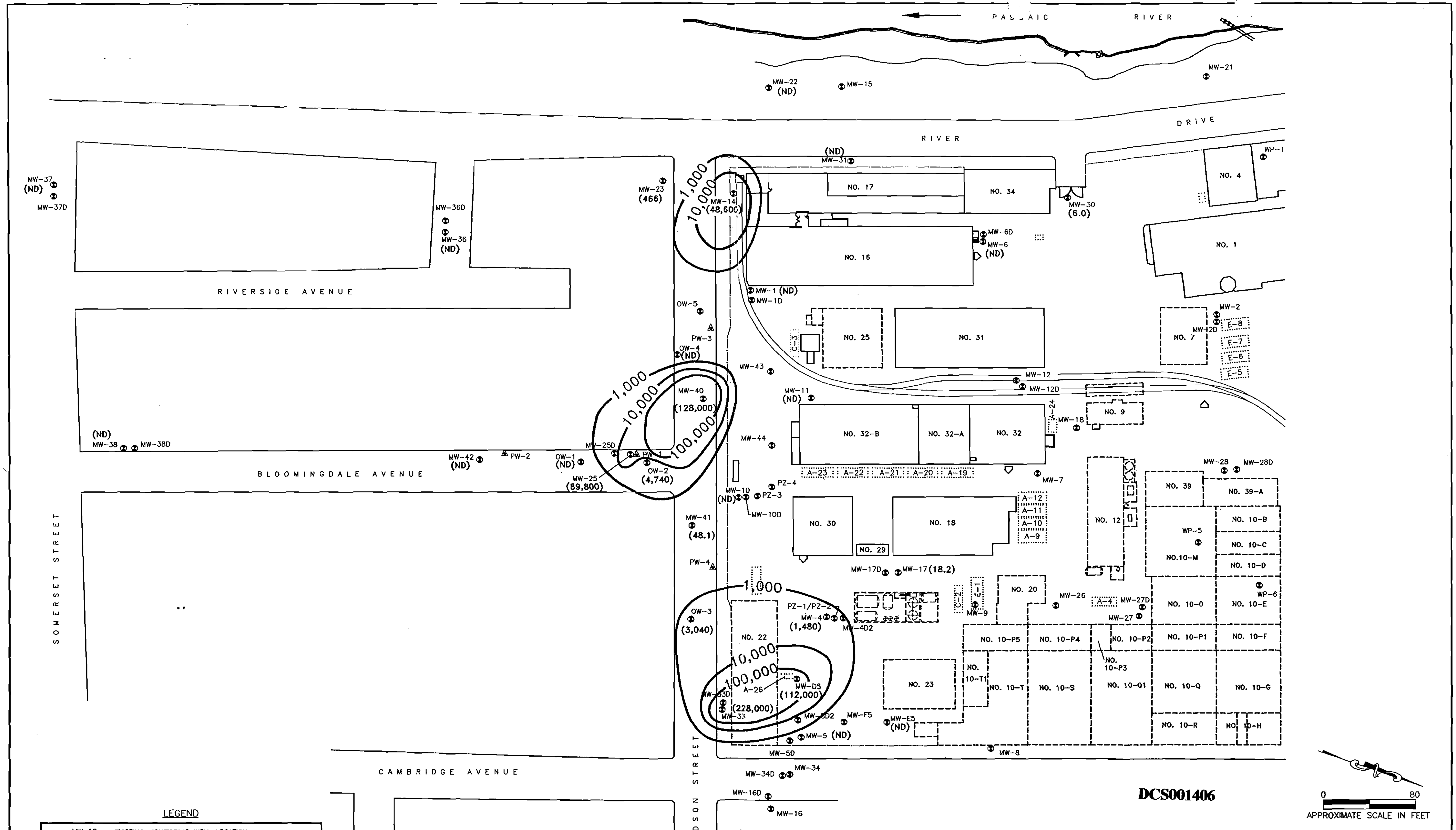

DCS001406

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(3,040)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 24
DISTRIBUTION OF TOLUENE IN GROUNDWATER
APRIL/MAY 1999

KALAMA CHEMICAL INC.
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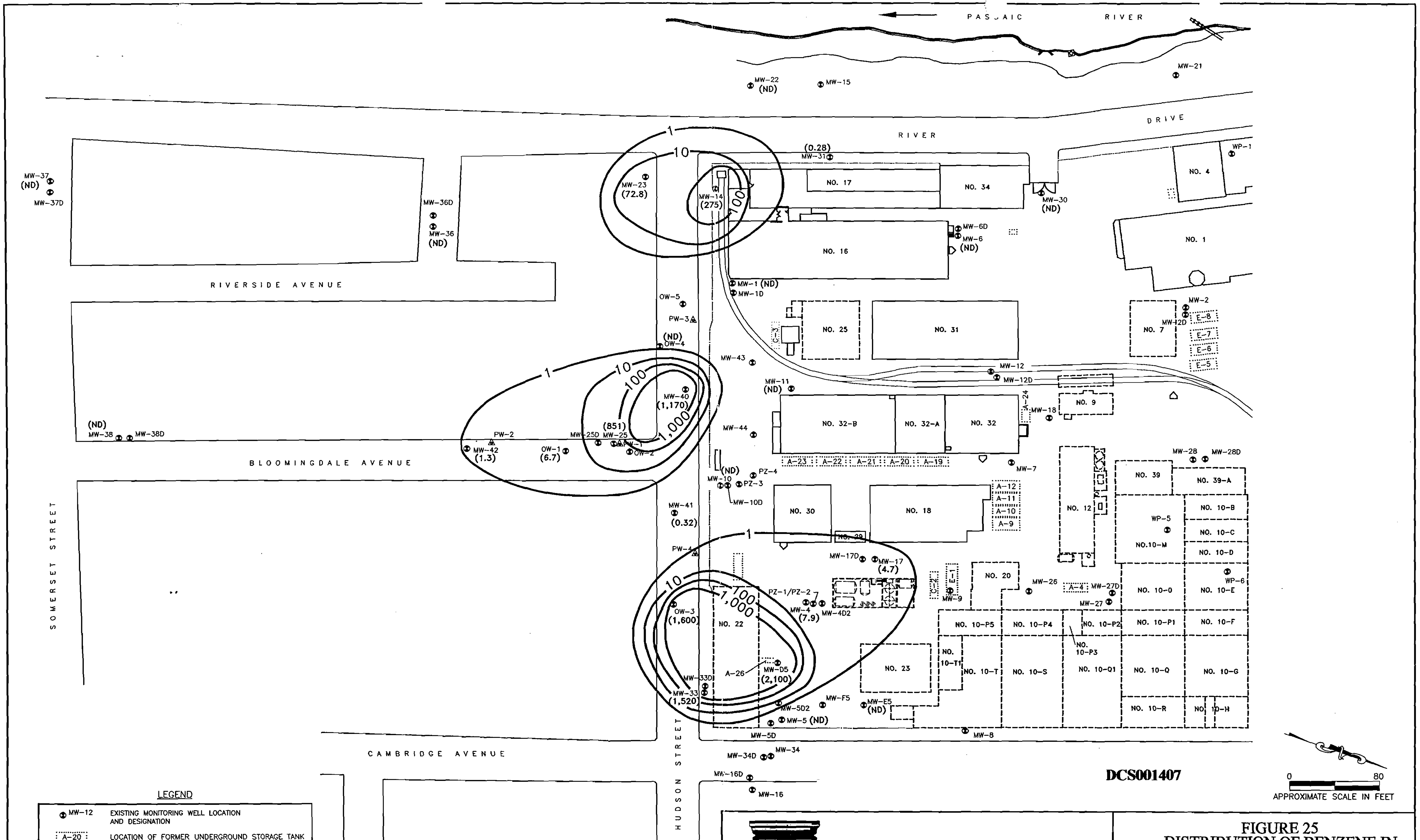

DCS001407

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(4.7)	BENZENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
100 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
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Date: 7/24/01

FIGURE 25
DISTRIBUTION OF BENZENE IN GROUNDWATER APRIL/MAY 1999

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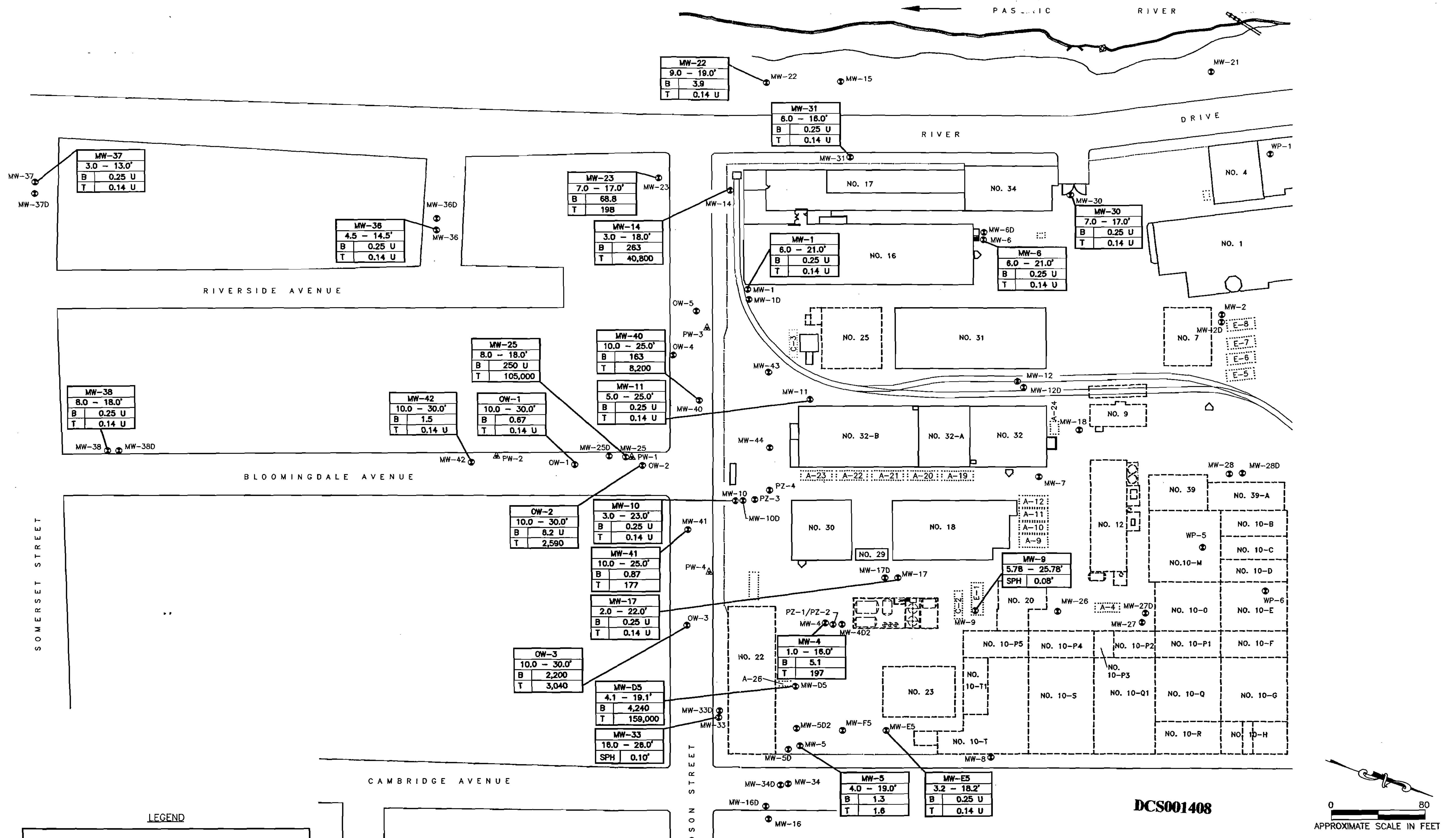

DCS001408

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
10.0 – 30.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
U	NOT DETECTED
SPH	SEPARATE PHASE HYDROCARBONS

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 26
TOLUENE SPILL AREA
BENZENE AND TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 1999

KALAMA CHEMICAL INC.
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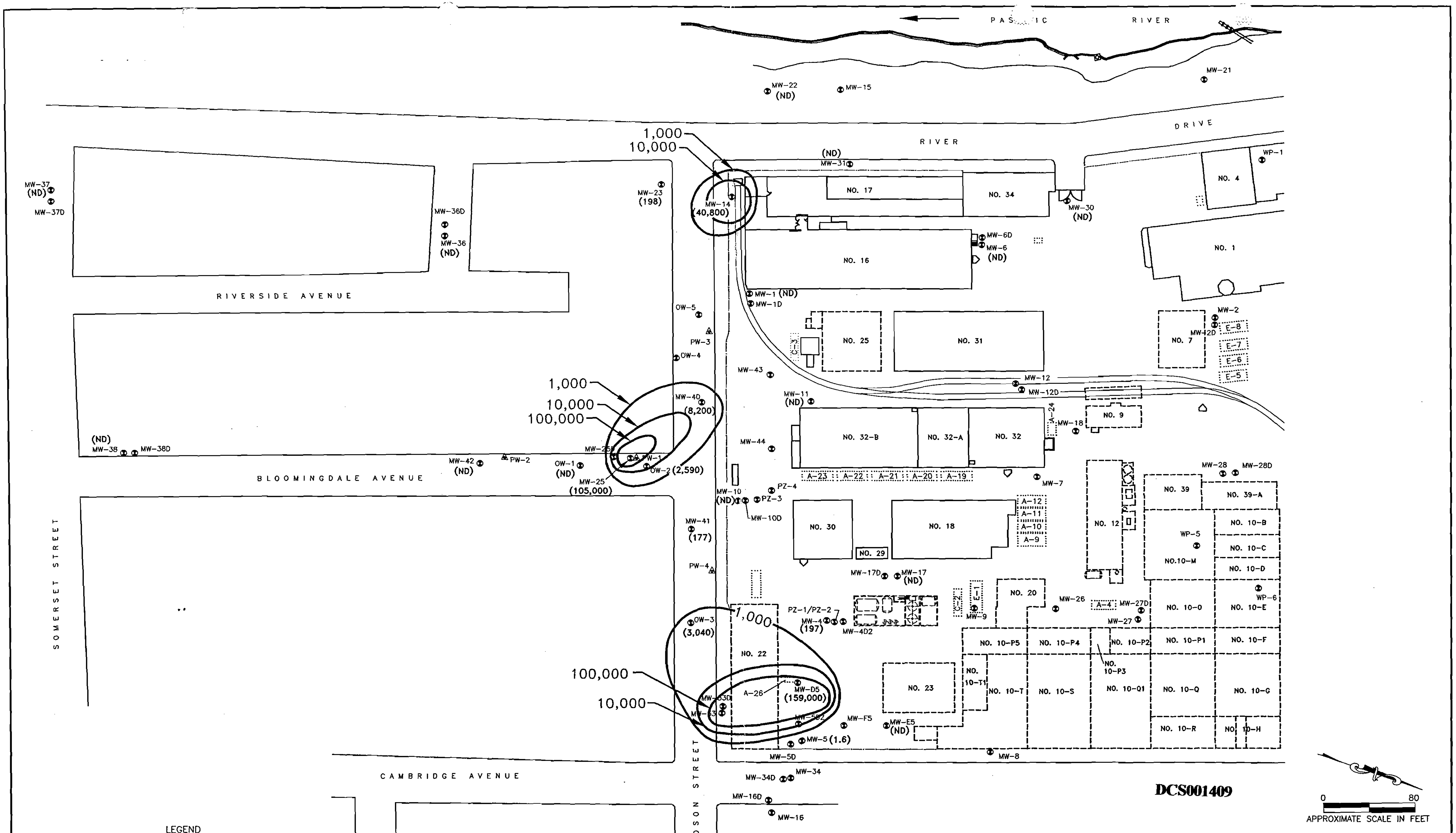

DCS001409

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(197)	TOLUENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 27
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 1999

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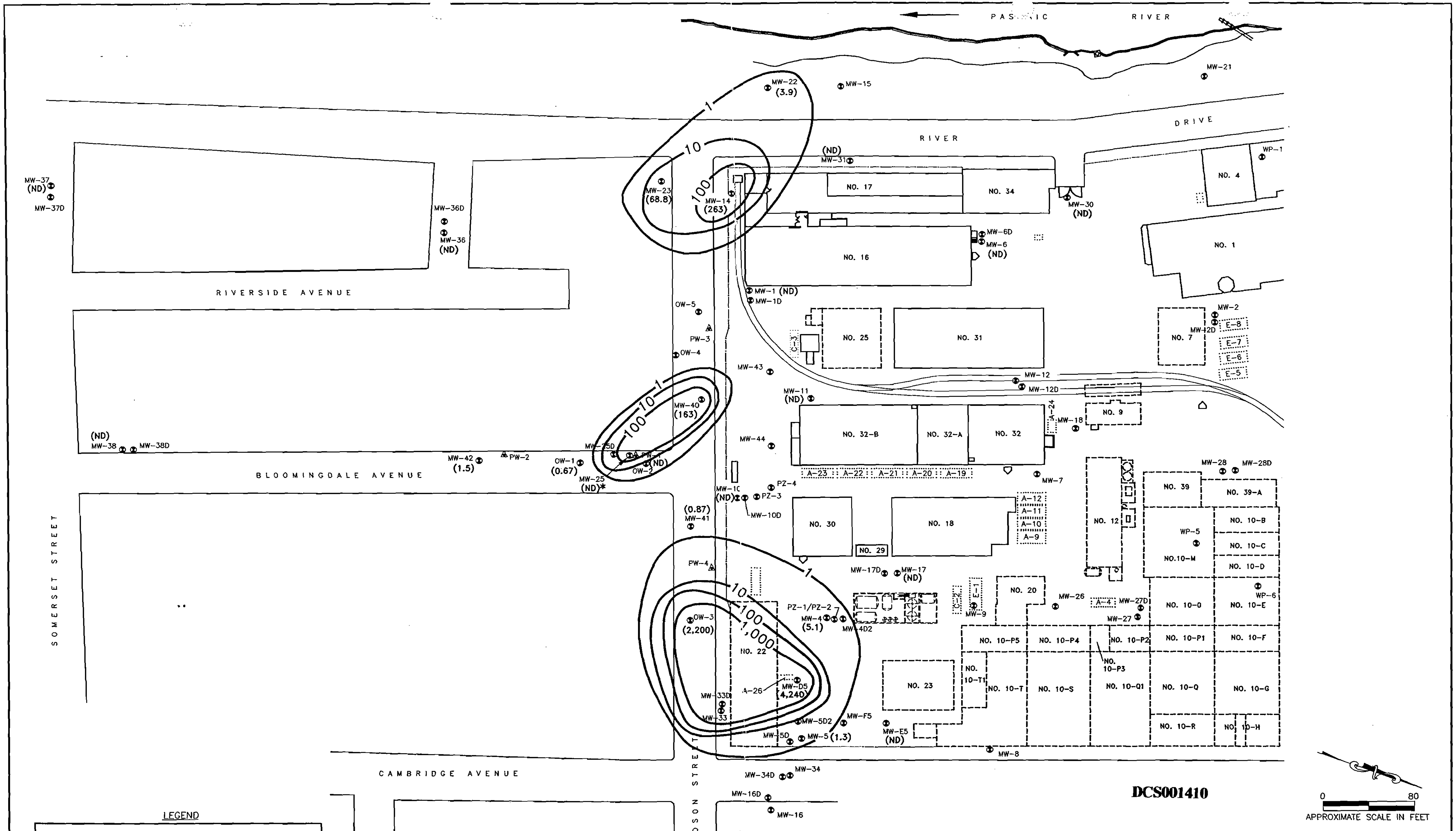

DCS001410

LEGEND

⊛ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(68.8)	BENZENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE
*	ELEVATED DETECTION LIMIT

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Date: 7/24/01

FIGURE 28
DISTRIBUTION OF BENZENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE
JULY 1999

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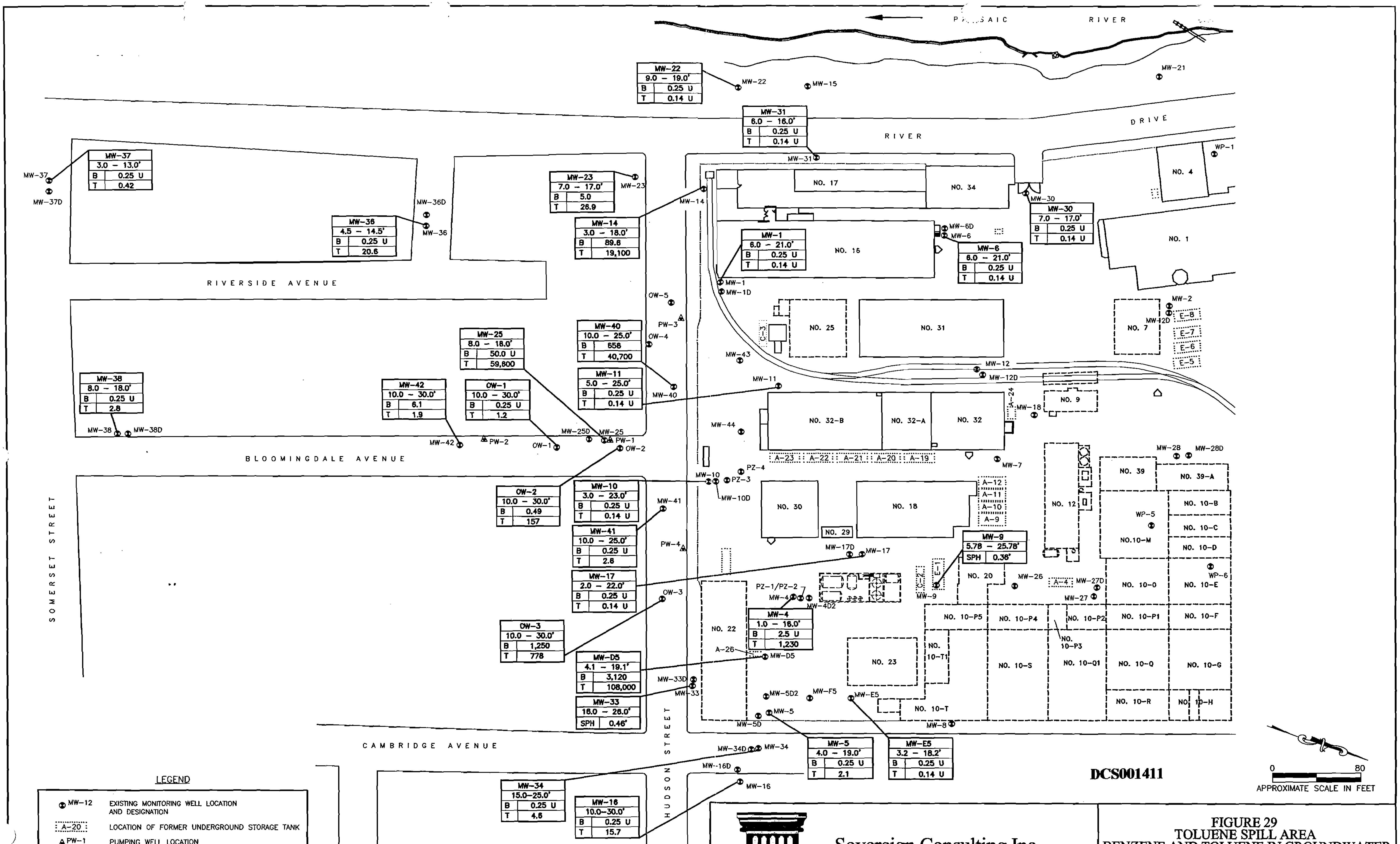

LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
10.0 – 30.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN µg/l
T	TOLUENE CONCENTRATION IN µg/l
U	NOT DETECTED
SPH	SEPARATE PHASE HYDROCARBONS (IN FEET)

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2–3.

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Date: 7/24/01

FIGURE 29
TOLUENE SPILL AREA BENZENE AND TOLUENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 1999

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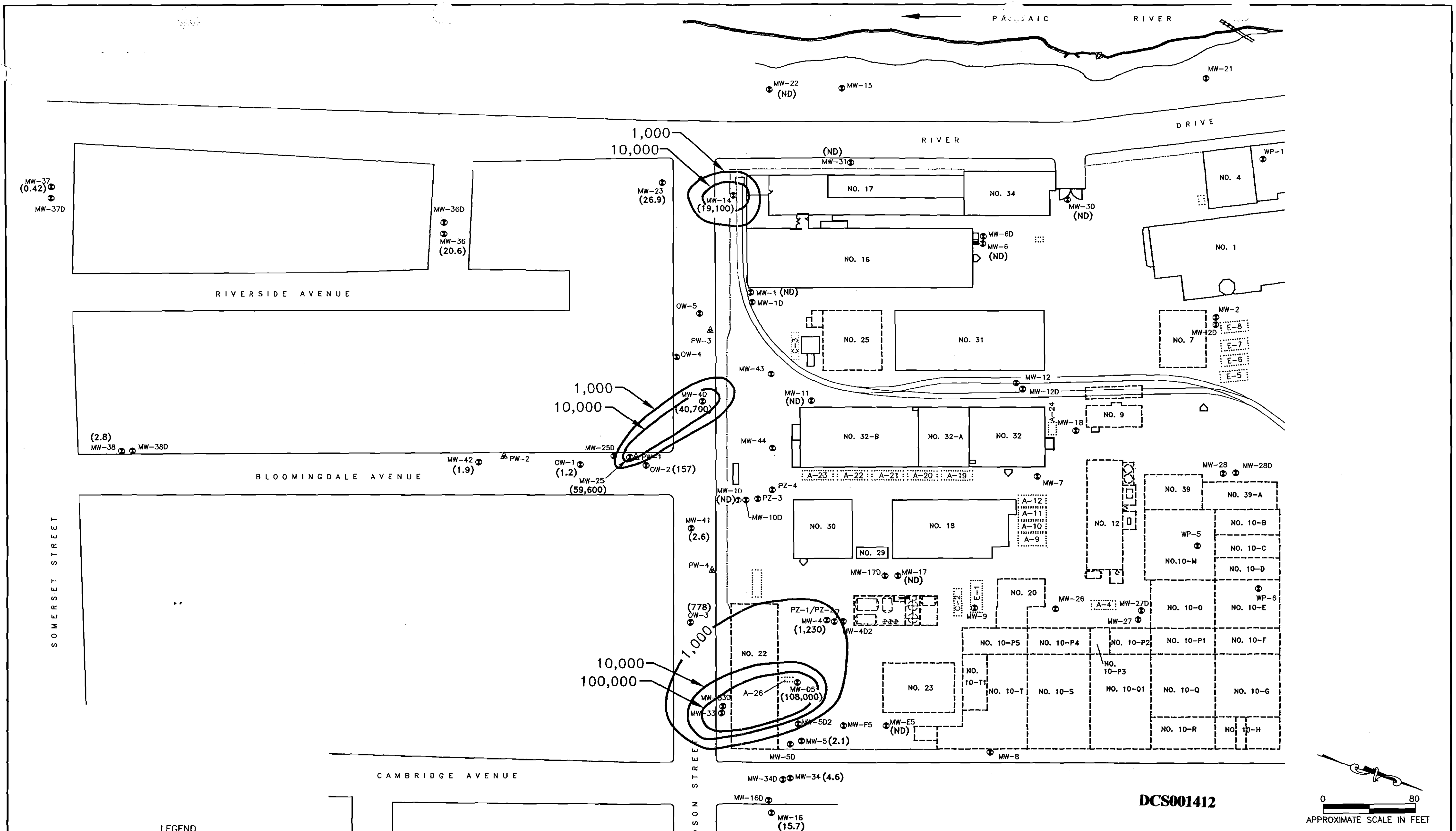

LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
△ PW-1	PUMPING WELL LOCATION
(778)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 —	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
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FIGURE 30
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 1999

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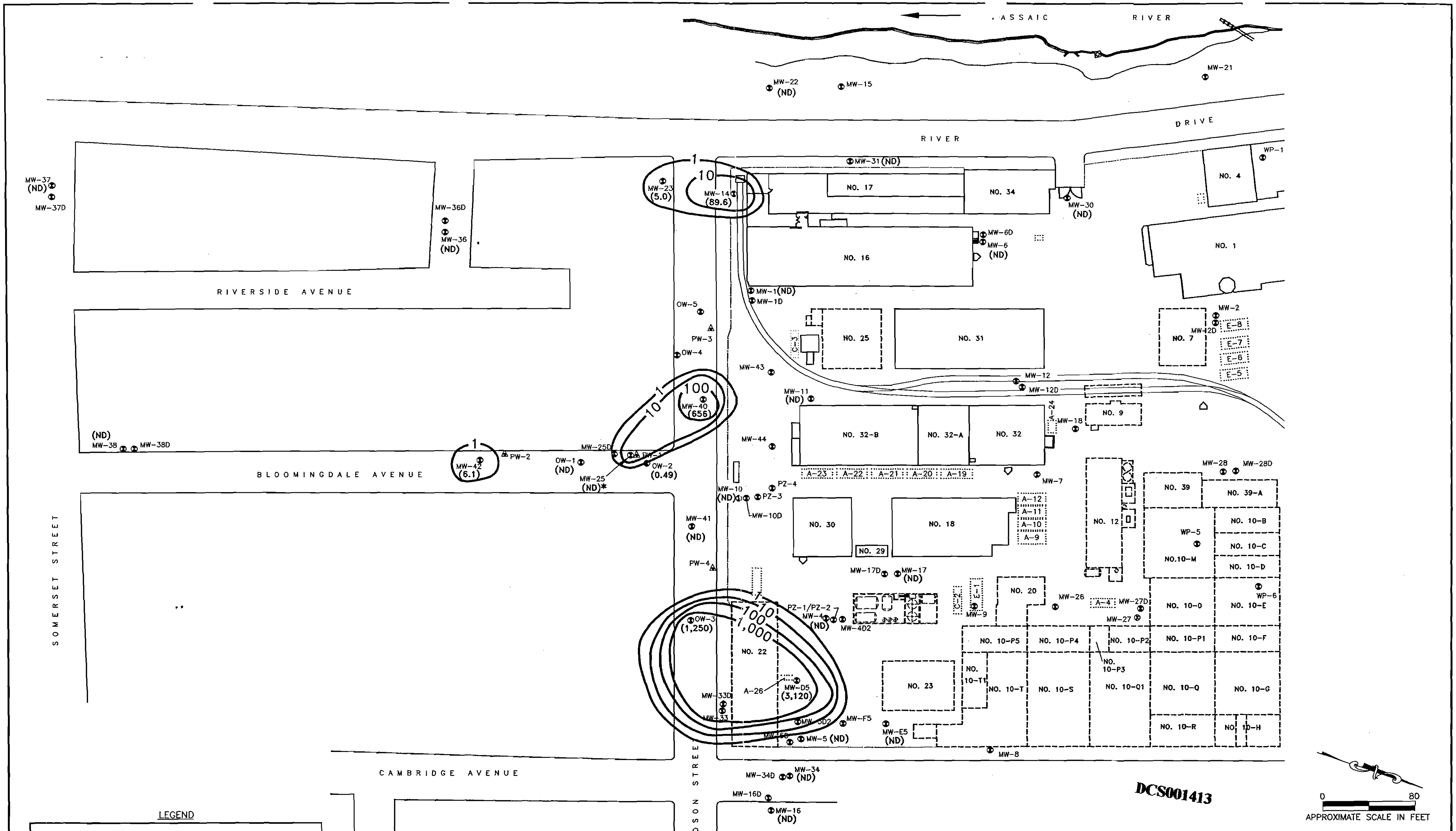

DCS001413

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(89.6)	BENZENE CONCENTRATION IN μg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE
*	ELEVATED DETECTION LIMIT

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 31
DISTRIBUTION OF BENZENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 1999

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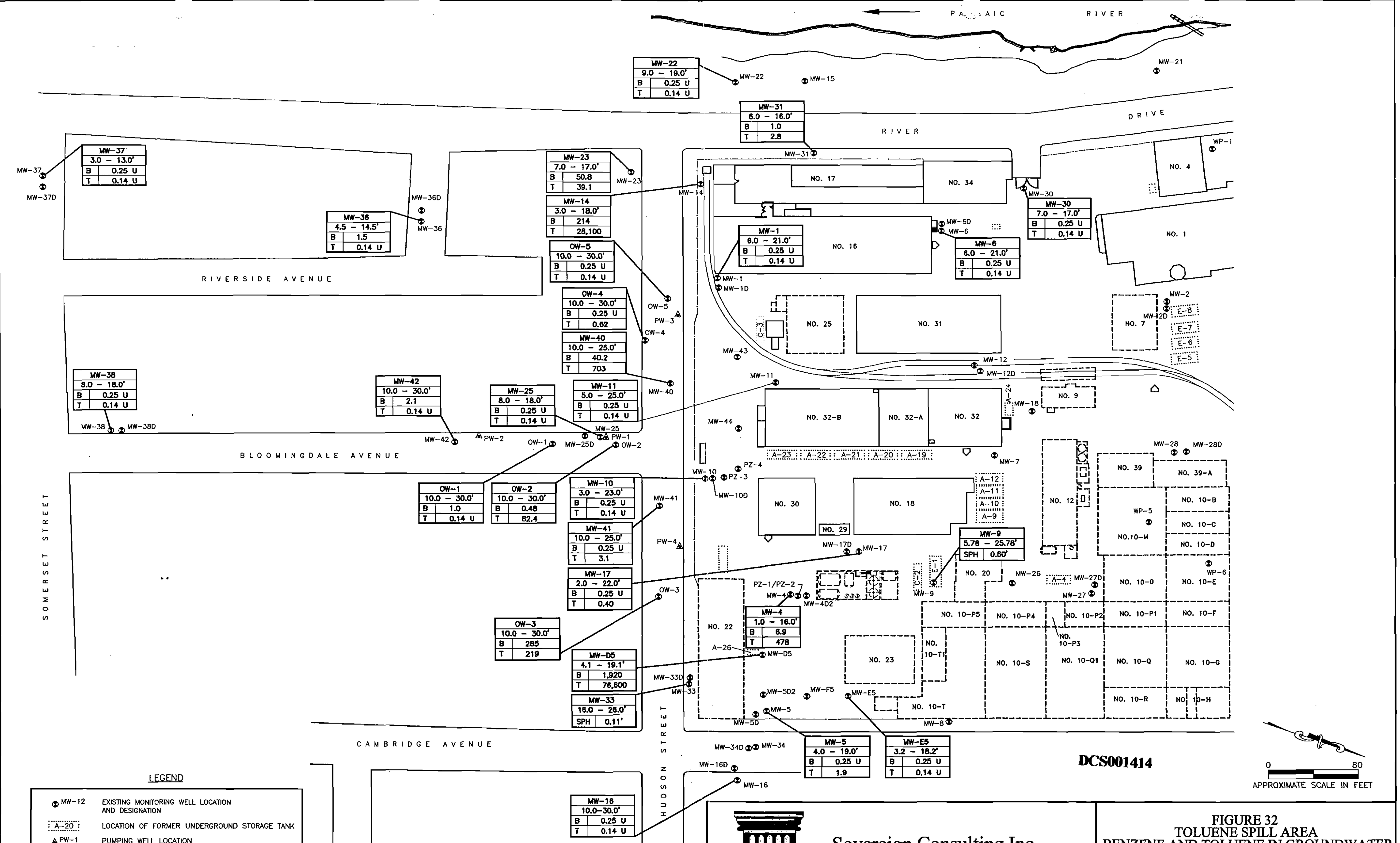

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
10.0 – 30.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN µg/l
T	TOLUENE CONCENTRATION IN µg/l
U	NOT DETECTED
SPH	SEPARATE PHASE HYDROCARBONS (IN FEET)

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
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FIGURE 32
TOLUENE SPILL AREA
BENZENE AND TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 2000

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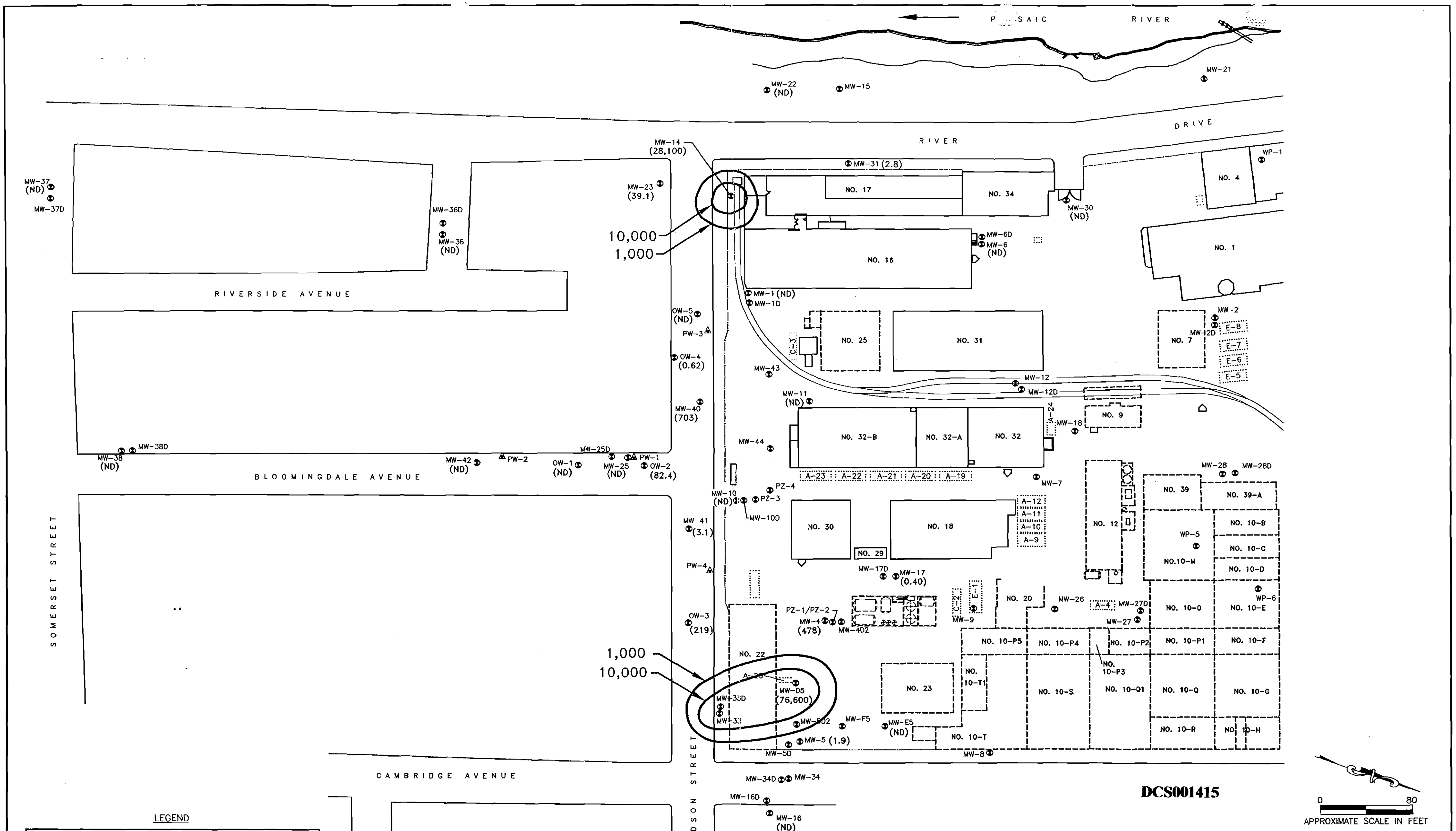
Project No. File: POINTMAP\KAL-FIG32-JULY01.dwg Date: 7/24/01



DCS001415

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(703)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 —	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Date: 7/24/01

FIGURE 33
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JANUARY 2000

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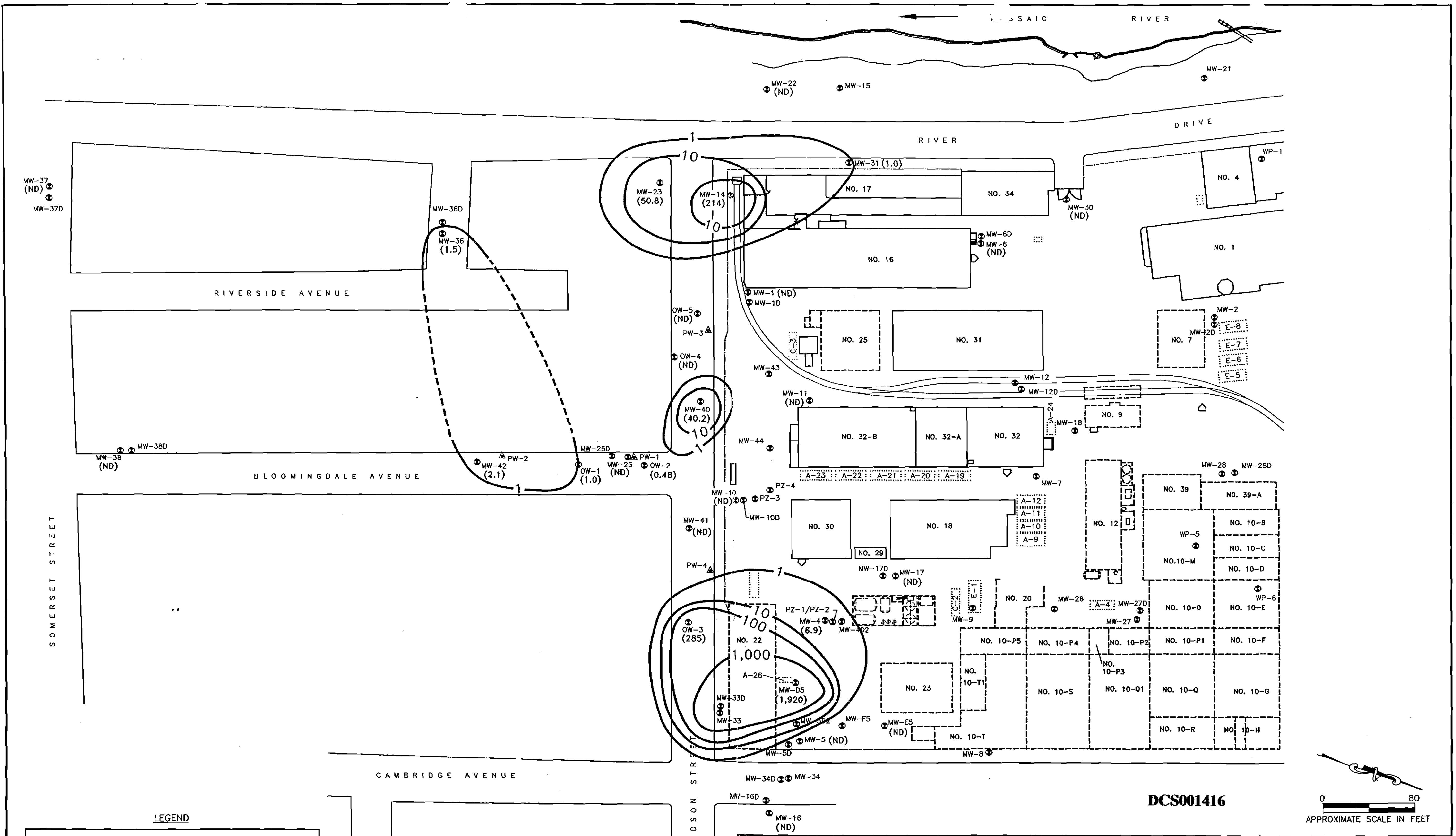

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(40.2)	BENZENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ———	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 34
DISTRIBUTION OF BENZENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE JANUARY 2000

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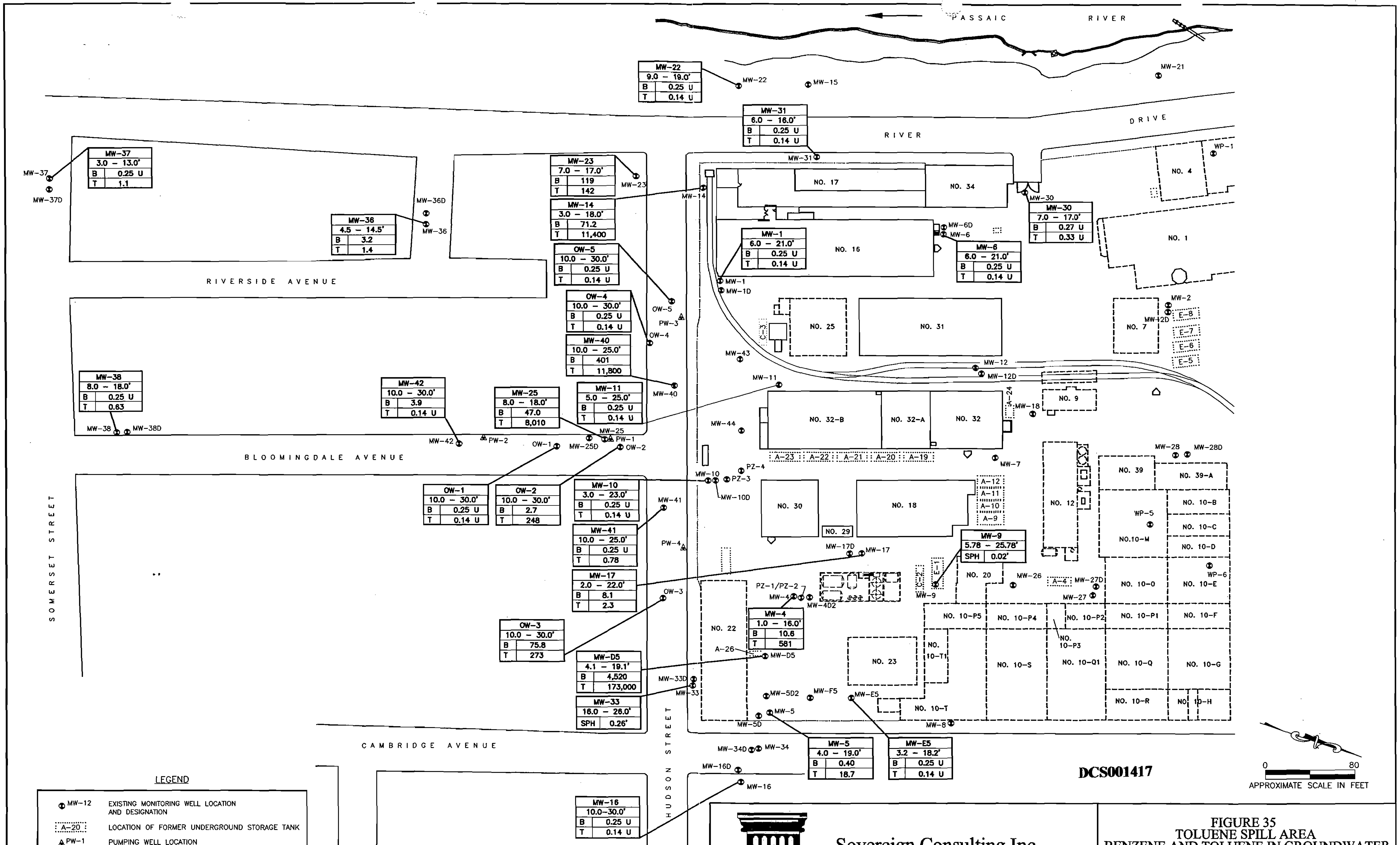
Project No. File: POINTMAP\KAL-FIG34-JULY01.dwg Date: 7/24/01



DCS001417

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
10.0 – 30.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
U	NOT DETECTED
SPH	SEPARATE PHASE HYDROCARBONS (IN FEET)

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 35
TOLUENE SPILL AREA
BENZENE AND TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2000

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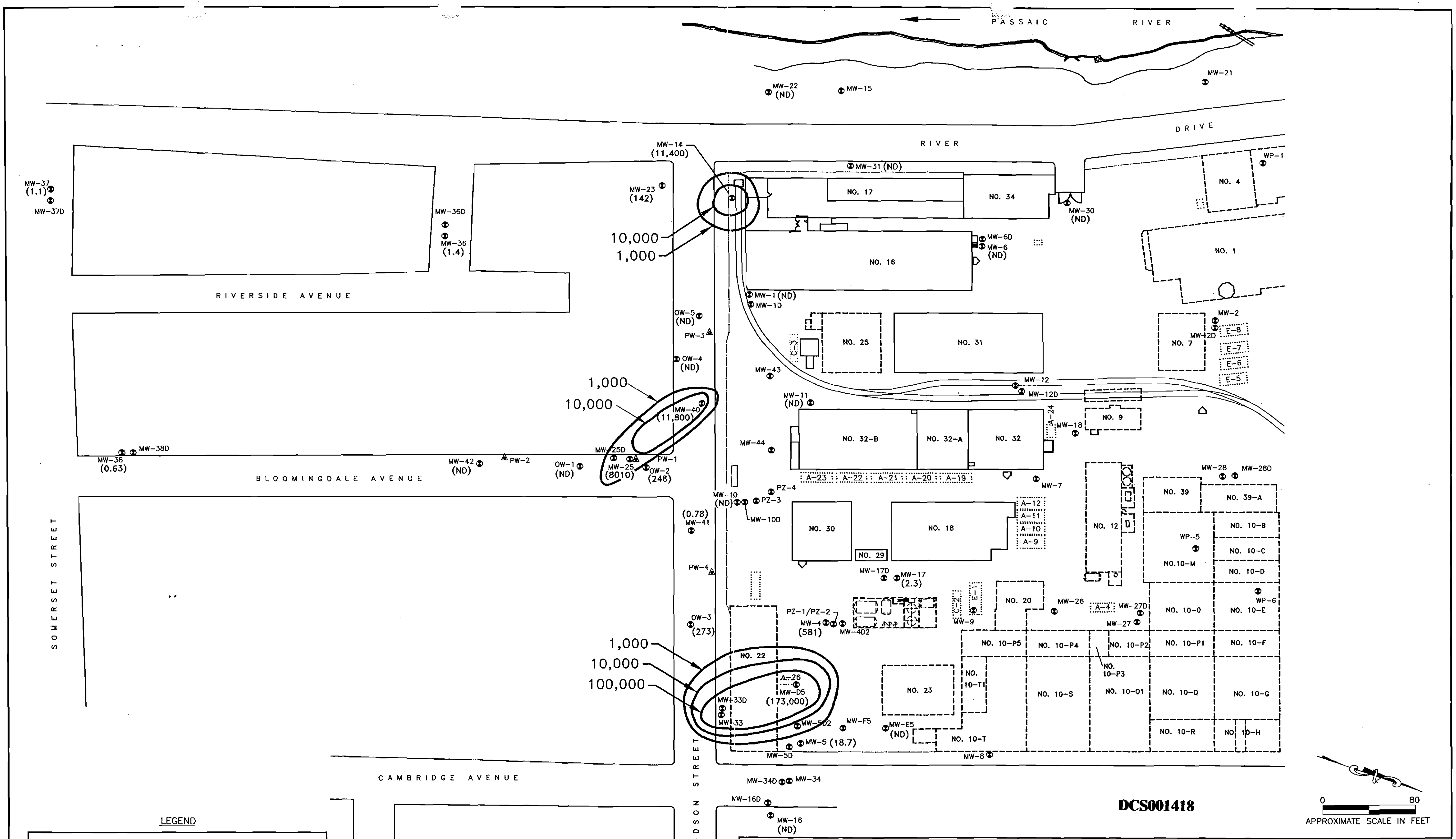
Project No.
File: POINTMAP\KAL-FIG35-JULY01.dwg
Date: 7/24/01



LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(581)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
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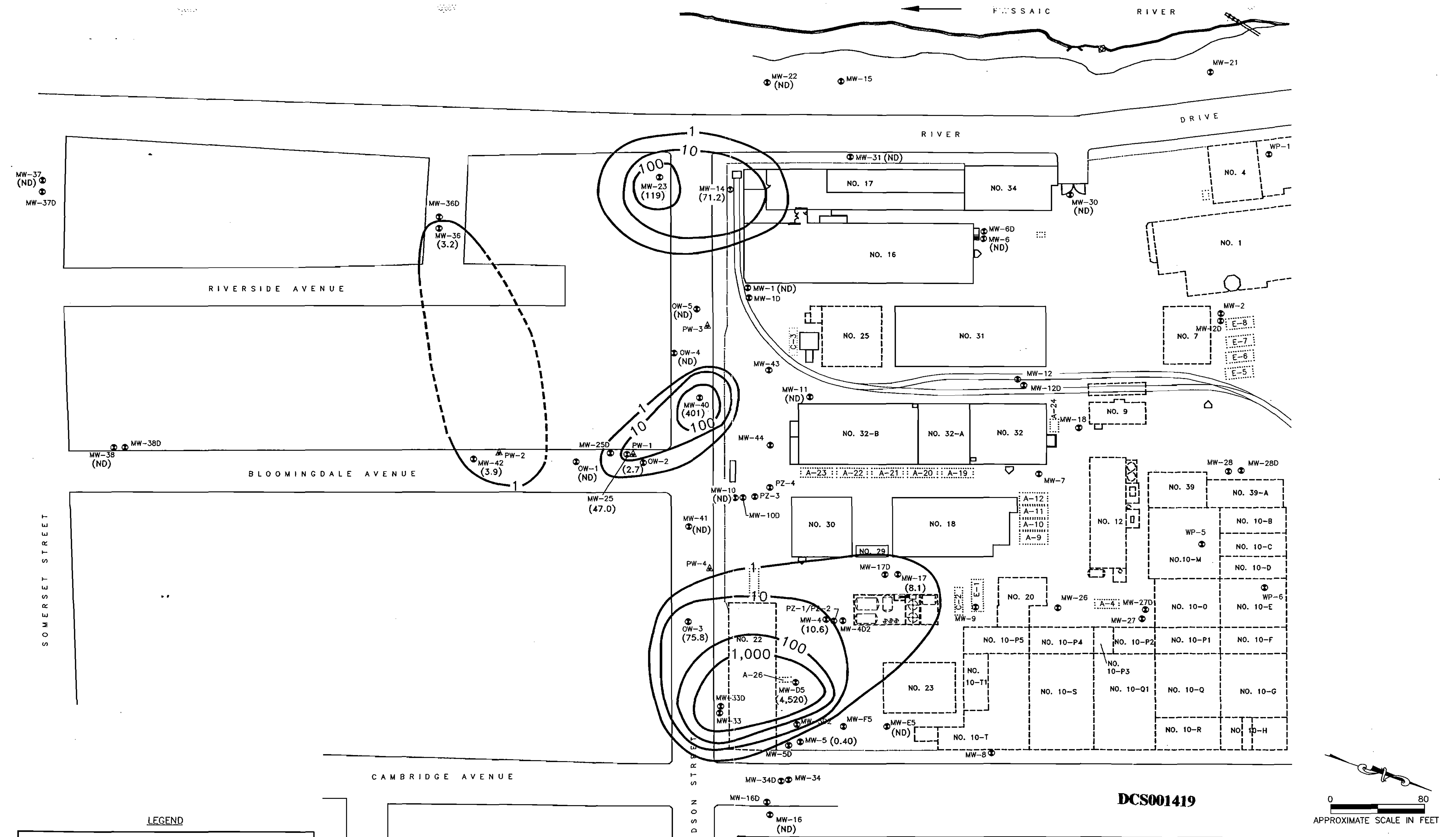
Project No. File: pointman\KAL-FIG36-JULY01.dwg Date: 7/24/01

FIGURE 36
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



DCS001419

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(47.0)	BENZENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Project No.
File: POINTMAP\KAL-FIG37-JULY01.dwg
Date: 7/24/01

FIGURE 37
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
APRIL 2000

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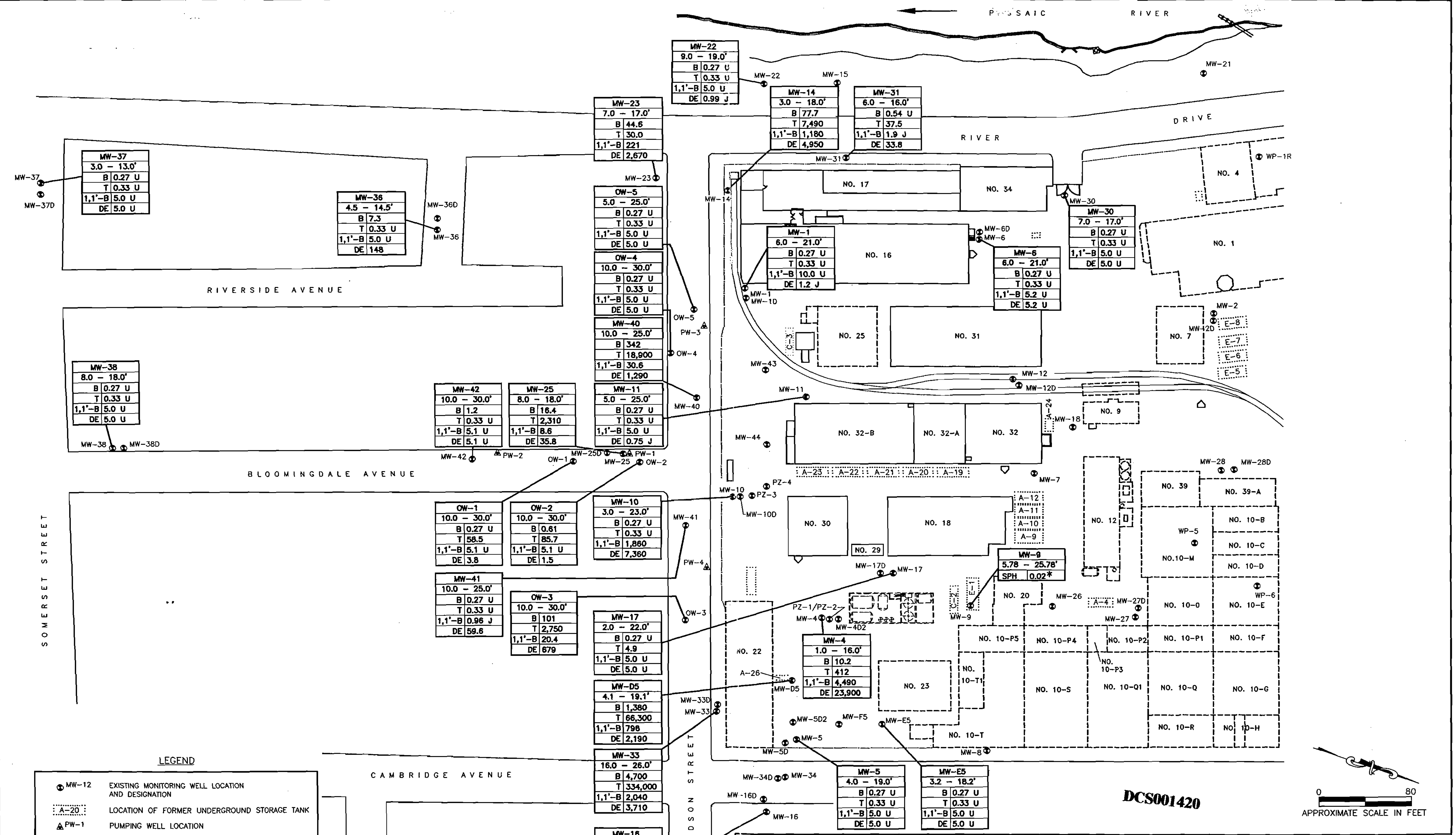
GARFIELD, NEW JERSEY



LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
10.0 – 30.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
1,1'-B	1,1'-BIPHENYL CONCENTRATION IN μg/l
DE	DIPHENYL ETHER CONCENTRATION IN μg/l
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
SPH	SEPARATE PHASE HYDROCARBONS (IN FEET)
*	SPH ENTERED WELL AFTER PURGING

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

DCS001420

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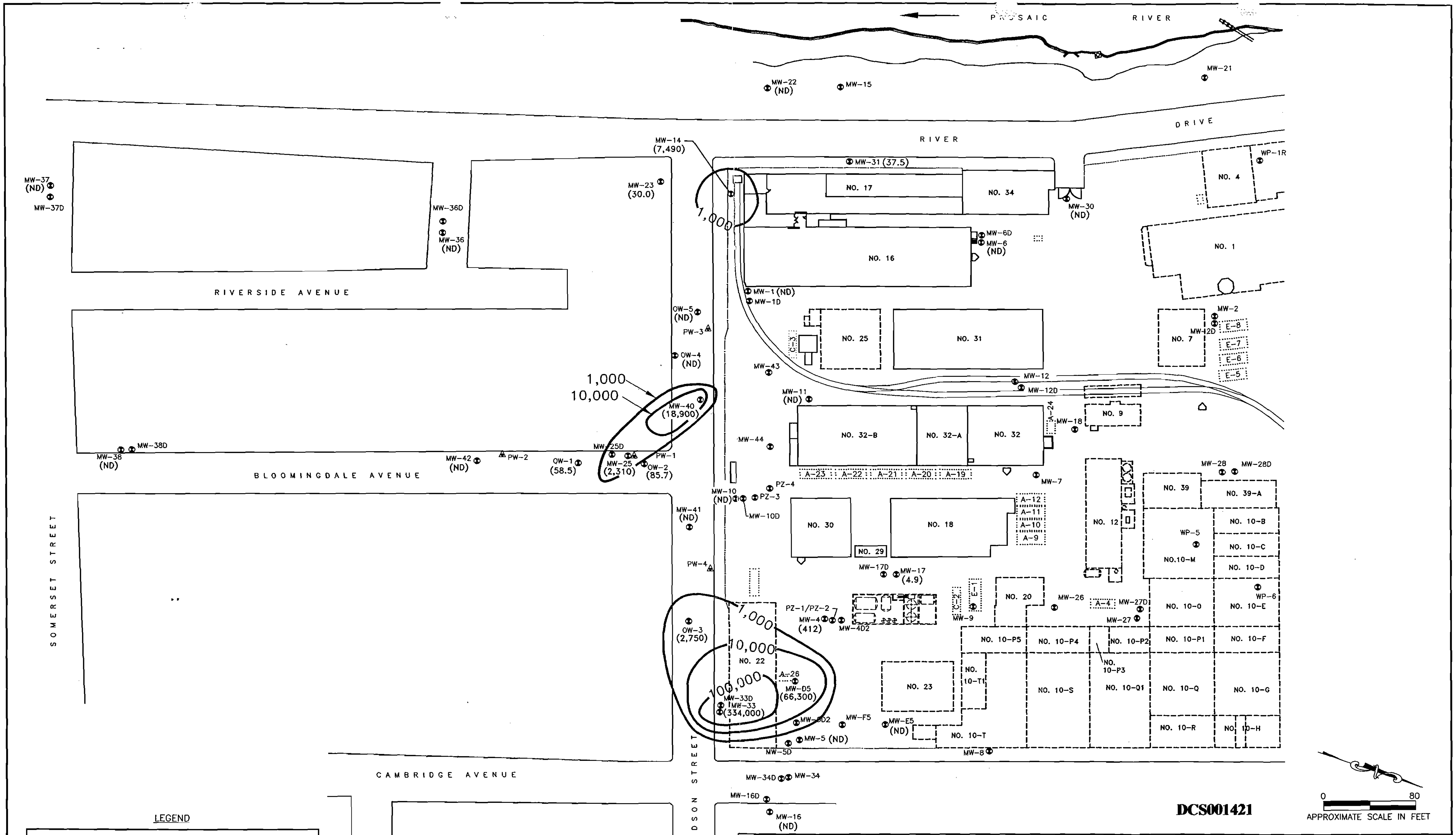
Project No.
File: POINTMAP\KAL-FIG38-JULY01.dwg
Date: 7/24/01

FIGURE 38
TOLUENE SPILL AREA
BENZENE, TOLUENE, 1,1'-BIPHENYL AND
DIPHENYL ETHER IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(412)	TOLUENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000—	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

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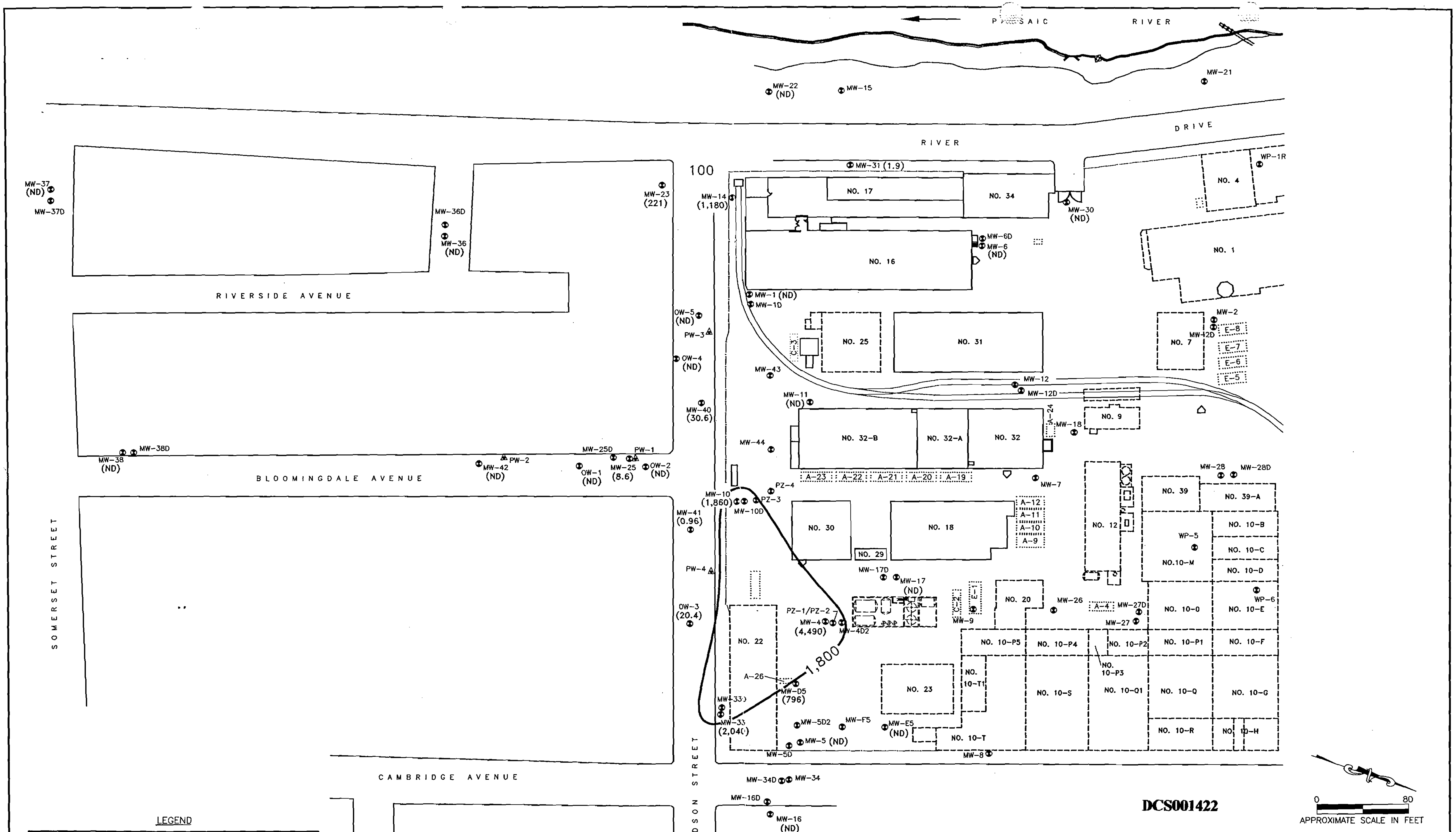
Project No.
File: POINTMAP\KAL-FIG39-JULY01.dwg
Date: 7/24/01

FIGURE 39
DISTRIBUTION OF TOLUENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE
JULY 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



DCS001422

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(796)	1,1'-BIPHENYL CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,800 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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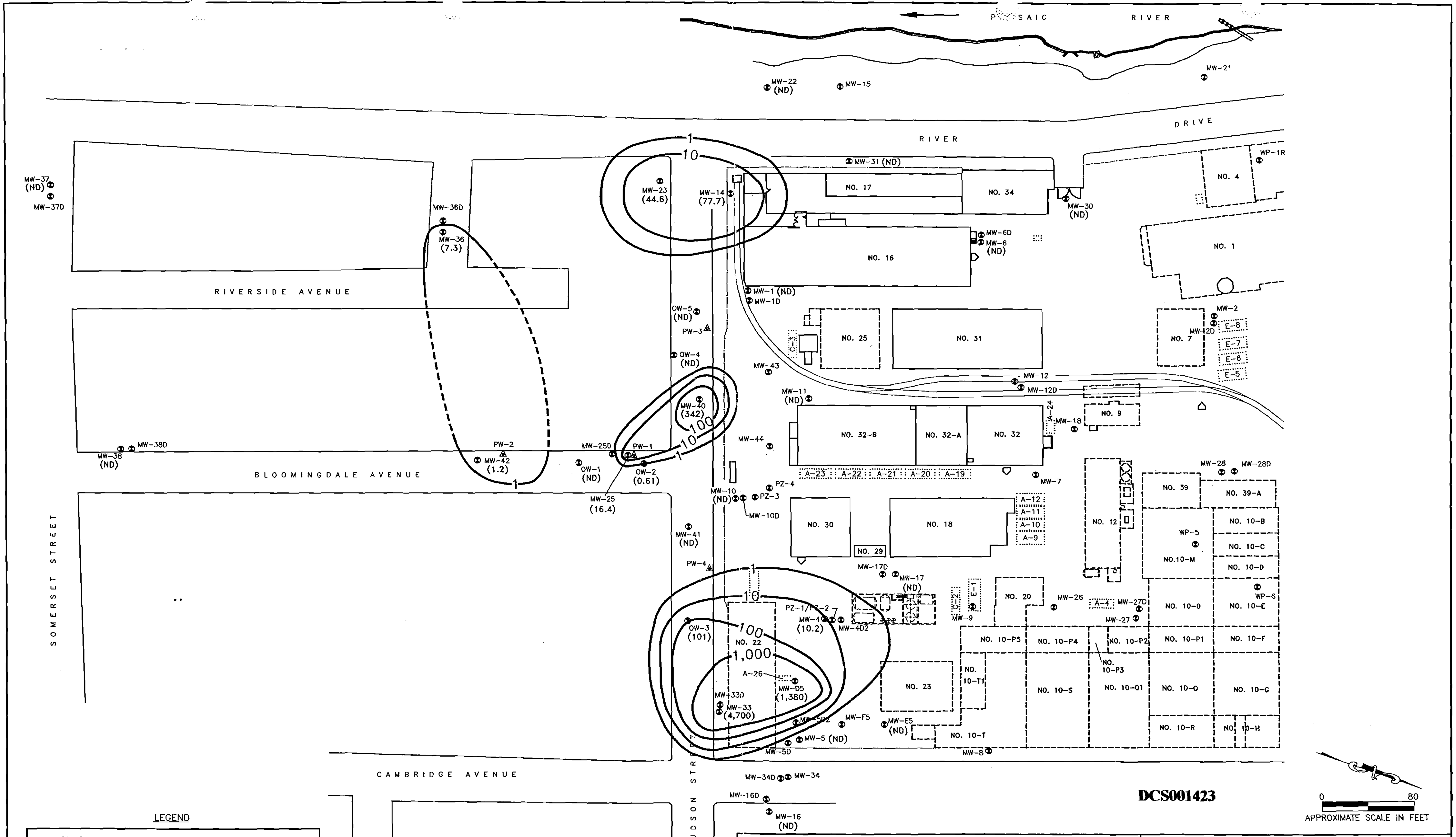
Project No.
File: POINTMAP\KAL-FIG41-JULY01.dwg
Date: 7/24/01

FIGURE 41
DISTRIBUTION OF 1,1'-BIPHENYL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
JULY 2000

KALAMA CHEMICAL INC.



DCS001423

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(101)	BENZENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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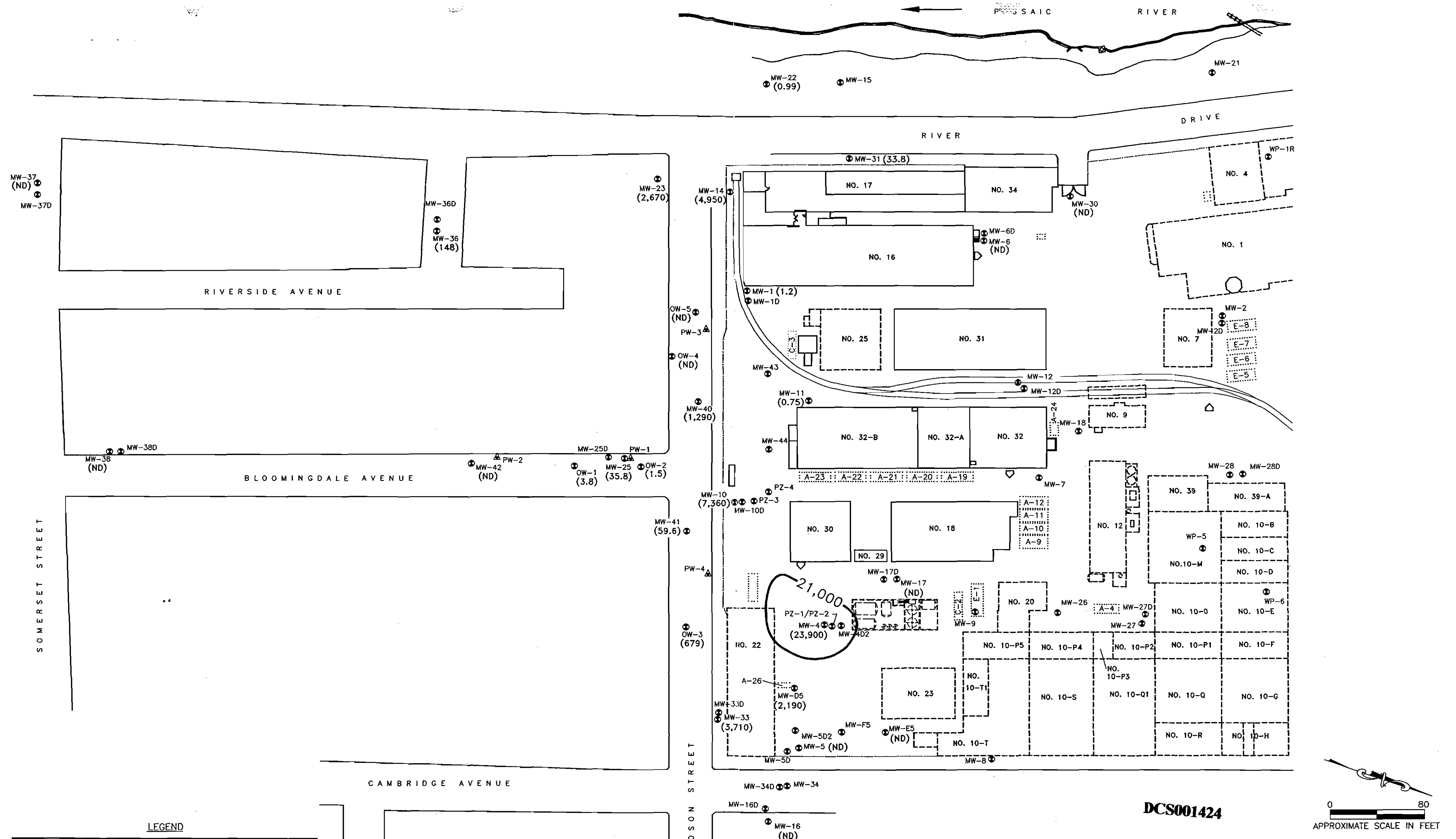
FIGURE 40
DISTRIBUTION OF BENZENE IN GROUNDWATER SHALLOW OVERBURDEN ZONE JULY 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No.
File: POINTMAP\KAL-FIG40-JULY01.dwg
Date: 7/24/01



DCS001424

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(148)	DIPHENYL ETHER CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
21,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 42
DISTRIBUTION OF DIPHENYL ETHER IN GROUNDWATER SHALLOW OVERBURDEN ZONE JULY 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No.
File: POINTMAP\KAL-FIG42-JULY01.dwg
Date: 7/24/00

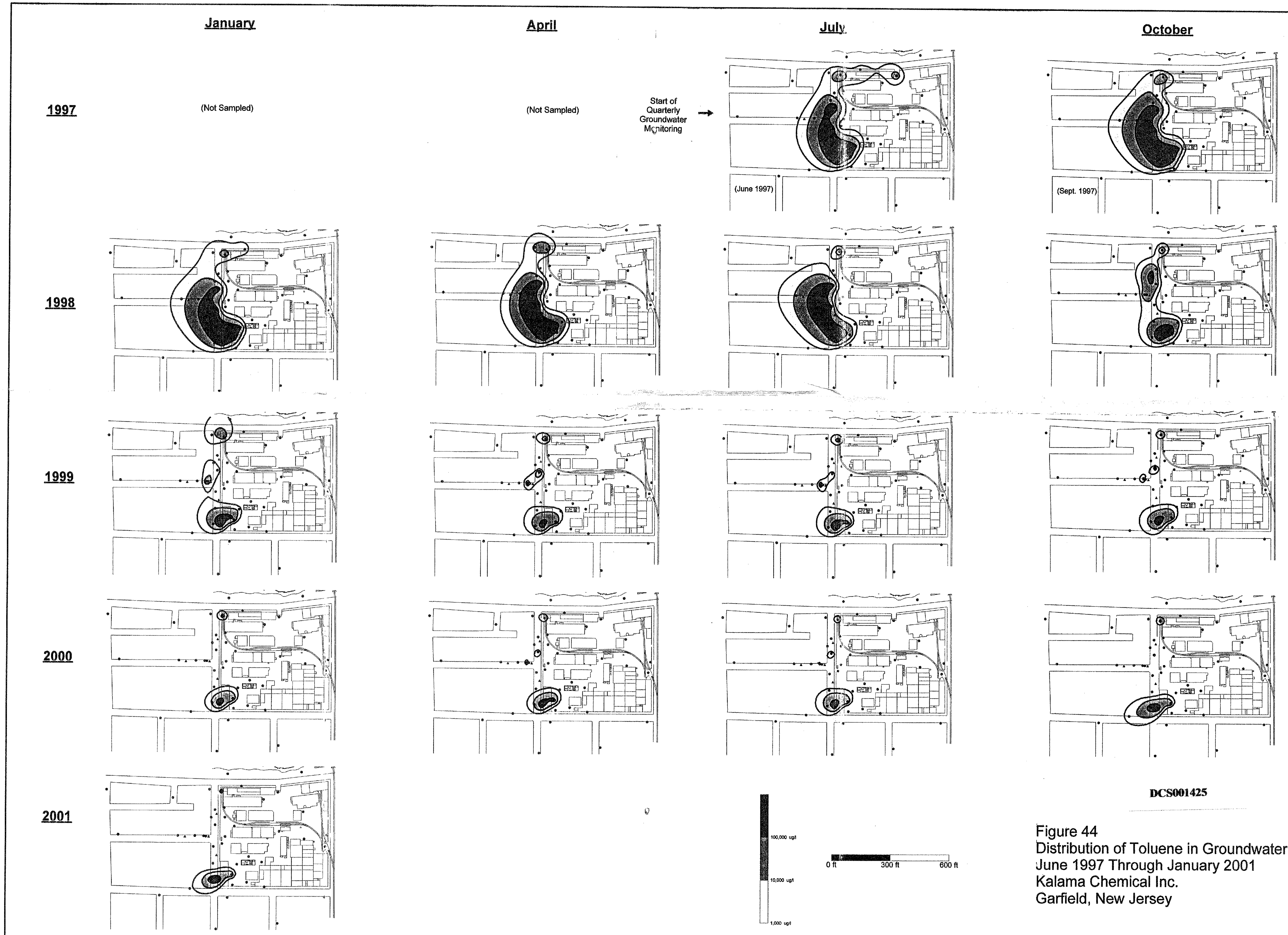


Figure 44
Distribution of Toluene in Groundwater
June 1997 Through January 2001
Kalama Chemical Inc.
Garfield, New Jersey

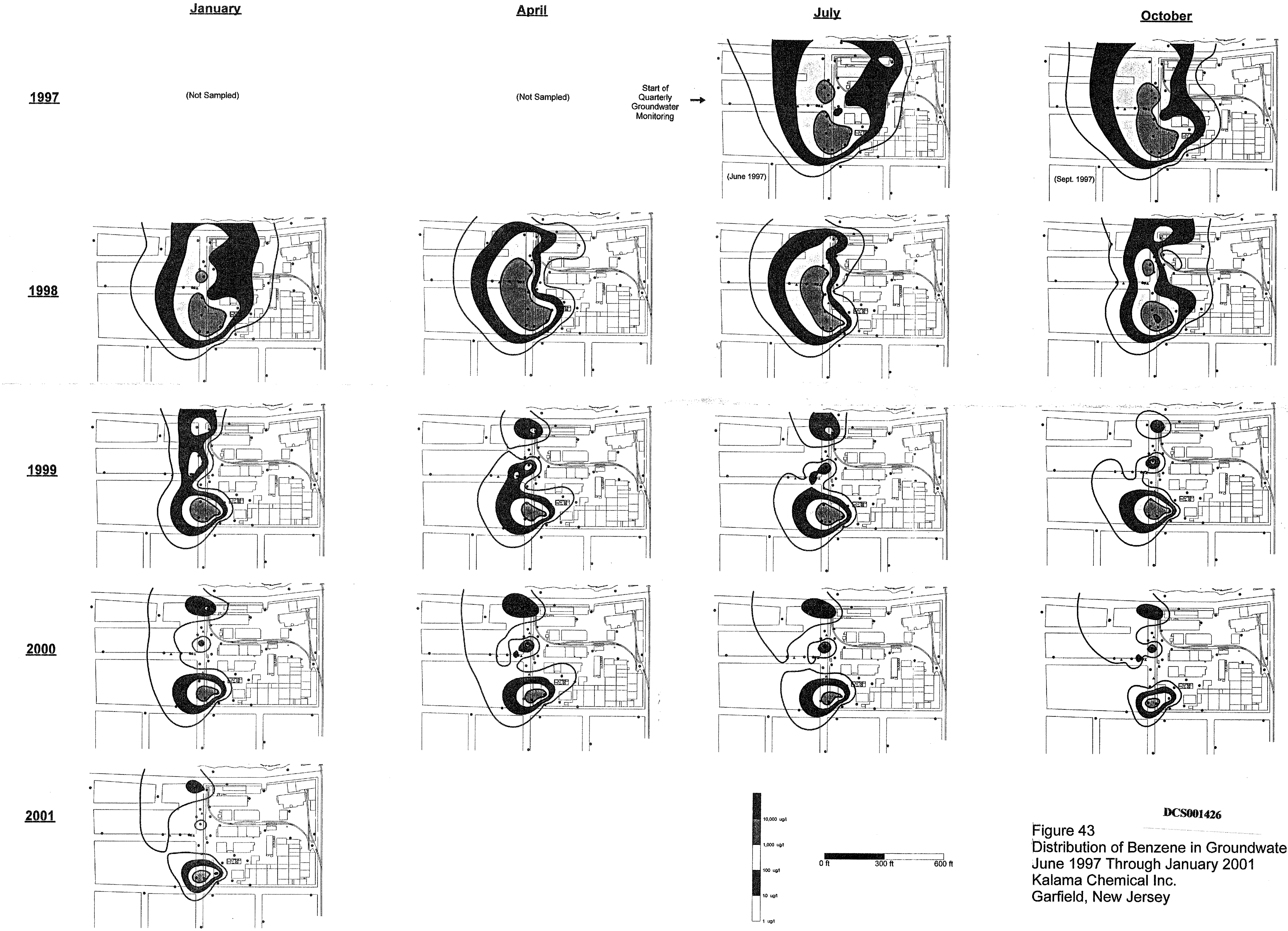
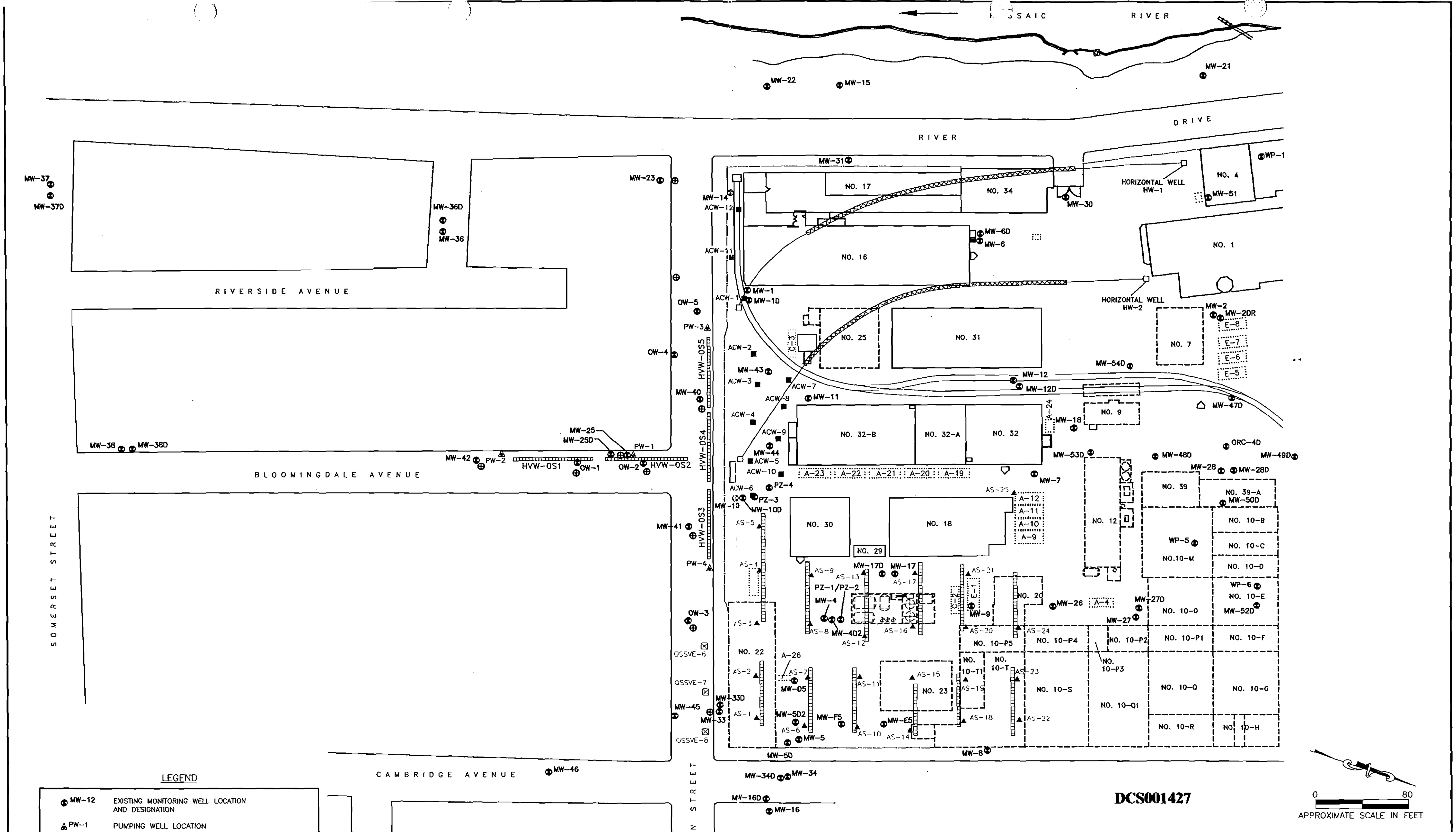


Figure 43
Distribution of Benzene in Groundwater
June 1997 Through January 2001
Kalama Chemical Inc.
Garfield, New Jersey



LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
▲ PW-1	PUMPING WELL LOCATION
■ ACW-2	VERTICAL AIR CURTAIN WELL
▲ AS-5	AIR SPARGE WELL LOCATION
☒ OSSVE-6	VERTICAL SVE WELL LOCATION
⊕	PROPOSED SOIL BORING LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

DCS001427

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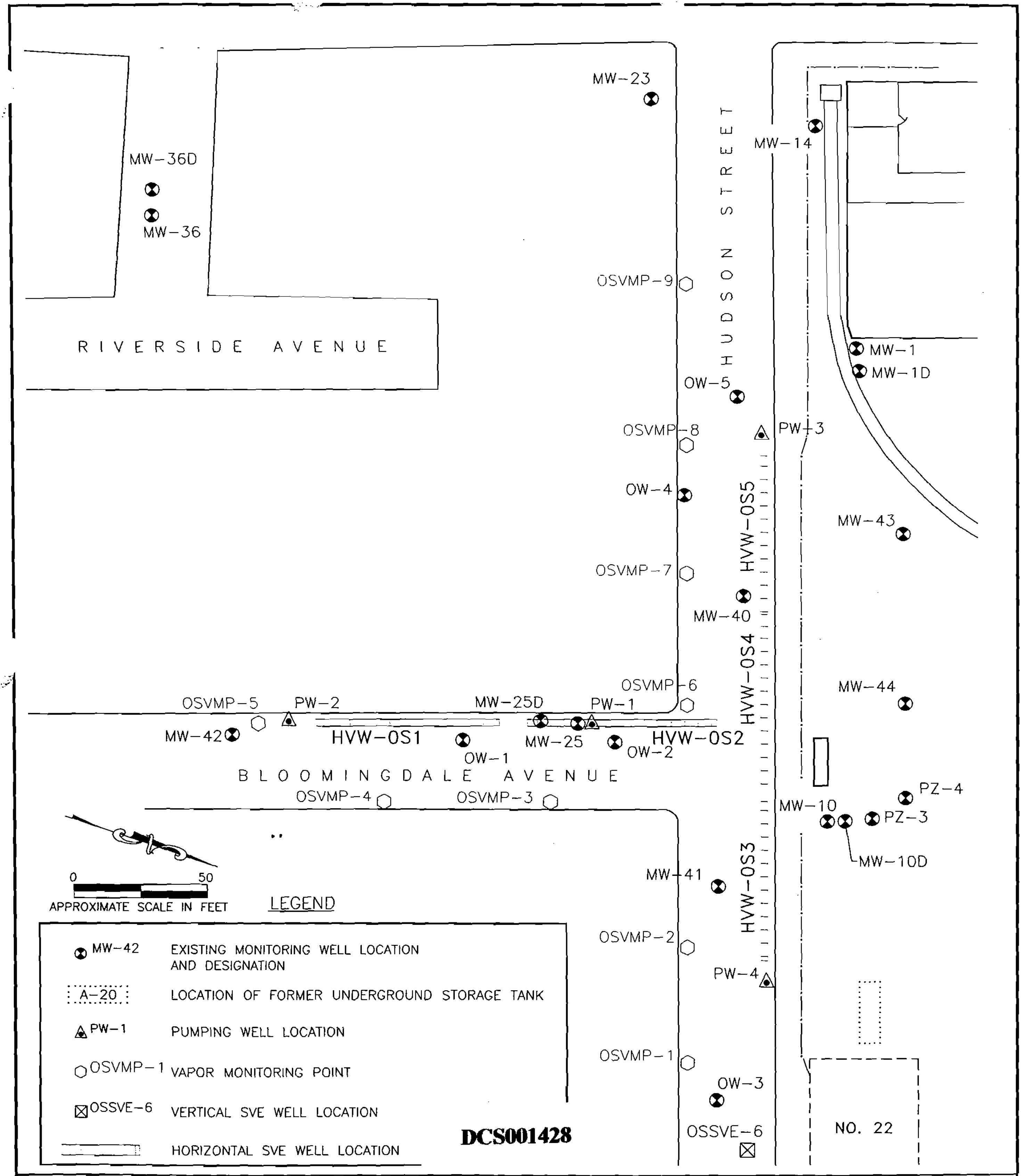
FIGURE 45
PROPOSED "SMEAR ZONE" INVESTIGATION SOIL BORING LOCATIONS

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. File: POINTMAP\KAL-FIG45-JULY01.dwg Date: 7/24/01



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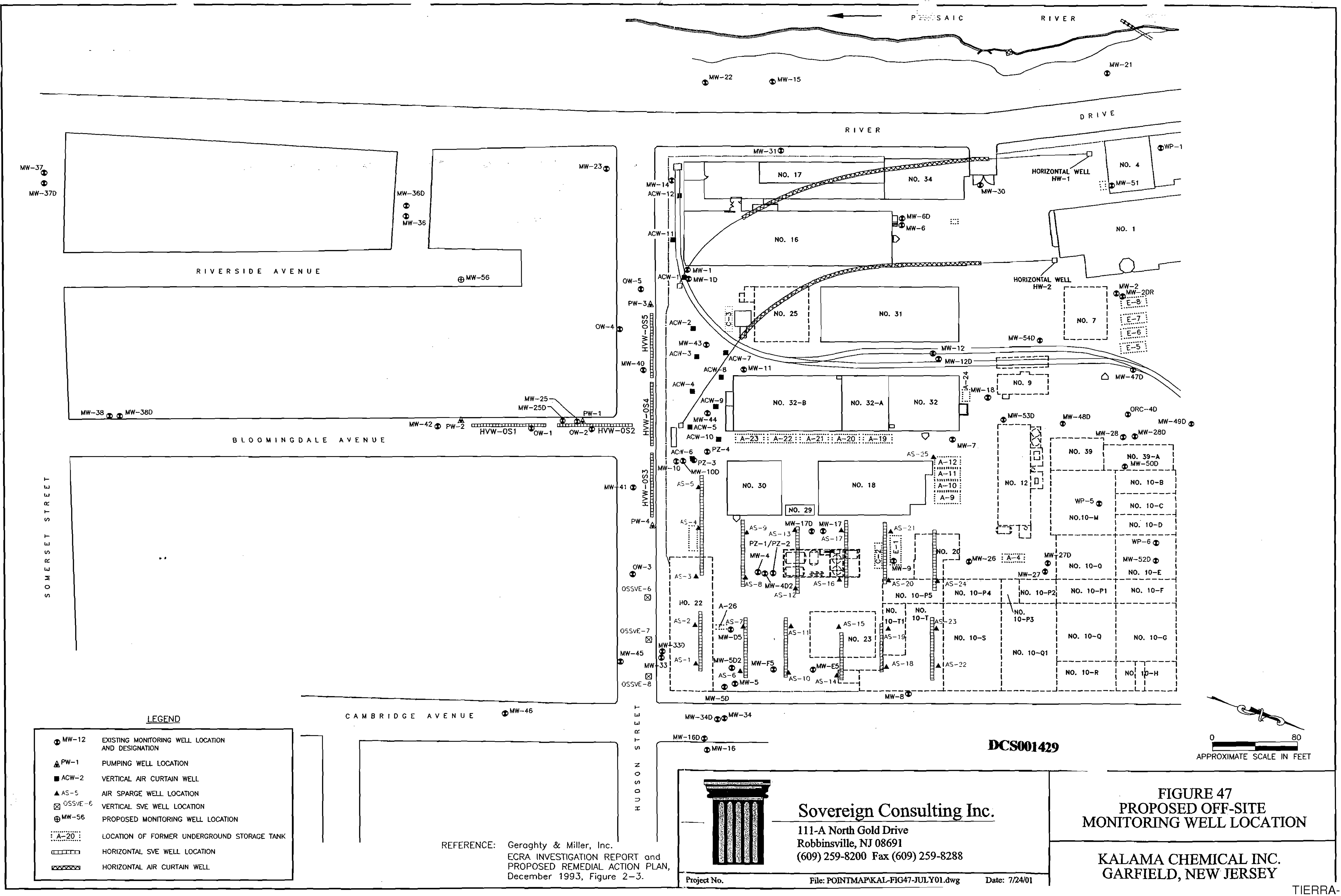
Project No. File: POINTMAP\KAL-FIG46-JULY01.dwg Date: 7/24/01

FIGURE 46
DPVE PILOT TEST AREA WELLS

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
PW-1	PUMPING WELL LOCATION
ACW-2	VERTICAL AIR CURTAIN WELL
AS-5	AIR SPARGE WELL LOCATION
OSSVE-6	VERTICAL SVE WELL LOCATION
MW-56	PROPOSED MONITORING WELL LOCATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▭▭▭	HORIZONTAL SVE WELL LOCATION
▨	HORIZONTAL AIR CURTAIN WELL

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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Robbinsville, NJ 08691
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Project No.
File: POINTMAP\KAL-FIG47-JULY01.dwg
Date: 7/24/01

FIGURE 47
PROPOSED OFF-SITE MONITORING WELL LOCATION

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

SOVEREIGN CONSULTING INC.

L

1 December 2000

Mr. Andrew Dillman
New Jersey Department of Environmental Protection
Bureau of Environmental Evaluation Cleanup & Responsibility Assessment
Division of Responsible Party Site Remediation
401 E. State Street, 5th Floor
P.O. Box 432
Trenton, New Jersey 08625-0432

RECEIVED
DEC 1 2000

RE: Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

HAND DELIVERED

Dear Mr. Dillman:

Attached please find an original and two copies of the *Quarterly Groundwater Sampling Results* report for the monitoring event conducted between 10 and 12 October 2000 at the above referenced site. This report has been prepared by Sovereign Consulting Inc. (SCI) on behalf of EPEC Polymers Inc. (EPI). In addition, one copy of Attachment I (Analytical Data Packages) and one computer diskette containing the required electronic data deliverables are also being provided.

EPI initiated a groundwater monitoring program in June 1997 to establish a base-line against which remediation progress could be compared. Groundwater sampling is currently conducted in January, April, July, and October, with the next quarterly monitoring event scheduled for 23 - 26 January 2001.

If you should have any questions or require additional information, please feel free to contact me at (609) 259-8200 or Mr. Roger Towe of El Paso Energy Corporation (EPEC) at (713) 420-4755.

Sincerely,
Sovereign Consulting Inc.

Paul I. Lazaar
Principal Project Manager

c: Project File
R. Towe, EPEC
T. LoBue, BFGoodrich Kalama
R. Smith, Belkorp Industries

111-A N. Gold Drive • Robbinsville, NJ 08691 • Tel: 609-259-8200 • Fax: 609-259-8288

SOVEREIGN CONSULTING INC.

Quarterly Groundwater Sampling Results
10 - 12 October 2000

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

1 December 2000

Prepared For:

EPEC Polymers, Inc.
1001 Louisiana Street
Houston, Texas 77002

Prepared By:

Sovereign Consulting Inc.
111-A North Gold Drive
Robbinsville, New Jersey 08691

Paul I. Lazaar, P.G.
Principal Project Manager

Ravi Gupta
Principal E

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (SCI) has prepared this *Quarterly Monitoring Report* for the groundwater sampling event conducted from 10 to 12 October 2000 at the Kalama Chemical Inc. site in Garfield, New Jersey (Figure 1). A groundwater monitoring program was originally proposed to the New Jersey Department of Environmental Protection (NJDEP) in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan has not yet been approved by the NJDEP, a monitoring program was implemented in June 1997 to establish a base-line against which remediation progress could be compared. The monitoring program started in June 1997 has subsequently been modified to include additional compounds of concern.

The January 1995 groundwater sampling event identified three areas of the site requiring remediation and/or monitoring: 1) the Northeast Phenol Hot Spot (Former Building 10/36); 2) the Northwest Phenol Hot Spot (Former Building 33-B); and, 3) the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14). In addition, benzene, toluene, phenol, benzoic acid, methanol, and formaldehyde were identified as the six primary compounds of concern in groundwater, although the distribution of these compounds varied across the site.

Based on the results of grab groundwater samples collected following the demolition of the Building 10/36 complex, salicylic acid (or 2-hydroxybenzoic acid) was added to the list of analytical parameters for the monitoring wells in the Northeast Phenol Hot Spot area. Based on the quarterly sampling results from June 1997 through October 1998, phenol and benzoic acid are no longer considered to be compounds of concern in the Toluene Spill Area and have been eliminated from the monitoring program for the wells addressing this AEC. The results from the 13 previous quarterly monitoring events will be submitted to the NJDEP as part of the response to the Department's 26 June 2000 letter.

In response to comments in the NJDEP's letter dated 26 June 2000, 1,1'-biphenyl and diphenyl ether were added to the monitoring program for wells addressing the Toluene Spill Area during the July 2000 sampling event.

1.1 Groundwater Quality Standards

The groundwater quality standards (GWQS) for the six primary compounds of concern identified at the Kalama site are summarized below.

Site Specific Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Benzene	1.0
Toluene	1,000
Phenol	4,000
Benzoic Acid	30,000
Methanol	3,500
Formaldehyde	110

The benzene, toluene, and phenol standards are from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The standard for methanol was proposed in the March 1995 Revised RAW and was approved by the NJDEP in their letter dated 6 September 1995. The values for benzoic acid and formaldehyde were established by the NJDEP in their 30 August 1996 letter following the submission of proposed standards in the Revised RAW Addendum.

Although there is only limited health-risk data specific to salicylic acid, toxicological and health-risk information for the general class of salicylates indicates that the ingestion of up to 150 parts per million (ppm) of salicylates does not cause adverse health effects in children. Therefore, EPI has been using a groundwater quality standard of 30,000 ppb for salicylic acid, which is the same as had been approved by the NJDEP for benzoic acid.

In the 22 April 1998 *Remedial Investigation Report* (RIR) detailing the results of the dense non-aqueous phase liquid (DNAPL) investigation that had been conducted around former Building 23, EPI proposed a groundwater standard of 1,750 ppb for both 1,1'-biphenyl and diphenyl ether. In their letter dated 24

August 1998, the NJDEP indicated that the Interim Generic Groundwater Quality Standard (IGGWQS) of 100 ppb for non-carcinogen synthetic organic compounds (SOCs) should be applied. Although EPI believes that a higher standard should be applied for these compounds, the 100 ppb IGGWQS has been used for this report.

1.2 Monitoring Well Abandonment and Installation

On 29 June 1998, well point WP-3, which was located in the basement of Building 36, was abandoned during the demolition of this building by a licensed New Jersey well sealer from Summit Drilling Co., Inc. (Summit). Since WP-3 was a source area well for phenol in the deep overburden zone in the northeast corner of the site, a replacement well (WP-3R) was installed to continue monitoring natural biodegradation and attenuation processes.

On 1 October 1998, replacement well WP-3R was installed using a hollow stem auger drill rig operated by a New Jersey licensed driller (Summit). Fill material consisting of silty sand, stones, and brick fragments were encountered while drilling through the basement. Auger refusal (assumed to be part of the concrete floor of the basement) was encountered at nine feet below grade in the first boring attempted (within five feet of the original well location). The replacement well was successfully installed in a second boring drilled three feet further away from the original well location.

Since the basement of Building 36 was approximately 10.0 feet deep, and since WP-3 originally extended 10 feet below the floor of the basement, replacement well WP-3R was installed to a depth of 20.0 feet below grade. The well was constructed with 10.0 feet of 2.0-inch diameter, 20-slot, Sch. 40 PVC screen and 10.0 feet of PVC casing. However, while removing the augers from the borehole, they became stuck on debris in the fill material which resulted in the well material be dragged upward approximately three feet. Although the final depth of WP-3R is only 17 feet below grade, there is sufficient overlap with the screened interval of the original well to insure that the same groundwater zone is being monitored. The well head for WP-3R was completed with a protective steel standpipe and locking cap. The location and elevation of WP-3R were measured by a licensed New Jersey professional surveyor. A copy of the well log for WP-3R is included in Appendix A.

Well points WP-1 and WP-2, which were located in the basements of Building 33 and Building 33-B, respectively, were abandoned on 6 January 2000. Each well was sealed by a licensed New Jersey well driller from Summit, prior to the demolition of the Building 4/33/33-A/33-B complex. Since WP-2 was a source area well for phenol in the northwest corner of the site, and WP-1 was the closest downgradient monitoring point, both wells were replaced to continue monitoring natural biodegradation and attenuation processes.

Replacement wells for well points WP-1 and WP-2 were installed on 16 June 2000. The material used to fill in the basements of Building 33 and 33-B was comprised primarily of sand and gravel, and the floor in the basements was broken up during the demolition process. Therefore, both replacement wells were able to be installed using a hollow stem auger drill rig. Since the basement of Building 33 was approximately 8.0 feet deep, and since WP-1 extended 12.0 feet below the floor of the basement, replacement well WP-1R was installed to a depth of 20.0 feet below grade. Similarly, since the basement of Building 33-B was approximately 10.0 feet deep, and since WP-2 extended 6.0 feet below the floor of the basement, replacement well WP-2R was installed to a depth of 16.0 feet below grade.

Each replacement well was able to be installed immediately adjacent to the original well location. WP-1R was constructed with 10 feet of 2.0-inch diameter, 20-slot, Sch. 40 PVC screen and 12.0 feet of PVC casing (to account for the stick-up above grade). WP-2R was constructed with 5.0 feet of 2.0-inch diameter, 20-slot, Sch. 40 PVC screen and 13.0 feet of PVC casing. The length of screen in the replacement wells is identical to the original wells. Each well head was completed with a protective steel standpipe and locking cap. The locations and elevations of each well were measured by a licensed New Jersey professional surveyor.

Fill material consisting of gravel, silt, and fine, medium, and coarse sand was encountered while drilling through the basements. Continuous split spoon soil samples were collected from 10.0 feet below grade to the completion depth of each well. At both well locations, native soil (consisting of fine sand, silt, and clay) was not encountered until 14.0 feet below grade. No detectable concentrations of volatile organic compounds (VOCs) were found using a photo-ionization detector (PID) during the installation of WP-2R. However, PID readings of 22.2 ppm to 33.5 ppm were detected from 16.0 to 20.0 feet below grade at the location of WP-1R. Copies of the well logs for WP-1R and WP-2R are included in Appendix A.

During the demolition of Building 1, the top of MW-2D was severely damaged, which allowed soil and debris to enter and fill the bottom 10.0 feet of the well. Several attempts to redevelop MW-2D to remove the obstruction were unsuccessful, and it became necessary to abandon the well. On 26 October 2000, Summit abandoned MW-2D by first over-drilling the well to remove all well materials from the subsurface, and then sealing the borehole to grade with grout. Since MW-2D monitored the downgradient extent of compounds of concern from the Northeast Phenol Hot Spot in the deep overburden zone, a replacement well was required.

The replacement well for MW-2D was also installed by Summit on 26 October 2000. MW-2DR is located approximately 3.0 feet of the original well location, has a depth of 34.0 feet, and is constructed with 10.0 feet of 4.0-inch diameter, 20-slot, Sch. 40 PVC screen and approximately 26.0 feet of PVC casing (to account for the stick-up above grade). The screened interval of MW-2DR is identical to that of the original well. The well head was completed with a protective steel standpipe and locking cap; the location and elevation of the well was measured by a licensed New Jersey professional surveyor. A copy of the well log for MW-2DR is included in Appendix A.

2.0 GROUNDWATER SAMPLING PROCEDURES

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of separate phase hydrocarbons (SPH) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones. If three well volumes could not be purged due to poor recharge, the water level in the well was allowed to recover to within two feet of static conditions (or sufficiently to allow sample collection) prior to sampling.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rates generally ranged from 1.0 to 1.5 gallons per minute (gpm). In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

Before Purging

- Date, time, and weather conditions
- Well number
- Head space reading immediately after well cap is removed
- Product thickness, if any
- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

Well purging information is summarized on the tables included in Appendix B.

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for VOC analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling. At the end of each day, the samples for benzene, toluene, phenol, salicylic acid, 1,1'-biphenyl, diphenyl ether, and methanol were either delivered to the analytical laboratory (Accutest in Dayton, New Jersey; Certification No. 12129) or returned to the office where they were picked up by an Accutest courier the following morning. The formaldehyde samples were shipped via overnight courier to STL/Savannah Laboratories (STL/SL) in Tallahassee, Florida. Copies of the analytical data packages for these samples (including the electronic data disk deliverables) are included under separate cover as Attachment I.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

3.0 GROUNDWATER SAMPLING RESULTS

Groundwater samples were collected from 57 wells between 10 and 12 October 2000. Monitoring well MW-9 was not sampled due to the presence of a heavy sheen on the groundwater. Monitoring well MW-2D was damaged during the demolition of Building 1 and could not be sampled. A sample could not be collected from well point WP-6 since the well did not recharge after purging. All wells were sampled the day they were purged, except MW-4 which did not recharge sufficiently on 11 October 2000, and was not sampled until the following day. The monitoring program and sampling results for the three source areas are discussed separately, below.

3.1 Groundwater Elevations

Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 1 and were used to prepare the groundwater elevation contour maps shown on Figure 2 and Figure 3. No measurable amounts of SPH were found in any wells during this monitoring event.

Figure 2 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. The air sparging system in the southeast corner of the site and the vertical and horizontal injection wells of the air curtain in the southwest corner of the site were both in operation at the time of sampling. The gauging data from MW-1, MW-11, MW-41, OW-2, OW-4, and OW-5 were not used in preparing Figure 2 due to surging groundwater resulting from the air curtain injection wells. A water table mound is still present in the northeast corner of the site, most likely due to the clay layer that is underlies this area. Groundwater elevation contours for the deep overburden zone are shown on Figure 3. The direction of groundwater flow in the deep overburden zone is generally westward, with no apparent mounding.

3.2 Northeast Phenol Hot Spot (Former Building 10/36)

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones in the area of former Building 10/36 in the northeast corner of the site, groundwater samples were collected from the following wells:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, WP-3R, WP-5, WP-6, ORC-2, ORC-4D
Monitoring Points	MW-2, MW-2D/2DR, MW-3, MW-3D, MW-12D, MW-18, MW-28, MW-32, MW-32D

As was discussed in Section 1.2, MW-2D was damaged during building demolition activities and could not be sampled. Replacement well MW-2DR was not installed until after the October 2000 monitoring event was completed, but will be included in future sampling events. Monitoring wells MW-47D through MW-50D were installed in July 2000 as part of an investigation of the elevated concentrations of phenol, salicylic acid, and methanol present in ORC-4D. Each well is 33.0 feet deep, and is screened entirely within the deep overburden zone. The findings of this investigation will be submitted to the NJDEP as part of the remedial action work plan addendum.

Both the shallow overburden zone (i.e., above the clay layer) and the deep overburden zone (below the clay layer) have historically contained compounds of concern at concentrations exceeding the GWQS. Each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015-Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315. The results of these analyses are summarized on Table 2 and are presented on Figures 4 and 5. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix C. The historical (i.e., before July 1998) salicylic acid concentrations shown in Appendix B were taken from the library search portions of the previous semi-volatile analyses. Since no calibrations were performed for salicylic acid when these analyses were performed, the reported concentrations should only be considered estimates.

3.2.1 *Shallow Overburden Zone*

The shallow overburden zone in the source area is monitored by WP-5, WP-6, and ORC-2 (Figure 4). The concentrations of phenol, methanol, formaldehyde, and salicylic acid in WP-5 and ORC-2 were either not detectable or below their GWQS in each well during this monitoring event. As indicated in Section 3.0, well point WP-6 did not recharge after purging and could not be sampled.

None of the groundwater samples from the downgradient monitoring points in the shallow overburden zone (MW-2, MW-3, MW-18, MW-28, and MW-32) had detectable concentrations of phenol, salicylic acid, formaldehyde, or methanol (except MW-18 which contained 2.3 ppb of phenol and 8.9 ppb of salicylic acid).

Since January 1998, the concentrations of phenol and methanol in the shallow overburden zone have been below their respective GWQS. The only exceptions were: 1) in October 1998 when MW-3 contained 5,000 ppb of phenol; 2) in April 1999 when WP-5 contained 5,750 ppb of phenol; and, 3) in January 1999 when ORC-2 contained 7,940 ppb of methanol. Formaldehyde was either not detected or below its GWQS in all of the shallow overburden zone wells for the eighth consecutive quarter. The concentrations of salicylic acid were below the applied GWQS for the ninth consecutive quarter.

3.2.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, ORC-4D, and WP-3R (Figure 5). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (7,170 ppb), MW-47D (330,000 ppb), MW-48D (14,500 ppb), MW-50D (49,000 ppb), and ORC-4D (94,500 ppb). Methanol and formaldehyde were detected in ORC-4D at concentrations of 2,470 ppb and 52.0 ppb, respectively, and in MW-47D at concentrations of 7,550,000 ppb and 1,600 ppb, respectively. Salicylic acid was detected in three of the source area wells at concentrations exceeding the applied GWQS of 30,000 ppb, including MW-47D (573,000 ppb), MW-48D (346,000 ppb), and ORC-4D (243,000 ppb).

The concentrations of the phenol, salicylic acid, methanol, and formaldehyde were either not detectable or below their respective GWQS in all of the downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, and MW-32D).

The highest concentrations of phenol, methanol, and salicylic acid were found in MW-47D, located 40 feet downgradient from ORC-4D (which had originally been considered the source area well). Elevated concentrations of methanol and phenol were also found in MW-50D, located 50 feet upgradient from ORC-4D. The fact that MW-50D, located much closer to the suspected source area (i.e., the former Building 10/36 complex) for the three compounds of concern, contained lower levels of methanol, phenol, and salicylic acid than downgradient wells ORC-4D, MW-47D, and MW-48D, suggests that the current distribution reflects a plume that has migrated away from the source area. The concentrations in MW-47D represent the leading edge of the plume, while the concentrations in ORC-4D, MW-48D, and MW-50D represent residual concentrations that were left behind as the plume migrated. The fact that methanol has never been detected in MW-2D (located 65 feet downgradient from MW-47D), and the fact that levels of phenol and salicylic acid have generally been below their respective GWQS in MW-2D, suggests that the plume has not migrated significantly past MW-47D. Since the source has been eliminated (the facility is no longer operating and the process lines have been removed), the plume may have achieved a steady-state and may no longer be migrating.

A second potential source for the methanol in MW-47D could have been area of environmental concern (AEC) No. 2, which consisted of six former methanol underground storage tanks (USTs; Nos. A-13 through A-18). EPI believes these USTs are less likely to be the source for the methanol in MW-47D due to the fact that:

- the post-excavation samples collected following the removal of the USTs (between May and September 1988) only contained low to non-detectable concentrations of methanol. Only two samples (A-13C and A-14B) contained methanol at a concentrations above 100 ppm (116 ppm and 122 ppm, respectively).
- MW-47D contains the highest concentrations of phenol and salicylic acid, as well as the highest concentration of methanol. Since phenol was not stored in the area of MW-47D, and since salicylic acid was not produced in this area of the site, the distribution of these compounds suggests that they migrated to this location from the former Building 10/36 complex.

3.3 Northwest Phenol Hot Spot (Building 33-B)

Previous rounds of sampling have confirmed that well point WP-2 is a hotspot for phenol in groundwater. Unlike in the wells located in the Northeast Phenol Hot Spot, phenol concentrations in the shallow overburden zone have not significantly decreased over the last several years. Based on observations made during the demolition of other buildings at the site, it is possible that well point WP-2 was installed within a honeycomb of footings that created isolated pockets of groundwater. The demolition of the Building 4/33/33-A/33-B complex and the removal of the footings should create more favorable conditions for biodegradation to occur.

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

<u>Source Area Well</u>	WP-2R
<u>Monitoring Points</u>	WP-1R, MW-21

Each groundwater sample was analyzed for phenol by USEPA Method 8270. The analytical results for these samples are summarized on Table 3 and are presented on Figure 6. Concentration vs. Time graphs summarizing historical data for all three wells are included in Appendix D.

WP-2R contained 180,000 ppb of phenol, which is consistent with the historical concentrations for original well WP-2. This is the highest concentration of phenol seen since January 1999 (144,000 ppb), and may reflect phenol being flushed from the soil into the groundwater. A similar type of concentration spike was observed in several of the wells in the Northeast Phenol Hot Spot area after the Building 10/36 complex was demolished.

Downgradient monitoring point WP-1R contained 71.4 ppb of phenol, while no detectable concentrations of phenol were found in MW-21. These results are consistent with the historical data for both wells.

3.4 Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14)

This area is located in the southeast corner of the site and represents the source area for the benzene and toluene in groundwater. Soil and groundwater is being actively remediated by the operation of an air sparge/soil vapor extraction (AS/SVE) system, an air curtain system comprised of both vertical and horizontal air injection wells, and an off-site SVE system located beneath portions of Hudson Street and Bloomingdale Avenue to the south of the site. The locations of these remediation systems are shown on Figure 1.

3.4.1 *SVE and Monitoring Well Installations*

On 15 December 1999, three off-site soil vapor extraction (SVE) wells were installed in the vicinity of monitoring well MW-33 (after receiving approval from the City of Garfield). The installation of OSSVE-6, OSSVE-7, and OSSVE-8 was proposed to the NJDEP in the 16 July 1999 *Remedial Investigation Report* as a way of enhancing the groundwater remediation in this area. EPI believed that addressing any benzene or toluene adsorbed to soil in the vadose zone would help eliminate a potential source of continuing groundwater contamination. This effect had been seen in the area of MW-25, MW-40, and MW-41 due to the operation of the off-site horizontal SVE wells located in Hudson Street and Bloomingdale Avenue.

At the time OSSVE-6, OSSVE-7, and OSSVE-8 were proposed, monitoring well MW-33 contained 1,520 ppb of benzene and 228,000 ppb of toluene. However, since the July 1999 groundwater sampling event, MW-33 had consistently contained measurable amounts of separate phase hydrocarbons (SPH). Each vertical SVE well is approximately 20.0 feet deep and extends several feet into groundwater. These wells were brought on-line during the last week of December 1999. On 17 March 2000, OSSVE-8 (the well closest to MW-33) was found to contain 0.61 feet of SPH. During the same gauging event, MW-33 contained 0.22 feet of SPH. Although the extent of the SPH plume had been defined to the north, east, and west by existing monitoring wells, EPI believed an additional well was required to the south to complete the delineation.

On 1 September 2000, after receiving approval from the City of Garfield, monitoring well MW-45 was installed on the south side of Hudson Street, approximately 40.0 feet from MW-33 and 30.0 feet from OSSVE-8. At the same time, EPI also installed side gradient delineation well MW-46 in Cambridge Avenue, approximately 100 feet south of Hudson Street, to further define the extent of the affected area. The locations of MW-45 and MW-46 are shown on Figure 1.

MW-45 has a total depth of 25.0 feet, and is constructed with 15.0 feet of 4.0-inch diameter PVC screen and 10 feet of PVC casing. MW-46 has a total depth of 30.0 feet, and is constructed with 20.0 feet of 4.0-inch diameter PVC screen and 10.0 feet of PVC casing. Each well head is completed with a flush mounted, water tight manhole and locking cap. A Hurricane rig operated by a New Jersey licensed driller from Summit was used to install both wells. Soil samples were collected for lithologic characterization using direct-push methodology, while hollow stem augers were used to install the wells.

At the location of MW-45, the soil consisted of fine to medium grained sand to the completion depth of 25 feet. Gravel was encountered between 6.0 feet and 12.0 feet below grade. No VOCs were detected by the PID until immediately above the water table (encountered at approximately 17.5 feet below grade). The PID detected 135 ppm of VOCs at 17.0 feet below grade, and 927 ppm at 18.0 feet below grade. Running sands were encountered at 19.0 feet, so no soil samples could be collected below this depth.

At MW-46, the soil consisted of fine to medium sand, with trace amounts of silt and coarse sand. No VOCs were detected by the PID in the top 12.0 feet of soil. Running sands were encountered at 12.0 feet below grade in MW-46, which prevented collecting deeper soil samples. However, PID readings of 0.1 ppm to 9.2 ppm were recorded while screening the drill cuttings from 12.0 feet to the completion depth of 30.0 feet. Groundwater was encountered at approximately 21.0 feet below grade at this location. The locations and elevations of each well were measured by a licensed New Jersey professional surveyor. Copies of the well logs for MW-45 and MW-46 are included in Appendix A.

3.4.2 *Groundwater Sampling Results*

In order to monitor the effectiveness of the AS/SVE, air curtain, and the off-site SVE systems, groundwater samples were to be collected from the following wells:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33
Monitoring Points	MW-16, MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, MW-45, MW-46, OW-1, OW-2, OW-3, OW-4, and OW-5

As indicated in Section 3.0, groundwater from MW-9 exhibited a heavy sheen and was not sampled. The groundwater samples collected from the remaining wells addressing this area of environmental concern were analyzed for benzene and toluene by USEPA Method 624, and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270[1]. The analytical results for these samples are summarized on Table 4 and are presented on Figure 7. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix E.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 11 of the 30 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 1.9 ppb in MW-4 to 1,110 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.1 ppb in OW-1 to 4,440 ppb in MW-33. The benzene concentration detected in MW-40 (93.1 ppb) was significantly less than in July 2000, and continues the overall decreasing trend that has been observed in this well. Benzene concentrations also decreased relative to the July 2000 sampling event in MW-D5, MW-14 (67.3 ppb), MW-23 (20.6 ppb), and OW-3 (0.31 ppb).

Benzene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW-1 - Not detected for the 8th consecutive quarter.
- MW-5 - Not detected; below the GWQS for the 5th consecutive quarter.
- MW-6 - Not detected for the 8th consecutive quarter.

---

[1] The 1,1'- biphenyl and diphenyl ether sample from MW-1 contained excessive amounts of sediment and could not be analyzed.

- MW-10 - Not detected for the 8th consecutive quarter.
- MW-11 - Not detected for the 8th consecutive quarter.
- MW-22 - Not detected for the 5th consecutive quarter.
- MW-30 - Not detected for the 8th consecutive quarter.
- MW-31 - Not detected (at or below the GWQS for the 8th consecutive quarter).
- MW-41 - Not detected (below the GWQS for the 8th consecutive quarter).
- OW-4 - Not detected for the 5th consecutive sampling event.
- OW-5 - Not detected for the 4th consecutive quarter.

Low concentrations of benzene continue to be found in off-site wells MW-36 (10.5 ppb) and MW-42 (1.3 ppb). Recently installed monitoring well MW-45, which is located across Hudson Street from MW-33, contained 3,730 ppb of benzene. No detectable concentrations of benzene were found in MW-46, located approximately 150 feet cross-gradient from MW-33.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in on-site wells MW-D5 (54,800 ppb) and MW-14 (20,700 ppb); the concentration in MW-D5 is the lowest ever detected in this well. Toluene concentrations exceeded the GWQS in off-site wells MW-40 (2,180 ppb), MW-46 (4,800 ppb), MW-45 (263,000 ppb), and MW-33 (350,000 ppb). The concentrations in MW-25 (291 ppb) and OW-3 (24.5 ppb) decreased 87% and 99%, respectively, relative to the July 2000 sampling results. The toluene concentration in MW-33 is consistent with the historic levels for this well.

Toluene concentrations remained below the GWQS in several formerly contaminated on-site and off-site wells, including:

- MW- 1- Not detected for the 8th consecutive quarter; below GWQS for the 11th consecutive quarter.
- MW-4 - 31.4 ppb; below GWQS for the 4th consecutive quarter.
- MW-5 - Not detected; below GWQS for the 12th consecutive quarter.
- MW- 6- Not detected for the 8th consecutive quarter; below GWQS for the 14th consecutive quarter.
- MW-10- 0.49 ppb; below GWQS for the 14th consecutive quarter.
- MW-11- Not detected for the 9th consecutive quarter; below GWQS for the 13th consecutive quarter.
- MW-17- Not detected ; below the GWQS for the 14th consecutive quarter.
- MW-23- 5.7 ppb; below GWQS for the 7th consecutive quarter.

•	MW-30-	Not detected for the 6th consecutive quarter; below the GWQS for the 13th consecutive quarter.
•	MW-31-	Not detected; below the GWQS for the 10th consecutive quarter.
•	MW-41-	Not detected; below the GWQS for the 8th consecutive quarter.
•	OW-2-	6.6 ppb; below the GWQS for the 5th consecutive quarter.
•	OW-4-	Not detected; below the GWQS for the 5th consecutive sampling event.
•	OW-5-	Not detected; below the GWQS for the 4th consecutive quarter.

During recent sampling events, the benzene and toluene concentrations in several of the off-site wells appear to have been influenced by changes in groundwater elevations. The groundwater elevation in each well at the time of sampling is also shown on the graphs in Appendix E. No significant changes in groundwater elevations were observed between the July 2000 and October 2000 monitoring events. Therefore, the decreased benzene and/or toluene concentrations observed in MW-D5, MW-14, MW-23, MW-25, MW-40, and OW-3 cannot be attributed to fluctuations in the water table.

1,1'-biphenyl was detected at concentrations above the IGGWQS of 100 ppb in on-site wells MW-4 (5,720 ppb), MW-D5 (891 ppb), and MW-14 (1,790 ppb). In the off-site wells, 1,1'-biphenyl was detected at 278 ppb in MW-45, 377 ppb in MW-46, and 1,930 ppb in MW-33. Diphenyl ether was also detected, although at higher concentrations, in MW-4 (19,800 ppb), MW-D5 (1,910 ppb), and MW-14 (10,600 ppb). Diphenyl ether was also detected in off-site wells MW-23 (2,190 ppb), MW-25 (310 ppb), MW-33 (3,010 ppb), MW-40 (364 ppb), MW-45 (555 ppb), and MW-46 (697 ppb).

As can be seen on Table 4, the concentrations of 1,1'-biphenyl and/or diphenyl ether only exceeded the IGGWQS of 100 ppb in those wells that also contained elevated concentrations of benzene and/or toluene. This apparent correlation suggests that the distribution of the 1,1'-biphenyl and diphenyl ether is related to the migration of the benzene and toluene.

3.5 Background Groundwater Quality

The sampling program in the March 1995 Revised RAW included monitoring the background groundwater quality around the site on an annual basis. Groundwater samples were collected from monitoring wells MW-19 and MW-19D (located on the corner of Cambridge Avenue and Monroe Street), MW-20 and MW-20D (located on Commerce Street), MW-35 and MW-35D (located on Hudson Street), and MW-8 (located to the east of former Building 10-T on Cambridge Street). Each sample was analyzed for benzene, toluene, phenol, salicylic acid, methanol, formaldehyde, 1,1'-biphenyl, and diphenyl ether. The analytical results for these samples are summarized on Table 5. Tables summarizing the historical data for each well are included in Appendix F.

No detectable concentrations of the compounds of concern were found in the background wells during the October 2000 sampling event. These results are the same as the last time the background wells were sampled in January 1999.

3.6 Distribution of Compounds of Concern

The distribution of toluene and benzene in the shallow overburden zone using the July 2000 groundwater sampling results is shown on Figure 8 and Figure 9, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to the area around MW-33 and MW-45. Concentrations of toluene exceeding the GWQS of 1,000 ppb are also found in the vicinity of MW-14 and MW-40.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found around MW-D5, MW-33, and MW-45. Benzene concentrations exceeding 10.0 ppb were also found around MW-14, and MW-25 and MW-40.

The distribution of 1,1'-biphenyl in the shallow overburden zone is shown on Figure 10. Concentrations exceeding the IGGWQS of 100 ppb exist in the southeast corner of the site (between MW-4, MW-33, and MW-46), and, to a lesser extent, in the southwest corner of the site (MW-14). The distribution of diphenyl ether is shown on Figure 11. The highest concentrations (above 10,000 ppb), are limited to the areas of MW-4 and MW-14. Concentrations exceeding 100 ppb are found in three areas: the southeast corner of the site (MW-4, MW-D5, MW-33, MW-45, and MW-46); the southwest corner (MW-14 and MW-23); and to the south of the site around MW-25 and MW-40.

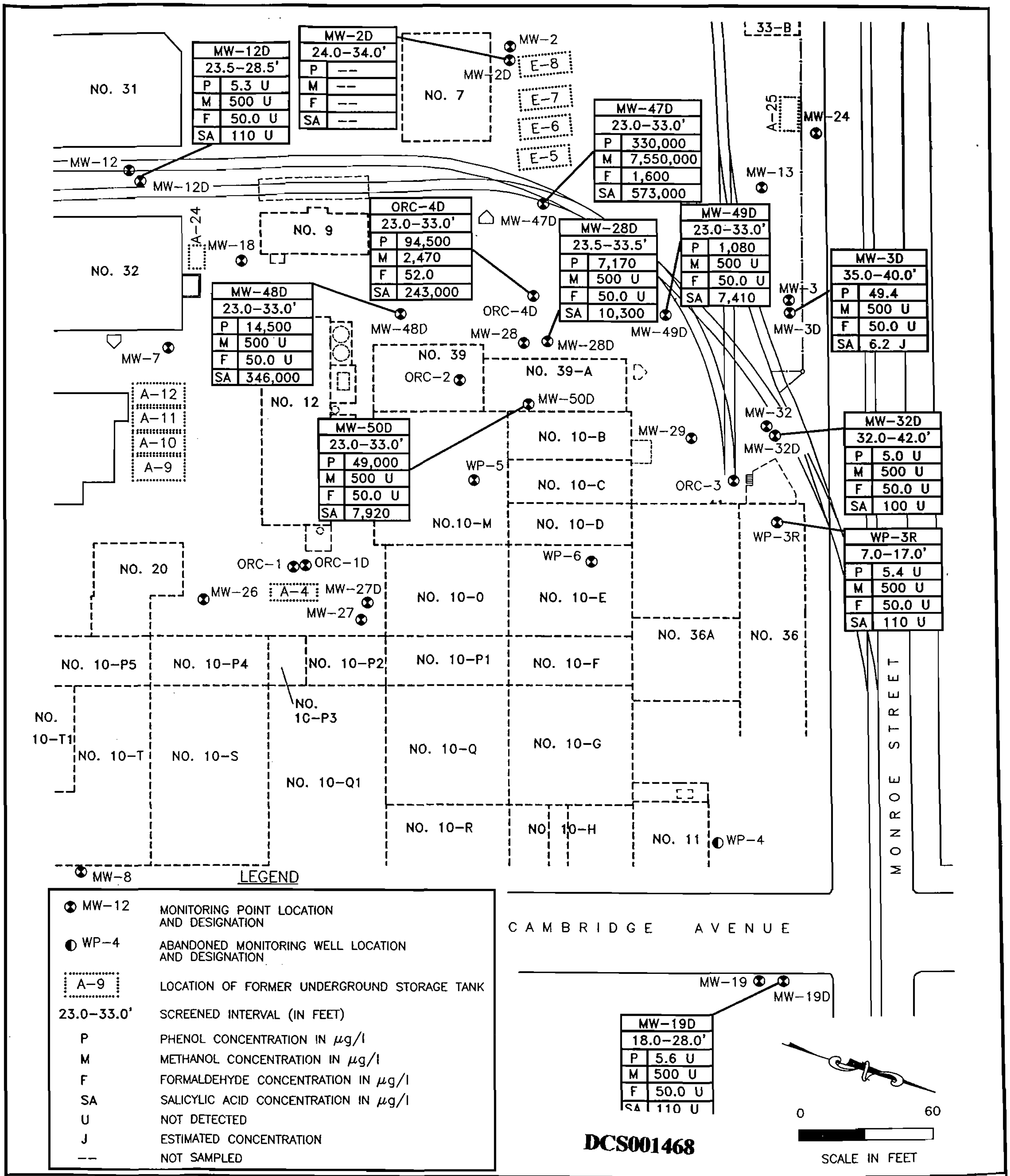
No detectable concentrations of benzene, 1,1'-biphenyl, and diphenyl ether, and only trace amounts of benzene (0.63 ppb), were found in upgradient well MW-16. These results confirm previous analytical data which indicated that the area affected by the toluene spill did not extend off-site to the east.

The distribution of phenol within the shallow overburden zone is shown on Figure 12. The area with the highest concentration of phenol is limited to beneath former Building 33-B (180,000 ppb in WP-2R). The distribution of phenol in the deep overburden zone is depicted on Figure 13. Concentrations over 100,000 ppb extend to MW-47D (40 feet downgradient from ORC-4D), while the area exceeding the 4,000 ppb GWQS extends over 80 feet to the east (MW-50D) and south (MW-48D) of ORC-4D.

As shown on Figure 14, formaldehyde was not detected in the shallow overburden zone. In the deep overburden zone (Figure 15), formaldehyde was only detected at a concentration exceeding the GWQS of 110 ppb in MW-47D (1,600 ppb).

The distribution of salicylic acid in the shallow and deep overburden zones is shown on Figures 16 and 17, respectively. Salicylic acid concentrations in the shallow overburden zone were below the applied GWQS of 30,000 ppb in all wells. As shown on Figure 17, salicylic acid concentrations only exceeded the applied GWQS in ORC-4D (243,000 ppb), MW-47D (573,000 ppb), and MW-48D (346,000 ppb).

The distribution of methanol in the shallow and deep overburden zones is shown on Figures 18 and 19, respectively. Methanol was not detected in the shallow overburden zone. In the deep overburden zone, methanol was only detected at a concentration exceeding the GWQS of 3,500 ppb in MW-47D (7,550,000 ppb).



LEGEND

MW-12	MONITORING POINT LOCATION AND DESIGNATION
◐ WP-4	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-9	LOCATION OF FORMER UNDERGROUND STORAGE TANK
23.0-33.0'	SCREENED INTERVAL (IN FEET)
P	PHENOL CONCENTRATION IN µg/l
M	METHANOL CONCENTRATION IN µg/l
F	FORMALDEHYDE CONCENTRATION IN µg/l
SA	SALICYLIC ACID CONCENTRATION IN µg/l
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
--	NOT SAMPLED

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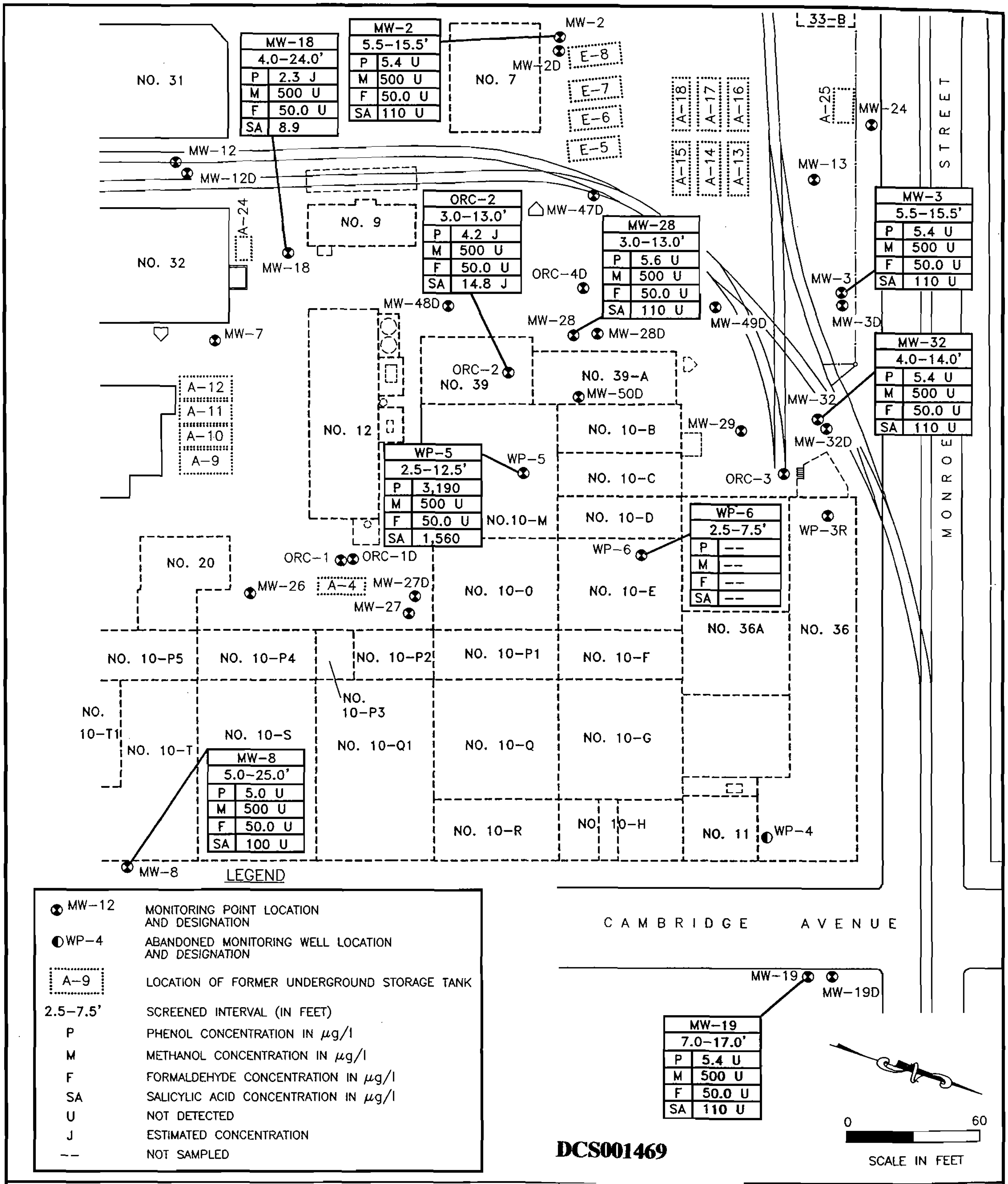
Project No. EP001 File: pointmap\K_FIG5_OCT00.dwg Date: 11/15/00

FIGURE 5
NORTHEAST PHENOL HOT SPOT
PHENOL, METHANOL, FORMALDEHYDE, & SALICYLIC ACID IN GROUNDWATER
DEEP OVERBURDEN ZONE
OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW J



LEGEND

⊗ MW-12	MONITORING POINT LOCATION AND DESIGNATION
◐ WP-4	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-9	LOCATION OF FORMER UNDERGROUND STORAGE TANK
2.5-7.5'	SCREENED INTERVAL (IN FEET)
P	PHENOL CONCENTRATION IN μg/l
M	METHANOL CONCENTRATION IN μg/l
F	FORMALDEHYDE CONCENTRATION IN μg/l
SA	SALICYLIC ACID CONCENTRATION IN μg/l
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
--	NOT SAMPLED

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FIGURE 4
NORTHEAST PHENOL HOT SPOT
PHENOL, METHANOL, FORMALDEHYDE, & SALICYLIC ACID IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

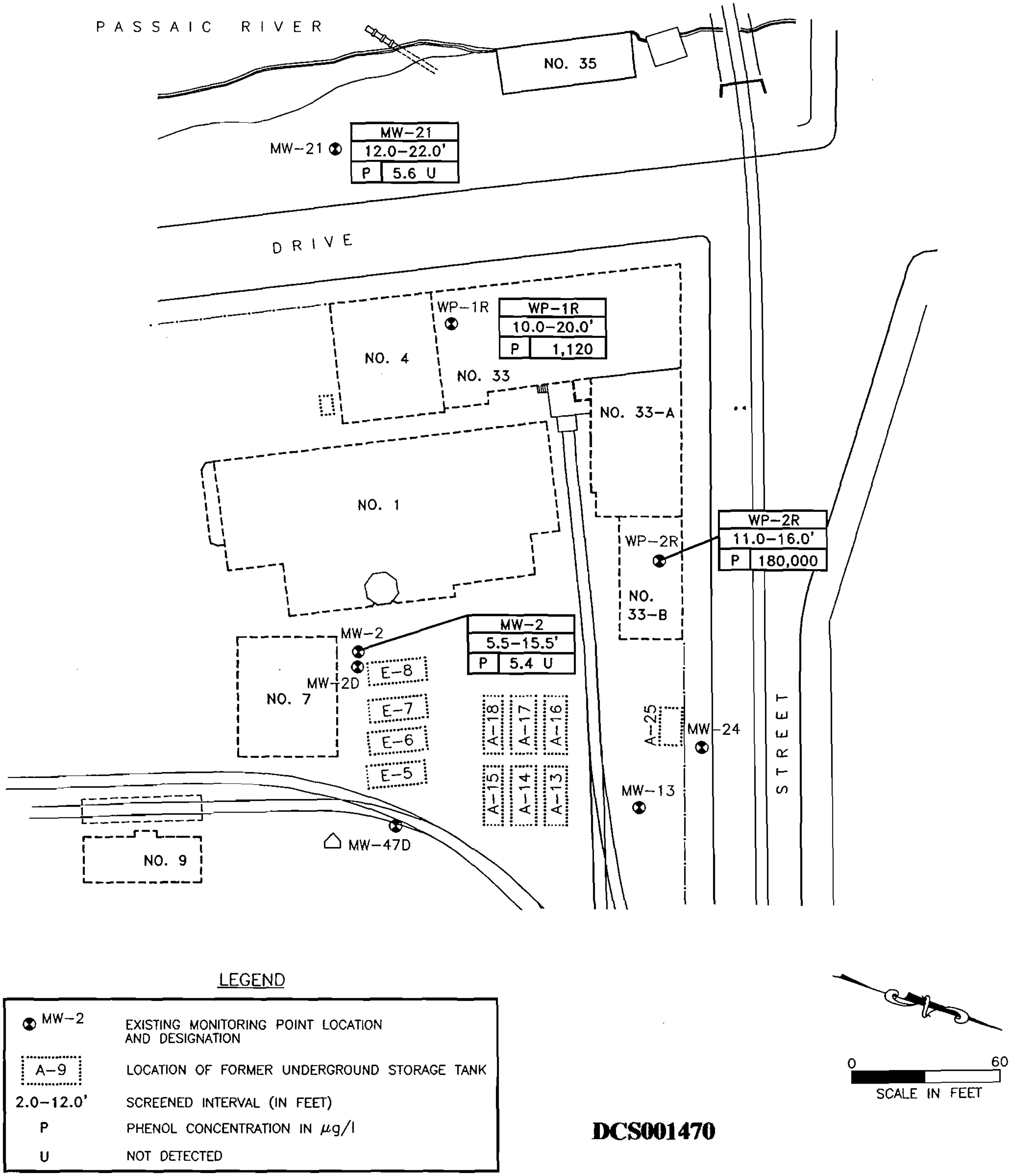

FIGURE 6
NORTHWEST PHENOL HOT SPOT PHENOL IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

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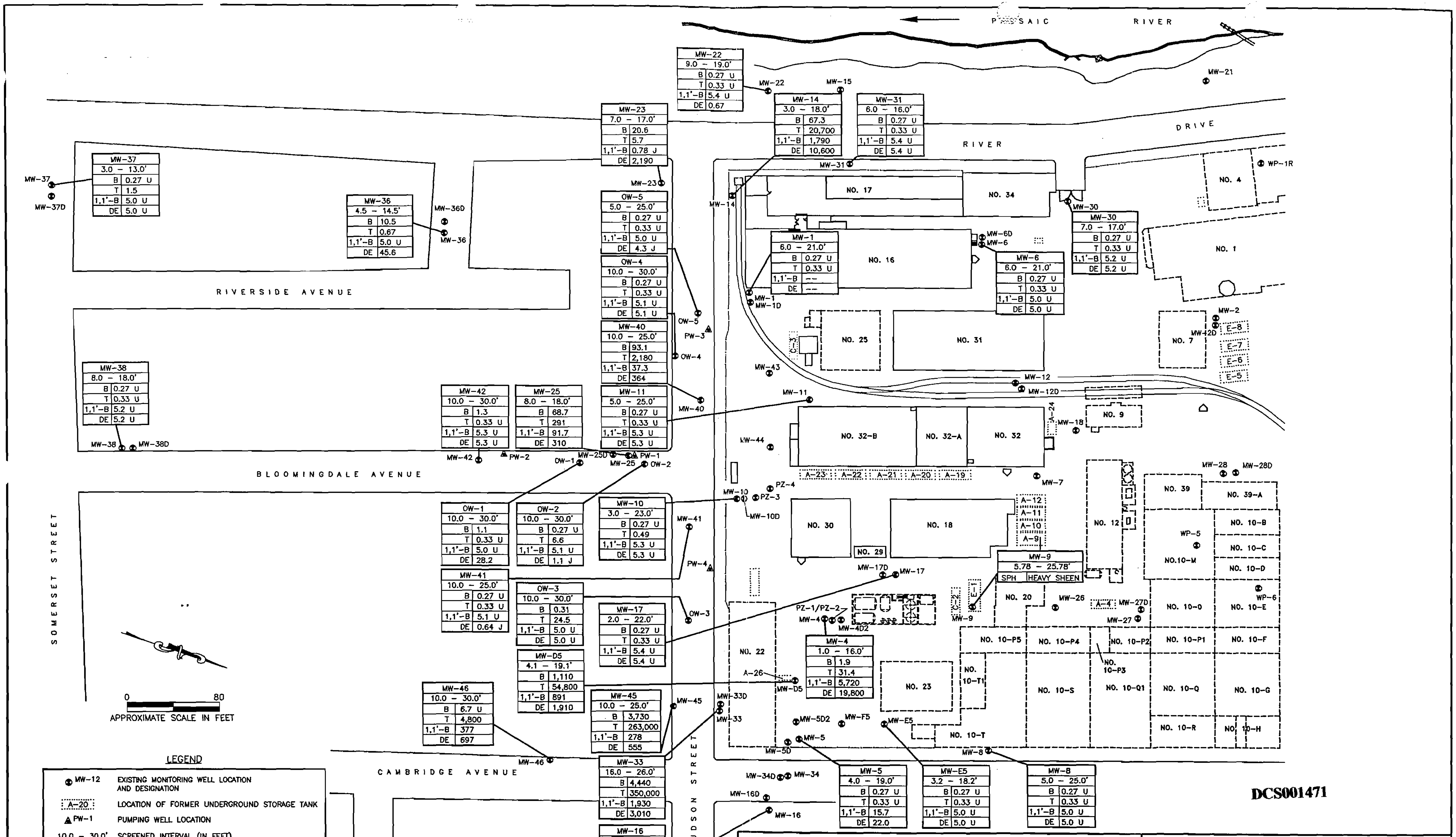
Project No. EP001 File: pointmap\K_FIG6_OCT00.dwg Date: 11/15/00



LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
10.0 – 30.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
1,1'-B	1,1'-BIPHENYL CONCENTRATION IN μg/l
DE	DIPHENYL ETHER CONCENTRATION IN μg/l
U	NOT DETECTED
J	ESTIMATED CONCENTRATION
SPH	SEPARATE PHASE HYDROCARBONS (IN FEET)
— —	NOT ANALYZED

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

DCS001471

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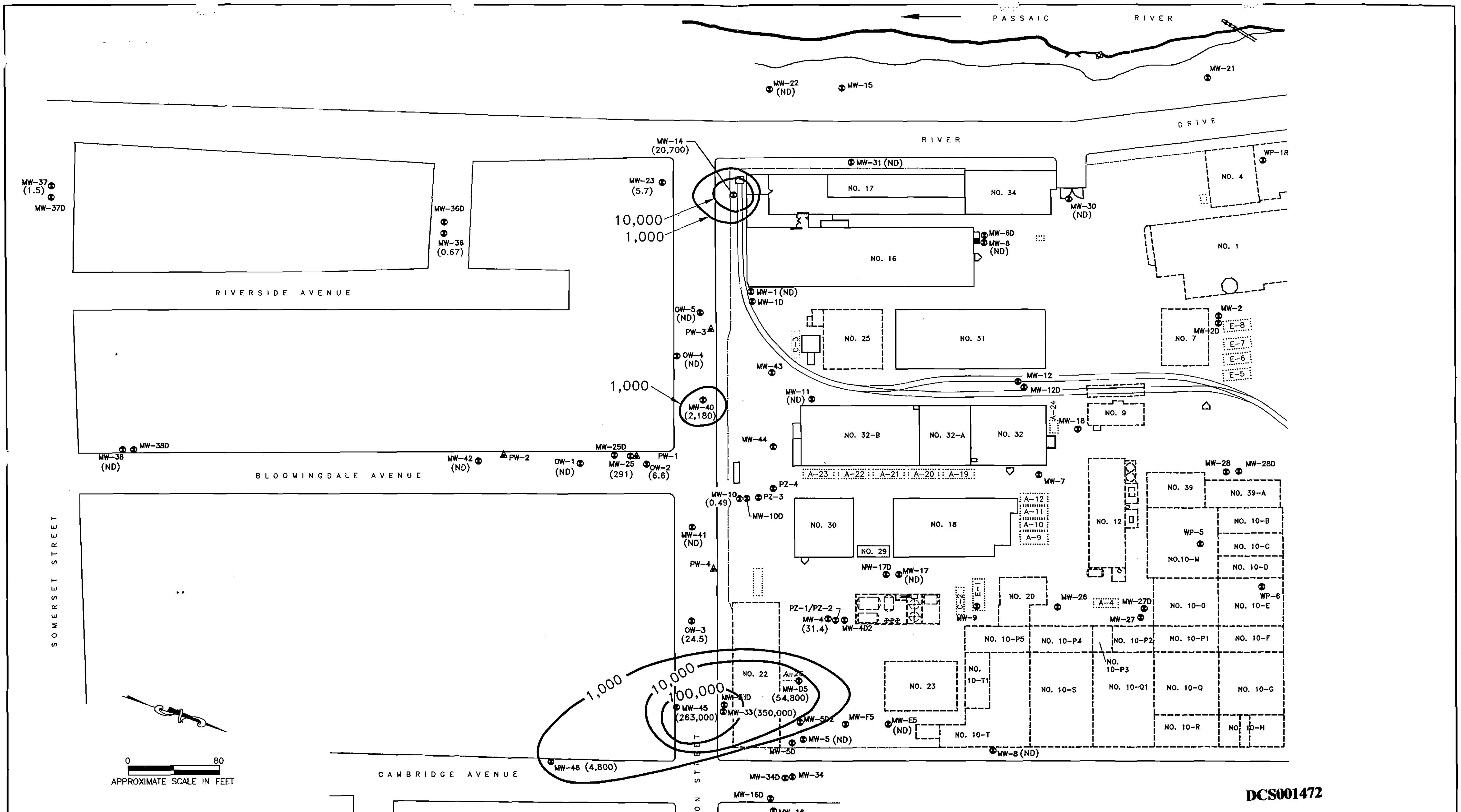
Project No. EP001 File: pointmap\K_FIG7_OCT00.dwg Date: 11/16/00

FIGURE 7
TOLUENE SPILL AREA
BENZENE, TOLUENE, 1,1'-BIPHENYL AND DIPHENYL ETHER IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(2,180)	TOLUENE CONCENTRATION IN μg/l
(ND)	NOT DETECTED
1,000 ──	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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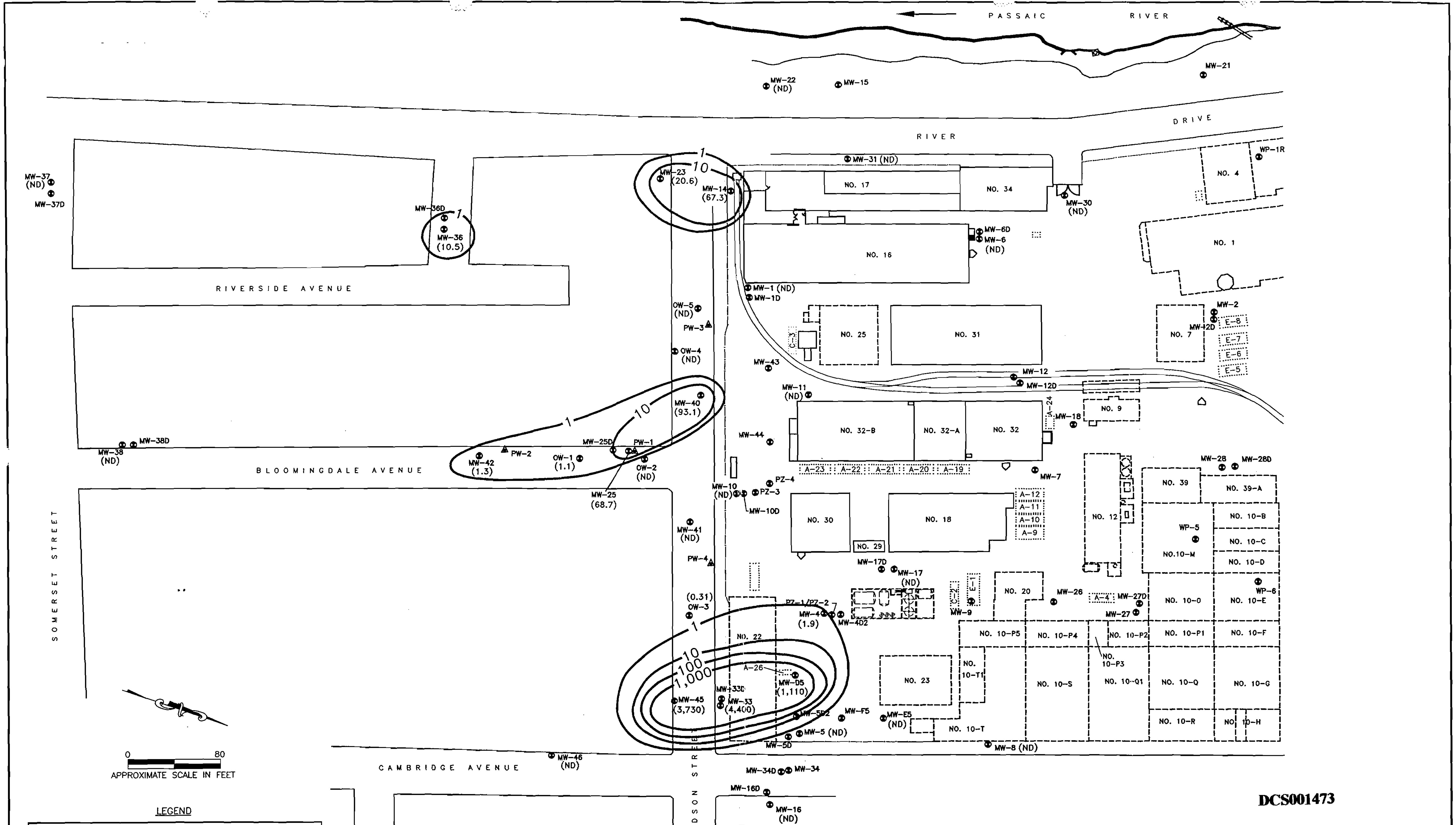
FIGURE 8
DISTRIBUTION OF TOLUENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: pointmap\K FIG8 OCT00.dwg Date: 11/16/00



LEGEND

⊗ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(1,110)	BENZENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

DCS001473

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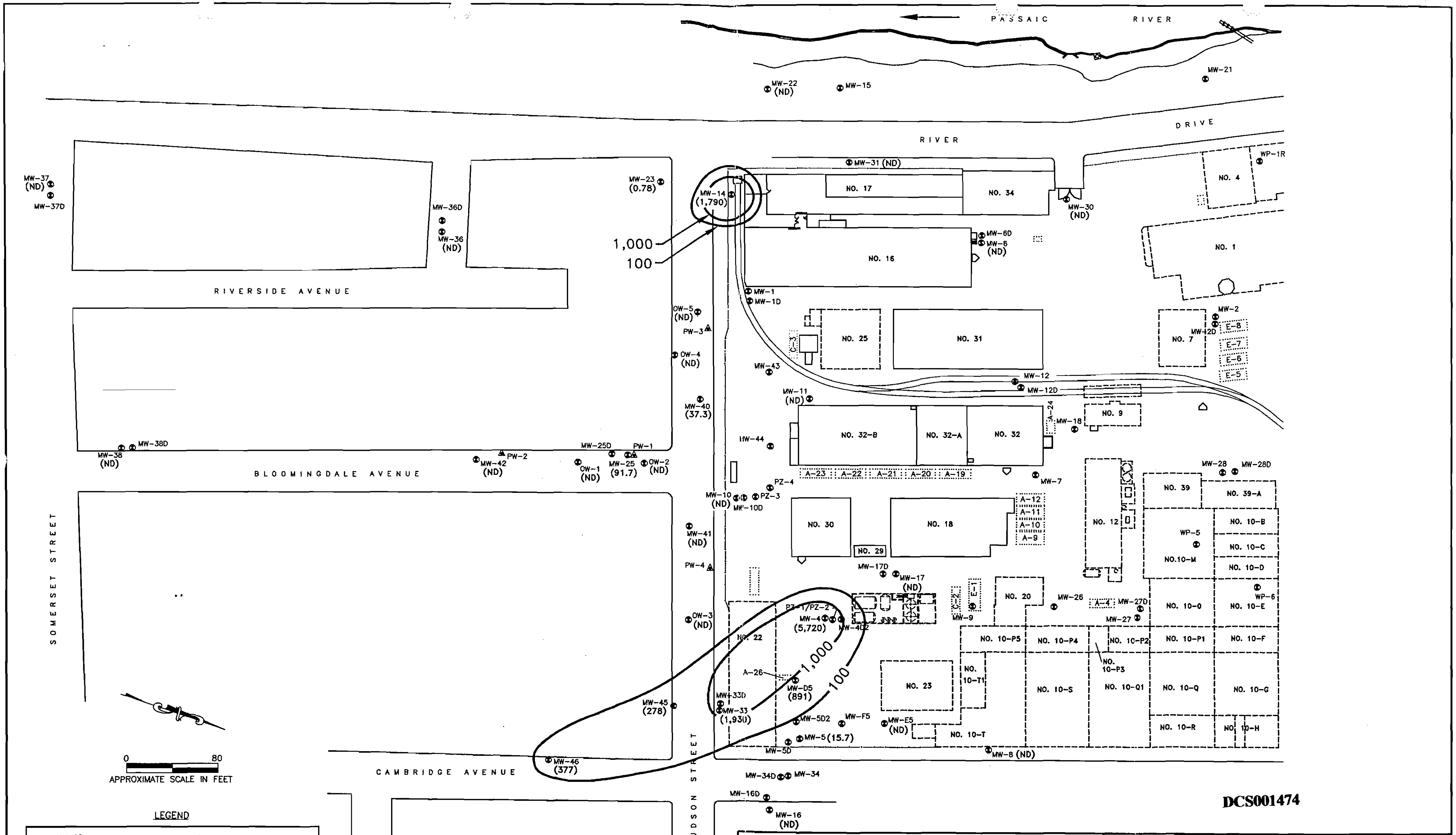
FIGURE 9
DISTRIBUTION OF BENZENE IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: pointman\K_F8_AUG001.dwg Date: 8/21/00



DCS001474

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲PW-1	PUMPING WELL LOCATION
(891)	1,1'-BIPHENYL CONCENTRATION IN μg/l
(ND)	NOT DETECTED
100 ──	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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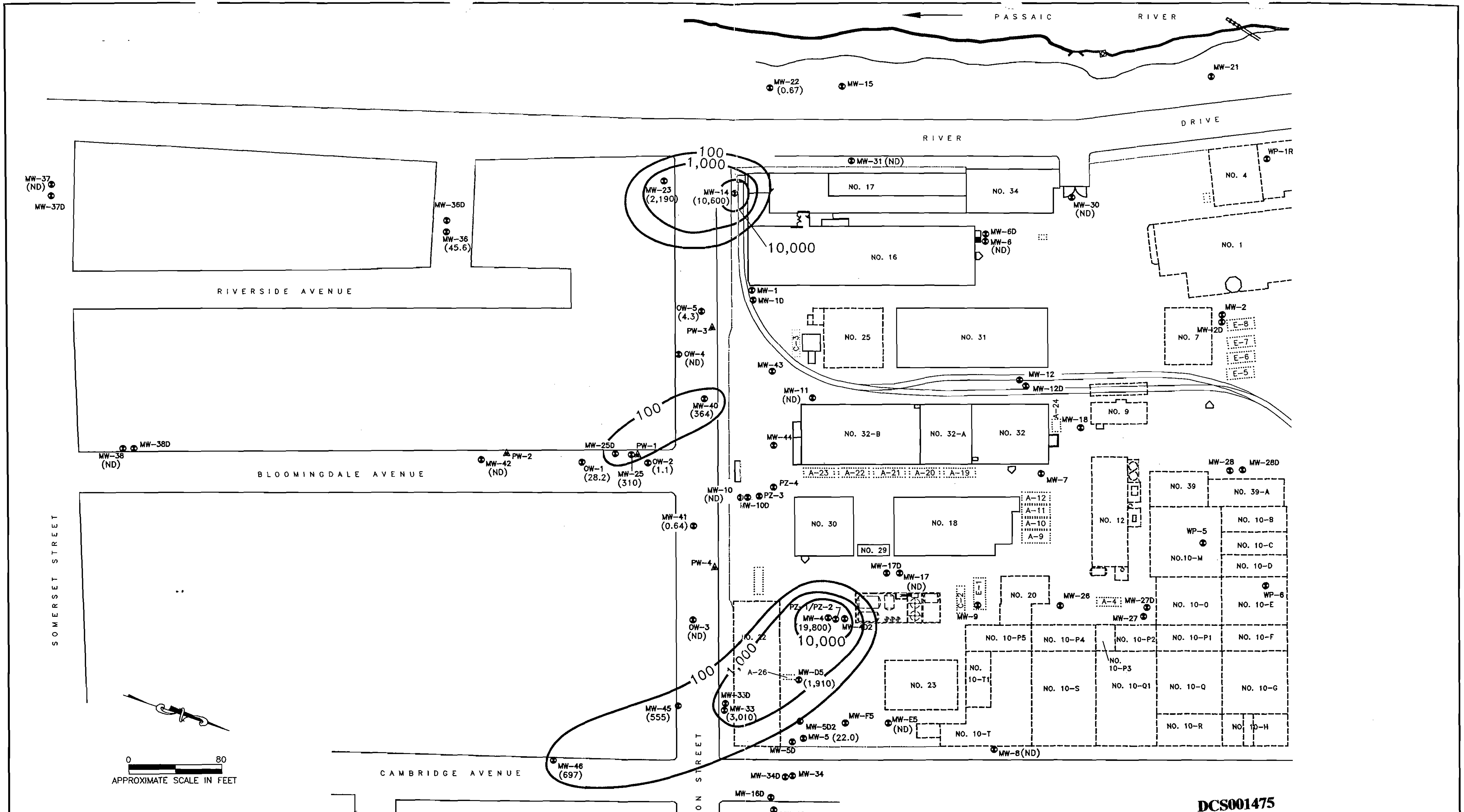
FIGURE 10
DISTRIBUTION OF 1,1'-BIPHENYL IN GROUNDWATER
SHALLOW OVERBURDEN ZONE
OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: pointmap\K_FIG10_OCT00.dwg Date: 11/16/00



LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(364)	DIPHENYL ETHER CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
100 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

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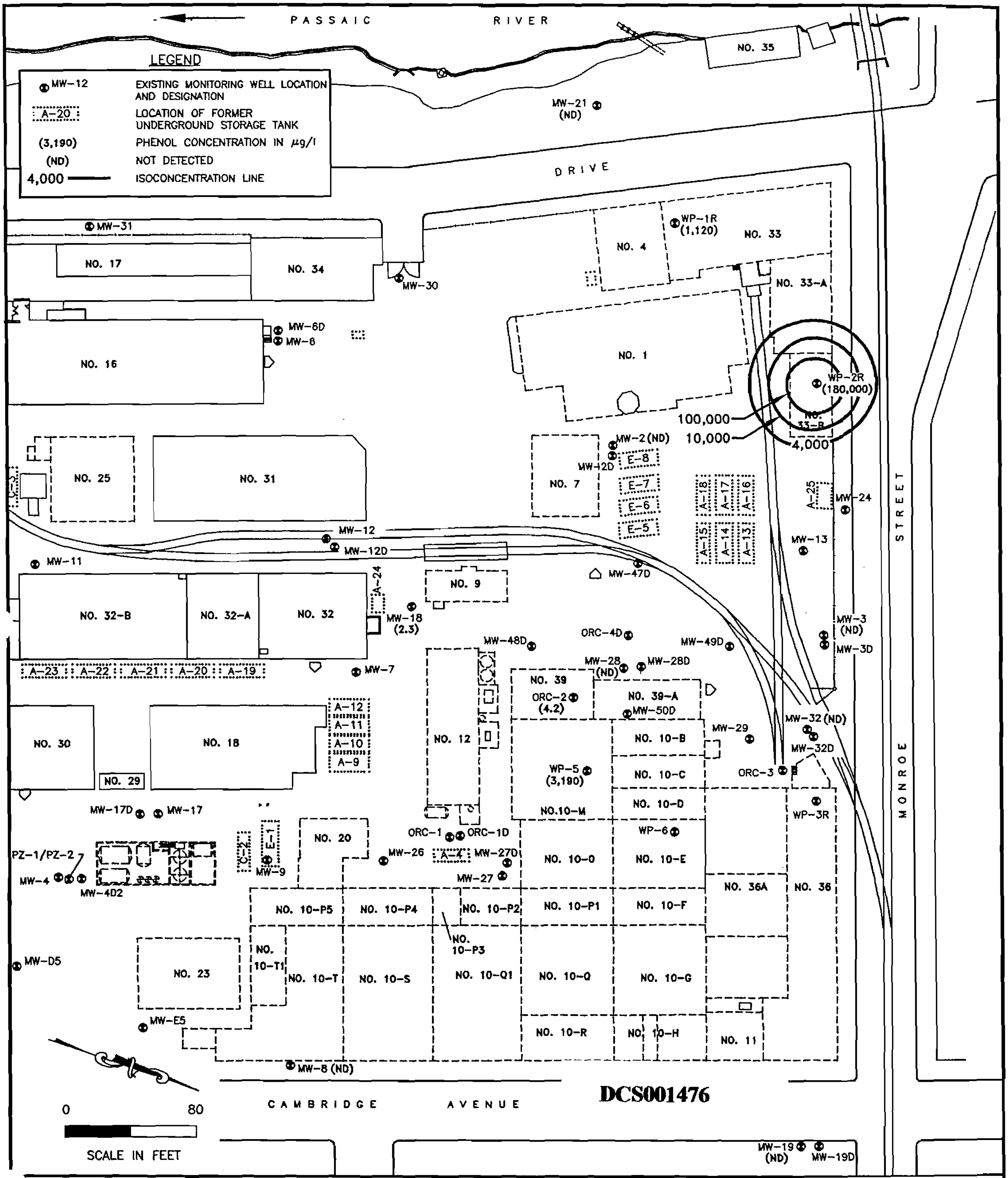
FIGURE 11
DISTRIBUTION OF DIPHENYL ETHER IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: pointmap\K_FIG11_OCT00.dwg Date: 11/16/00



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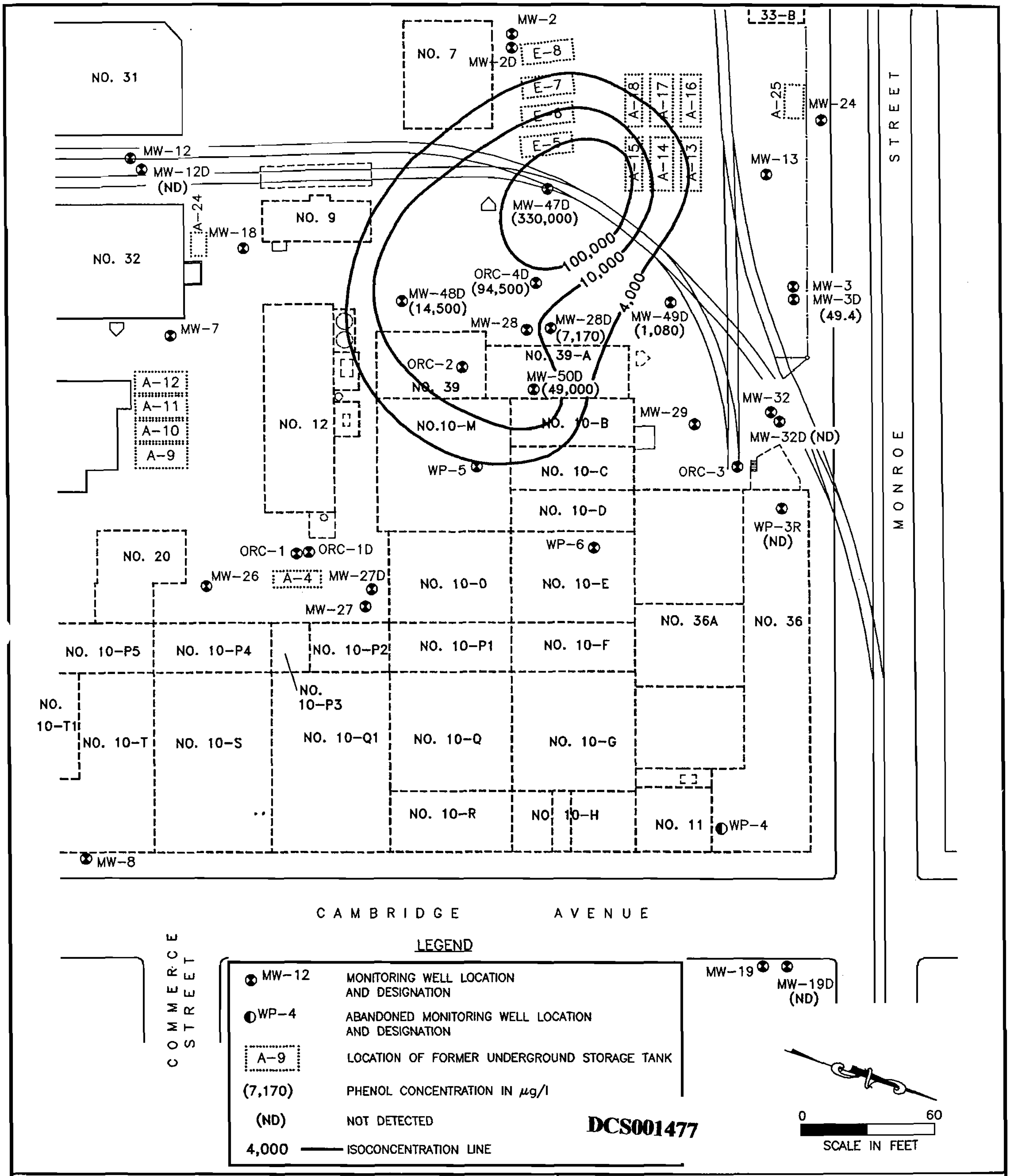
Project No. EP001 File: pointmap\K_FIG12_OCT00.dwg Date: 11/16/00

FIGURE 12
DISTRIBUTION OF PHENOL IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD. NEW JER



LEGEND

MW-12	MONITORING WELL LOCATION AND DESIGNATION
WP-4	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-9	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(7,170)	PHENOL CONCENTRATION IN µg/l
(ND)	NOT DETECTED
4,000 ———	ISOCONCENTRATION LINE

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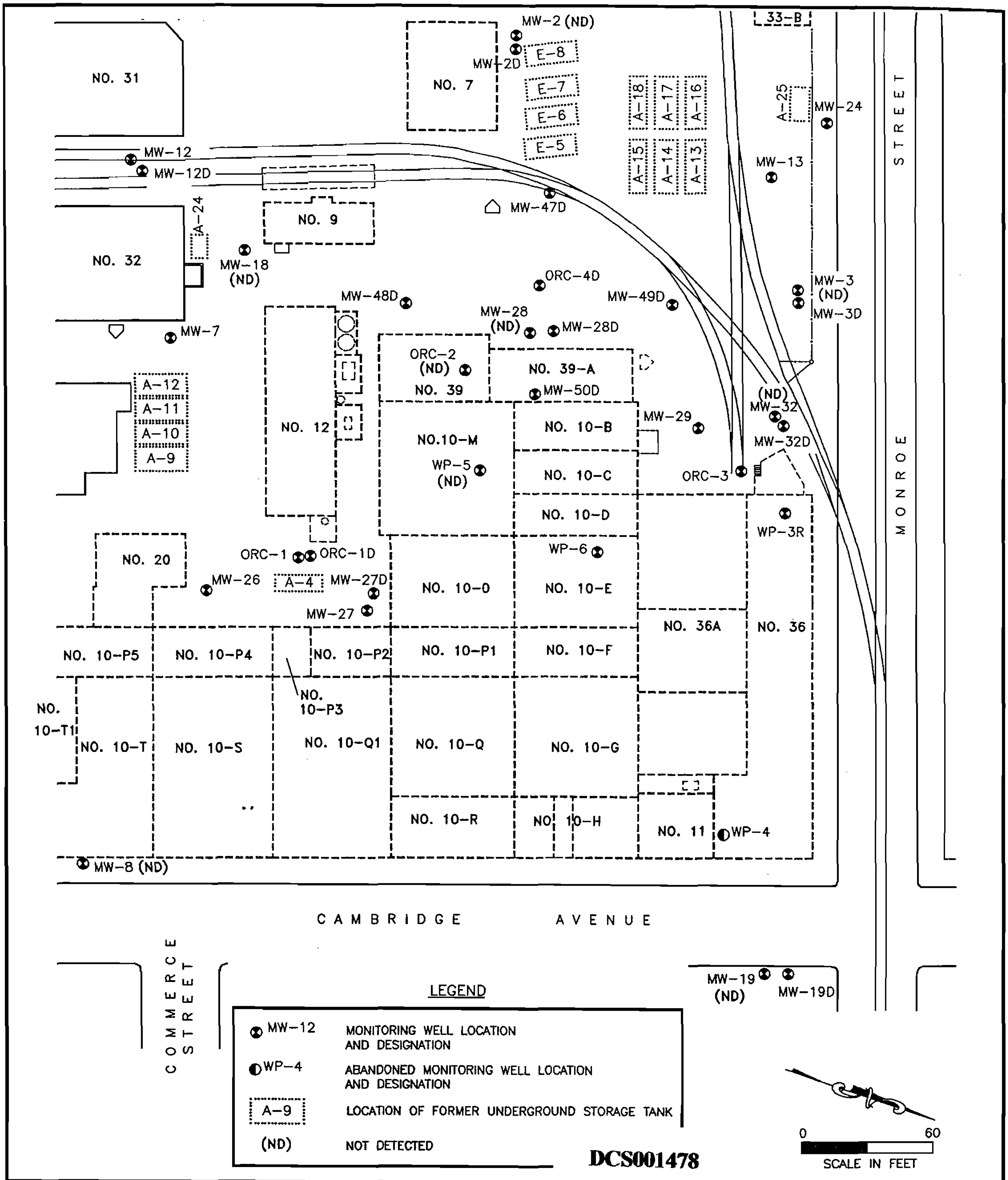
Project No. EP001 File: pointmap\K_FIG13_OCT00.dwg Date: 11/16/00

FIGURE 13
DISTRIBUTION OF PHENOL IN GROUNDWATER DEEP OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



LEGEND

⊗ MW-12	MONITORING WELL LOCATION AND DESIGNATION
◐ WP-4	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-9	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(ND)	NOT DETECTED

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FIGURE 14
DISTRIBUTION OF FORMALDEHYDE IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

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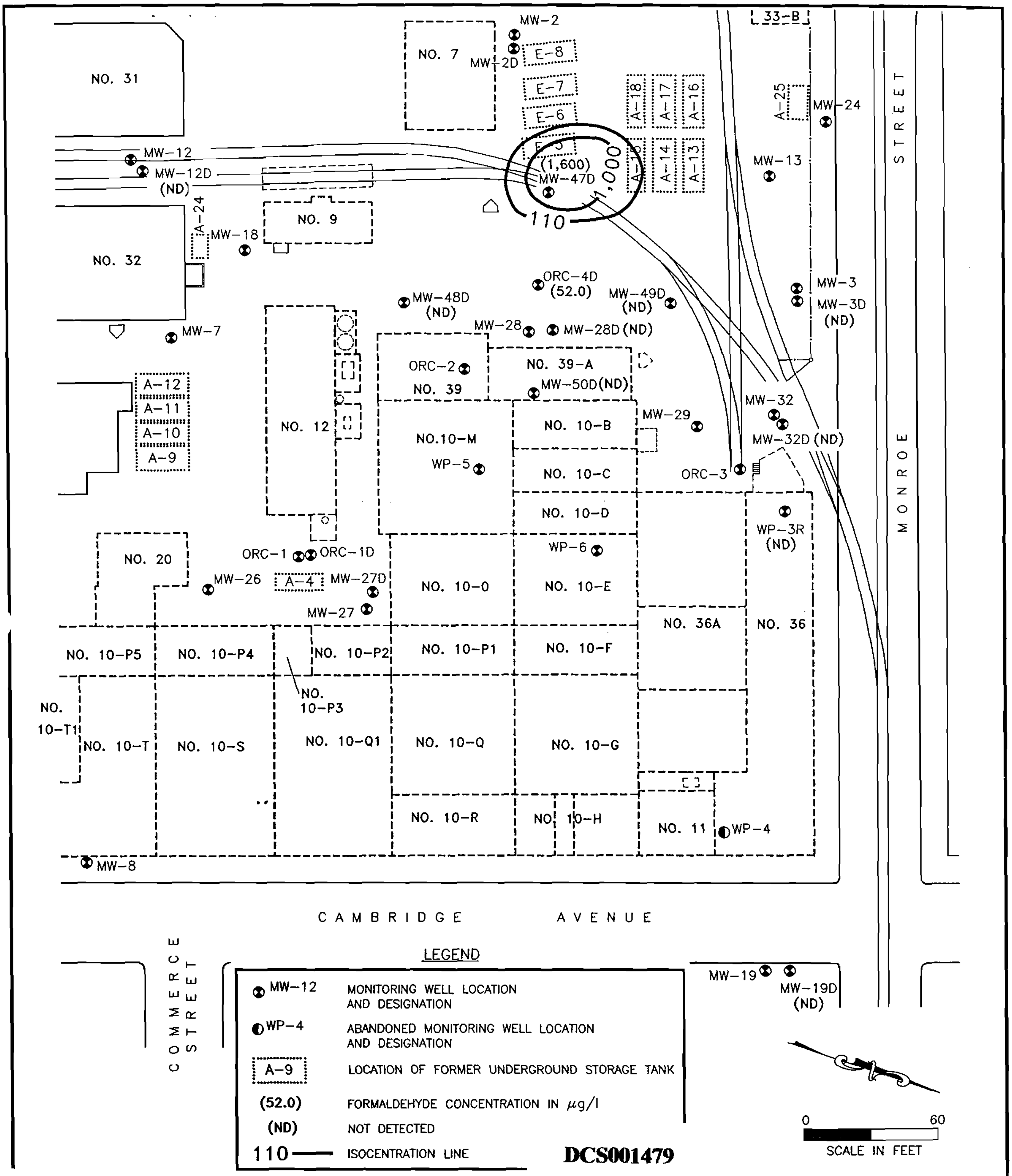
GARFIELD, NEW JE

Project No. EP001 File: pointmap\K_FIG14_OCT00.dwg Date: 11/16/00



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Project No. EP001 File: pointmap\K_FIG15_OCT00.dwg Date: 11/16/00

FIGURE 15
DISTRIBUTION OF FORMALDEHYDE IN GROUNDWATER DEEP OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JER

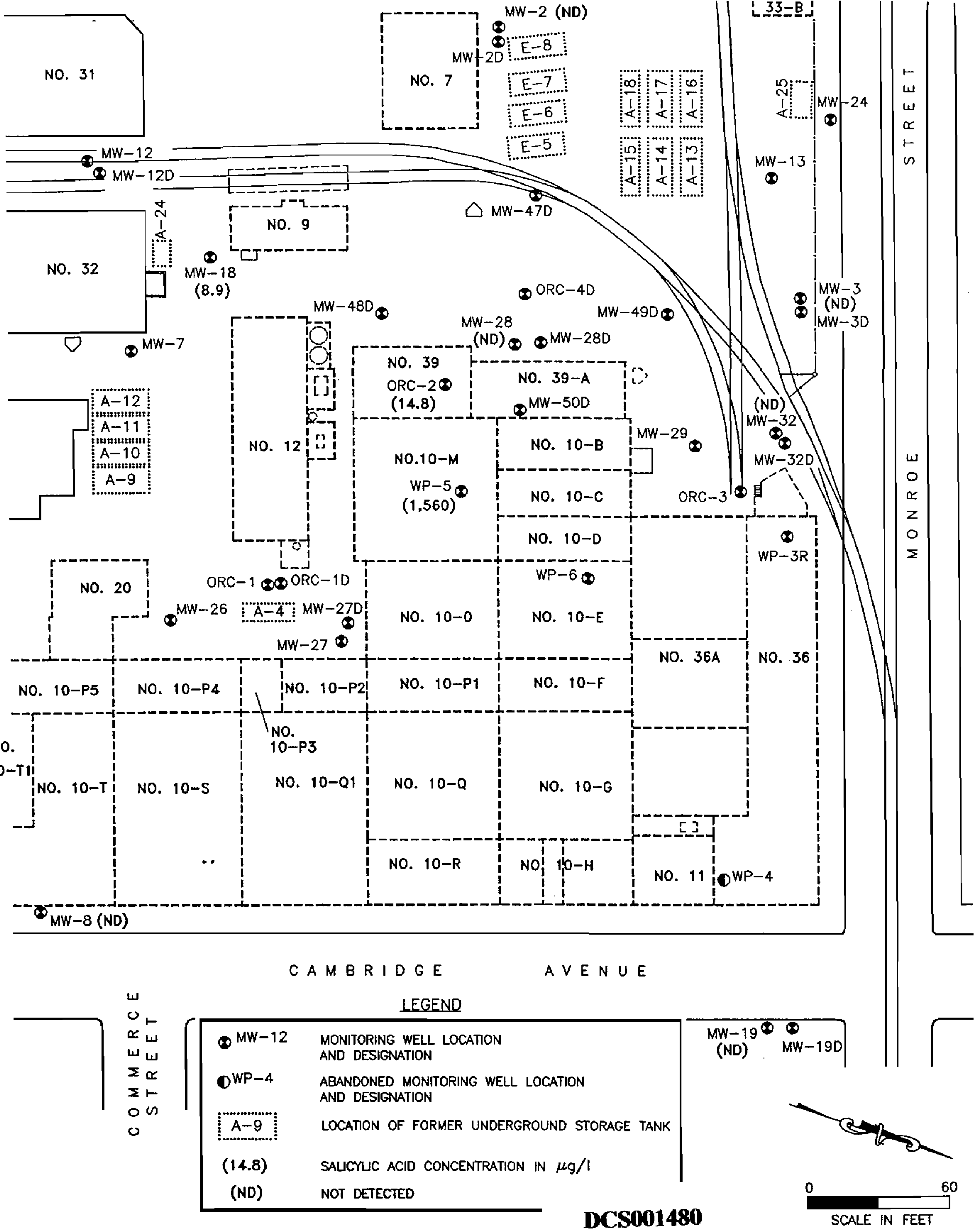

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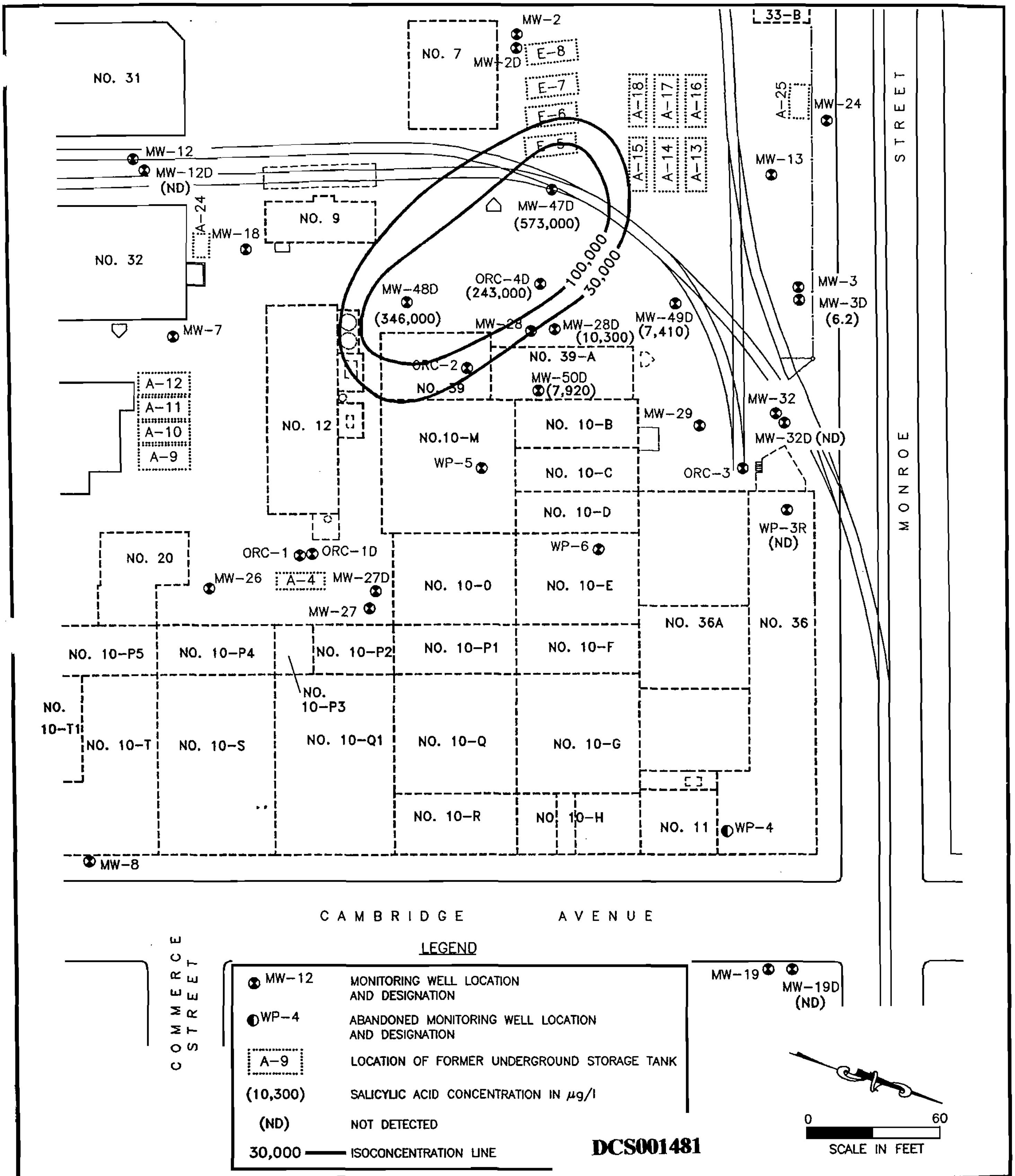
FIGURE 16
DISTRIBUTION OF SALICYLIC ACID IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: pointmap\K_FIG16_OCT00.dwg Date: 11/16/00



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Project No. EP001 File: pointmap\K_FIG17_OCT00.dwg Date: 8/24/00

FIGURE 17
DISTRIBUTION OF SALICYLIC ACID IN GROUNDWATER DEEP OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
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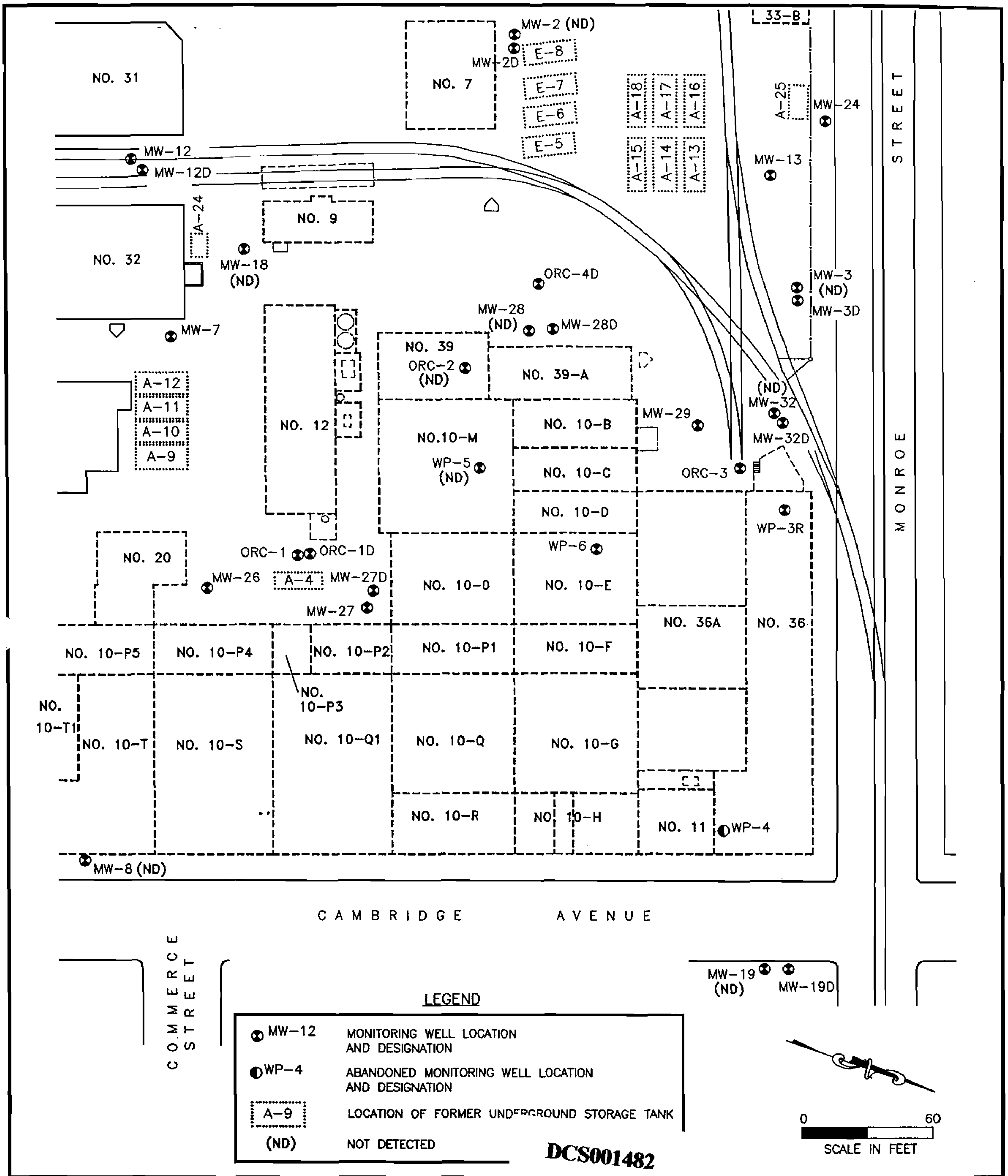

LEGEND

⊗ MW-12	MONITORING WELL LOCATION AND DESIGNATION
◐ WP-4	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-9	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(ND)	NOT DETECTED

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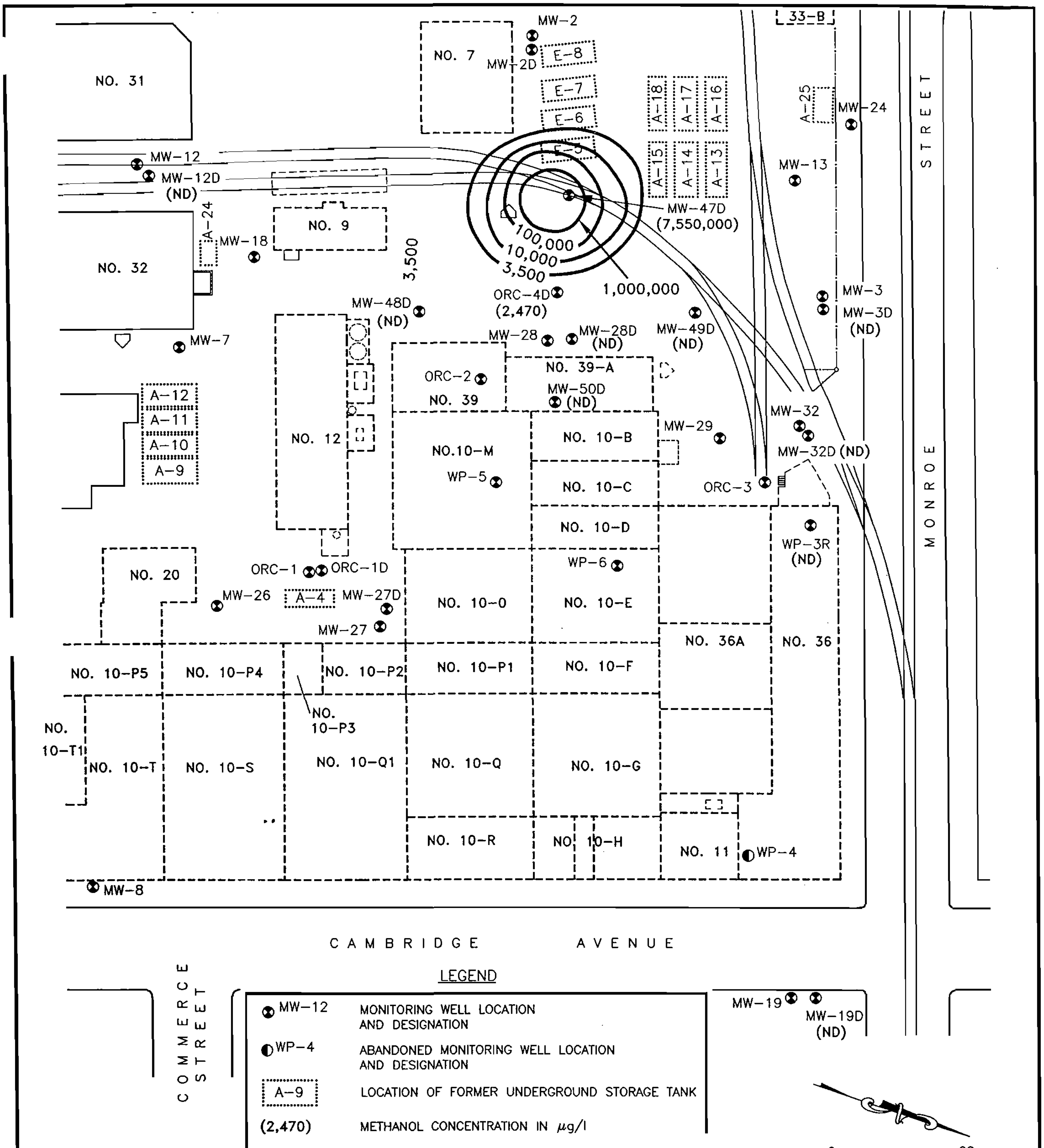
FIGURE 18
DISTRIBUTION OF METHANOL IN GROUNDWATER SHALLOW OVERBURDEN ZONE OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: pointmap\K_FIG18_OCT00.dwg Date: 11/16/00



LEGEND

MW-12	MONITORING WELL LOCATION AND DESIGNATION
◐WP-4	ABANDONED MONITORING WELL LOCATION AND DESIGNATION
A-9	LOCATION OF FORMER UNDERGROUND STORAGE TANK
(2,470)	METHANOL CONCENTRATION IN μg/l
(ND)	NOT DETECTED
3,500 ——	ISOCONCENTRATION LINE

DCS001483

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FIGURE 19
DISTRIBUTION OF METHANOL
IN GROUNDWATER
DEEP OVERBURDEN ZONE
OCTOBER 2000

KALAMA CHEMICAL INC.
GARFIELD, NEW JERS

Project No. EP001 File: pointmap\K FIG19 OCT00.dwg Date: 11/16/00

SOVEREIGN CONSULTING INC.

REMEDIAL INVESTIGATION REPORT

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County New Jersey
ISRA Case No. 86B73

16 July 1999

Prepared for:

EPEC Polymers Inc.
1001 Louisiana Street
Houston, Texas 77002

Prepared by:

Sovereign Consulting Inc.
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DCS001484

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Principal Project Manager

Ravi Gupta

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Principal Engineer

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FIGURES

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TABLES

APPENDICES

ATTACHMENT (under separate cover)

1.0 INTRODUCTION

Sovereign Consulting Inc. (SCI), on behalf of EPEC Polymers Inc. (EPI), has prepared this *Remedial Investigation Report* presenting the results of aquifer testing and groundwater sampling conducted at the Kalama Chemical Inc. facility in Garfield, Bergen County, New Jersey (Figure 1). In July 1996, EPI installed a series of four recovery wells (PW-1 through PW-4) in Hudson Street and Bloomingdale Avenue (see Figure 2) to remove groundwater from those portions of the off-site plume containing the highest concentrations of benzene and toluene. Details on the performance of the recovery wells and the design of a groundwater treatment and re-injection system were submitted to the NJDEP in August 1997 as part of a New Jersey Pollutant Discharge Elimination System - Discharge to Groundwater (NJPDES-DGW) permit application.

On 3 April 1998, the NJDEP issued a letter with comments on the NJPDES-DGW permit application. EPI responded to the NJDEP's comments on 23 April 1998, and made a proposal for allowing the system to be operated for 90 days to allow actual performance data to be collected. On 19 August 1998, the NJDEP issued a letter indicating that they still believed additional aquifer tests were necessary to insure that the proposed groundwater recovery system was adequately designed to address the off-site benzene and toluene plume.

On 27 August 1998, EPI submitted a written request to the City of Garfield to obtain permission to install the required five observation wells (OW-1 through OW-5) and one monitoring well (MW-42) in Hudson Street and Bloomingdale Avenue. EPI received permission from the City of Garfield on 14 September 1998, and the six additional off-site well were installed between 29 September 1998 and 1 October 1998.

Following a quarterly groundwater sampling event in October 1998 in which the six new wells were sampled, preparation began for conducting the aquifer tests on recovery wells PW-1 and PW-3. While attempting to re-develop the wells in November 1998, it was discovered that they had become severely fouled with inorganic (i.e., scaling) and biologic deposits. EPI conducted an extensive well rehabilitation program following the recommendations of the well screen manufacturer. The aquifer tests were subsequently conducted between 7 and 18 December 1998.

During this time, EPI continued to conduct a quarterly groundwater monitoring program that had been implemented to document the effectiveness of the other remediation systems at the site, namely the air sparge/soil vapor extraction (AS/SVE) system in the southeast corner of the property, the air curtain in the southwest corner of the property, and the off-site SVE system in Hudson Street and Bloomingdale Avenue (Figure 2). In reviewing the data from eight quarters of sampling between June 1997 (when the monitoring program was initiated) and April/May 1999, it became apparent that the concentrations of benzene and toluene in groundwater to the south of the site had decreased significantly, and that there had been a corresponding decrease in the size of the benzene and toluene affected area.

2.0 AQUIFER TESTING

Between September and December 1998, EPI conducted several activities associated with performing the required aquifer tests, including:

- Installing observation wells OW-1 through OW-5 and monitoring well MW-42 in Hudson Street and Bloomingdale Avenue;
- Re-developing groundwater recovery wells PW-1 and PW-3; and,
- Conducting two, 72-hour aquifer tests on PW-1 and PW-3.

Each of these activities are discussed in detail in the following sections.

2.1 Installation of Observation and Monitoring Wells

As shown on Figure 2, a total of five observation wells, designated OW-1 through OW-5, were installed in Hudson Street and Bloomingdale Avenue to monitor the effectiveness of the groundwater recovery system. These wells were to be used to measure water level drawdown in the area of the recovery wells. The wells were installed between 29 September 1998 and 1 October 1998 by Summit Drilling Co., Inc. (Summit), using a hollow stem auger drill rig, under the supervision of a SECOR International Inc. (SECOR) geologist. Well OW-1 is located on Bloomingdale Avenue, half way between recovery wells PW-1 and PW-2. Well OW-2 is located approximately 20 feet to the north of PW-1, while OW-3 was installed approximately 30 feet to the east (up-gradient) of recovery well PW-4. The last two wells, OW-4 and OW-5, were installed approximately 30 feet to the south and west, respectively, of recovery well PW-3. Each observation well has a total depth of approximately 30 feet and is constructed with 20 feet of 2.0-inch diameter 20-slot PVC screen and 10 feet of PVC casing. The well heads were completed with flush mounted, water tight manholes and locking caps. The locations of these wells and their construction details had been proposed by EPI in their letter dated 23 April 1998, and were approved by the NJDEP in their letter dated 19 August 1998.

Monitoring well MW-42 was installed approximately 20 feet to the south of well PW-2 to collect water level measurements during the operation of the groundwater recovery system, as well as to help define the southern extent of the dissolved benzene and toluene plume. MW-42 is constructed similarly to the observation wells with 20 feet of 2.0-inch diameter 20-slot PVC screen and 10 feet of PVC casing. The NJDEP required that this well be installed in their 19 August 1998 letter. Copies of the boring logs for MW-42 and OW-1 through OW-5 are included in Appendix A.

The locations and elevations of monitoring wells MW-42 and observation wells OW-1 through OW-5 were measured by a New Jersey Licensed Professional Land Surveyor (Steve Parent; New Jersey License No. 36269). Latitude and longitude of each well were measured to the nearest one-tenth (0.10) of a second; elevations were measured to the nearest one-hundredth (0.01) of a foot. Elevation measurements were taken from each well casing with the inner protective cap removed.

2.2 Re-Development of PW-1 and PW-3

The four off-site recovery wells (PW-1 through PW-4) were installed in July 1996 and a 48-hour performance test was conducted in August 1996 to determine their combined pumping rate. Since these wells had been idle since August 1996, the wells were re-developed to maximize the well yields prior to conducting the aquifer tests. The Hammerhead™ pumps installed in the wells in 1996 were removed to facilitate the re-development. The four recovery wells were re-developed by Summit on 7 October 1998 using Weltone®, a commercially available product made specifically for developing and cleaning water wells. After completing the well re-development, the wells were pumped and determined to have very poor yields ranging from less than 0.1 to 0.3 gallons per minute (gpm), as compared to yields of 0.25 to 3 gpm in August 1996. Given the poor well yields observed, recovery wells PW-1 and PW-3 were re-developed a second time by Summit on 14 October 1998 using NW-100, a pelletized chemical treatment for encrusted wells produced by U.S. Filter/Johnson Screens, the manufacturer of the Channel Pack well screen used in the recovery wells. A custom-made surge block was used to force the NW-100 through the well screen to increase the effectiveness of the treatment. However, only a slight improvement in well yield was observed after the second re-development.

At the recommendation of U.S. Filter/Johnson Screens, recovery wells PW-1 and PW-3 were re-developed a third time by Summit on 2 November 1998 using NW-100 and NW-310, an acid dispersant and organic cleaner produced by U.S. Filter/Johnson Screens. A wire brush was attached below the surge block to further aid in the removal of scaling from the well screen. The third re-development improved the yield of recovery wells PW-1 and PW-3 to approximately 0.5 gpm each. Given the favorable results of the third re-development, these two wells were re-developed a fourth time by Summit on 30 November 1998 using the same methods employed during the previous re-development. After the fourth attempt at re-development, recovery well PW-1 produced approximately 0.6 to 0.7 gpm and PW-3 produced approximately 1 to 1.5 gpm.

2.3 Aquifer Testing

In accordance with the NJDEP letter dated 19 August 1998, aquifer tests were performed using recovery wells PW-1 and PW-3 in December 1998. The air curtain in the southwest corner of the site was shut down several weeks prior to initiating the aquifer tests. The purpose of the aquifer tests was to better determine aquifer properties to enable modeling of the proposed groundwater recovery system under pumping and injecting conditions. A discussion of the aquifer test procedures and results for each test are provided in the following sections.

2.3.1 *Aquifer Test Procedures*

Well PW-1

Well PW-1 is located in Bloomingdale Avenue (Figure 2). Groundwater levels were monitored in PW-1 and nine nearby wells using automated data loggers. Troll® data loggers manufactured by Insitu, Inc. were deployed in wells OW-1, OW-2, MW-25D, MW-40, and MW-41 and Levelogger™ data loggers manufactured by Solinst were deployed in wells PW-1, MW-25, MW-42, OW-3 and OW-5. Additionally, barometric pressure was monitored using a Solinst Levelogger™. The Trolls® were used in wells closest to the pumping well because they can be programmed to record water levels using either a fixed or logarithmic sampling interval which allows for collection of early data at the start and end of pumping when changes occur rapidly. The Leveloggers™ were used in more distant wells where early test data is not as crucial.

The background phase of the test was conducted over a weekend from Friday, 4 December 1998 to Monday, 7 December 1998. The Trolls® and Leveloggers™ were programmed to record water levels at 15 minute intervals to collect background water level (and barometric pressure) trends prior to the aquifer test. The 72 hour pumping phase of the test was conducted from Monday, 7 December 1998 to Thursday, 10 December 1998. The well was pumped using the Hammerhead™ pump and the water was routed through the subgrade piping to a 21,000 gallon storage tank located on the Kalama site. The pumping rate was measured using a pneumatic pump cycle counter located at the well and a turbine flow totalizer located on the discharge piping to the storage tank. The Trolls® were programmed to record water levels using a logarithmic sampling interval during the first 4 hours of the test and then at 15 minute intervals for the remainder of the pumping phase. The Leveloggers™ continued to record water levels (and barometric pressure) at 15 minute intervals during the pumping phase. The recovery phase of the test was conducted from Thursday, 10 December 1998 to Friday, 11 December 1998. The Trolls® were again programmed to record water levels using a logarithmic sampling interval and the Leveloggers™ continued to record water levels (and barometric pressure) at 15 minute intervals during the recovery phase.

Well PW-3

Well PW-3 is located in Hudson Street (Figure 2). Groundwater levels were monitored in PW-3 and nine nearby wells using automated data loggers. Troll® data loggers were deployed in wells OW-2, OW-4, OW-5, MW-1D, and MW-40 and Levelogger™ data loggers were deployed in wells PW-3, MW-1, MW-11, MW-14 and MW-23. Additionally, barometric pressure was monitored using a Solinst Levelogger™. Similar to the test at PW-1, the Trolls® were used in wells closest to the pumping well and the Leveloggers™ were used in more distant wells.

The background phase of the test was conducted over a weekend from Friday, 11 December 1998 to Monday, 14 December 1998. The Trolls® and Leveloggers™ were programmed to record water levels at 15 minute intervals to collect background water level (and barometric pressure) trends prior to the aquifer test. The 72 hour pumping phase of the test was conducted from Monday, 14 December 1998 to Thursday, 17 December 1998. The well was pumped using the Hammerhead™ pump and the water was routed through the subgrade piping to the on-site storage tank. The pumping rate was measured using a pneumatic pump cycle counter located at the well and a turbine flow totalizer located on the discharge piping to the storage tank. The Trolls® were programmed to record water levels using a logarithmic sampling interval during the first 4 hours of the test and then at 15 minute intervals for the remainder of the pumping phase. The Leveloggers™ continued to record water levels (and barometric pressure) at 15 minute intervals during the pumping phase. The recovery phase of the test was conducted from Thursday, 17 December 1998 to Friday, 18 December 1998. The Trolls® were again programmed to record water levels using a logarithmic sampling interval and the Leveloggers™ continued to record water levels (and barometric pressure) at 15 minute intervals during the recovery phase.

2.3.2 *Aquifer Test Results - PW-1*

Well PW-1 is 32 feet deep from ground surface or approximately 31.25 feet deep from the top of casing. The top of the Hammerhead™ pump is approximately 26.5 feet below the top of casing (the pump is 4 feet, 7 inches long and is set approximately 3 inches off the bottom). Given that the depth to water in PW-1 prior to pumping was approximately 14.5 feet below the top of casing, the maximum available drawdown was 12 feet. Utilizing the full 12 feet of available drawdown, PW-1 was pumped at a rate of 0.5 gpm for approximately 73.5 hours. At a pumping rate of 0.5 gpm and a drawdown of 12 feet, the three day specific capacity of PW-1 was 0.04 gpm/ft of drawdown. A total of 2,225 gallons were pumped during the 3 day aquifer test conducted using PW-1.

The water level (and barometric pressure) readings collected by the Troll® and Levelogger™ data loggers were downloaded into spreadsheet format and used to prepare hydrographs (Appendix B) for each well from the start of the background phase (4 December 1998) through the end of the recovery phase (11 December 1998). The barometric pressure was plotted with the water level to evaluate if changes in water level could be attributed to changes in barometric pressure. When barometric pressure decreases, the water levels in a well can rise, and vice versa. By comparing the barometric pressure changes with the water levels during the background phase, the barometric efficiency of the aquifer can be determined (Kruseman and de Ridder, 1990). With a decrease in barometric pressure of 1.0 inch of mercury (1.13 feet of water) over a 12 to 24 hour period, the water level in a well in an aquifer with a 50% barometric efficiency would rise 0.56 feet (50% of 1.13 feet). Therefore, the effect of barometric pressure can be significant when evaluating aquifer test data.

During the seven day period of the test, the maximum barometric pressure change was approximately 0.62 inches of mercury (0.7 feet of water). Therefore, if the barometric efficiency of the aquifer was 100%, the change in water levels attributable to changes in barometric pressure would be a maximum of 0.7 feet. To determine the barometric efficiency of the aquifer, water levels collected during the background phase of the test are compared to the barometric pressure, using consistent units (e.g. feet of water). If the water level in a well decreases 0.1 feet during the same period that the barometric pressure increases 0.25 feet, the barometric efficiency of the aquifer at the location of that particular well is 40%. To correct for water level changes in a well caused solely by changes in barometric pressure over the duration of the test, the water levels recorded during the test would be corrected by 40% of the change in barometric pressure.

Inspection of the hydrographs for the nine observation wells used during the test (Appendix B) indicates water level changes occurred in most of the wells during the background and recovery phases of the test which are not attributable to changes in barometric pressure. The changes appear to be cyclic and range from 0.25 to 0.5 feet in wells MW-25D and MW-40 and from 1.0 to 2.5 feet in wells OW-1, OW-2, OW-3, and MW-41. The changes are cyclic, although they are asymmetric rather than the typical sinusoidal shape of tidally influenced aquifers. Additionally, the cyclic changes do not continue during the pumping phase as would be expected with the limited drawdown due to pumping. Therefore, the cause of the water level changes is likely due to tidal fluctuations in the Passaic River.

Since the water level changes observed mask any changes which can be attributed to barometric pressure, it is not possible to accurately determine barometric efficiency and, therefore, not possible to correct for changes in barometric pressure. Additionally, since the water levels tended to be higher in the wells after the pumping phase than before the start of pumping, it is not possible to accurately determine the drawdown at observation wells as a result of pumping from PW-1. With these limitations, an attempt was made to estimate the drawdown attributable to pumping from PW-1 at several of the observation wells after one, two, and three days of pumping. First, a correction for barometric efficiency was made using a small portion of the data where the recorded water levels appeared to be influenced by changes in barometric pressure. A visually estimated best-fit straight line was then extrapolated between the corrected background and recovery phase water levels. The drawdown was then taken as the difference between the extrapolated best-fit line and the corrected water levels. A summary of the results is provided below:

Well	Distance from PW-1 (ft)	Barometric Efficiency	Estimated Drawdown (ft)		
			1 Day	2 Days	3 Days
OW-2	10	25 %	0.15	0.50	0.79
MW-25D	20	75 %	0.48	0.61	0.66
OW-1	50	25 %	0.05	0.21	0.38
MW-40	80	10 %	0.06	0.13	0.18
OW-5	150	10 %	0.04	0.09	0.10

The above data were used to estimate the transmissivity and storage coefficient of the aquifer by the Cooper-Jacob distance-drawdown method (Driscoll, 1986). As shown on Figure 3, a relatively good fit was achieved using the drawdown data after three days of pumping, resulting in an estimated transmissivity of 419 gallons/day per foot (gpd/ft), a storage coefficient of 0.01 (unitless), and a hydraulic conductivity of 3 ft/day. The hydraulic conductivity value obtained from the PW-1 aquifer test is consistent with previous estimates for the site by Geraghty & Miller (3 ft/day) and SECOR (5 to 10 ft/day).

The distance-drawdown plot shown on Figure 3 indicates the drawdown at pumping well PW-1 would be approximately 1.5 feet. Since the actual drawdown observed at PW-1 was 12 feet, the well efficiency is estimated to be approximately 12%. This low well efficiency is partly the cause of the low specific capacity (0.04 gpm/ft of drawdown) of PW-1. The maximum theoretical specific capacity of a well can be estimated from the transmissivity using the following equation (Driscoll, 1986):

$$\frac{Q}{s} = \frac{T}{1{,}500}$$

Where: Q/s = specific capacity of the well, in gpm/ft of drawdown
T = transmissivity, in gpd/ft

From this relationship, the maximum theoretical specific capacity (assuming 100% well efficiency) is estimated to be 0.28 gpm/ft of drawdown. Since wells in unconfined aquifers are typically less than 60% efficient, the best specific capacity which could be expected would be approximately 0.17 gpm/ft of drawdown. Thus, with an available drawdown of 12 feet, the maximum yield which could be expected from a pumping well (at 60% efficiency) is 2.0 gpm.

2.3.3 *Aquifer Test Results - PW-3*

Well PW-3 is 30 feet deep from ground surface or approximately 29.25 feet deep from the top of casing. The top of the Hammerhead™ pump is approximately 24 feet below the top of casing (the pump is 4 feet, 7 inches long and is set approximately 6 inches off the bottom). Given the depth to water in PW-3 prior to pumping was approximately 12.5 feet below the top of casing, the maximum available drawdown was 11.5 feet. Utilizing the full 11.5 feet of available drawdown, PW-3 was pumped at a rate of 1.1 gpm for approximately 73.5 hours. At a pumping rate of 1.1 gpm and a drawdown of 11.5 feet, the three day specific capacity of PW-3 was 0.10 gpm/ft of drawdown. A total of 4,741 gallons were pumped during the three day aquifer test conducted using PW-3.

The water level (and barometric pressure) readings collected by the Troll® and Levelogger™ data loggers were downloaded into spreadsheet format and used to prepare hydrographs (Appendix C) for each well from the start of the background phase (11 December 1998) through the end of the recovery phase (18 December 1998). The barometric pressure was plotted with the water level to evaluate if changes in water level could be attributed to changes in barometric pressure. As previously discussed, when barometric pressure decreases, the water levels in a well can rise, and vice versa. By comparing the barometric pressure changes with the water levels during the background phase, the barometric efficiency of the aquifer can be determined (Kruseman and de Ridder, 1990).

During the seven day period of the test, the maximum barometric pressure change was approximately 0.81 inches of mercury (0.92 feet of water). Therefore, if the barometric efficiency of the aquifer was

100%, the change in water levels attributable to changes in barometric pressure would be a maximum of 0.92 feet. To determine the barometric efficiency of the aquifer, water levels collected during the background phase of the test are compared to the barometric pressure, using consistent units (e.g. feet of water). If the water level in a well decreases 0.1 feet during the same period that the barometric pressure increases 0.25 feet, the barometric efficiency of the aquifer at the location of that particular well is 40%. To correct for water level changes in a well caused solely by changes in barometric pressure over the duration of the test, the water levels recorded during the test would be corrected by 40% of the change in barometric pressure.

Inspection of the hydrographs for the nine observation wells used during the test (Appendix C) indicates water level changes occurred in most of the wells during the background and recovery phases of the test which are not attributable to changes in barometric pressure. The changes appear to be cyclic and range from 0.25 to 0.5 feet in wells OW-4, OW-5 and MW-40 and from 1.0 to 3.0 feet in wells OW-2 and MW-1D. The changes are cyclic, although they are asymmetric (with the exception of MW-1D) rather than the typical sinusoidal shape of tidally influenced aquifers. Unlike the test performed using PW-1, the cyclic changes continued during the pumping phase of the test performed using PW-3. The cause of the water level changes is likely due to tidal fluctuations in the Passaic River.

Since the water level changes observed mask any changes which can be attributed to barometric pressure, it is not possible to accurately determine barometric efficiency and, therefore, not possible to correct for changes in barometric pressure. Additionally, since the water changes due to tidal fluctuations tended to be greater than the drawdown due to pumping, it is not possible to accurately determine the drawdown at observation wells as a result of pumping from PW-3. With these limitations, an attempt was made to estimate the drawdown attributable to pumping from PW-3 at several of the observation wells after one, two, and three days of pumping. First, a correction for barometric efficiency was made using a small portion of the data where the recorded water levels appeared to be influenced by changes in barometric pressure. A visually estimated best-fit straight line was then extrapolated between the corrected background and recovery phase water levels. The drawdown was then taken as the difference between the extrapolated best-fit line and the corrected water levels. A summary of the results is provided below:

Well	Distance from PW-3 (ft)	Barometric Efficiency	Estimated Drawdown (ft)		
			1 Day	2 Days	3 Days
OW-4	28	15 %	0.09	0.14	0.18
OW-5	30	25 %	0.08	0.16	0.24
MW-1D	60	25 %	0.10	0.15	0.20
MW-1	65	15 %	0.05	0.10	0.15
MW-11	105	15 %	0.08	0.17	0.30
MW-14	135	15 %	0.00	0.05	0.14
MW-23	145	10 %	0.00	0.04	0.06

The above data were used to estimate the transmissivity and storage coefficient of the aquifer by the Cooper-Jacob distance-drawdown method (Driscoll, 1986). As shown on Figure 4, the drawdown data after three days of pumping resulted in an estimated transmissivity of 5,808 gallons/day per foot (gpd/ft), a storage coefficient of 0.005 (unitless), and a hydraulic conductivity of 39 ft/day. The transmissivity and hydraulic conductivity values obtained from the PW-3 aquifer test are higher than previous estimates for the site (by up to one order of magnitude) and are therefore considered suspect given the problems experienced in obtaining drawdown values from the water level data.

2.4 Groundwater Recovery System Capture

The results of the aquifer tests conducted in December 1998 using wells PW-1 and PW-3 indicate the hydraulic conductivity ranged from 3 ft/day (PW-1) to 39 ft/day (PW-3). Given the limited drawdown observed in observation wells in comparison to the fluctuations in water level (presumably caused by tidal fluctuations in the Passaic River), the hydraulic conductivity and other aquifer properties obtained from these tests should be considered order-of-magnitude estimates. Based on these results and previous estimates of aquifer properties for the site vicinity by Geraghty & Miller and SECOR, a hydraulic conductivity of 5 ft/day was used to evaluate groundwater capture for the recovery system. The two-dimensional groundwater flow model WinFlow (Environmental Simulations, 1995) was used to simulate pumping from the off-site recovery system and re-injecting into the proposed on-site injection system.

The pumping rates used for the simulations were based upon the recent pumping rates achieved during the three day aquifer tests. The modeling indicates that a total pumping rate of 5 gpm from seven recovery wells would be needed to achieve the desired groundwater capture (Figure 5). The parameters used in the model simulation are summarized below:

Parameter	Value
Hydraulic Conductivity	5 ft/day
Aquifer Thickness	20 ft
Hydraulic Gradient	0.01
Aquifer Porosity	0.3
Pumping Rates	
PW-1	0.75 gpm
PW-2	0.75 gpm
PW-3	1.00 gpm
PW-4	0.25 gpm
PW-5	0.75 gpm
PW-6	0.75 gpm
PW-7	<u>0.75 gpm</u>
	5.00 gpm total
Injection Rates	
IW-1	1.25 gpm
IW-2	1.25 gpm
IW-3	1.25 gpm
IW-4/MW-12	<u>1.25 gpm</u>
	5.00 gpm total

The influence of the proposed re-injection wells is also shown on Figure 5. In their letter dated 19 August 1998, the NJDEP expressed concerns that the re-injection system might increase the groundwater gradient, resulting in a reduced residence time through the air curtain. In the 29 February 1996 *Remedial Action Work Plan Addendum*, a groundwater velocity of 1.5 ft/day was used to demonstrate that the residence time through the air curtain would be twice what was required to remediate any benzene and toluene that might be discharged to the subsurface after passing through the treatment system. This groundwater velocity was a conservative estimate[1] and was not specific to the area of the air curtain in

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[1] Based on Geraghty & Miller's estimated groundwater velocity in the vicinity of the groundwater mound present in the northeast corner of the site.

the southwest corner of the site. The WinFlow simulations of groundwater recovery and re-injection shown on Figure 5 indicate that the groundwater velocity between the re-injection wells and the western property line (River Drive) would range from 0.4 to 0.6 ft/day. Therefore, the residence time through the air curtain on the west side of the site would be approximately three times greater than what was originally estimated. The groundwater velocity along the southern property line (between the re-injection wells and the recovery wells in Hudson Street) would range from 0.5 to 1.0 ft/day. These velocities would also result in a residence time that was 1.5 to three times greater than was originally estimated.

3.0 DISCUSSION OF GROUNDWATER SAMPLING RESULTS

As discussed in Section 2.4, it would be necessary to install three additional recovery wells to capture the portions of the benzene and toluene plume containing total concentrations greater than 10,000 ppb. However, quarterly groundwater monitoring conducted since June 1997 indicates that there has been a significant reduction in the size of the off-site plume (and in the concentrations of benzene and toluene) since the other remediation systems at the site (i.e., the AS/SVE system in the source area, the air curtain along the southern and western property lines, and the off-site SVE system) were brought on-line. The following sections discuss the groundwater sampling that has been conducted and the concentrations of benzene and toluene that have been found in the off-site affected area.

3.1 Groundwater Monitoring Program

The Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (Area of Environmental Concern [AEC]-14) is located in the southeast corner of the facility and is the source of the benzene and toluene found in groundwater at the site. In order to monitor the effectiveness of the air sparge/soil vapor extraction (AS/SVE) and air curtain systems, groundwater samples are collected on a quarterly basis from the following wells:

Source Area Wells	MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-25, and MW-33
Monitoring Points	OW-1, OW-2, OW-3, OW-4, OW-5, MW-22, MW-23, MW-30, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, and MW-42

The groundwater samples from these wells were analyzed for benzene and toluene by either USEPA Methods 602 or 624. Observation wells OW-1 through OW-5 have only recently been added to the monitoring program (to help define the shape of the benzene and toluene affected area) so only two rounds of data are available for these wells. MW-42 has been included in the monitoring program since October 1998. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix D.

3.1.1 *Groundwater Sampling Procedures*

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of separate phase hydrocarbons (SPH) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the vicinity of the well. If three well volumes could not be purged due to poor recharge, the water level in the well was allowed to recover to within two feet of static conditions (or sufficiently to allow sample collection) prior to sampling.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rate was kept below five gallons per minute (gpm). The flow rate for purging the final well volume did not exceed one gpm. Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string; the samples were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling. All samples were analyzed by New Jersey Certified Laboratories (either RECRA Environmental in Amherst, New York, or Accutest in Dayton, New Jersey).

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

3.1.2 *Groundwater Sampling Results - June 1997*

Groundwater samples were collected from 18 wells as part of the June 1997 sampling event. Monitoring wells MW-4, MW-D5, MW-9, and MW-41 were not sampled due to the presence of separate phase hydrocarbons (SPH). Monitoring well MW-42 and observation wells OW-1 through OW-5 had not been installed at the time of this sampling event. The June 1997 samples were collected before any of the remediation systems at the site were brought on-line, and therefore serve as a baseline against which subsequent groundwater samples can be compared.

The analytical results for the June 1997 groundwater sampling event are summarized on Table 1 and are presented on Figure 6. Benzene was detected at concentrations above the NJDEP's Groundwater Quality Standard (GWQS) of 1.0 ppb in 14 of the 18 wells sampled, while toluene was detected at concentrations above the NJDEP's GWQS of 1,000 ppb in seven wells.

In the on-site wells, benzene concentrations exceeding the GWQS ranged from 16.0 ppb in MW-5 to 770 ppb in MW-17. Benzene was detected in all of the wells sampled along the southern property line (Hudson Street) and along the southwestern property line (River Drive). In the off-site wells, benzene concentrations ranged from 26.0 ppb in MW-36 to 9,300 ppb in MW-33.

Toluene exceeded the GWQS in on-site wells MW-14 (90,000 ppb) and MW-30 (44,000 ppb). In the off-site wells, toluene exceeded the GWQS in MW-23 (3,600 ppb), MW-25 (94,000 ppb), MW-31 (4,300 ppb), MW-33 (610,000 ppb) and MW-40 (480,000 ppb).

In general, benzene and toluene concentrations in June 1997 did not reflect any significant changes from previous sampling events. The one exception was the toluene concentration in MW-17, which dropped from 240,000 ppb in May 1993 (the last time the well was sampled) to 170 ppb in June 1997.

3.1.3 *Groundwater Sampling Results - April/May 1999*

Groundwater samples were collected from 26 wells in April and May 1999. Monitoring well MW-9 was not sampled due to the presence of SPH. Observation wells OW-1 through OW-4 were sampled in May 1999 to help further define the shape of the benzene and toluene plumes. OW-5 was silted up and could not be sampled. The analytical results for the April/May 1999 sampling event are summarized on Table 2 and are presented on Figure 7. Copies of the analytical data packages for the April/May 1999 groundwater samples, as well as the Electronic Data Deliverables, are provided under separate cover as Attachment I.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 12 of the 26 wells sampled. In the on-site wells, benzene concentrations exceeding the GWQS ranged from 4.7 ppb in MW-17 to 2,100 ppb in MW-D5. In the off-site wells, benzene concentrations exceeding the GWQS ranged from 1.3 ppb in MW-42 to 1,600 ppb in OW-3.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in three on-site wells including MW-4 (1,480 ppb), MW-D5 (112,000 ppb), and MW-14 (48,600 ppb). In the off-site wells, toluene exceeded the GWQS in MW-25 (89,800 ppb), MW-33 (228,000 ppb), MW-40 (128,000 ppb), OW-2 (4,740 ppb) and OW-3 (3,040 ppb).

4.0 EVALUATION OF NATURAL ATTENUATION

In order to evaluate whether natural attenuation was occurring in the off-site benzene and toluene plume, EPI reviewed the groundwater data collected over the last two years (eight quarters since June 1997).

4.1 Primary Lines of Evidence for Natural Attenuation

The primary line of evidence for remediation by natural attenuation is provided by observed reductions in plume geometry and observed reductions in concentrations of constituents of concern (ASTM, 1998). A shrinking plume is indicative of a rate of natural attenuation that is greater than the rate at which benzene or toluene are entering the plume from the source area. At the Kalama site, the operation of the AS/SVE system and the air curtain have served to prevent the continued migration of benzene and toluene from the on-site source area (AEC-14).

The distributions of toluene and benzene in the shallow overburden zone using the June 1997 groundwater sampling results are shown on Figure 8 and Figure 9, respectively. The highest concentrations of toluene (greater than 100,000 ppb) were found in a lenticular shaped plume which originated from the toluene spill area (MW-33) and extended westward along Hudson Street. Upon reaching River Drive, the toluene plume extended to the north to MW-30. This distribution was consistent with those from historical sampling events. The benzene plume roughly mirrored the toluene plume, with the highest concentrations (greater than 1,000 ppb) being found in a lenticular shaped plume extending from MW-33 westward to MW-40. The benzene plume had two lobes which extended to the north, one in the toluene spill area and one along the southwestern property line. The benzene plume also extended further to the south, although at significantly lower concentrations than seen in the wells within Hudson Street.

The distribution of toluene and benzene in the shallow overburden zone using the April/May 1999 groundwater sampling results are shown on Figure 10 and Figure 11, respectively. The toluene plume has been reduced to three small areas, with the highest concentrations of toluene (greater than 100,000 ppb) limited to the vicinities of MW-33 and MW-40. The third area is centered around MW-14 in the southwest corner of the site; toluene concentrations in this well exceed 10,000 ppb. The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) also being found near MW-33 and MW-40. Benzene concentrations in MW-14 exceeded 100 ppb.

The sizes of the benzene and toluene affected areas are significantly smaller in April/May 1999 than in June 1997. The following table summarizes the changes in concentrations observed between the two sampling events.

	Benzene			**Toluene**		
Well	6/97	4/99 - 5/99	% Change	6/97	4/99 - 5/99	% Change
MW-1	320	<GWQS	-100%	<GWQS	<GWQS	
MW-4	SPH (1)	7.9	-100%	SPH (1)	1,480	-100%
MW-5	16.0	<GWQS	-100%	<GWQS	<GWQS	
MW-D5	SPH (1)	2,100	-100%	SPH (1)	112,000	-99%
MW-E5	<GWQS	<GWQS		<GWQS	<GWQS	
MW-6	53.0	<GWQS	-100%	<GWQS	<GWQS	
MW-9	SPH	SPH		SPH	SPH	
MW-10	49.0	<GWQS	-100%	<GWQS	<GWQS	
MW-11	67.0	<GWQS	-100%	<GWQS	<GWQS	
MW-14	760	275	-64%	90,000	48,600	-46%
MW-17	770	4.7	-99%	<GWQS	<GWQS	
MW-22	110	<GWQS	-100%	<GWQS	<GWQS	
MW-23	520	72.8	-86%	3,600	<GWQS	-87%
MW-25	1,100*	851	-23%	210,000*	89,800	-57%
MW-30	230	<GWQS	-100%	44,000	<GWQS	-100%
MW-31	170	<GWQS	-100%	4,300	<GWQS	-100%
MW-33	9,300	1,520	-84%	610,000	228,000	-63%
MW-36	26.0	<GWQS	-100%	<GWQS	<GWQS	

	Benzene			Toluene		
Well	6/97	4/99 - 5/99	% Change	6/97	4/99 - 5/99	% Change
MW-37	<GWQS	<GWQS		<GWQS	<GWQS	
MW-38	<GWQS	<GWQS		<GWQS	<GWQS	
MW-40	5,000	1,170	-77%	480,000	128,000	-73%
MW-41	SPH (2)	<GWQS	-100%	SPH (2)	<GWQS	-100%
MW-42	0.67**	1.3	94%	<GWQS**	<GWQS	
OW-1	18.0**	6.7	-63%	<GWQS**	<GWQS	
OW-2	560**	34.9	-94%	93,000**	4,740	-95%
OW-3	9,300**	1,600	-83%	12,000**	3,040	-75%
OW-4	3,800**	<GWQS	-100%	190,000**	<GWQS	-100%

Notes:
All concentrations reported in ppb.
(1) - SPH sample from the area contained 2,100 ppm of benzene and 33,000 ppm of toluene.
(2) - SPH sample from MW-41 contained 1,700 ppm of benzene and 660,000 ppm of toluene.
* - The 6/97 results for this well were anomalously low, so concentrations shown are from 9/97.
** - Data from 10/97 when wells were first sampled.

The analytical results for the April/May 1999 sampling event indicate that the areal extent of the benzene plume has been reduced by 65%, while the extent of the toluene plume has been reduced by 79%. In addition, concentrations of benzene have decreased from 23% to 100% in all but one well (MW-42) since June 1997. The benzene concentration in MW-42 increased slightly from 0.67 ppb in October 1997 to 1.3 ppb in April 1999; benzene was not detected in MW-42 in January 1999 (see the historical data summary in Appendix D). Toluene concentrations have decreased between 46% to 100% in all wells. These results are indicative of a "shrinking plume" (as defined by ASTM) where the plume margins are shrinking over time and/or the concentrations within the plume are decreasing over time. Therefore, it appears that natural attenuation/biodegradation is actively occurring in the off-site benzene/toluene plume.

To further evaluate the declining concentration trends for benzene and toluene, concentration vs. time plots were prepared for twelve monitoring/observation wells at the site. The benzene and toluene concentrations were plotted using a logarithmic scale to determine if they plot as a straight line, which is indicative of first-order exponential decay (i.e., $Y = Y_0 e^{-kx}$). Inspection of the plots (Appendix E) indicates a straight line fit through the data, suggesting the concentrations are, in fact, declining exponentially. Additionally, in some cases where sufficient historical data was available, the slope of the decline increased since 1997, indicating the on-site AS/SVE and air curtain systems are accelerating the decline in benzene and toluene concentrations.

Linear regressions were performed to obtain the best-fit straight line (of the form $C = C_0 e^{-kt}$) and the degradation constant (k) and half-life ($t_{½}$). The half-life is related to the decay constant by:

$$t_{½} = \frac{\ln(2)}{k}$$

As shown on the plots in Appendix E, the half-life of benzene ranged from 17 days at OW-4 to 1.97 years at MW-25, with an average of 0.64 years (or 0.88 years if OW-1 through OW-4 are excluded since they have only been sampled twice). Similarly, the half-life of toluene ranged from 12 days at OW-4 to 3.28 years at MW-D5, with an average of 0.88 years (or 1.22 years excluding OW-1 through OW-4). Based on the results of the regression analyses, the concentrations of benzene and toluene are following a first-order exponential decline with half-lives of approximately one year. Therefore, the regression lines can be used to estimate future concentrations of benzene and toluene.

The distribution of toluene and benzene in January 2000, 2001, and 2002 were estimated by extrapolating the linear regression line for each well into the future and then contouring the data using SURFER in the same manner that the July 1997 and April/May 1999 data were contoured. The extrapolated distributions of toluene and benzene (Figures 12 and 13, respectively) illustrate the expected continued reduction in size of the affected area based on current trends.

The distribution maps were used to estimate the mass of benzene and toluene in the dissolved and adsorbed phases assuming equilibrium conditions (USEPA, 1989) for 1997 through 2002. First, the mass of benzene and toluene in groundwater were calculated using the distribution maps based on groundwater sample results, an estimated saturated thickness of 20 feet, and an assumed porosity of 30%. The total mass of contaminant present (including the adsorbed phase) was then determined by multiplying the dissolved mass by the retardation factor (Rf). The estimated total mass (dissolved and adsorbed) of benzene and toluene present based on groundwater sample results and estimated retardation factors are summarized below:

Date	Mass of Benzene (lbs.)			Mass of Toluene (lbs.)		
	Dissolved	Adsorbed (Rf=3.6)	Total	Dissolved	Adsorbed (Rf=4.6)	Total
June 1997	56	144	200	3,727	13,251	16,978
April/May 1999	7	18	25	223	973	1,016
January 2000	3	9	12	130	461	591
January 2001	1	4	5	58	206	264
January 2002	<1	2	3	28	101	129

As shown above, the mass of benzene and toluene declined significantly between June 1997 and April/May 1999 and, based on the current trends observed over the past eight quarterly groundwater sampling events, are expected to continue to decline at similar rates.

4.2 Secondary Lines of Evidence for Natural Attenuation

Secondary lines of evidence for remediation by natural attenuation would be changes in geochemical indicators specific to the biodegradation process. Hydrocarbons are metabolized by bacteria through a series of enzyme-catalyzed, oxidative-reductive reactions. These reactions yield electrons which, through a series of enzyme-catalyzed electron transport steps, produce the energy the cell needs for maintenance and growth. In order for the electrons to pass through the energy generating steps, an electron acceptor is required. In the case of aerobic respiration, molecular oxygen (O_2) would be the electron acceptor. In the absence or near absence of molecular oxygen (i.e., anaerobic respiration), the following geochemical parameters (in the order listed) may serve as electron acceptors: nitrate (NO_3^-); manganese (Mn^{+4}); ferric iron (Fe^{+3}); sulfate (SO_4^{-2}); and carbon dioxide (ASTM, 1998; NJDEP, 1996).

In May 1999, EPI collected groundwater samples from the following off-site wells to determine if the geochemical parameters indicated that biodegradation was occurring:

Background Wells

•	MW-35	Located 200 feet to the east (upgradient) of the site
•	MW-37	Located 580 feet to the south (side gradient) of the site
•	MW-38	Located 520 feet to the south (side gradient) of the site

Wells on Fringe of Plume

•	MW-36	Located 240 feet to the south of the site (formerly contained benzene at concentrations above the GWQS)
•	MW-42	Located 210 feet to the south of the site (contains trace amount of benzene)

Wells Within the Plume

•	MW-25	Contained 851 ppb of benzene and 89,800 ppb of toluene in April 1999
•	MW-33	Contained 1,520 ppb of benzene and 228,000 ppb of toluene in April 1999
•	MW-41	Located between MW-25 and MW-33. Formerly contained SPH, but benzene and toluene concentrations are currently below the GWQS

Each sample was analyzed for the following inorganic parameters: alkalinity (as $CaCO_3$); ferrous (Fe^{+2}) and total iron; nitrate; total phosphorous; sulfate; dissolved oxygen; redox potential (Eh); pH; specific conductivity; and temperature. In addition, the samples were analyzed for a suite of biological parameters, including: phenanthrene degraders; fluorescent pseudomonas; total viable and non-viable cells; and total viable organisms. The results of these analyses are summarized on Table 3. The following table summarizes the uses of each inorganic and biologic parameter (ASTM, 1998).

Parameter	Use of Data
pH*	Difference in pH between contaminated and uncontaminated groundwater may indicate biological activity is occurring.
Temperature*	Biodegradation rates may depend on temperature. An increase in temperature may be seen within the contaminant plume.
Dissolved Oxygen (D.O.)*	An inverse correlation between D.O. and benzene/toluene concentrations indicates aerobic biodegradation is occurring. D.O. concentrations should be lower within the plume relative to background wells.
Redox Potential*	Evaluate potential for biologically mediated redox reactions to occur.

Parameter	Use of Data
Ferrous Iron	Increased concentrations may indicate that ferric iron is being used as an electron acceptor during anaerobic biodegradation.
Total Iron	Increased dissolved iron may indicate that ferric iron is being used as an electron acceptor during anaerobic biodegradation.
Nitrate	Decreased concentrations may indicate use of nitrate as a nutrient in aerobic biodegradation or as an electron acceptor during anaerobic biodegradation.
Sulfate	Decreased concentrations may indicate use of sulfate as an electron acceptor during anaerobic biodegradation.
Alkalinity	A zone of increased alkalinity indicates biodegradation is either producing organic acids which lower the pH and solubilize carbonates, or that CO_2 is being produced.
Phenanthrene Degraders	These organisms have been identified as a source for the remediation of heavier petroleum fuels. The higher the count of these organisms, the more rapidly biodegradation would be expected to occur.
Fluorescent pseudomonas	These organisms have been identified as a source for the remediation of lighter petroleum fuels. The higher the count of these organisms, the more rapidly biodegradation would be expected to occur.
Total Viable & Non-Viable Cells	A direct measurement of all bacteria, including active, dormant, or dead organisms.
Total Viable Organisms	A measurement of all viable bacteria. These results are an indicator of the ability of the sample to support bacterial growth.

Notes:
* - measured in the field after purging the well.

Dissolved oxygen content of the groundwater in the background wells ranged from 2.51 parts per million (ppm) in MW-37 to 5.22 ppm in MW-38 to 6.59 ppm in MW-35. D.O. levels tended to be lower within the plume (0.49 in MW-33; 2.67 ppm in MW-41; 3.25 ppm in MW-25), and lowest on the fringes of the plume (0.85 ppm in MW-42; 2.10 ppm in MW-36). Lower D.O. concentrations within the plume relative to the background wells would be expected if aerobic biodegradation was occurring. The D.O. levels within the plume are most likely elevated due to the operation of the air sparging and air curtain system at the site. The locations of these systems are shown on Figure 2. The lower D.O. levels on the fringes of the plume may be representative of oxygen depleted groundwater migrating from the area of active biodegradation.

Groundwater temperature also varied in relation to the benzene/toluene plume. The average temperatures in the background wells, fringe wells, and source area wells were 15.5°C, 16.1°C, and 17.4°C, respectively.

The Eh values observed do not appear to correlate with the dissolved oxygen levels. Eh values were 70.7 mV to 80.2 mV in the background wells, -101.1 mV to -53.9 mV in the fringe wells, and -70.9 mV to 51.3 mV in the wells within the affected area. These values suggest that an anaerobic environment exists, in contrast to the dissolved oxygen levels which suggest that the system is aerobic.

Alkalinity was observed to increase with proximity to the source area wells (MW-25 and MW-33). The alkalinity in the background wells ranged from 66.4 ppm in MW-35 to 157 ppm in MW-38. Alkalinity increased in the wells closer to the plume (223 ppm in MW-42; 311 ppm in MW-36), and increased again in the source area wells (249 ppm in MW-33; 380 ppm in MW-25). The level of alkalinity in MW-41 (48.1 ppm), which is a clean well between MW-25 and MW-33, was comparable to the levels in the background wells. As indicated above, a decrease in pH would be expected to accompany an increase in alkalinity. On average, the pH levels within the plume (6.13) were lower than in the background wells (6.68) and wells on the fringe of the plume (6.69).

Nitrate concentrations in the background wells ranged from 6.2 ppm (MW-38) to 13.6 ppm (MW-35). No detectable concentrations of nitrate were found in the wells on the fringe of the plume (MW-36, MW-42), or in two of the three source area wells (MW-25 and MW-41); MW-33 contained 0.19 ppm of nitrate. These results suggest that nitrate is being used as a nutrient during aerobic biodegradation.

Total iron and ferrous iron concentrations were significantly higher in wells within and on the fringes of the plume, relative to the background wells. However, given the apparent aerobic environment, it is unlikely that ferric iron is being converted through anaerobic respiration. The higher ferrous iron and total iron concentrations in the fringe and source area wells may be related to increased turbidity in the samples due to the proximity of these wells to the air sparging/air curtain systems.

Phosphorous was not detected in the background wells, but was present in all of the wells on the fringe of the plume (0.10 ppm in MW-42; 0.18 ppm in MW-36), and in the source area wells (0.79 ppm in

MW-33; 1.3 ppm in MW-42; 2.5 ppm in MW-25). Phosphorous can be used a nutrient during aerobic biodegradation. Sulfate was detected at 33.8 ppm to 45.3 ppm in the background wells, 14.0 ppm to 140 ppm in the wells on the fringe of the plume, and 47.2 ppm to 304 ppm in the wells in the middle of the plume. The fact that sulfate levels were similar between the background, fringe, and source area wells would be expected since sulfate concentrations would only be expected to decrease under anaerobic respiration.

Consistent with the fact that groundwater at the site has not been impacted by heavy-end petroleum compounds, phenanthrene degraders were only present in background well MW-37 (1,000 colonies/ml). Fluorescent pseudomonas were present in background wells MW-37 (700 col/ml) and MW-38 (900 col/ml), as well as in source area wells MW-25 (4,700 col/ml) and MW-33 (2,100 col/ml). Total viable & non-viable (TVNV) cells ranged from 3.0×10^6 cells/ml to 4.5×10^6 cells/ml in the background wells to 6.0×10^6 cells/ml to 8.6×10^6 cells/ml in the source area wells. The number of total viable organisms (TVO) was also higher in the source area wells (7,000 col/ml to 56,000 col/ml) relative to the background wells (3,000 col/ml to 9,000 col/ml). This distribution is consistent with the other data suggesting that biodegradation is occurring in the benzene/toluene affected area.

5.0 EVALUATION OF REMEDIATION ALTERNATIVES

In light of the significant reduction in the size of, and concentrations in, the off-site benzene/toluene affected area that has been observed since June 1997, and given the data discussed in Section 4.0 documenting that biodegradation is occurring within and around the plume, EPI believes a re-evaluation of the proposed remediation program for the off-site area is warranted. EPI proposes to defer the completion and operation of the groundwater recovery and treatment system, and to allow the natural biodegradation and attenuation that is presently occurring to continue.

To date, EPI has spent approximately $260,000 to install the existing recovery wells and sub-grade piping, and to design and construct the groundwater treatment system. As discussed in Section 2.4, three additional groundwater recovery wells would be required to address the portions of the off-site plume containing the highest concentrations of benzene and toluene. EPI estimates that installing these additional recovery wells and making new connections to the subgrade piping would cost approximately $60,000. Installing the three proposed re-injection wells, the two observation wells required by the NJDEP in their 19 August 1998 letter, and the subgrade piping to connect the re-injection wells to the treatment system would cost an additional $60,000. EPI estimates that the operation and maintenance (O&M) costs for the groundwater recovery and treatment system would be approximately $90,000 per year. Given these significant expenses, and the significant decrease in concentrations noted over the last two years, EPI has evaluated if operating the recovery wells would greatly enhance the remediation of the benzene and toluene affected area.

Since the historical groundwater sampling results and current trends discussed in Section 4.0 indicate that significant reductions in benzene and toluene concentrations have occurred, EPI performed groundwater flow and contaminant transport modeling to evaluate the added benefit of operating the off-site groundwater recovery system. The evaluation was performed by modeling the distribution of benzene and toluene in groundwater under pumping and non-pumping scenarios using WinTran (Environmental Simulations, 1995). WinTran is a two-dimensional numerical solute transport model which computes changes in concentration over time caused by the processes of advective transport, hydrodynamic dispersion, retardation, and first-order decay.

The April/May 1999 groundwater sampling results were used as the starting concentrations for both scenarios. The flow-related parameters (e.g. hydraulic conductivity) were identical to those used in the WinFlow simulations discussed in Section 2.4. The transport-related parameters used in the model to simulate the future concentration distributions are summarized below:

Parameter	Value
Retardation factor, Rf	
Benzene	3.6
Toluene	4.6
Half-life, $t_{½}$	1 year
Dispersivity	
Longitudinal	50 ft
Transverse	5 ft

Figure 14 shows the projected shapes of the toluene affected area in January 2000 through January 2002 while operating the seven recovery wells at a combined flow rate of 5.0 gpm. For purposes of comparison, the predicted distributions of toluene under non-pumping conditions are also shown on Figure 14. Under pumping conditions, toluene concentrations would be reduced to below 5,000 ppb throughout the affected area by January 2002, and the size of the plume would be reduced by approximately 35%. The highest concentrations of toluene would remain in the vicinity of the southeast corner of the site (i.e., the toluene spill area). These changes equate to the total mass of toluene in the dissolved and adsorbed phases being reduced by approximately 549 pounds. Under non-pumping conditions, the highest toluene concentrations would be less than 5,600 ppb by January 2002. The size of the affected area would be reduced by approximately 35%, and the mass of toluene in the dissolved and adsorbed phases would be reduced by 537 pounds. Therefore, operating the groundwater recovery system would only result in an additional 12 pounds (or 1.7 gallons) of toluene being remediated.

Figure 15 shows the projected shapes of the benzene affected area in January 2000 through January 2002 under pumping and non-pumping conditions. Under pumping conditions, benzene concentrations would almost be reduced to 100 ppb, while the size of the plume would be reduced by 17%. The total mass of benzene in the dissolved and adsorbed phases would be reduced by approximately 14 pounds. Under non-pumping conditions, the highest concentrations of benzene (approximately 130 ppb) are limited to a small area near the southeast corner of the site. The areal extent of the benzene plume would be reduced by 8%, and the total mass of benzene in the dissolved and adsorbed phases would be reduced by approximately 13 pounds. Therefore, operating the groundwater recovery system would only result in an additional one pound (or 0.14 gallons) of benzene being remediated.

When EPI first proposed the groundwater recovery system in the March 1995 *Revised Remedial Action Work Plan*, computer modeling had been performed to determine the locations for the recovery wells, and to estimate the amount of time the treatment system would need to be operational. The model simulations at that time indicated that pumping from four off-site wells located in the area of highest dissolved concentrations would reduce benzene and toluene levels significantly during the first few years of operation, but would provide diminishing returns after approximately four years. This decline in effectiveness would be related to the decreasing dissolved concentrations. Although a groundwater recovery system has not been running for the last four years, the AS/SVE, air curtain, and off-site SVE systems have apparently achieved the same effect in less than two years of combined operation.

EPI estimates that completing the groundwater recovery and treatment system and then operating the system for approximately 2.5 years would cost at least $345,000. As discussed above, operating this system over this time period would only result in an additional 13 pounds of benzene and toluene being remediated. Therefore, the cost per pound of benzene and toluene being remediated would be $26,500. Given that the typical cost per pound of remediation would be on the order of $10 to $500 for a pump and treat system, the estimated cost per pound at the Kalama site is excessive, and indicates that operating the groundwater recovery system is inappropriate given the current site conditions.

6.0 PROPOSED REMEDIATION PROGRAM

As was discussed in Section 5.0, operating the groundwater recovery system would result in only a minimal increase in the rate at which the off-site benzene and toluene affected area would be remediated. Therefore, EPI has developed a new remediation program to address the benzene and toluene present in groundwater to the south of the Kalama site. Under this new remediation program, the AS/SVE system, the air curtain, and the off-site SVE system would continue to be operated. In addition, EPI proposes to add three off-site SVE wells in the vicinity of MW-33 to enhance the remediation in the area of this well. EPI believes that the operation of the off-site SVE system has enhanced the degradation rates observed in MW-25, MW-40, and MW-41 by remediating benzene and toluene that are adsorbed to soil that becomes exposed during seasonal fluctuations in the water table. Although MW-33 is currently influenced by the AS/SVE system in AEC-14, the installation of additional off-site SVE wells would increase the effectiveness of the remediation system.

The locations of the proposed off-site SVE wells (to be designated OSSVE-6, OSSVE-7, and OSSVE-8) are shown on Figure 16. The estimated radius of influence for each well shown on Figure 16 (approximately 25 feet) is based on historic pilot tests conducted at the Kalama site. Each well would be installed to a depth of 20 feet (approximately three feet below the water table as of June 1999) and would be constructed with 13 feet of 4.0-inch diameter, 20-slot PVC screen. The wells would be connected to the on-site SVE system in AEC-14 via subgrade piping. The SVE blower and the thermal oxidizer currently in operation are sufficiently sized to allow these wells to be brought on-line without requiring any equipment or operating modifications.

As indicated above, EPI would continue to operate the current remediation systems at the site. EPI would also continue to perform quarterly groundwater sampling (as outlined in Section 3.0), to monitor the effectiveness of the enhanced natural attenuation program. EPI would evaluate the progress of the enhanced natural attenuation program annually to determine if more active remedial measures are necessary. The need to start the groundwater recovery and treatment system would be based on performing statistical analyses on the last eight quarters of data as per 7:26E-6.3 *et seq*. If only a limited number of off-site wells fail the statistical analyses, actions would be directed towards those individual wells. If concentration trends in a majority of the off-site wells fail the statistical analyses, EPI would perform the work necessary to complete the groundwater recovery and treatment system and obtain a NJPDES-DGW permit from the NJDEP so the system could be operated.

EPI proposes to initiate an enhanced form of "monitored natural attenuation" at the Kalama site to address the off-site area affected by dissolved concentrations of benzene and toluene. The term "monitored natural attenuation", as defined by the USEPA, refers to the reliance on natural processes (i.e., biodegradation, dispersion, dilution, sorption, and/or volatilization) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by more active methods (USEPA, 1999). The USEPA has recently approved monitored natural attenuation as an appropriate option to be considered when reviewing possible remediation strategies. In recent years, the NJDEP has also modified their environmental statutes and regulations to allow natural attenuation to be used as a remedial alternative (NJDEP, 1996). Given the remediation systems that are currently operating at the site (i.e., the AS/SVE system, the air curtain system, and the off-site SVE system), EPI would actually be implementing an <u>enhanced</u> natural attenuation program.

As EPI and the NJDEP have discussed in the past, a classification exception area (CEA) will need to be established for the Kalama site to restrict groundwater usage for a specified period of time to allow benzene and toluene to be remediated through natural processes. As discussed in Section 4.0, operation of the groundwater recovery system would have only a minimal impact on the rate at which benzene and toluene are currently being remediated. EPI estimates that a CEA would need to be in place for approximately 10 years to allow natural attenuation/biodegradation to reduce the concentrations of benzene and toluene to below their respective groundwater quality criteria.

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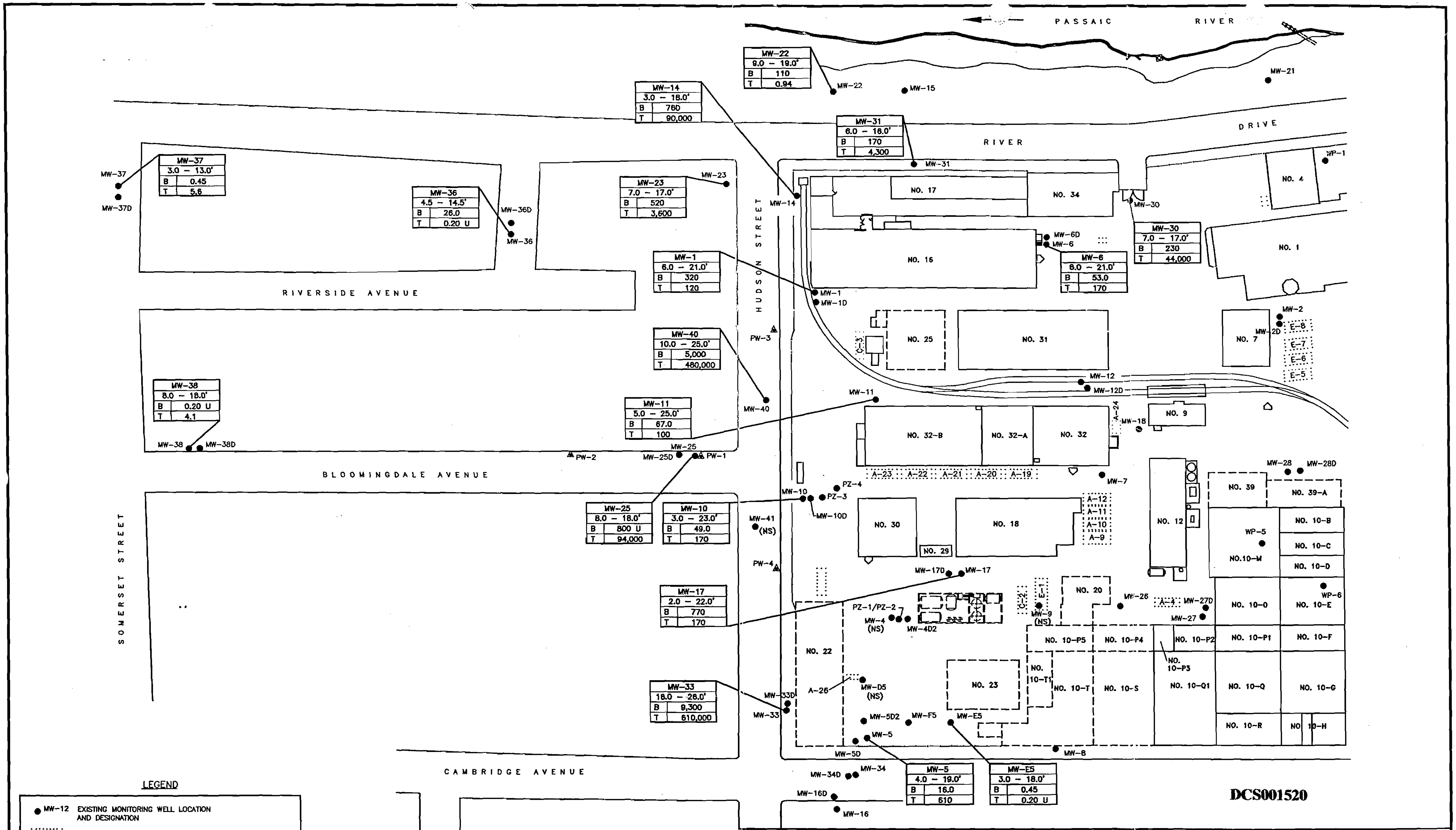
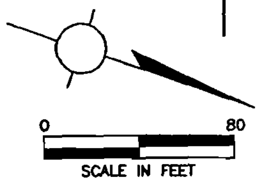


DCS001520

LEGEND

● MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN $\mu g/l$
T	TOLUENE CONCENTRATION IN $\mu g/l$
U	NOT DETECTED
NS	NOT SAMPLED DUE TO SEPARATE PHASE HYDROCARBONS



REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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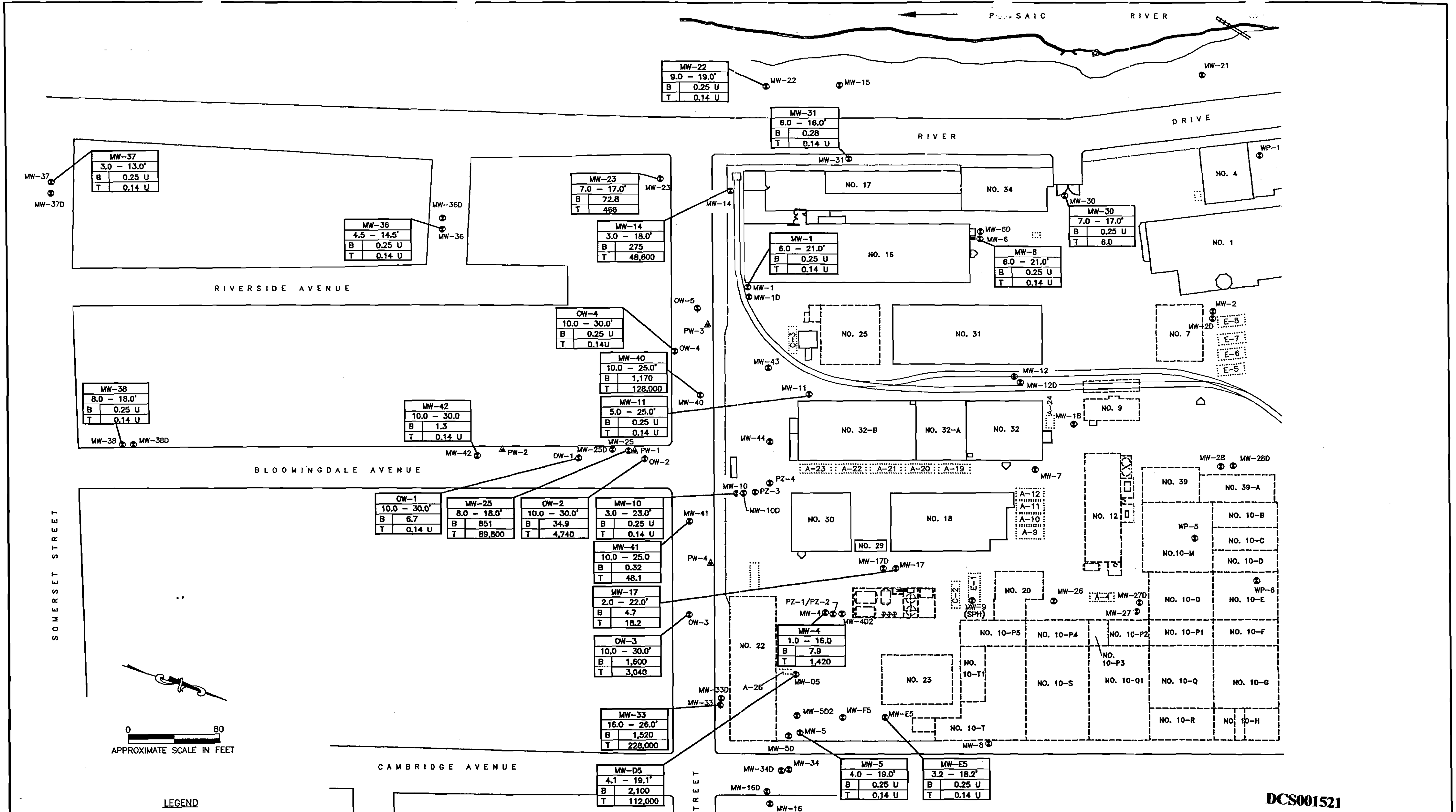
FIGURE 6
BENZENE AND TOLUENE CONCENTRATIONS IN GROUNDWATER JUNE 1997

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



DCS001521

LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
3.0 – 13.0'	SCREENED INTERVAL (IN FEET)
B	BENZENE CONCENTRATION IN μg/l
T	TOLUENE CONCENTRATION IN μg/l
U	NOT DETECTED
SPH	SEPARATE PHASE HYDROCARBONS

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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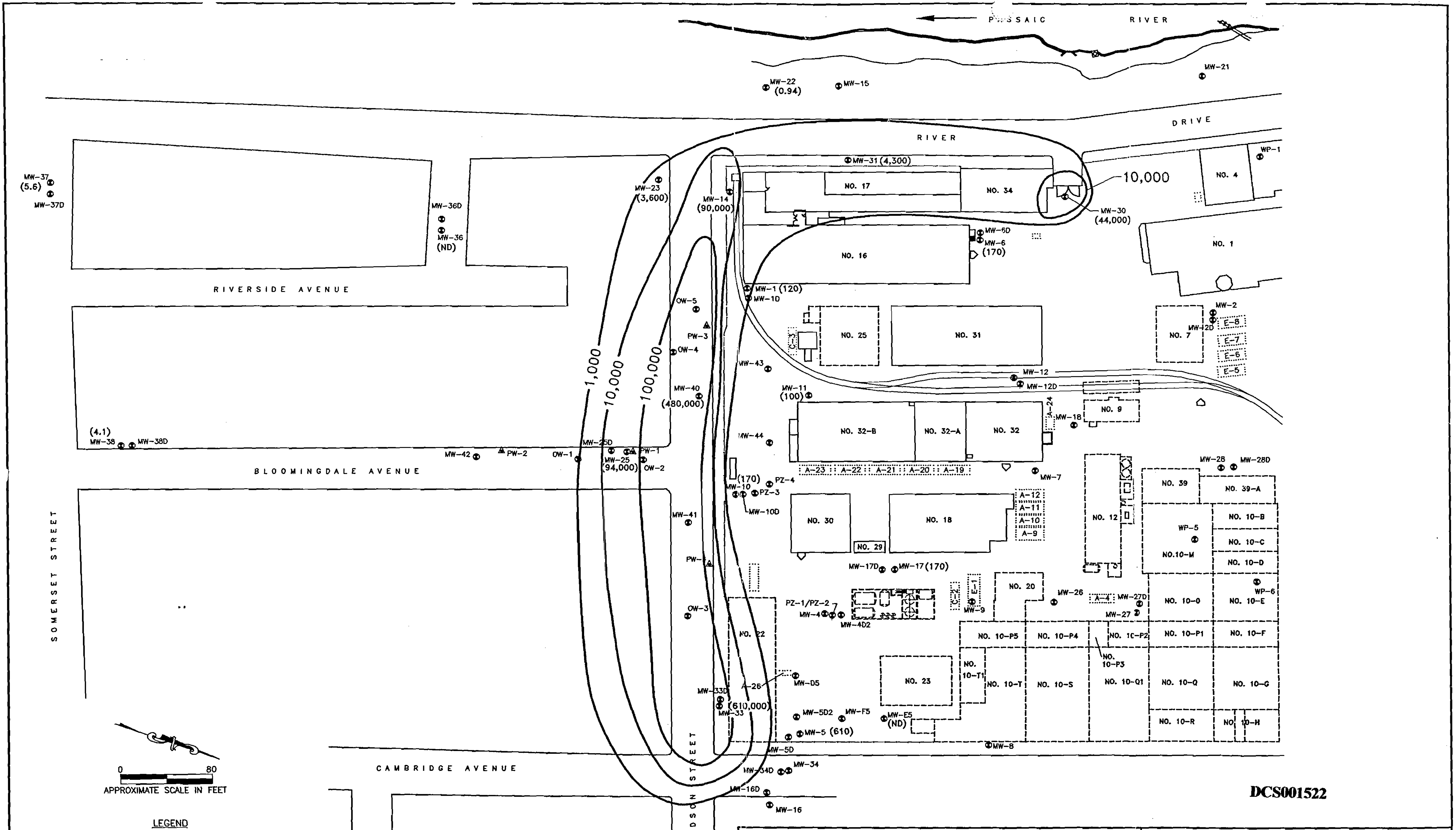
FIGURE 7
BENZENE AND TOLUENE CONCENTRATIONS IN GROUNDWATER APRIL/MAY 1999

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

Project No. EP001 File: PJ CADD\KALAMA7.dwg Date: 6/30/99



LEGEND

⊕ MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(170)	TOLUENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
1,000 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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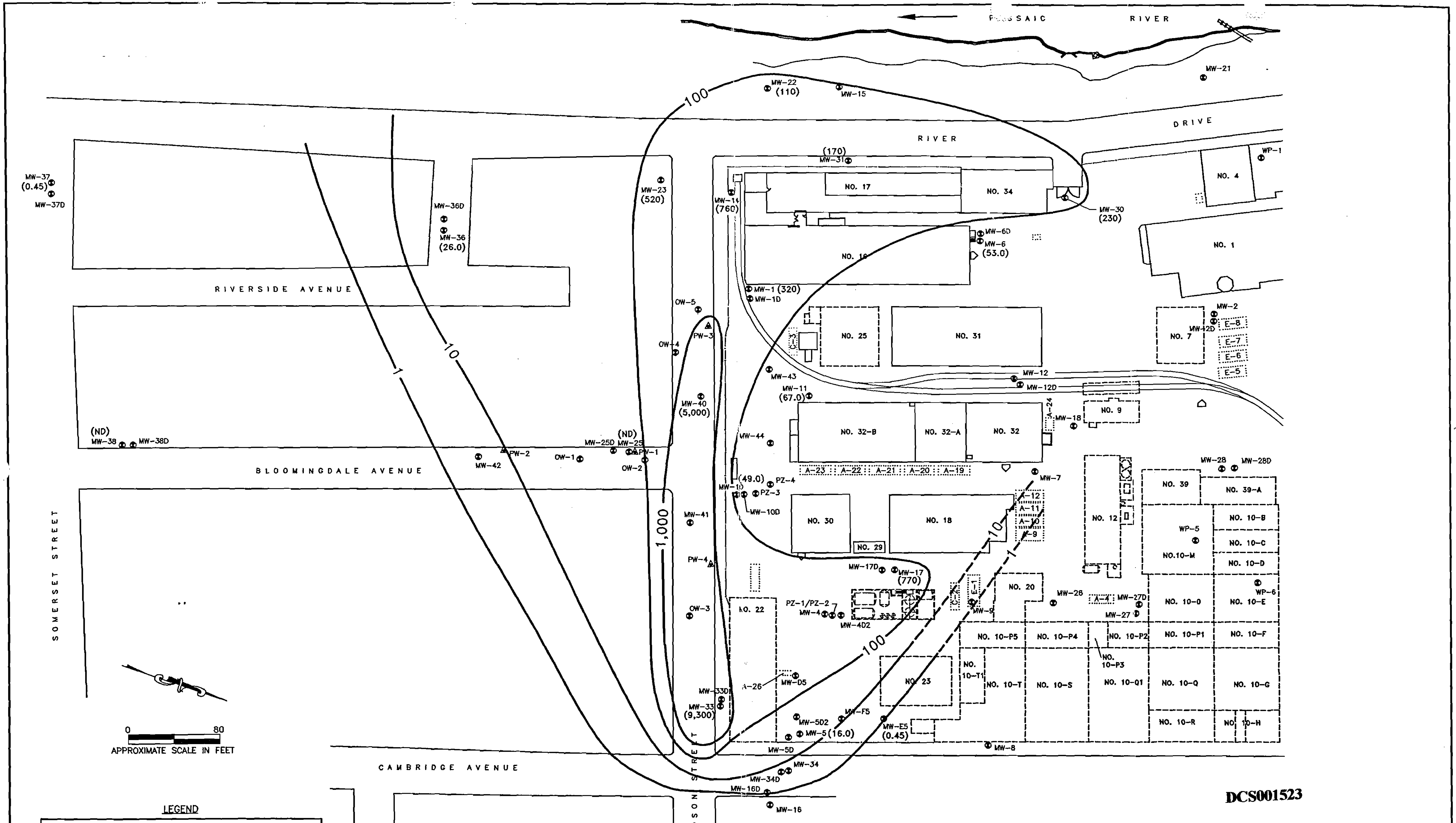
FIGURE 8
DISTRIBUTION OF TOLUENE IN GROUNDWATER
JUNE 1997

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



DCS001523

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲ PW-1	PUMPING WELL LOCATION
(320)	BENZENE CONCENTRATION IN µg/l
(ND)	NOT DETECTED
100 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and
PROPOSED REMEDIAL ACTION PLAN,
December 1993, Figure 2-3.

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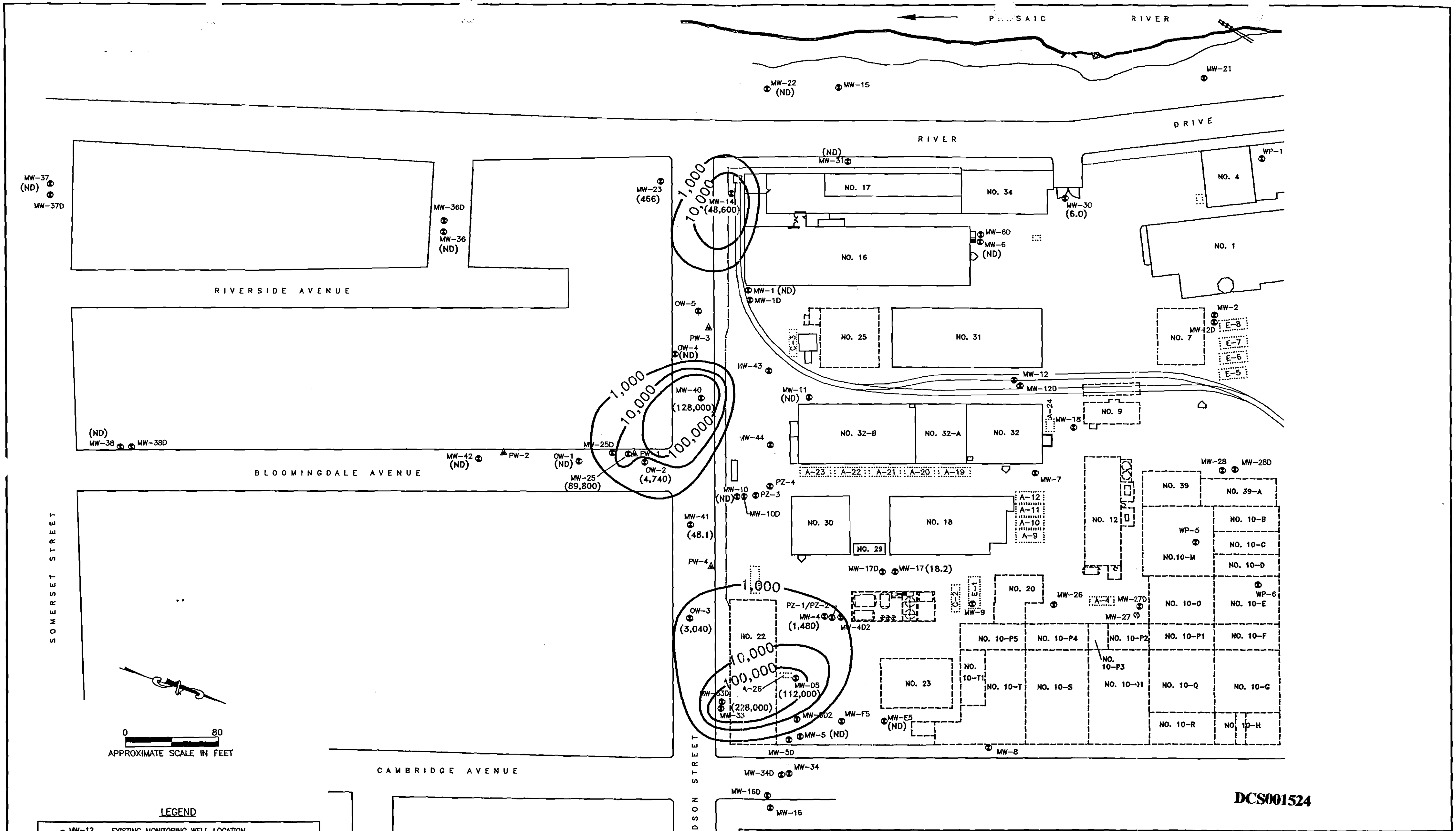
Date: 7/1/99

FIGURE 9
DISTRIBUTION OF BENZENE IN GROUNDWATER JUNE 1997

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY



LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
PW-1	PUMPING WELL LOCATION
(3,040)	TOLUENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
1,000——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 10
DISTRIBUTION OF TOLUENE IN GROUNDWATER
APRIL/MAY 1999

KALAMA CHEMICAL INC.
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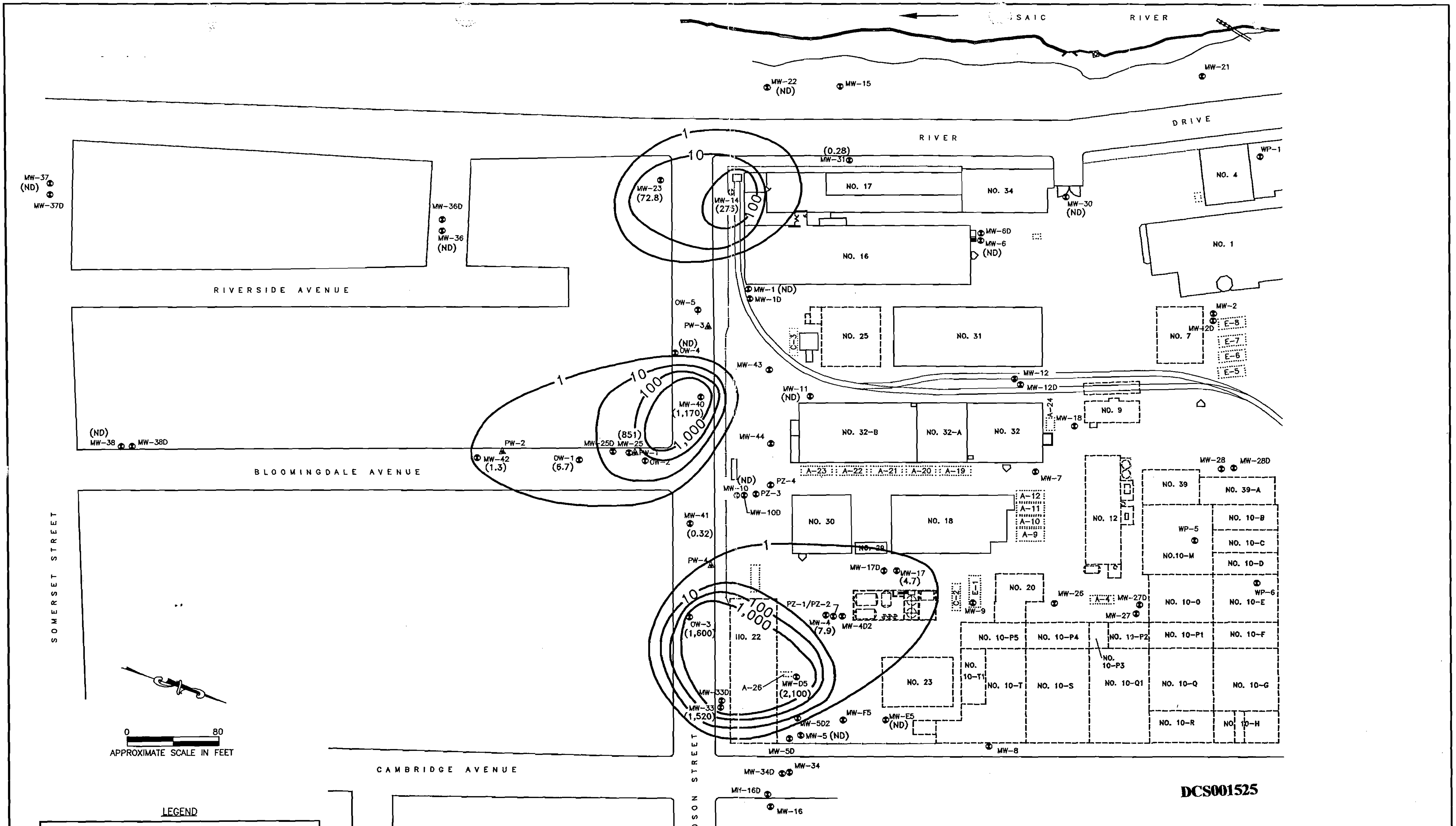

DCS001525

LEGEND

MW-12	EXISTING MONITORING WELL LOCATION AND DESIGNATION
A-20	LOCATION OF FORMER UNDERGROUND STORAGE TANK
▲PW-1	PUMPING WELL LOCATION
(4.7)	BENZENE CONCENTRATION IN $\mu g/l$
(ND)	NOT DETECTED
100 ——	ISOCONCENTRATION LINE

REFERENCE: Geraghty & Miller, Inc.
ECRA INVESTIGATION REPORT and PROPOSED REMEDIAL ACTION PLAN, December 1993, Figure 2-3.

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FIGURE 11
DISTRIBUTION OF BENZENE IN GROUNDWATER APRIL/MAY 1999

KALAMA CHEMICAL INC.
GARFIELD, NEW JERSEY

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), SECOR International Inc. (*SECOR*) has prepared this report detailing the results of soil and groundwater sampling at the Kalama Chemical Inc. facility (Kalama) in Garfield, Bergen County, New Jersey (Figure 1). During the 1 May 1996 meeting between EPI, *SECOR*, and the NJDEP, the Department expressed their concern that a source of dense non-aqueous phase liquid (DNAPL) may be present in the southeast corner of the Kalama Chemical site (Figure 2). The NJDEP's concerns about DNAPLs were based on the presence of six inches of DNAPL found in MW-5 in November 1991. The DNAPL was removed from MW-5 in December 1991 and has not been detected since. In order to address the NJDEP's concern, while not delaying the installation of the air sparging/soil vapor extraction (AS/SVE) system, EPI agreed to perform an investigation in the southeast corner of the site (AEC-14) to determine the possible presence of DNAPL. This investigation was conducted in two phases between 17 June 1996 and 16 August 1996, both during and after the installation of the air sparge points. The results of both phases of the DNAPL investigation are discussed in this report.

2.0 DNAPL INVESTIGATION AROUND BUILDING 23

The DNAPL investigation was to have consisted of visually inspecting soil samples collected from 10.0-12.0 feet, 15.0-17.0 feet, and continuously from 20.0 to 30.0 feet during the installation of air sparge points AS-1, AS-6, AS-7, AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, AS-20, and AS-22 (see Figure 3). Each sparge point was installed to the top of the till layer, which averaged approximately 28 feet below grade. However, due to the presence of running sands[1], soil samples could not be collected below 17 feet, and in two locations (AS-7 and AS-10), no soil samples could be collected. During the installation of the remaining sparge points, samples were collected from 10.0-12.0 feet and 15.0-17.0 feet below grade.

The methods used to enhance the visual inspection of soil samples for DNAPL were consistent with the guidance included in the USEPA's January 1992, *Quick Reference Fact Sheet: Estimating Potential for DNAPL at Superfund Sites.* Approximately 2 oz. of soil were placed in a 4 oz. jar and a similar amount was placed in a paint filter. A sufficient amount of water was added to the jar to saturate the soil, and the jar was then shaken for 15 to 20 seconds. The sediment was allowed to settle and the contents were checked for the presence of separate phases (i.e., a sheen or discrete drops of product). Water was also added to the soil in the paint filter and allowed to drain into an 8 oz. jar. The paint filter and the water collected in the 8 oz. jar were then checked for separate phases.

If the DNAPL screening suggested the possible presence of product, duplicate samples (not the soil which was screened in the field) were retained for laboratory analysis. Samples were submitted to RECRA Environmental, Inc. in Amherst, New York (RECRA; New Jersey Certification No. 73455) and analyzed for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8240) and base neutral acid extractable compounds (including benzoic acid and benzaldehyde) plus an NBS library search (BNA+20; USEPA Method 8270). A total of 17 soil samples from nine sparge points (AS-1, AS-6, AS-11, AS-12, AS-16, AS-18, AS-19, AS-20, and AS-22) were submitted for laboratory analysis. The DNAPL screening was negative on samples from AS-14 and AS-15; as indicated above, no samples could be collected from AS-7 and AS-10. The analytical results for the samples collected for laboratory analysis are

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[1] The presence of running sands had not been anticipated since they had rarely been reported by Geraghty & Miller. This can be attributed to the fact that the vast majority of the borings drilled in the southeast corner of the site by Geraghty & Miller were shallower than the depth at which the running sands were encountered.

summarized on Table 1. Copies of the analytical data packages for these samples are provided under separate cover in Attachment I.

2.1 Lithology

The lithology of the investigation area is characterized as consisting of 5.0 to 10 feet of coarse sand and fine gravel fill material, underlain primarily by fine to medium sand containing trace amounts of silt and clay. However, discontinuous lenses of finer grained material (silty sand, sandy silt, and sandy silty clay) were noted throughout the area. Copies of the boring logs for both phases of the DNAPL investigation are included in Appendix A. Cross-sections through the investigation area are shown on Figure 4 (North-South) and Figure 5 (East-West).

2.2 Results of Phase I DNAPL Investigation

As shown on Table 1, nine targeted and 38 nontargeted VOCs, and 26 targeted and 20 nontargeted BNAs were detected in the soil samples. However, only two VOCs (toluene at 960 parts per million [ppm] in sample AS-1B and chlorobenzene at 1.7 ppm in AS-22B) and one BNA (benzo[a]pyrene in samples AS-11B [0.81 ppm] and AS-20C [1.2 ppm]) exceeded their respective remediation criteria of 500 ppm, 1.0 ppm, and 0.66 ppm.

Toluene was detected in all of the soil samples, although generally at low concentrations; in 10 samples toluene was detected at less than 1.0 ppm. Excluding toluene, the total concentration of targeted VOCs was generally less than or equal to 1.0 ppm, with individual compounds being detected at levels well below their respective remediation criteria. The most common nontargeted VOCs were biphenyl and diphenyl compounds. Identical types of compounds were also detected in the BNA analyses, although at significantly higher concentrations. Given the nature of the suspected DNAPL (see below), the concentrations reported from the BNA analyses for the biphenyl and diphenyl compounds are considered more representative of site conditions.

The results of the BNA analyses indicate that targeted BNAs are not of concern in this area. Previous sampling has documented that benzo(a)pyrene is related to the fill material and is not related to operations at the site. The concentrations of targeted and nontargeted BNAs ranged from 0.024 ppm in AS-18C to 4,657 ppm in AS-20C, with an average concentration of 456 ppm; nontargeted compounds comprised the majority of the total concentrations. The distribution of total targeted and nontargeted BNAs are shown in Figure 6. The most wide-spread nontargeted BNAs were biphenyl, diphenyl ether, methylbiphenyl isomers, and an unknown compound, which were detected at the following frequency:

Compound & CAS No.	No. Samples Detected	Percentage of Samples	Concentration Range (ppm)	Sample with Highest Concentration
Biphenyl (92-52-4)	14	82%	2.0 - 570	AS-20C
Diphenyl Ether (101-84-8)	13	76%	0.19 - 530	AS-22B
Methylbiphenyl Isomers (N/A)	16	94%	0.71 - 2,370	AS-20C
Unknown (N/A)	15	88%	0.21 - 242	AS-20C
No. of Samples = 17 N/A = Not Applicable				

Numerous other biphenyl and diphenyl compounds were detected in these samples, but their concentrations and distributions were much lower than the ones listed above. These compounds are of particular interest since the suspected DNAPL at the site (Dowtherm®) is comprised of biphenyl (27%) and diphenyl ether (73%)[2]. These results suggest that Dowtherm has migrated through the soil column to a depth of at least 17 feet below grade. In addition, the concentrations of biphenyl and diphenyl ether in soil are greater than the solubility of Dowtherm in water (13.8 ppm at 60°F), which would be one of the indicators of a separate phase[3].

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[2] Dowtherm Material Safety Data Sheet, Dow Chemical Co., 10 June 1994.

[3] Cohen, Robert M. and James W. Mercer, 1993, *DNAPL Site Evaluation.*

Two data gaps remained at the completion of the initial round of soil sampling:

- No soil samples had been collected from below 17 feet, so the vertical extent of the Dowtherm had not been defined.
- The historical groundwater data for AEC-14 was inconclusive as to the concentrations of biphenyl and diphenyl ether present in the shallow and deep overburden zones. The concentrations of these two compounds in groundwater needed to be evaluated to determine if the presence of Dowtherm in soil was impacting groundwater quality.

2.3 Phase II DNAPL Investigation

EPI installed six more soil borings in the area of former Buildings 23 and 10-P5 (see Figure 7). Four of these borings (SB-1, SB-2, SB-3, SB-4) served to satisfy the NJDEP's requirements that samples be collected on 20 foot centers; during the 1 May 1996 meeting, the NJDEP expressed concerns that the 40 to 45 feet spacing between the sparge points was to large to adequately assess the area around former Building 23. The remaining two borings (SB-5, SB-6) were used to delineate the high concentrations of BNAs detected in sample AS-20C.

Each boring was advanced using a hollow stem auger drill rig, and samples were collected using split spoon samplers. Soil samples were collected and screened for DNAPL following the procedures discussed in Section 2.2, above. Based on the results of the Phase I investigation, the Phase II soil samples were only analyzed for biphenyl and diphenyl ether by USEPA Method 8270[4].

In order to indirectly evaluate soil quality from immediately above the till layer (and to determine if groundwater quality has been impacted by Dowtherm), each boring was advanced to approximately 28 feet below grade and an *in situ* groundwater sample was collected using HydroPunch® methodology. The HydroPunch is a stainless steel and Teflon sampling tool which has been approved by the NJDEP for use in

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[4] The analytical laboratory obtained standards for biphenyl and diphenyl ether to allow calibrations to be made for these compounds.

site characterization[5]. The hollow stem augers were advanced to approximately 23 feet below grade and then the HydroPunch was driven like a split spoon until refusal (assumed to be the top of the till layer). Due to the volume of water required (up to two liters), samples were collected using the Hydrocarbon Mode (HP-II). In this sampling mode, a five feet long section of PVC screen is exposed when the HydroPunch is opened; water and hydrocarbons (if present) can then enter the sampling chamber. A Teflon bailer was then lowered through the drill stem to the sampling chamber to collect the necessary groundwater sample; it is not necessary to purge the HydroPunch prior to sample collection. Each groundwater sample was analyzed for BNA+20 by USEPA Method 8270 (including calibrations for biphenyl, diphenyl ether, benzoic acid, and benzaldehyde).

The Phase II DNAPL investigation was completed by gauging and sampling the nine air sparge points which were installed in and around the foot print of former Building 23 (AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, and AS-20). Since the sparge points extend to the top of the till layer and are constructed with two feet of screen, they serve to monitor the same zone that was sampled by the HydroPunch. Prior to purging, each sparge point was gauged for DNAPL using an interface probe; no measurable amounts of DNAPL were found in any of the sparge points. Groundwater sampling was conducted following the procedures outlined in the NJDEP's May 1992 *Field Sampling Procedures Manual*. Field sampling forms are included in Appendix B. Each groundwater sample was analyzed for BNA+20.

2.4 Calculation of Soil and Groundwater Remediation Criteria

The NJDEP has not proposed or established remediation criteria for biphenyl and diphenyl ether in soil or groundwater. However, since both of these compounds have been determined to be present in soil and groundwater (see Section 2.5, below), numeric "no further action" criteria for biphenyl and diphenyl ether using the NJDEP's standard models for calculating human-health based criteria have been developed.

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[5] *Alternative Ground Water Sampling Techniques Guide*, NJDEP, July 1994.

2.4.1 *Groundwater Criteria*

The human health-based groundwater quality criteria were derived by (i) using the toxicity information included in the USEPA Integrated Risk Information System (IRIS) and the Health Effects Assessment Summary Tables (HEAST); (ii) using an exposure scenario based on ingestion of groundwater as drinking water; and, (iii) using groundwater quality criterion equations developed by the NJDEP and included in N.J.A.C. 7:9-6. The primary difference between the generic and simple site-specific methods for developing numeric groundwater values (in this evaluation) is the variation of the relative source contribution factor (RSC) percentage used in the NJDEP's standardized equations for determining groundwater quality criteria. In the generic method, a 20% relative source contribution factor was used to account for the contribution from other sources of exposure including air and water. However, in the simple site-specific method, contribution from other sources of exposure were not considered.

The basis for the variation in the relative source contribution factor was the fact that the groundwater from the site is not consumed and that the volatilization of these chemicals from solution is highly unlikely. The determination of minimal volatilization from water is based on the review of physical and chemical properties (degradability, solubility, Henry's Law Constant, etc.) of biphenyl and diphenyl ether. Since factors such as degradability, full scale risk models, fate or complex transport models were not considered in this method, the derivation of numeric values by the simple site-specific method is conservative and more appropriate than the generic method. The groundwater quality criterion equation developed by the NJDEP and included in N.J.A.C. 7:9-6 for compounds with reference dose values and without oral carcinogenic potency factors is:

$$\textit{Criterion} = \frac{\text{RfD (mg/kg/day)} \times 70\text{ kg} \times 1000\text{ ug/mg} \times \text{RSC}}{2\text{ L/day}}$$

Where:

RfD = Oral Reference Dose
70 kg = assumed weight of average adult
RSC = relative source contribution
2 L/day = assumed daily water consumption

A review of the USEPA's Health Effects Assessment Summary Tables and IRIS data base revealed an RfD for 1,1'-biphenyl of 0.05 mg/Kg/day. According to the Merck Index[6], 1,1'-biphenyl is a synonym for diphenyl, which in turn is a synonym for biphenyl. Although no listings were found for diphenyl ether (or its synonyms), the physical properties of this compound suggest it is similar to biphenyl. Consequently, the RfD value for 1,1'-biphenyl was used in calculating the health-based groundwater quality criteria for biphenyl and diphenyl ether.

Groundwater Quality Criteria - Derivation Factors for Human Health Concerns

Chemicals	Oral Reference Dose RfD (mg/kg/day)	GW Quality Criteria (μg/L)	
		Generic	Simple Site-Specific
Biphenyl	0.05	350	1,750
Diphenyl Ether	0.05	350	1,750

Since there is no route of exposure to groundwater (there are no public or private supply wells in the vicinity of the site), it is overly conservative to use the Relative Source Contribution factor in this calculation. Therefore, EPI proposes to use the groundwater quality criteria derived from the Simple Site Specific calculation (1,750 ppb).

2.4.2 *Soil Criteria*

For semi-volatile organic compounds, a ranking system to score chemicals based on solubility, degradation and toxicity was employed. Consistent with the NJDEP's approach, the degradation and toxicity criteria were assigned a value of 1, 2, or 3 and solubility was weighted by a factor of 4 relative to the other criteria. The categories of the criteria, the values assigned and the resulting soil cleanup standard based on the NJDEP's basis for determining impact to groundwater criteria from soils is presented below:

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[6] *The Merck Index*, 12th Edition, 1996.

Criteria	Ranking Category
Solubility (mg/l)	
$<1 \times 10^{-2}$	4
1×10^{-2} to 1×10^{2}	8
$>1 \times 10^{2}$	12
Biodegradation	
Relatively undegradable	3
Moderately degradable	2
Significantly degradable	1
Toxicity	
Non-carcinogens (oral RfD (mg/kg/day))	
$<1 \times 10^{-4}$	3
(1×10^{-4}) to (1×10^{-1})	2
$>1 \times 10^{1}$	1

Total Ranking Sum	Assigned Generic Soil Standard (ppm)
6-9	500
10-12	100
13-14	50
15-16	10
18	1

Based on the review of the physical, chemical and toxicity information for biphenyl and diphenyl ether, the ranking category for solubility, biodegradation, and toxicity is 8, 2, and 2 respectively. Therefore, the assigned soil standard for both biphenyl and diphenyl ether by the generic method is 100 ppm each.

2.5 Phase II Investigation Results

The Phase II DNAPL investigation consisted of collecting 12 soil samples from six soil borings (SB-1 through SB-6), six HydroPunch groundwater samples (SB-1W through SB-6W), and nine groundwater samples from air sparge points AS-10, AS-11, AS-12, AS-14, AS-15, AS-16, AS-18, AS-19, and AS-20. The locations of the Phase II investigation borings and air sparge points are shown on Figure 7.

2.5.1 *Soil*

Detectable concentrations of biphenyl and/or diphenyl ether were detected in all six samples from 10.0-12.0 feet below grade. Biphenyl concentrations ranged from not detected (SB-5A) to 180 ppm (SB-6A), while diphenyl ether concentrations ranged from 0.49 ppm (SB-4A) to 420 ppm (SB-6A). Only the sample from SB-6A contained biphenyl and diphenyl ether at concentrations exceeding the calculated soil quality criterion of 100 ppm. Concentrations in the deeper samples (15.0-17.0 feet below grade) tended to be two to three orders of magnitude lower than in the shallow samples. The exception to this trend was in sample SB-2B, in which no significant change in concentrations was noted. The decreasing concentrations with depth can be attributed to the presence of a layer of finer grained sand and silt which separated the two sampling intervals; this layer is not present at the location of boring SB-2. The analytical results for these samples are summarized on Table 2 and are presented on Figure 8. Copies of the analytical data packages for these samples are included under separate cover in Attachment II.

2.5.2 *Groundwater*

The analytical results for the groundwater samples are summarized on Table 3 (HydroPunch) and Table 4 (air sparge wells) and are presented on Figure 9 (BNAs) and Figure 10 (biphenyl and diphenyl ether). Targeted BNAs were detected in all six HydroPunch samples with total concentrations ranging from 103 ppb (SB-2W) to 1,699 ppb (SB-5W). Bis(2-ethylhexyl)phthalate exceeded the NJDEP's groundwater quality standard (GWQS) of 30.0 ppb in sample SB-1W (150 ppb) and sample SB-3W (110 ppb). Sample SB-5W contained 110 ppb of 2-methylnaphthalene, which is slightly above the GWQS 100 ppb. The concentrations of nontargeted BNAs (primarily methyl biphenyl isomers and unknown compounds) ranged from 472 ppb in SB-2W to 3,959 ppb in SB-5W. Although biphenyl and diphenyl ether were detected in all six HydroPunch samples, the concentrations of these compounds were below the calculated groundwater quality criterion of 1,750 ppb.

Targeted and nontargeted BNAs were detected in all nine air sparge wells sampled. The concentrations of total targeted BNAs ranged from 19.0 ppb in AS-10 to 14,503 ppb in AS-20. In samples AS-10, AS-11, AS-14, AS-15, AS-18, and AS-19, the concentrations of targeted BNAs were all below their respective groundwater quality criteria. Sparge point AS-15 contained 34.0 ppb of bis(2-ethylhexyl)phthalate, slightly above the GWQS of 30.0 ppb, while the sample from AS-20 contained 6,400 ppb of benzyl alcohol (GWQS of 2,000 ppb). Unlike in the HydroPunch samples, biphenyl and diphenyl ether exceeded the calculated GWQS in two samples. Sparge points AS-12 and AS-16 contained biphenyl at 2,000 ppb and 1,900 ppb, respectively, and diphenyl ether at 5,900 ppb and 5,000 ppb, respectively. The concentrations of nontargeted BNAs (primarily methyl biphenyl isomers and unknown compounds) ranged from 4.0 ppb in AS-10 to 6,372 ppb in AS-20.

Copies of the analytical data packages for the Phase II DNAPL investigation groundwater samples are included under separate cover in Attachment II.

2.6 Effective Solubility

Effective solubility can be defined as the upper-level dissolved-phase concentration of a constituent in groundwater that is in equilibrium with a separate phase mixed product (product containing several NAPL compounds). The effective solubility of a particular organic compound can be estimated by multiplying its mole fraction in the product mixture by its pure form aqueous solubility.

The effective solubilities for biphenyl and diphenyl ether (using the concentrations found in AS-12 and AS-16) were calculated as follows:

$$S^e_i = X_i * S_i$$

where

S^e_i = Effective Solubility in mg/L

X_i = Mole fraction of compound in NAPL mixture

S_i = Pure phase solubility of compound

The pure phase solubilities of biphenyl and diphenyl ether in water are 7.5 mg/L and 21.0 mg/L, respectively[7]. Using the analytical results for AS-12 and AS-16, the mole fractions for these compounds

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[7] *Handbook of Environmental Data on Organic Chemicals*, 2nd ed., 1983.

were calculated to be 0.29 for biphenyl and 0.72 for diphenyl ether. Therefore, the effective solubilities for biphenyl and diphenyl ether are 2.18 mg/L and 15.1 mg/L, respectively. These solubilities are significantly higher than those which would be calculated assuming 1% of the pure-phase solubility (0.075 mg/L for biphenyl and 0.21 mg/L for diphenyl ether).

2.7 Discussion of Results

In the area of former Building 23, soil and groundwater samples were collected on a 23.5' x 23.5' grid (one sample for every 552 square feet). This sampling frequency is greater than that typically required by the NJDEP and the USEPA (30' x 30'). Based on the results of the Phase I and Phase II investigations, EPI has concluded that the soil and groundwater data do not indicate that a "pool" of DNAPL is present in the area of Building 23. This conclusion is supported by the fact that:

- The concentrations of biphenyl and diphenyl ether (the two components of the suspected DNAPL Dowtherm) are below 0.05% (500 ppm) in soil; NAPL would be suspected if concentrations approached 1% (10,000 ppm).

- The dissolved concentrations of biphenyl and diphenyl ether are below their respective effective solubilities.

- Concentrations of biphenyl and diphenyl ether generally decrease by two to three orders of magnitude with depth. This distribution supports previous observations that the finer grained native soils are acting as a confining layer, and serve to trap any separate phase hydrocarbons within the upper fill material.

- Separate phase hydrocarbons were not observed during groundwater sampling using the HydroPunch.

- No measurable amounts of separate phase hydrocarbons were detected in the air sparge points (which had been in place for almost six weeks prior to sampling).

Although soil and groundwater contain concentrations of biphenyl and diphenyl ether, the area of impact is of limited extent and is confined to an area well within the property boundaries. The physical parameters for these two compounds suggest that they will not be readily removed by the air sparge/soil vapor extraction (AS/SVE) system. However, technical literature indicates that biphenyl can be biodegraded. Therefore, it is possible that concentrations of biphenyl (and possibly diphenyl ether) will be degraded as a result of the increased biological activity which will result from operating the AS/SVE system. Given the relatively low concentrations of biphenyl and diphenyl ether which have been identified, EPI does not believe the remediation program for this area of the site needs to be modified to address these compounds.

SECOR
International Incorporated

REVISED REMEDIAL ACTION WORK PLAN ADDENDUM

Former Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

29 February 1996

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EXECUTIVE SUMMARY

This report serves as an Addendum to the "Revised Remedial Action Work Plan" dated 31 March 1995 for the former Kalama Chemical Inc. (Kalama) facility in Garfield, Bergen County, New Jersey. This Addendum has been prepared to address the issues raised by the New Jersey Department of Environmental Protection in their letter dated 6 September 1995. A total of 121 additional soil samples were collected to confirm and/or delineate the results of historical sampling, and a soil vapor extraction pilot test was conducted in the toluene spill area (AEC-14) to aid in designing the final system. In preparation for the installation of the air sparging/soil vapor extraction system in AEC-14, eight buildings have been demolished in the southeast corner of the site.

- The area to be remediated by the AS/SVE system in AEC-14 has been expanded to the north and to the west, resulting in the need for five additional AS points and three additional SVE wells.
- The area requiring remediation in AEC-9 has been reduced to a small area at the northwest corner of Building 18.
- The SVE pilot test demonstrated that this technology can be effectively applied to the site, with a conservative radius of influence of 30 feet and mass removal rates of up to 2.6 pounds per hour.

The proposed remedial actions for the Kalama site include the following:

- Air sparging and soil vapor extraction to address the soil and groundwater contamination in the toluene spill area;
- Enhanced, in-situ biodegradation to reduce the dissolved concentrations of compounds of concern present in the southwestern portion of the property line;
- Installation of an air curtain (instead of a biotrench) on the southern property line to stop the continued off-site migration of compounds of concern; and,
- Combination of groundwater extraction and natural attenuation/degradation to reduce the concentrations of compounds of concern in the off-site dissolved plume.

Tenneco does not believe an effective biotrench can be installed as was originally proposed due to the number of underground utilities which have been found along the southern property line.

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ATTACHMENT (Provided Under Separate Cover)

1.0 INTRODUCTION

In response to the New Jersey Department of Environmental Protection's (NJDEP's) letter dated 6 September 1995, SECOR International Inc. (*SECOR*), on behalf of Tenneco Polymers Inc. (Tenneco), has prepared this "Revised Remedial Action Work Plan Addendum" (RAW Addendum) for the Kalama Chemical Inc. (Kalama) facility in Garfield, Bergen County, New Jersey (ISRA Case No. 86B73). Investigative activities have been conducted at the site since 1986. In June 1994, Tenneco assumed responsibility for compliance with the ISRA requirements as part of a revised Administrative Consent Order. The purpose of this RAW Addendum is to respond to the NJDEP's comments, and to present additional information pertaining to the proposed remedial activities for the site. In an effort to facilitate the review of this document, the RAW Addendum has been structured to match the sections and order of comments in the NJDEP's 6 September 1995 letter.

1.1 Background Information

The Kalama Chemical Inc. site is located at 290 River Drive in Garfield, Bergen County, New Jersey (Figure 1). The site consists of two properties, one measuring 6.4 acres (the manufacturing facility) and one measuring 0.5 acres (an employee parking area). The two properties are divided by River Drive, which runs roughly north-south along the Passaic River. The site is bordered to the north, south, and east by mixed residential, commercial, and industrial properties. The Passaic River forms the western property line.

The first buildings at the site were constructed in 1891 and chemical manufacturing has been performed since that time. Over the years, the ownership of the property changed hands several times. In 1963, the Heyden Newport Chemical Corporation was purchased by Tenneco Chemicals, Inc., who continued to operate the facility until 1982, when they sold the property to Kalama Chemical Inc.

The chemicals produced at the site were used in pharmaceuticals, cosmetics, food packaging and preservatives, synthetic flavorings, printing inks, dyestuffs, and other products. The following are the primary chemicals either used or produced at the site:

Primary Chemicals	Period Used/Produced
Salicylic acid Sodium, potassium, and methyl salicylate	Produced from turn of the century to 1994.
Parasepts (esters of para-hydroxy benzoic acid) Methylene disalicylic acid	Produced from the 1940s to 1994.
Formaldehyde	Produced from the 1930s to 1982.
Pentaerythritol (a glycerine substitute)	Produced from early 1940s to 1962.
Benzoic acid Benzaldehyde Sodium Benzoate	Produced from 1961 to February 1984.
Toluene	Used in benzoic acid/benzaldehyde production from 1961 to 1984.
Benzene	Used in Resorcinol production from early 1940s to 1950s. Also generated as a waste by-product of benzoic acid/benzaldehyde production from 1961 to 1984.
Phenol	Used in the production of salicylic acid from the turn of the century to 1994.
Methanol	Used in the production of methyl salicylate and formaldehyde from the turn of the century to 1994.

Manufacturing operations were conducted in approximately half of the 38 existing buildings at the site. Several buildings have been subdivided into separately numbered structures such as Building 10-P1 through 10-P4. When the facility was in operation, the other buildings were either vacant, idle, or used for storage, machine shops, or offices. Between May 1994 and August 1994, most manufacturing equipment and all production related chemicals were removed from the site. To date, 17 buildings (2, 3, 8, 10-A, 10-N, 10-P4, 10-P5, 10-S, 10-T, 10-T1, 20, 22, 23, 37, 38, 39, and 39A) have been dismantled over the years; the tank farm associated with the benzoic acid/benzaldehyde production area has also been removed. A Site Plan showing existing and recently demolished buildings is included as Figure 2.

2.0 SOIL ISSUES

Section I of the NJDEP's letter dated 6 September 1995 dealt primarily with issues related to soil sampling at the site. The following sections address the issues raised by the NJDEP.

2.1 Impact to Groundwater Quality Soil Cleanup Criteria for Site Specific Compounds

In Section I of the 6 September 1995 letter, the NJDEP requested that Tenneco list all the input values used in deriving the impact to groundwater quality soil cleanup criteria for the site specific compounds formaldehyde and methanol. According to the NJDEP, Tenneco's calculated levels for these compounds are greater than the Department's calculation by a factor of 1.69.

Tenneco has reviewed the calculations used in the Revised RAW and has determined that the primary difference between the Department's calculation of impact to groundwater soil cleanup criteria and Tenneco's calculation is the assumption regarding the volume of groundwater into which the compound of concern dilutes. The dilution depth used by the Department is 10 feet (a general value to be used which is not site specific) and that applied by Tenneco in it's submission of 31 March 1995 is 17 feet (a conservative estimate based on the site specific saturated thickness). Tenneco's dilution depth is greater than the Department's dilution depth by a factor of 1.7, hence the reason for the discrepancy.

The soil cleanup criterion equation developed by the NJDEP and included in N.J.A.C. 7:26D for volatile organic compounds is:

$$C = \frac{GW_{std} \; x \; V_{gw} \; x \; D^{gw} \; x \; W \; x \; 365 \; x \; 70 \; x \; 28}{D_L \; x \; L \; x \; W \; x \; 28 \; x \; 10^3 \; x \; 1.3}$$

and

$$S = C/F$$

Where:

C = the soil concentration of a compound (ppm) without adjusting for volatilization;

GW_{std} = site-specific groundwater quality standard;

V_{gw} = the velocity of ground water (feet/day) is the same as NJDEP's assumption of 0.25 feet/day;

D_{gw} = the dilution depth of compound entering ground water (ft) for the facility is 17 feet as compared to NJDEP assumption of 10 feet;

365 = days/year;

70 = years of flow (as based on risk assessment);

28 = liters/cubic ft;

L_{70} = the liters of ground water that the compound dilutes into over 70 years;

D_L = the depth of contamination (feet) value is the same as the NJDEP's assumption of 4 feet;

L = the length of contaminated area parallel to ground water flow (feet) is the same as the NJDEP's assumption of 100 feet;

W = width of the contaminated area perpendicular to ground water flow (feet) is the same as the NJDEP's assumption of 100 feet;

28 = L/cubic foot;

10^3 = cc/L;

1.3 = the dry soil bulk density (g/cc) values is the same as NJDEP assumption of 1.3 g/cc;

S = Impact to Groundwater Quality Soil Cleanup Criteria; and

F = the fraction of applied chemical that would leach to groundwater; value used for methanol and formaldehyde is 1 (a conservative assumption).

Impact to Groundwater Quality Soil Cleanup Criteria for Formaldehyde and Methanol

Chemicals	GW_{std} (ppb)	D_{gw} (ft)	D_L (ft)	L (ft)	W (ft)	C (ppm)	F	S (ppm)
Formaldehyde	1,400	17	4	100	100	292.35	1	292
Methanol	3,500	17	4	100	100	730.88	1	731

2.2 Soil Vapor Inhalation Risks

Tenneco has reviewed the letter dated 6 September 1995 from the NJDEP regarding the 31 March 1995 RAW. In summary, the NJDEP's letter makes two comments on the soil vapor inhalation risks: 1) it finds the 1993 and 1995 revision of the enclosed-space soil vapor risk assessment unacceptable;

and, 2) it requests Tenneco to follow the April 1995 Draft Indoor Air Sampling Guidance issued by the Hazardous Site Science Element (HSSE). Based on Tenneco's actions to date, and plans for remediation, Tenneco requests that the NJDEP re-evaluate its position expressed in these two comments.

Regarding the first comment, the enclosed-space soil vapor risk assessment was originally submitted to the NJDEP in the December 1993 "ECRA Investigation Report and Proposed Remedial Action Plan". Since Tenneco did not receive any comments on that assessment, Tenneco is unclear about why this has recently become unacceptable to the NJDEP.

The 1993 assessment used the Johnson and Ettinger model (Johnson and Ettinger, 1991) to estimate indoor benzene risk to a basement resident from soil vapor at 2E-07, which is below the EPA's acceptable risk range of 1E-06 to 1E-04. During the preparation of the "Revised Remedial Action Work Plan", the assessment was reviewed and corrected. The revised estimate for benzene risk to the basement resident (1E-08), is significantly below the EPA's point of departure of 1E-06. Tenneco verified these results by using the standardized Johnson and Ettinger methodology from the recent American Society for Testing and Materials (ASTM) Risk-Based Corrective Action (RBCA) E1739-95 (ASTM 1995), which uses conservative standardized default input parameter values. Using this standardized and nationally recognized method, lifetime inhalation benzene risk to the basement resident was estimated as 3E-07, which is still an order of magnitude less than EPA's 1E-06 point of departure.

To place these modeled basement air concentrations and estimated lifetime risks in perspective, published literature indicates that national indoor background concentrations of benzene range from 3.25E+00 to 2.15E+01 $\mu g/m^3$ (ASTM 1995). These concentrations were measured in occupied living areas of dwellings by EPA and other researchers, and are primarily from indoor sources such as smoking, commercial products, and attached garages. In comparison, the modeled (using ASTM) concentration in the basement due to soil vapor is 1.1E-01 $\mu g/m^3$, one to two orders of magnitude below national indoor background concentration measurements made in living areas.

The modelling process used by Tenneco incorporates a number of conservative assumptions. Therefore, the model is more likely to over-predict than under-predict indoor air concentrations and risk. These conservative assumptions include:

- no source depletion over the 30 year period of exposure;
- no loss of chemical as it diffuses toward the surface;
- the percentage of crack area in the floor is assumed to be 1% (the high end of the 0.1% to 1% range) in order to bias the indoor air concentration high;
- the air exchange rate is assumed to 0.5 changes per hour (the low end of the 0.5 to 2 air changes per hour) in order to bias the indoor air concentration high;
- the enclosed space volume to infiltration area ratio is assumed to be 200 cm (representing a one story structure with a height of 200 cm, that is, no multiple stories) in order to bias the indoor air concentration high; and,
- the hypothetical resident is assumed to spend approximately 18 hours/day indoors for 350 days/year for 30 years in order to bias the risk high.

In conclusion, the soil vapor inhalation risk assessment and the use of a standardized, nationally recognized methodology using conservative input values show that basement air concentrations of soil gas are expected to be one to two orders of magnitude below national indoor background concentration measurements made in living areas, and the risk from benzene is expected to be an order of magnitude below EPA's 1E-06 point of departure.

The NJDEP's 6 September 1995 letter required Tenneco to follow the April 1995 Draft Indoor Air Sampling Guidance prepared by HSSE. This guidance document provides a 2.0 $\mu g/m^3$ soil gas trigger level for benzene based on an EPA calculated indoor air concentration of 0.22 $\mu g/m^3$, representing 1E-06 risk. Because indoor concentrations of benzene are typically higher than 0.22 $\mu g/m^3$, comparison of indoor air quality to this level would result in false positive or otherwise inconclusive data. This conclusion is based on published literature (ASTM, 1995) indicating that ambient indoor background concentrations of benzene are typically in the range of 3.25E+00 to 2.15E+01 $\mu g/m^3$. Therefore, indoor air sampling for benzene will more likely measure "domestic" sources rather than provide useful information to determine if remediation is needed.

The guidance document provides a tiered screening approach, with each tier of the screen requiring more extensive information and monitoring, for investigating indoor air quality. The primary objective of the investigation is to determine the need for remediation. For the Kalama site, Tenneco's actions to date (soil, groundwater, and soil gas sampling) are similar to Phases I through III of the initial site assessment recommended in the April 1995 Draft Indoor Air Sampling Guidance. Based on the results of numerous soil and groundwater sampling events, Tenneco already plans remediation, consisting of on-site source removal and control, and off-site extraction wells to reduce dissolved concentrations in groundwater. Investigating indoor air quality for the purpose of determining if remediation is needed is unnecessary.

2.3 Site Specific Areas of Environmental Concern

Section 4.0 of the 31 March 1995 "Revised Remedial Action Work Plan" divided the site into 28 areas of environmental concern (AECs) and summarized the results of the soil samples collected specific to each area. The NJDEP has approved Tenneco's proposal for no further action in the following AECs:

■	AEC-1	Former No. 6 Fuel Oil Underground Storage Tanks (USTs; E-5, E-6, A-7, E-8)
■	AEC-2	Former Methanol USTs (A-13 through A-18)
■	AEC-3	Former No. 2 Fuel Oil UST (A-25)
■	AEC-4	Former Methanol UST (A-27)
■	AEC-6	Former No. 2 Fuel Oil UST (C-3)
■	AEC-7	Former Methanol UST (A-24)
■	AEC-8	Former Methanol, MIBK, and Hexene USTs (A-19 through A-23)
■	AEC-10	Former No. 2 Fuel Oil UST (A-4)
■	AEC-13	Former Gasoline UST (A-26)
■	AEC-16	Pentaerythritol/Fumaric Acid Production
■	AEC-22	Product Drum Steam Cleaning Pad
■	AEC-23	Transformers (Building 1)
■	AEC-25	Chemical Loading/Unloading Area (Building 16)

AEC-27	Chemical Loading/Unloading Area (Building 33)
AEC-28	Chemical Loading/Unloading Area (Building 36)

Tenneco's actions relative to each of the remaining AECs are discussed below. The locations of the 13 AECs requiring further action are shown on Figure 3.

2.3.1 *AEC-5 - Suspected Former UST#1*

This AEC consists of the location of a suspected former UST, which is believed to have been located near the northeast corner of Building 34. Tenneco proposed no further action for this AEC, based on the clean field screening results obtained from soil samples collected from boring B-74. The NJDEP required that Tenneco verify that the UST was not present prior to approving no further action.

Since the exact location of the suspected former UST was uncertain, Tenneco elected to confirm the absence/presence of the UST using a non-intrusive ground penetrating radar (GPR) survey. A GPR survey of approximately 1,750 ft^2 around boring B-74 (see Figure 4) was conducted on 16 November 1995. The GPR survey was conducted by EnviroPhysics, Inc. of Lawrenceville, New Jersey. A discussion of the methodology used and supporting radar records are included in EnviroPhysics' report in Appendix A.

The results of the GPR survey show that there are no USTs in this area. Based on these findings, Tenneco requests that the NJDEP approve no further action for this AEC.

2.3.2 *AEC-9 - Former USTs A-9 through A-12*

This AEC encompasses the locations of former USTs A-9, A-10, A-11, and A-12, which were located on the north side of Building 18. Each UST had a capacity of 16,500 gallons and was used to store toluene. Soil samples from below the water table at three locations (A-9[C], A-12[B], and B-4-02) contained toluene at concentrations above the NJDEP's remediation criteria of 500 parts per million (ppm). Tenneco proposed to re-sample these locations to confirm the toluene concentrations.

On 18 and 19 October 1995, Tenneco collected confirmatory and contingency samples from soils around A-9(C), A-12(B), and B-4-02 using GeoProbe methodology. Soil samples were screened for toluene in the field in a mobile laboratory which was equipped to perform analyses by USEPA Method 8020. Selected samples were also submitted to an off-site laboratory for confirmation analyses by the same method. See Appendix B for a complete discussion of the soil sampling methods used during this investigation. Soil boring logs showing lithologies and photo-ionization detector (PID) readings are included in Appendix C.

Post-Excavation Sample A-9(C)

Since post-excavation sample A-9(C) was collected at a depth of 8.5-9.0 feet below grade in October 1987 and contained 805 ppm of toluene, soil boring AEC-9-1 was advanced to 16.0 feet at the location of A-9(C), and samples were collected from 8.5-9.0 feet and 10.5-11.0 feet for field analysis. Similar samples were also collected from borings AEC-9-1A, AEC-9-1B, and AEC-9-1C to horizontally delineate around AEC-9-1. The results of the field screening and laboratory analyses are summarized below. The locations of these samples relative to sample A-9(C) are shown on Figure 5. The laboratory analytical results are presented on Table 1.

AEC-9
Confirmation/Delineation Sampling Around A-9(C)

Sample ID	Depth (Feet)	Toluene Conc. by Field Analysis	Toluene Conc. by Lab Analysis
AEC-9-1	8.5-9.0 10.5-11.0	8.24 ppm Not Analyzed	0.058 U ppm Not Analyzed
AEC-9-1A	8.5-9.0 10.5-11.0	0.10 U ppm Not Analyzed	0.96 ppm Not Analyzed
AEC-9-1B	8.5-9.0 10.5-11.0	41.0 ppm Not Analyzed	113 ppm Not Analyzed
AEC-9-1C	8.5-9.0 10.5-11.0	0.10 U ppm Not Analyzed	1.76 ppm Not Analyzed

Notes:
U - Not detected.

As indicated above, none of the samples collected relative to the original post-excavation sample A-9(C) contained toluene at concentrations above the NJDEP's remediation criterion of 500 ppm.

Post-Excavation Sample A-12(B)

Post-excavation sample A-12(B) was collected at a depth of 12.5-13.5 feet below grade in October 1987 and contained 594 ppm of toluene. Soil boring AEC-9-2 was advanced to 16.0 feet at the location of A-12(B), and samples were collected from 12.5-13.5 feet and 14.5-15.5 feet for field analysis. Similar samples were also collected from borings AEC-9-2A through AEC-9-2F to horizontally delineate around AEC-9-2. The results of the field screening and laboratory analyses are summarized below. The locations of these samples relative to sample A-12(B) are shown on Figure 5. The laboratory analytical results are presented on Table 1.

AEC-9
Confirmation/Delineation Sampling Around A-12(B)

Sample ID	Depth (Feet)	Toluene Conc. by Field Analysis	Toluene Conc. by Lab Analysis
AEC-9-2	12.5-13.5 14.5-15.5	0.10 U ppm Not Analyzed	0.018 ppm Not Analyzed
AEC-9-2A	12.5-13.5 14.5-15.5	0.10 U ppm Not Analyzed	0.006 ppm Not Analyzed
AEC-9-2B	12.5-13.5 14.5-15.5	51.0 ppm Not Analyzed	0.28 U ppm Not Analyzed
AEC-9-2C	12.5-13.5 14.5-15.5	0.10 U ppm Not Analyzed	0.099 ppm Not Analyzed
AEC-9-2D	12.5-13.5 14.5-15.5	6,700 ppm 14.7 ppm	18,600 ppm 0.80 ppm
AEC-9-2E	12.5-13.5 14.5-15.5	Not Analyzed Not Analyzed	0.006 U ppm Not Analyzed
AEC-9-2F	12.5-13.5 14.5-15.5	Not Analyzed Not Analyzed	3.49 ppm Not Analyzed

Notes:
U - Not detected.

Delineation sample AEC-9-2D, which contained 18,600 ppm of toluene, was collected to the south of post-excavation sample A-12(B). Consequently, two additional borings were installed to collect samples to the south (AEC-9-2E) and to the west (AEC-9-2F) of AEC-9-2D; delineation to the east was accomplished by samples from boring AEC-9-3B (see below).

Soil Sample B-4-02

As part of the "Revised ECRA Sampling Plan Investigation", soil sample B-4-02 was collected to the west of the toluene tanks in January 1991. This sample was collected at a depth of 8.0-9.0 feet below grade and contained 17,000 ppm of toluene. Soil boring AEC-9-3 was advanced to 12.0 feet at the location of B-4-02, and samples were collected from 8.0-9.0 feet and 10.0-11.0 feet. Similar samples were also collected from borings AEC-9-3A and AEC-9-3B (both extended to 16.0 feet below grade) and AEC-9-3C to horizontally delineate around AEC-9-2. Boring AEC-9-3B also served to horizontally delineate boring AEC-9-2E.

Unlike the two previous locations, the samples collected around B-4-02 were not analyzed in the field. Instead, samples were submitted to an off-site laboratory and analyzed for toluene using an expedited (72 hour) turn around time to determine if additional sampling and analyses would be required. The results of the laboratory analyses are summarized below. The locations of these samples relative to sample B-4-02 are shown on Figure 5. The laboratory analytical results are presented on Table 1.

AEC-9
Confirmation/Delineation Sampling Around B-4-02

Sample ID	Depth (Feet)	Toluene Conc. by Lab Analysis
AEC-9-3	8.0-9.0 10.0-11.0	0.006 U ppm Not Analyzed
AEC-9-3A	8.0-9.0 10.0-11.0 12.5-13.5 14.5-15.5	0.006 U ppm Not Analyzed 0.11 ppm Not Analyzed

AEC-9 Confirmation/Delineation Sampling Around B-4-02		
Sample ID	Depth (Feet)	Toluene Conc. by Lab Analysis
AEC-9-3B	8.0-9.0 10.0-11.0 12.5-13.5 14.5-15.5	0.10 ppm Not Analyzed 0.010 ppm Not Analyzed
AEC-9-3C	8.0-9.0 10.0-11.0	0.006 U ppm Not Analyzed
Notes: U - Not detected.		

As indicated above, none of the samples collected relative to sample B-4-02 contained toluene at concentrations above the NJDEP's remediation criterion of 500 ppm.

The results of the confirmation soil sampling indicated that the toluene concentrations originally detected in post-excavation samples A-9(C) and A-12(B), and soil sample B-4-02 have naturally degraded to below the NJDEP's remediation criterion and do not require active remediation. The delineation samples collected around these locations indicate that a residual hot-spot of toluene exists beneath the northwest corner of Building 18. This hot-spot is of limited extent (less than 600 ft^2) and is less than two feet thick. Since sample AEC-9-2D (12.5-13.5 feet) was collected from below the water table, Tenneco proposes to address the hot-spot as part of the groundwater remediation program for the site (see Section 5.1 for further discussion).

2.3.3 *AEC-11 - Former USTs C-2 and E-1*

This AEC includes former USTs C-2 and E-1 and is located to the south of Building 20. Both C-2 and E-1 were used to store No. 2 fuel oil and had capacities of 5,000 gallons and 16,500 gallons, respectively. These USTs were excavated in November 1987 and one post-excavation sample (E-1[B]) contained 18,500 ppm of total petroleum hydrocarbons (TPH). Based on the results of the soil sampling, monitoring well MW-9 was installed within the excavation area. Due to the persistent presence of separate phase hydrocarbons (SPH) in this well, a passive bailer (Petrotrap^{TM}) was installed in June 1994 to augment the periodic manual bailing program. Tenneco proposed to incorporate this AEC into the soil/groundwater remediation program for the site. The NJDEP required Tenneco to perform additional delineation of the area and determine if the vadose soils had been impacted.

Tenneco collected a confirmation soil sample (AEC-11-1) from the location of post-excavation sample E-1(B) on 18 October 1995. Additional sampling for benzene and toluene was conducted as part of the delineation program for AEC-14 (see Section 2.3.6, below). Sample AEC-11-1 was collected at a depth of 8.0-10.0 feet below grade and was analyzed for TPH by USEPA Method 418.1. No detectable concentration of TPH was found in sample AEC-11-1, suggesting that the TPH in the original sample was of limited extent and/or has naturally degraded. The analytical result for this sample is summarized on Table 2 and is presented on Figure 6.

Since Tenneco proposed to incorporate AEC-11 into the remediation program for the adjacent AEC-14, and since the proposed remediation technology (air sparging and soil vapor extraction) will be able to address both vadose and saturated zone soils, Tenneco believes no further soil sampling is required to address this area of the site.

2.3.4 *AEC-12 - Suspected Gasoline UST*

The 31 March 1995 RAW identified this AEC as the location of a suspected former UST. Historical site plans showed a UST on the west side of Building 22, but no information was available about the contents of the UST, or when it may have been removed. Tenneco had proposed no further action specific to the suspected former UST. The presence of 7,300 ppm of toluene in sample B-75-B was attributed to the toluene spill area (AEC-14) which encompasses AEC-12. Therefore, Tenneco proposed to incorporate this area into the remediation program for AEC-14. The NJDEP required Tenneco to confirm the presence/absence of the UST and to delineate the toluene detected in sample B-75-B.

Since the exact location of the suspected former UST was uncertain, Tenneco elected to confirm the absence/presence of the UST using a GPR survey. A GPR survey of approximately 1,600 ft^2 around boring B-75 (see Figure 7) was conducted on 16 November 1995. The GPR survey was conducted by

EnviroPhysics, Inc. of Lawrenceville, New Jersey. A discussion of the methodology used and supporting radar records are included in EnviroPhysics' report in Appendix A.

The results of the GPR survey showed that a large parabolic reflector indicative of a buried tank was found in the radar data collected in this area. Tenneco excavated to the top of the anomaly (approximately 2.5 feet below grade) and confirmed the presence of a steel UST measuring approximately 22 feet long and 6.0 feet in diameter. Given the proximity of this UST to Building 22, which served as a garage from 1941 to the 1960s, Kalama personnel believe the tank was used to store gasoline. A UST Closure Plan Approval Application was submitted to the NJDEP on 12 February 1996. This UST will be excavated and disposed following receipt of NJDEP approval.

Delineation of the toluene detected in sample B-75-B was conducted as part of the soil sampling program associated with AEC-14 (see Section 2.3.6, below).

2.3.5 *AEC-13 - Former UST A-26*

This AEC consists of the location of former UST A-26, which was located along the north side of Building 22. This UST had a capacity of 550 gallons and was used to store gasoline. UST A-4 was excavated in October 1987. Since no gasoline related constituents were detected in the soil samples collected around the UST, Tenneco had proposed no further action specific to this area. The toluene detected in these samples can be attributed to, and addressed by, the remediation program for the toluene spill in the surrounding AEC-14.

The NJDEP approved remediating this area as part of AEC-14, but required that the toluene be delineated. The required delineation soil sampling was conducted as part of the sampling program for AEC-14 (see Section 2.3.6, below).

2.3.6 *AEC-14 - Benzoic Acid/Benzaldehyde Production ("Toluene Spill")*

The benzoic acid/benzaldehyde production plant was operated from 1963 to 1984 and consisted of Building 10-T and a diked pad in the southeast corner of the facility; the entire area is roughly defined by Buildings 10, 18, 20, 22, 23, and 30. Based on extensive sampling, benzene and toluene have been identified as the two primary compounds of concern in the soil in this AEC.

Due to its size, AEC-14 encompasses five other areas of environmental concern, including AEC-11, AEC-12, AEC-13, AEC-19, and AEC-20. In each of these areas, benzene and/or toluene has been detected in soil at concentrations above the NJDEP's remediation criteria. The NJDEP required that delineation of these compounds be performed for each of the AECs listed above. Rather than delineate each AEC separately, samples were collected on the perimeter of the AEC-14 remediation area. Soil sampling was conducted using GeoProbe methodology (see Appendix B), and samples were analyzed in the field for benzene and toluene using a mobile laboratory equipped to perform USEPA Method 8020 analyses.

A total of 51 soil samples were collected from 17 soil borings (AEC-14-1 through AEC-14-17) and analyzed by the mobile laboratory for benzene and toluene; all of these samples were subsequently sent to an off-site laboratory for confirmatory analyses. One sample (AEC-14-18) was also collected from a test pit on the west side of Building 29 after the results of the initial soil sampling had been received. The results of the off-site laboratory analyses are summarized on Table 3 and are presented on Figure 8. The results of the field screening analyses are presented in Appendix D.

To vertically delineate benzene and toluene, borings AEC-14-1 and AEC-14-2 were located adjacent to previous sample locations S-8 and B-71, respectively. Benzene and/or toluene had been detected in samples collected from 6.5-8.5 feet (S-8) and 6.0-8.0 feet (B-71-D) below grade. Boring AEC-14-1 was advanced to 12 feet, and samples were collected from 8.0-10.0 feet and 10.0-12.0 feet. Boring AEC-14-2 was advanced to 16 feet, and samples were collected at 2.0 feet intervals from 8.0 to 16.0 feet below grade (for a total of four samples). No detectable concentrations of benzene were found in any of the vertical delineation samples, while toluene concentrations ranged from non-detect to 22.7 ppm. These results indicated that the benzene and toluene were limited to the top 8.0 feet of soil. Based on these results, the remaining horizontal delineation borings were only advanced to 8.0 feet below grade. To insure that all historical sampling intervals were delineated, samples were collected from 2.0-4.0 feet, 4.0-6.0 feet, and 6.0-8.0 feet. The analytical results for these samples indicated that benzene and toluene concentrations were below the NJDEP's remediation criteria in all of the samples from borings AEC-14-1, AEC-14-2, AEC-14-5 through AEC-14-9, and AEC-14-12 through AEC-14-17. No detectable concentrations of benzene or toluene were found in the sample collected from test pit AEC-14-18.

Borings AEC-14-3 and AEC-14-4 are located along the south side of this AEC, and were installed through the floor of Building 22. All three samples from AEC-14-3 contained toluene at concentrations (820 ppm to 6,990 ppm) exceeding the NJDEP's remediation criterion of 500 ppm; the sample from 4.0-6.0 feet also contained 1.13 ppm of benzene. In boring AEC-14-4, the sample from 6.0-8.0 feet contained 1,230 ppm of toluene.

Borings AEC-14-10 and AEC-14-11 are located adjacent to Building 29 and Building 30, respectively, along the west side of this AEC. The sample from 2.0-4.0 feet in AEC-14-10 contained 989 ppm of toluene. However, this location was delineated to the west by collecting one sample (from 2.0-4.0 feet below grade) from a test pit (AEC-14-18) on the west side of Building 29; the analytical results for this sample indicated that the benzene and toluene concentrations were below their respective remediation criteria. In boring AEC-14-11, 1,240 ppm of toluene was detected at 2.0-4.0 feet and benzene was detected at 1.53 ppm in the 4.0-6.0 feet sample. Both of these intervals have been delineated to the west by samples from boring AEC-14-13.

Buildings 22 and 23 were demolished in June 1995 in preparation of installing the air sparging/soil vapor extraction system which had been proposed to remediate this area of the site. Based on observations made during the demolition of Building 23, Tenneco collected four soil samples from two soil borings located within Building 10-T1 (designated 10-T1) and Building 10-T (designated VMP-13). Samples were collected from 3.0-3.5 feet and 4.0-4.5 feet below the floor of the buildings and analyzed for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8240) and base neutral/acid extractable compounds (including benzoic acid and benzaldehyde) plus an NBS library search (BNA+25; USEPA Method 8270). The results of these analyses are summarized on Table 3 and are presented on Figure 8.

No VOCs were detected at concentrations exceeding their respective remediation criteria. Benzo(a)anthracene (4.1 ppm), benzo(a)pyrene (2.3 to 2.5 ppm), and dibenzo(a,h)anthracene (0.67 ppm), and dibenzofuran (24.0 ppm) were detected in the soil samples from boring 10-T1. Tenneco believes the PAHs can be attributed to the fill material at the site since they would not have been used at the facility (see Section 2.3.7). No BNAs were detected at concentrations exceeding the remediation criteria in the samples from VMP-13.

Tenneco believes the soil sampling activities discussed above have succeeded in delineating the extent of the benzene and toluene on-site. Based on these findings, and observations made during the demolition of numerous buildings in the area, Tenneco has expanded the area to be covered by the AS/SVE system (see Section 5.1).

Source of Benzene and Toluene

The source of the toluene and benzene in this area can be attributed to the use and incidental spillage of toluene during the operation of the benzoic acid/benzaldehyde production plant between 1963 and 1984. Toluene was the principal raw material for this manufacturing process and was regularly delivered to the site in large quantities (up to 6,500 gallons per day during peak production). Benzene was used as a raw material in the manufacture of Resorcinol in Building 10-T in the 1940s and 1950s. However, Tenneco believes the primary source of the benzene at the site can be attributed to toluene usage. Benzene is known to form during benzoic acid production by the thermal degradation of toluene in the reactor. The similar distribution of benzene and toluene in soil and groundwater also supports the belief that both compounds can be attributed to the same source.

2.3.7 *AEC-15 - Salicylic Acid/Salicylate Production (Buildings 10/36/39)*

The northeastern corner of the site comprises this area of concern, specifically the buildings which housed the salicylic acid/salicylate production facility (Buildings 10B through 10T, 36, 36-A, 39, and 39-A). It should be noted that Buildings 39 and 39-A were demolished in the summer of 1994 as part of the decommissioning of the facility.

Fill Material

The NJDEP is requiring that Tenneco "...document the physical and chemical characteristics ... and also the areal extent of the fill". After 10 years of investigation activities and the installation of over 170 soil borings and monitoring wells, Tenneco feels that the presence of fill material has been clearly determined to extend to the limits of the site and to off-site property's. A review of the boring logs for the 27 off-site monitoring wells found that fill material (consisting primarily of sand and gravel, but also including brick and rock fragments, cinders, and ash) was present in 21 wells at depths of up to 10 feet; these wells are located to the north, south, and east of the site. The only exceptions were the two nested well sets of MW-20/20D/20D2 and MW-35/35D/35D2, which are located to the east of the site (at the highest elevations and farthest from the Passaic River).

As stated in Section 35.h(1) of N.J.A.C. 13:1K, for parcels of land which have been demonstrated to contain large quantities of historic fill material[1], it is acceptable to use engineering or institutional controls that are designed to prevent exposure to humans, that allow for the continued use of the property, that are less costly than removal or treatment, which maintain established health risk levels, and are protective of the environment.

Tenneco proposed to re-sample three shallow soil sample locations to confirm previously detected concentrations of beryllium, lead, and zinc (B-47), phenol (B-49), and polynuclear aromatic hydrocarbons (B-52).

Boring B-52

Sample B-52-A, collected from 0.0-2.0 feet below grade, contained concentrations of polynuclear aromatic hydrocarbons (PAHs) exceeding the NJDEP's remediation criteria. Boring AEC-15-1 was located adjacent to B-52[2] and samples were collected at 0.0-2.0 feet and 2.0-4.0 feet below grade. In addition, four borings (AEC-15-1A, 1B, 1C, 1D) were located on all four sides of B-52, and samples

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[1] "Historic fill material" is defined by the NJDEP as large volumes of non-indigenous material, used to raise the topographic elevation of a site, which were contaminated before emplacement and are in no way connected with the operations at the location of emplacement. These materials include, but are not limited to, construction debris, dredge spoils, incinerator residue, demolition debris, fly ash, and non-hazardous solid waste.

[2] Once the original soil samples had been collected, B-52 was converted into monitoring well MW-26.

were collected from similar intervals. Each sample was analyzed for PAHs by USEPA Method 8270. The results of these analyses are summarized on Table 4 and are presented on Figure 9.

Elevated concentrations of PAHs were found in six of the 10 samples collected in this area. Of the PAHs exceeding the NJDEP's remediation criteria, benzo(a)pyrene was the most prevalent, with concentrations ranging from 0.80 ppm to 42.0 ppm. Other PAHs detected in more than one sample include benzo(a)anthracene, benzo(b)fluoranthene, and dibenzo(a,h)anthracene. There does not appear to be a pattern to the distribution of the PAHs, with concentrations of various compounds fluctuating with depth. Since these compounds would never have been used in facility operations, Tenneco believes that they are related to the fill material which exists at the site. The soil in this area (as indicated on the boring logs for AEC-15-1 through AEC-15-1D) consists of sand, silt, gravel and cinders. It should be noted that the groundwater samples collected from MW-26 have not detected PAHs at concentrations exceeding the NJDEP's remediation criteria.

Since this area of the site is already paved with asphalt, the necessary engineering controls to comply with Section 35.h(1) are already in place. Therefore, Tenneco proposes no further action for this area of the site.

Boring B-49

Sample B-49-A, collected from 0.0-1.1 feet below grade, contained phenol at 150 ppm, which exceeds the NJDEP's remediation criterion of 50.0 ppm. Due to the highly degradable nature of phenol, Tenneco proposed to re-sample this location to determine if the phenol concentration had decreased since the original sample was collected in January 1991. A total of five borings (AEC-15-2 through AEC-15-2D) were installed adjacent to and surrounding boring B-49[3], and 10 soil samples were collected from 0.0-1.1 feet and 1.5-2.5 feet; each sample was analyzed for phenol by USEPA Method 8270. The analytical results for these samples are summarized on Table 4 and are presented on Figure 9.

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[3] Once the original soil samples had been collected, B-49 was converted into monitoring well MW-29.

The source of the phenol in boring B-49 was most likely an isolated surface spill; phenol was used as a raw material in the production of salicylic acid up until the facility ceased operations in 1994. The source of the phenol which had been detected in some of the deeper soil samples in this area can be related to the leaking process lines which ran beneath the Building 36 complex. Given the historically high concentrations found in groundwater samples from beneath Building 36, the leaking line was probably located near well point WP-3. Since operations at the facility have ceased, the source of the phenols has been eliminated.

The results of the confirmation/delineation sampling indicated that the phenol had degraded and was no longer present at a concentration exceeding the NJDEP's remediation criteria. No detectable concentrations of phenol were found in eight of the 10 samples. The samples from AEC-15-2B contained 1.6 ppm (0.0-1.1 feet) and 0.41 ppm (1.5-2.5 feet) of phenol. Based on these results, Tenneco proposes no further action for this location.

Boring B-47

A sample of the fill material present in boring B-47 contained beryllium (8.3 ppm), lead (820 ppm), and zinc (2,820 ppm) at concentrations which exceeded the NJDEP's remediation criteria. Since beryllium, lead, and zinc were never used in the manufacturing processes at the facility, Tenneco believes these metals can be attributed to the fill material in the area, and the proximity of boring B-47 to a railroad spur. Tenneco collected soil samples from three soil borings (AEC-15-3, AEC-15-3A, AEC-15-3B) at this location to characterize the fill material. Three samples were collected from 0.0-0.5 feet and one sample was collected from 1.0-1.5 feet. Each sample was analyzed for beryllium, lead, and zinc by USEPA Method 6010. The analytical results for these samples are summarized on Table 4 and are presented on Figure 9.

The shallow and deep samples from boring AEC-15-3, which was located adjacent to boring B-47, did not contain concentrations of metals exceeding the NJDEP's remediation criteria. Beryllium was detected in samples AEC-13-3A and AEC-15-3B at concentrations of 2.71 ppm and 2.45 ppm, respectively. Tenneco believes these results are consistent with the heterogeneous nature of the fill material and are not indicative of a point source.

Tenneco proposes to address this area of the site by employing engineering controls (i.e., paving with asphalt) to prevent human contact with the fill material. See Section 5.5 for further discussion.

2.3.8 *AEC-17 - Formaldehyde Production*

Tenneco originally proposed no further action for this AEC since no compounds of concern were detected at concentrations exceeding the applied remediation criteria. However, the NJDEP required Tenneco perform additional investigation activities due to 150 ppm of toluene in sample B-68-E (collected from 8.0-10.0 feet below grade). Tenneco believes that additional investigation of this area is unwarranted. Toluene was not used as a raw material during the production of formaldehyde. It should be noted that sample B-68-E was collected from within the vadose zone/water table interface; the toluene detected may be related to the elevated concentrations of this compound known to exist in groundwater in this area. Tenneco has proposed to remediate groundwater in this area of the site by the installation of two horizontal air injection wells to enhance natural biodegradation. Therefore, Tenneco proposes no further action specific to this AEC.

2.3.9 *AEC-18 - Sewer Lines*

One soil sample (B-55-FILL) was collected from the fill material along the railroad spur on the south side of Building 16. Cadmium was detected at 311 ppm, which is above the NJDEP's remediation criterion for this metal. Tenneco collected eight samples from four borings (AEC-18-1 through AEC-18-1C) located adjacent to and around boring B-55. Samples were collected from 0.5-1.2 feet and 2.0-2.5 feet and analyzed for cadmium and lead by USEPA Method 6010; lead analyses were performed as per the NJDEP's requirements. The results of these analyses are summarized on Table 5 and are presented on Figure 10.

Cadmium was detected in seven of the eight samples at concentrations ranging from 0.74 ppm to 2.62 ppm. Lead was detected in all eight samples at concentrations ranging from 26.2 ppm to 239 ppm. Sample AEC-18-1 (0.5-1.2 feet), which was collected to re-sample the same location and depth interval as B-55-FILL, contained 1.24 ppm of cadmium. Since the concentrations of cadmium and lead do not exceed the NJDEP's Non-Residential Direct Contact Criteria of 100 ppm and 600 ppm, respectively, the presence of these compounds can be addressed through the implementation of institutional controls (i.e., a Declaration of Environmental Use Restriction or DER), which Tenneco intends to apply to the entire property. As discussed in Section 2.3.7, above, metals were never used in the facility's manufacturing operations and Tenneco believes the cadmium can be attributed to the fill material.

2.3.10 *AEC-19 - Drum Storage Area (Building 22)*

The delineation of the benzene and toluene previously detected in this area was conducted as part of the soil sampling program for AEC-14 (see Section 2.3.6, above.)

2.3.11 *AEC-20 - Scrap Metal Storage*

The delineation of the benzene and toluene previously detected in this area was conducted as part of the soil sampling program for AEC-14 (see Section 2.3.6, above).

2.3.12 *AEC-21 - Drum Storage Area (Buildings 16 & 17)*

A paved drum storage area once existed between Buildings 16 and 17 in the southwest corner of the facility. This area was used for the temporary storage of drums of laboratory chemicals. Benzo(a)pyrene was detected at 1.3 ppm in a soil sample from boring S-9. In order to address the NJDEP's requirements, additional samples were collected to verify that a source of benzo(a)pyrene does not exist in this area. A total of six soil samples from three soil borings (AEC-21-1 through AEC-21-3) were collected adjacent to and around boring S-9. Samples were collected from 2.5-3.0 feet and 3.5-4.0 feet below grade, and analyzed for benzo(a)pyrene by USEPA Method 8270. The results of these analyses are summarized on Table 6 and are presented on Figure 11.

No detectable concentrations of benzo(a)pyrene were found in three of the samples collected; in the remaining samples, concentrations ranged from 0.050 ppm to 0.14 ppm. Since the average concentration of benzo(a)pyrene (0.42 ppm) in the 2.5-3.0 feet interval is below the NJDEP's remediation criterion of 0.66 ppm, and since benzo(a)pyrene was never used at the facility, Tenneco proposes no further action for this AEC.

2.3.13 *AEC-24 - Transformer (Building 12)*

One transformer is located on a concrete pad near the northeast corner of Building 12. Two samples from boring B-44-01 (one original and one duplicate) were analyzed for polychlorinated biphenyls (PCBs). Although the concentration of PCBs in the original sample (0.47 ppm) was below the NJDEP's remediation criterion of 0.49 ppm, the duplicate sample contained 2.2 ppm of PCBs. Tenneco re-sampled this area to confirm the findings of the previous investigation. A total of eight soil samples were collected from four soil borings (AEC-24-1 through AEC-24-4) located adjacent to and around boring B-44. Samples were collected from 0.3-0.8 feet and 1.5-2.0 feet below grade and analyzed for PCBs by USEPA Method 8080. The results of these analyses are summarized on Table 7 and are presented on Figure 12.

No detectable concentrations of PCBs were found in six of the eight samples; in the remaining two samples, PCBs were detected at 0.061 ppm (AEC-24-4) and 0.22 ppm (AEC-24-3). These results confirm that PCBs are not of concern, and Tenneco proposes no further action for this area of the site.

2.3.14 *AEC-26 - Chemical Loading/Unloading Area (Building 31)*

The transfer of chemicals (primarily formaldehyde) to and from rail cars occurred along the rail spur between Buildings 31 and 32/32-A/32-B from approximately 1929 to 1982. Previous soil sampling in this area had indicated that the soil had not been impacted by these chemical transfer activities, although benzo(a)anthracene (2.3 ppm) and benzo(b)fluoranthene (4.0 ppm) were detected in shallow sample B-42-01 (0.2-0.6 feet). As discussed in Section 2.3.7, PAHs were never used in the facility's manufacturing operations and Tenneco believes they can be attributed to the fill material. Since the concentrations of these compounds do not exceed the NJDEP's Non-Residential Direct Contact Criteria of 4.0 ppm each, the presence of these compounds can be addressed through the implementation of institutional controls (i.e., a DER), which Tenneco intends to apply to the entire property.

2.4 Areas Where Soils Have Not Been Addressed

Due to the numerous compounds which have been detected in groundwater but not in the soil, the NJDEP required Tenneco to identify and investigate all potential sources at the site. The NJDEP listed the following as the most obvious areas to investigate.

2.4.1 *Northeast Phenol/Source Area (Building 36)*

Tenneco does not agree that the soil below the process lines in this building require further investigation, based on the soil samples which have previously been collected, plus the presence of monitoring wells which indicate that only site related compounds are of primary concern in this area (i.e., phenol, methanol, and formaldehyde). Considering the high solubility and low chemical partitioning coefficients (K_D) of these compounds, it is Tenneco's position that these compounds are more likely to form solutions in water and less likely to bind to soil or sediment. In addition, the decreasing concentration trends noted in the wells installed through the floor of the building (WP-3, WP-5, WP-6) indicate that there is not a continuing source of contamination in the area.

2.4.2 *Northwest Phenol Hot Spot (Building 33-B)*

Tenneco has reviewed the operational history of Building 33-B and the areas surrounding this building to determine a source for the phenol which has been detected in well point WP-2. Phenol was not used as a raw material during the production of pentaerythritol or fumaric acid, nor was it stored in any underground tanks at the site. However, Building 33-B had been used as a warehouse between 1984 and 1994 and during this time, several floods occurred in the basement as a results of leaking water lines. It is possible that water leaking through the floor of the basement may have carried phenol to the groundwater.

Since the groundwater samples collected from WP-2 show a decreasing trend in the phenol concentrations, Tenneco believes there is no residual source of contamination beneath Building 33-B. Therefore, Tenneco does not propose to collect any additional soil samples in this area. The decreasing concentrations of phenol in groundwater will be monitored by the sampling program originally proposed for the site.

2.4.3 *Benzene and Chlorinated Compounds*

The primary source of the benzene being found in soil and groundwater was the toluene used in the manufacture of benzoic acid and benzaldehyde. Benzene is known to have formed during the thermal degradation of toluene in the benzoic acid manufacturing process. During the 24 years that benzoic acid and benzaldehyde were produced, small spills of toluene were not uncommon and the large spill which occurred in the late 1970s consisted of partially reacted toluene. Tenneco believes the similar distribution of these compounds supports the theory that they are related. Between the 1940s and the 1950s, benzene was also used as a raw material in the manufacture of Resorcinol in Building 10-T. However, since Building 10-T is currently situated within AEC-14, any impacts associated with the use of benzene would fall within the toluene spill area and would not be able to be differentiated.

Based on 35 years of experience, and a review of the available historical records, Kalama personnel have determined that chlorinated VOCs would never have been used as raw materials in the facility's manufacturing operations. Although chlorinated solvents may have been used in the machine shops, they would only have been present in small quantities. It would therefore be expected that the only way these compounds could result in an impact to groundwater would be through surface spills. However, the soil data collected at the site does not support this possibility.

Over the course of the investigation of the Kalama facility, close to 100 soil samples have been collected for VOC analyses[4]; approximately 25% of these samples were collected in and around AEC-14. Trace amounts (less than 0.10 ppm) of chlorinated VOCs were only detected in nine samples from

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[4] Samples were analyzed by either USEPA Method 624 (Priority Pollutant List) or USEPA Method 8240 (Target Compound List).

across the site. The highest concentration of a chlorinated VOC detected at the site was 4.4 ppm of 1,1,2,2-tetrachloroethane in sample B-4 (collected in 1986). It should be noted that this compound has only been detected once, and has never been detected in any of the 293 groundwater samples which have been collected over the course of this investigation.

Given the absence of all but trace amounts of chlorinated VOCs in soil, Tenneco maintains that a source of these compounds does not exist at the site. See Section 3.3.2 for further discussion about the chlorinated VOCs in groundwater.

3.0 GROUNDWATER ISSUES

Section II of the 6 September 1995 letter from the NJDEP dealt primarily with issues related to groundwater. The following sections address the issues raised by the NJDEP.

3.1 Proposed Groundwater Cleanup Criteria for Active Remediation

Tenneco has reviewed the Department's comments (Section II, page 10; page 13, Items 3 and 5) and does not understand the technical rationale for the Department not accepting Tenneco's proposed numeric criteria for determining when a natural remediation plan could be initiated. Tenneco is proposing a remediation program that consists of actively remediating the elevated concentrations in the groundwater plume followed by a natural remediation/attenuation program. Considering the fact that benzene and toluene are both very degradable compounds, it is Tenneco's opinion that the proposal of combining active and natural remediation plans is prudent and cost-effective.

The primary intent for developing the numerical criteria and determining the appropriate timing for instituting the natural remediation program is to: (i) take full advantage of the degradability of the compounds requiring remediation; (ii) maximize the effective utilization of financial resources available for cleanup; (iii) obtain a "no further action" approval from the NJDEP in a timely manner; and, (iv) avoid re-activation of the implemented remediation option. Tenneco does not intend to use the closure criteria for active remediation as the Groundwater Quality Standards for the area[5]. Tenneco intends to use alternate cleanup levels as a means for switching from an active remediation system to a natural attenuation/remediation program. The natural attenuation program would continue until the NJDEP's remediation criteria or asymptotic concentrations are achieved.

Tenneco's approach to addressing the groundwater contamination in the area is to (i) actively remediate the adsorbed mass of benzene and toluene present in soils below and above the water table (source of groundwater contamination); (ii) control further off-site migration of the groundwater contamination;

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[5] The proposed closure criteria for active remediation of benzene and toluene are 512 ppb and 53,400 ppb, respectively. See Section 6.2 of the Revised Raw for the derivation of these criteria.

(iii) actively remediate the most concentrated portions of the dissolved plume; (iv) implement a natural remediation plan; and, (v) request for "case closure" approval from the NJDEP.

In order to accomplish this objective, Tenneco is requesting that the NJDEP agree with it's framework for remediation of the groundwater and approve the proposed Remedial Action Work Plan for groundwater. It is Tenneco's opinion that the NJDEP could exercise its administrative authority within N.J.A.C. 7:9-6 and assist Tenneco in obtaining no further action (NFA) with the condition that Tenneco establishes a Classification Exception Area (CEA). It is Tenneco's position that upon implementation of the proposed RAW, all criteria for approval of an NFA with a CEA would be met. Tenneco intends to remediate the source area and establish a decreasing groundwater concentration gradient. In support of it's request for approval of the combined approach of active and natural remediation plans, Tenneco performed a comprehensive groundwater flow and solute transport computer model to predict the distribution of benzene and toluene with the passage of time[6]. The results of the computer modeling indicated a steady decrease in the concentrations of benzene and toluene during and after the cessation of the active remediation system.

Regarding the NJDEP's criteria of "no receptors are at risk and public supply is available"[7], Tenneco has conducted a survey of the surrounding area and has established that there are no potable domestic or industrial wells in use downgradient of the facility. In addition, there are no surface water withdrawal points along the Passaic River downgradient of the site. Tenneco has also performed computer modeling (based on present conditions with no remediation) to predict the impact of benzene and toluene at the point of recharge to the Passaic River and determined that concentrations of benzene and toluene will decrease with distance and time[8]. *SECOR* used the verified and accepted USEPA transport model FPLUME for the estimations, which allows for the computation of two-dimensional mass distribution in groundwater resulting from advection, retardation, dispersion, and decay resulting from microbial and physical (e.g. volatilization) processes.

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[6] See Section 9.4.1 and Appendix J of the Revised RAW for further discussion of the modeling performed.

[7] "Final Guidance on Designation of Classification Exception Areas"; 17 April 1995, pg. 10.

[8] Section 2.0 of the "Bioassay Work Plan" dated 13 July 1994.

The approach selected for the modeling assumed that no action occurs to reduce concentrations to particular constituents in groundwater in the vicinity of MW-14. Monitoring well MW-14 was selected since it contains elevated concentrations of site related compounds, including toluene and benzene. In addition, since MW-14 is located upgradient from MW-22, an off-site well adjacent to the Passaic River, actual analytical results could be compared to the modeling results.

The output data and graphs demonstrate that the constituents of concern significantly decrease in concentration toward the Passaic River. A comparison of the analytical results from MW-22 with the calculated concentration predicted by FPLUME confirms that the reductions in toluene and benzene concentrations are conservative. It is Tenneco's opinion that the estimates are conservative and provide enough room for factoring in uncertainties for the following reasons:

Steady-State Source	The simulations were conducted using the assumption that a contaminant source persists indefinitely in the vicinity of MW-14 and can be represented by steady-state conditions. This is a conservative assumption because Tenneco is proposing to conduct active remediation of the most concentrated portions of the plume.
Dilution From Recharge	Dilution from recharge was not considered. A constant concentration and flux was assumed for the source area but, in fact, recharge from precipitation adds water to the groundwater system. This would act to dilute plume concentrations.
Decay	The decay functions were based on typical values for biological reactions. However, the effects of volatilization are not included in the decay terms. Toluene and particularly benzene are highly volatile and escape the groundwater system as a vapor. This condition was not implicitly included in the decay function.
Dilution Effects of the River	Dilution adjacent to the river as a result of oscillatory (tidal) losing river conditions were not considered. Generally, groundwater flow is toward the river. However, periodically, the river loses water to the

aquifer and groundwater moves away from the river. Because of friction in the aquifer, groundwater levels cannot respond to a river rise as quickly as the river itself, and periodically, groundwater flows from the river to the aquifer. This flux adds river water to the aquifer and decreases contaminant concentrations. The amount of dilution is substantial. Based on mass balance equations and upon consideration of the annual mean flow of the Passaic River it is Tenneco's position that any dissolved compounds present in the groundwater would be diluted by a factor of at least 7,000 and possibly as high as 16,800. Tenneco's calculations are based on the annual mean river flow of 80.8 cubic feet per second (cfs) or 5.22×10^7 gallons per day (gpd) in the vicinity of the site and the minimum average seven consecutive day flow of 34 cfs (2.19×10^7 gpd). Based on the width of the site along the river (approximately 600 feet), and a saturated thickness of 20 feet, *SECOR* estimates that approximately 3,100 gallons of groundwater are discharging to the Passaic River each day. While Tenneco recognizes that dilution is not an acceptable form of remediation in and of itself, its influence on the concentrations of dissolved compounds reaching the Passaic River cannot be ignored.

Longer Flowpath

A straight line flow path from MW-14 to the river is a conservative distance. It is likely that flow has a downward component and enters the river not as leakage along the bank but more likely along the river bottom. The actual flow path from source to entry into the river is probably much longer, and lower concentrations would enter the river at the greater distance.

3.2 Remediation Proposals

Tenneco proposed to remediate groundwater using four separate systems, including 1) air sparging and soil vapor extraction in the toluene spill area (AEC-14); 2) enhanced biodegradation in the southwest corner of the site (beneath Buildings 16, 17, and 34); 3) a biotrench to stop off-site migration on the south side of the site (along Hudson Street); and, 4) groundwater extraction and treatment from four off-site recovery wells. The following sections provide additional information relative to each of these systems.

3.2.1 *Air Sparging/Soil Vapor Extraction*

Tenneco proposed to install an air sparging/soil vapor extraction (AS/SVE) system to remediate the toluene spill area (AEC-14). The original lay-out of the conceptual system consisted of 18 air sparging points (installed to a depth of 30 feet) and nine horizontal SVE wells. In preparation for installing this system, Tenneco demolished Buildings 22 and 23 and removed the remains of the benzoic acid/benzaldehyde production tank farm. During the demolition of Building 23, it became apparent that impacted soils extended further to the north, under Building 10-T1. Between December 1995 and February 1996, Tenneco demolished Buildings 20, 10-P5, 10-T, 10-T1, and 10-S; Building 10-P4 had been demolished during the Summer of 1995 to facilitate removal of equipment. Tenneco plans to expand the AS/SVE system to cover the area beneath these buildings (see Section 5.1, below).

3.2.2 *Enhanced In-Situ Biodegradation*

Tenneco proposes to install two horizontal air injection wells beneath Buildings 16, 17, and 34. The injection of air into the subsurface has been demonstrated (through the performance of two, 24 hour pilot tests) to stimulate the indigenous bacterial population and enhance the biodegradation of the primary compounds of concern (i.e., benzene, toluene, and phenol). Laboratory treatability testing has also been performed using soil and groundwater from the site to determine degradation rates. The time required to reduce concentrations to below the detection limits ranged from two weeks for phenol to four weeks for toluene.

The proposed enhanced biodegradation system will serve to 1) remediate the compounds of concern which currently exist below the buildings in the southwest corner of the site, and 2) create a zone of enhanced biological activity which will serve to stop possible off-site migration through this portion of the site. As groundwater containing dissolved compounds of concern flows towards the southwest corner of the site, it will have to pass through the zone of biological activity before reaching the property line. Using a 30 feet radius of influence (determined during the biodegradation pilot tests), Tenneco has designed a system which create an aeration zone approximately 130 feet wide. Given that the linear flow velocities at the site have been calculated to range from 0.3 ft/day to 1.5 ft/day, the residence time through this zone would be 87 to 433 days, at least three times the time necessary to reduce toluene concentrations to below the remediation criterion.

3.2.3 *Biotrench System*

Tenneco originally proposed to install a biotrench along the southern property line to stop further off-site migration. However, due to the number of underground utilities which have been found running through the area, Tenneco does not believe it will be possible to install an effective biotrench. Therefore, Tenneco proposes to use an air curtain generated by vertical air injection wells to achieve the desired goal of stopping off-site migration. See Section 5.3 for the conceptual design for this system.

3.2.4 *Groundwater Recovery System*

On 2 November 1995, Tenneco requested permission from the City of Garfield to install four groundwater recovery wells in Hudson Street and Bloomingdale Avenue. As of February 1996, Tenneco has yet to receive permission from the City of Garfield to install these wells. Until these wells are installed, Tenneco cannot begin collecting the data necessary to design the groundwater treatment system. Tenneco will submit the groundwater recovery and treatment system design, plus information on the ultimate discharge point for the treated water under separate cover.

3.3 Additional Groundwater Requirements

This section of the NJDEP's letter contained 10 comments pertaining to groundwater issues. Tenneco's responses to the NJDEP's comments are addressed below.

3.3.1 *Groundwater Discharge*

At this time, Tenneco anticipates that groundwater will either be discharged to the Passaic Valley Sewerage Commission (PVSC) sewer line, or will be discharged through a re-injection gallery (or wells) near the middle of the site. Both of these options would require a New Jersey Pollutant Discharge Elimination System (NJPDES) permit. Tenneco considers discharging the treated water to the Passaic River (under a NJPDES-Discharge to Surface Water permit) to be the least desirable option.

3.3.2 *Chlorinated VOCs*

Approximately 6.0-inches of a dense non-aqueous phase liquid (DNAPL) was detected in MW-5 during the December 1991 groundwater sampling event. This material was removed from the well, analyzed, and determined to contain 11% toluene, 16% biphenyl isomers, and 0.014% TCE. During numerous well gauging events since December 1991, DNAPL has never again been detected in MW-5. DNAPL has also never been detected in the shallow and deep wells surrounding MW-5. Therefore, Tenneco believes that the DNAPL found in MW-5 was of limited volume and extent, and is no longer of concern at the site.

Following the demolition of Building 23, Tenneco collected a soil sample that was saturated with separate phase hydrocarbons (PE-2), and a second sample of separate phase hydrocarbons (PE-3A). Each sample was analyzed for VOC+10 by USEPA Method 8240 and BNA+25 (including benzoic acid and benzaldehyde) by USEPA Method 8270. In addition, these samples were also submitted to Worldwide Geosciences, Inc. in Houston, Texas for additional characterization by high resolution capillary gas chromatography. The analytical results for the separate phase hydrocarbon (SPH) samples are summarized on Table E-1 in Appendix E. A copy of Worldwide Geosciences report is also included in Appendix E.

The SPH in samples PE-2 and PE-3A was found to contain toluene (7,100 ppm to 13,000 ppm), benzene (150 ppm), xylenes (214 ppm to 270 ppm), and ethylbenzene (68.0 ppm to 98.0 ppm); methylene chloride was also detected, but can be attributed to laboratory introduced contamination. The results of the BNA analyses indicated the SPH contained benzoic acid (950 ppm), 2,6-dinitrotoluene (41,000 ppm), benzaldehyde (6,900 ppm), and several PAHs (i.e., naphthalene, phenanthrene, fluoranthene, etc.). In addition, 74,190 ppm of nontargeted BNAs were found in sample PE-3A, primarily unknown compounds (19,570 ppm) and unknown aromatics (41,010 ppm).

Worldwide Geosciences confirmed the presence of toluene in both samples, and ruled out the possibility that the SPH was related to the No. 2 fuel oil release. Although some fuel oil components were detected, the chromatographic signatures of the SPH samples and a standard No. 2 fuel oil were significantly different. The mass spectra of the prominent peaks present in the samples were subsequently analyzed to determine their structure, and biphenyl and methylated biphenyls were found. Since biphenyl compounds had also been detected in the dense non-aqueous phase liquid (DNAPL) sample collected from MW-5 in December 1991, Tenneco reviewed the materials which were commonly used in the benzoic acid/benzaldehyde production area (AEC-14). Based on this review, Tenneco identified Dowtherm as the likely source for the biphenyls in these samples.

Dowtherm is a heat transfer fluid that was used in two boilers previously located in this area. A material safety data sheet (MSDS) obtained from Dow Chemical indicates that Dowtherm is comprised of 73% diphenyl oxide (phenyl ether) and 27% diphenyl (biphenyl). The absence of diphenyl oxide or phenyl ether in the SPH samples collected from the site may represent degradation to the methylphenyls which were detected. Dowtherm has limited solubility in water (13.8 ppm at 60°F) and has a specific gravity greater than water (1.050 - 1.075). These characteristics would result in Dowtherm manifesting itself as a DNAPL.

As was discussed in Section 2.4.3, chlorinated VOCs have only been detected in trace amounts in soil samples collected from across the site; TCE has never been detected in a soil sample. Further evidence that the DNAPL detected in MW-5 is not related to TCE or other chlorinated compounds comes from the concentrations of TCE in groundwater samples from this well and MW-5D. Since January 1988, TCE concentrations in MW-5 have ranged from 78.0 ppb (November 1994) to 1,400 ppb (January 1988), with an average concentration of 360 ppb. In MW-5D, which was installed in January 1991, TCE concentrations have ranged from 2,700 ppb (January 1991) to 4,200 ppb (October 1992), with an average concentration of 3,100 ppb. Therefore, the TCE concentrations in MW-5 and MW-5D are significantly below the NJDEP's guideline[9] for evaluating the potential for the presence of DNAPL.

Tenneco believes that the slight groundwater mound present in the southeast corner of the facility has not contributed to the spread of chlorinated compounds in a direction up-gradient to the site (i.e., to the east). The source of this mound has been demonstrated to be water perched atop a lens of silty clay and fine sand in the vicinity of MW-4 and piezometers PZ-1 and PZ-2. Tenneco has reviewed the groundwater contour maps from 11 rounds of well gauging between April 1991 and January 1995, and has determined that the largest mound was observed in April 1991. At that time, the mound was approximately 3.0 feet high at MW-4 and extended approximately 60 feet in an up-gradient direction. A mound of this magnitude would not extend to the up-gradient property line, and would not reverse the overall direction of groundwater flow (to the west-southwest), considering that the groundwater gradient from the east was 0.01 ft/ft. It should also be noted that elevated concentrations of TCE are also found in the deep monitoring wells up-gradient from the site (MW-16D, MW-19D, MW-20D, MW-34D, MW-35D), although a groundwater mound has not been detected in these wells.

Based on the information discussed above and in other sections of this report, Tenneco maintains that the chlorinated compounds being detected in the overburden and bedrock water bearing zones are not related to the Kalama Chemical site. Therefore, Tenneco does not propose any remedial actions specific to these compounds. It should be noted, that although the AS/SVE system which has been proposed for AEC-14 is being installed to remediate the benzene and toluene present in soil and groundwater, it will also serve to remove the chlorinated VOCs in groundwater. However, the chlorinated VOCs are not driving this remediation program and the continued operation of the AS/SVE system will be dictated by achieving the closure criteria for benzene and toluene.

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[9] In the Summer 1995 "Site Remediation News", the NJDEP states that "groundwater-quality data can lead one to suspect the presence of NAPL if dissolved concentrations are less than 10% or even approach 1% of their effective water solubility".

3.3.3 *Classification Exception Area*

Tenneco will establish a Classification Exception Area (CEA) around the Kalama site, once the issues relating to site related compounds of concern have been resolved. Since the chlorinated compounds are not considered to be related to the Kalama facility, Tenneco believes the CEA should only be established for benzene, toluene, phenol, methanol, formaldehyde, and benzoic acid.

3.3.4 *Groundwater Disposal*

The water requiring disposal from the AS/SVE system would be derived from the moisture separator that would be part of the treatment system. Any water which may accumulate in the moisture separator would be transferred to a drum during operation and maintenance of the AS/SVE system. As the drum becomes filled, the water would be run through the groundwater treatment system for disposal. Treatment of the moisture separator water in this way would eliminate the need for a NJPDES-Discharge to Groundwater permit for the AS/SVE system.

4.0 SOIL VAPOR EXTRACTION PILOT TESTS

Soil vapor extraction is an established remedial technology that involves drawing air through unsaturated soils to remove adsorbed VOCs. Compounds that have a high vapor pressure would be "stripped" from the surface of the soil particles and migrate through the soil to an extraction point. The vapors generated by the SVE system are typically treated prior to discharge. In the case of an AS/SVE system, the SVE portion of the system is used to treat the unsaturated soils and to control emissions from the AS portion of the system.

Soil vapor extraction (SVE) technology was proposed to address the separate, adsorbed, and vapor phase hydrocarbons present in the vadose zone in the southeast corner of the site. SVE pilot testing was performed to confirm the applicability of the technology to site conditions and to enable full scale system design. Horizontal pilot test wells were used for the SVE pilot testing rather then the more conventional vertical wells due to the shallow depth to water (approximately seven feet).

4.1 Installation of Pilot Test System

Two horizontal vent wells (HVW-1 and HVW-2) and eleven vapor monitoring probes (VMP-3 through VMP-13) were installed in AEC-14 for use in pilot testing. Horizontal vent well HVW-1 was installed in a trench north of former Building 22. Three vapor monitoring probes, VMP-3 through VMP-5, were installed towards the west end of HVW-1. Existing wells were used for monitoring at the east end of HVW-1.

Horizontal vent well HVW-2 was installed in a trench on the south side of Building 10-T (which has subsequently been demolished). This area became accessible following the demolition of Building 23. Six vapor monitoring probes, VMP-6 through VMP-11, were installed south of HVW-2 and two vapor monitoring probes, VMP-12 and VMP-13, were installed north of HVW-2 inside of Buildings 10-T1 and 10-T. The vapor monitoring probes were installed by a licensed driller using a GeoProbe, with the exception of VMP-12 and VMP-13, which were installed using a hand auger. The horizontal vent wells were installed by a general contractor using a trackhoe. The locations of these wells and monitoring probes are depicted on Figure 13. The construction details for these wells are provided below.

Horizontal Vent Wells

Horizontal vent wells HVW-1 and HVW-2 were installed in trenches at the locations shown on Figure 13. The trenches were excavated to a depth below grade of approximately three feet, to a length of 85 feet, and to a width of two feet. Each trench was backfilled with six inches of clean pea gravel prior to installing the SVE wells. Each well was constructed with 80 feet of horizontal well screen and five solid vertical risers spaced 20 feet apart. The five vertical risers at each horizontal well enabled pilot testing from any one of the five risers and monitoring from the remaining four. HVW-1 was constructed using 2-inch diameter schedule 40 PVC well screen and casing, and HVW-2 was constructed using 4-inch diameter schedule 40 PVC well screen and casing. Each horizontal well was then covered with an additional six inches of clean pea gravel. To help prevent short circuiting, the pea gravel was covered with 6-mil plastic sheeting. The remainder of each trench was backfilled with 8- to 12-inch lifts of compacted native soils.

The depth to water in nearby shallow wells was approximately seven feet below grade; however, perched water and some separate phase hydrocarbons were encountered in both trenches three to four feet below grade. Consequently, HVW-2 had to be installed only two feet below grade (HVW-1 was installed approximately 2.5 feet below grade as planned). Clean fill was brought to the site and placed over HVW-2 (and compacted) to a thickness of one foot for approximately ten feet on either side of the trench. The fill was used to help prevent short circuiting and to extend the radius of influence.

Vapor Monitoring Probes

The vapor monitoring probes were installed at locations without existing wells and at varying distances from the horizontal vent wells. The points were installed to a depth of four feet below grade and were constructed from 1-inch diameter schedule 40 PVC. The points were screened (0.020-inch slot size) from two to four feet below grade and were cased from one foot above grade to two feet below grade. The top of the points were fitted with a female threaded PVC adapter, a threaded PVC bushing, and a brass barb. Vinyl tubing (3/16-inch inside diameter) was attached to the brass barb fitting. The annulus of the bore hole was completed with Number 2 Morie sand from 1.75 feet to 4 feet below grade and was completed with a cement/bentonite grout from ground surface to 1.75 feet below grade.

The installation of the monitoring points was performed by Summit Drilling Co., Inc. of Bridgewater, New Jersey under the supervision of a *SECOR* geologist. In addition to the eleven vapor monitoring points, existing monitoring wells were used to collect pilot test data. The soil classifications for the vapor monitoring points are similar to prior logs, which indicate that the unconsolidated sediments are comprised primarily of poorly sorted sand and gravel fill material.

4.2 Pilot Test Methodology

On 25 September 1995, pre-test depth to water data was collected at the five risers of HVW-2 (B-1 through B-5), VMP-6 through VMP-13, WP-7, MW-9, and MW-5E (Figure 13). The pilot test equipment was assembled at the west end of HVW-2 at riser B-1. A 1.5 horsepower regenerative blower was connected to riser B-1 using 2.0-inch diameter PVC pipe, flexible hose, and a 2.0- to 4.0-inch Fernco (rubber sleeve with hose clamps) fitting. Ports were installed in the PVC piping to enable collection of data including the wellhead vacuum (using a Dwyer Magnehelic gauge), wellhead VOC concentration (using a Photovac Microtip photo-ionization detector), and extraction air flow rate (using a TSI air velocity meter). Additionally, a moisture separator was installed between the extraction well and blower. The exit piping from the blower was connected with 2.0-inch diameter schedule 40 PVC and 2.0-inch diameter flexible hose to two serially plumbed granular activated carbon (GAC) adsorbers. The air from the second GAC adsorber was discharged to the atmosphere via a six foot stack. Sampling ports were installed at the influent to the first GAC, between GACs, and at the effluent of the second GAC to allow for monitoring of hydrocarbon breakthrough. Nearby wells and risers B-2 through B-5 were fitted with pilot test well plugs to enable vacuum measurements with Dwyer Magnehelic gauges.

SVE pilot testing was initiated at riser B-1 of HVW-2 by starting the blower and partially closing the dilution valve. Testing was conducted at two steps (extraction well vacuums). The first step was conducted for 1 hour and 20 minutes and the second step was conducted for 2 hours. At various times during each test, the wellhead vacuum, wellhead VOC concentration, extraction air flow rate, and pre-GAC, between GAC and post-GAC VOC concentration data was collected. Additionally, vacuum readings were measured at the four other risers (B-2 through B-5), the vapor monitoring points (VMP-6 through VMP-13), and nearby wells (WP-7, MW-9 and MW-E5). During the second step, an influent air sample, SVE-B-1, was collected in a Tedlar bag. The air bag was labelled, logged on a chain of custody document, and delivered to Accutest in Dayton, New Jersey for analysis for VOCs by USEPA Method 8240.

Upon completing the test at B-1, the pilot test equipment was moved to and re-assembled at riser B-3 of HVW-2. Similar to testing at riser B-1, testing was conducted at two extraction well vacuums. The first step was conducted for 1 hour and the second step was conducted for 1 hour and 30 minutes. Wellhead vacuum, wellhead VOC concentration, extraction air flow rate, and pre-GAC, between GAC and post-GAC VOC concentration data was collected. Additionally, vacuum readings were measured at the four other risers (B-1, B-2, B-4, B-5), the vapor monitoring points (VMP-6 through VMP-13), and nearby wells (WP-7, MW-9 and MW-E5). During the second step, an influent air sample, SVE-B-3, was collected in a Tedlar bag. The air bag was labelled, logged on a chain of custody document, and delivered to Accutest for analysis for VOCs by USEPA Method 8240.

On 26 September 1995, pre-test depth to water data was collected at the five risers of HVW-1 (A-1 through A-5), vapor monitoring points VMP-3 through VMP-5, and monitoring wells MW-5, MW-A5, MW-B5, MW-C5, MW-D5 and MW-F5. Risers A-1 and A-2 at the west end of the HVW-1 and VMP-3 through VMP-5 contained a product/water mixture. Approximately five gallons of liquid were pumped from risers A-1 and A-2; however, liquid continued to recharge into the two risers and the western portion of the horizontal well[10]. Consequently, all of the testing of horizontal vent well HVW-1 was conducted by applying the vacuum at riser A-5 at the east end of the well.

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[10] The risers of HVW-2 have been incorporated into the bi-weekly gauging and product recovery program for the site. Approximately 4.0 gallons of SPH have been recovered from HVW-2. However, since 25 January 1996, no SPH has been detected.

Testing was conducted at riser A-5 for seven hours and at three extraction well vacuums. At various times during each step, the wellhead vacuum, wellhead VOC concentration, extraction air flow rate, and pre-GAC, between GAC and post-GAC VOC concentration data was collected. Additionally, vacuum readings were measured at the four other risers (A-1 through A-4), the vapor monitoring points (VMP-3 through VMP-5), and nearby wells (MW-5, MW-A5, MW-B5, MW-C5, MW-D5 and MW-F5). During the first step, influent air samples, SVE-A-5A and SVE-A-5B, were collected into Tedlar bags. The air bags were labelled, logged on a chain of custody document, and delivered to Accutest for analysis for VOCs by USEPA Method 8240.

4.3 Pilot Test Results

Data was collected at the horizontal vent wells, nearby vapor monitoring points, and nearby wells before and during pilot testing. The results of testing at HVW-2, from risers B-1 and B-3, are summarized on Tables 8 and 9. A relatively low applied vacuum, 2.3 to 4.0 inches of water, resulted in relatively high extraction air flow rates, 67 to 100 cubic feet per minute (CFM). The extraction VOC concentrations measured at the wellhead with a PID were relatively high ranging from 1,000 to 2,100 ppm. Results from the air bag samples collected from HVW-2 (SVE-B-1 and SVE-B-3) are summarized on Table 10. The analytical results confirm the high concentrations observed during testing with the PID and indicate the primary compound extracted to be toluene. Due to the relatively high extraction air flow rates and extraction VOC concentrations, the mass removal rates were relatively high. The mass removal rates observed when samples SVE-B-1 and SVE-B-3 were collected were 0.6 and 1.2 pounds per hour, respectively. The magnitude of the applied vacuum decreased along the length of the well, as measured in nearby risers. However, the vacuum remained high enough to influence the surrounding soil for the entire length of the well. Vapor monitoring points VMP-7, VMP-9, and VMP-10 contained liquid above the screened portion of the point, and, consequently, did not provide any useful vacuum data. The recorded vacuum readings at wells and vapor monitoring points three to five feet from the horizontal well ranged from 0.20 to 0.50 inches of water. The vacuum 25 feet away at VMP-6 ranged from 0.05 to 0.10 inches of water.

The results of testing at HVW-1, from riser A-5, are summarized on Tables 11 and 12. Similar to testing at HVW-2, relatively low applied vacuum, 3.5 to 7.0 inches of water, resulted in relatively high extraction air flow rates, 25 to 60 CFM. The extraction VOC concentrations measured at the wellhead with a PID were relatively high ranging from 1,500 to 1,800 ppm. Results from the air bag samples collected from HVW-1 (SVE-A-5A and SVE-A-5B) are summarized on Table 10.

The analytical results confirm the high concentrations observed during testing with the PID and indicate the primary compound extracted to be toluene. The toluene concentrations were an order of magnitude higher in HVW-1 than the concentrations at HVW-2. Due the relatively high extraction air flow rates and extraction VOC concentrations, the mass removal rates were high. The mass removal rates observed when samples SVE-A-5A and SVE-A-5B were collected were 2.6 and 2.2 pounds per hour, respectively. The magnitude of the applied vacuum decreased along the length of the well, as measured in nearby risers. However, the vacuum remained high enough to influence the surrounding soil for the entire length of the well which was free of liquid. The recorded vacuum readings at wells and vapor monitoring points four to ten feet from the horizontal well ranged from 0.62 to 1.35 inches of water. The vacuum 30 feet away at MW-F5 ranged from 0.18 to 0.29 inches of water. Depth to water in the nearby monitoring wells was approximately 7.5 feet below grade.

The air monitoring data required by the temporary air discharge authorization is summarized on Tables 8 and 11. The between GAC VOC concentration data indicates that there was breakthrough of the primary GAC during the second day of testing. The effluent VOC concentration data remained at or near zero (<5 ppm) throughout testing.

4.4 Discussion of Results

The relatively low applied vacuum that resulted in a moderate to high extraction air flow rate was anticipated based upon the soil type (poorly sorted sand and gravel), shallow depth of the well (approximately three feet below grade), and the extraction well configuration (80 foot horizontal well). The high concentrations of the extracted vapors were also anticipated based upon the presence of separate phase hydrocarbons. Analytical data indicated the presence of primarily toluene with lesser amounts of benzene, ethylbenzene, and xylenes. The pilot test demonstrated that high mass removal can be achieved at the site by employing SVE technology with horizontal wells.

The results of the vacuum readings at nearby wells indicate that the effective radius of influence was approximately 25 feet. With the addition of a surface seal (eg, asphalt pavement) the radius of influence will be somewhat larger. An estimated radius of influence of 30 feet will enable a full scale system to be installed with a reasonable number of SVE wells and, consequently, in a cost effective manner.

5.0 CHANGES TO PROPOSED REMEDIATION PROGRAM

In the Revised Remedial Action Work Plan dated 31 March 1995, Tenneco proposed to install four separate remediation systems at the Kalama site. These systems would address VOCs and other site related compounds present in the vadose and saturated zone soils and dissolved in groundwater. The first system proposed uses air sparge (AS) and soil vapor extraction (SVE) technologies to remediate soil and groundwater at the southeast corner of the site (the toluene spill area encompassing AECs-9, 11, 12, 13, 14, 19, and 20). Since submittal of the Revised RAW, Tenneco has conducted an SVE pilot test and additional soil sampling in the southeast corner of the site. Consequently, the layout of the proposed AS/SVE system has been expanded to incorporate additional areas requiring remediation. Modifications to the proposed AS/SVE system are discussed in more detail in Section 5.1, below.

The second system proposed uses enhanced in-situ biodegradation to remediate groundwater in the southwest corner of the site. The proposed system would address adsorbed and dissolved phase benzene, toluene, and phenol in the saturated zone, and would help to prevent off-site migration. The design of this system remains unchanged from that which was specified in Section 9.2 of the Revised RAW.

The third system proposed addresses groundwater flowing across the southern border of the site. In the Revised RAW, a biotrench was proposed to degrade and physically remove dissolved phase VOCs from the groundwater prior to flowing off-site. Due to an abundance of underground utilities in this area, Tenneco has determined that it would not be possible to install an effective system. Consequently, Tenneco proposes to install an air curtain using vertical injection wells in place of the biotrench. Similar to the biotrench, the air curtain would be designed to remediate the groundwater prior to migrating off-site. The air curtain, designed to degrade the VOCs, would be located on-site, parallel to Hudson Street between the AS/SVE system and the enhanced in-situ biodegradation system. Details of the air curtain system are discussed below in Section 5.3.

The fourth system proposed uses a groundwater recovery and treatment system to remediate groundwater located off-site to the south of Hudson Street. This system would reduce the off-site concentrations of benzene and toluene, and would help prevent the dissolved phase plume from migrating further to the south. Minor changes made to the groundwater extraction equipment to be used in this system are discussed below in Section 5.4. The layout of the proposed soil and groundwater remediation systems are shown on Figure 14.

5.1 Air Sparge/Soil Vapor Extraction System

Based upon additional soil sampling data collected since the submittal of the Revised RAW, the layout of the AS/SVE system has been expanded. Additionally, recent demolition of Buildings 10-T, 10-T1, 10-S, 10-P4, 10-P5, and 20 enables the installation of AS and SVE wells and piping in areas previously inaccessible. The layout of the AS/SVE system will now incorporate the areas beneath former Buildings 10-T, 10-T1, 10-P5, and 20 and the area surrounding existing Building 29, in addition to addressing the area defined in the Revised RAW (Figure 15).

As was discussed earlier in Section 2.3.2, the results of the additional soil sampling conducted in AEC-9 indicate that remediation is only required in a small area at the northwest corner of Building 18 (Figure 15). Additionally, consistent with previous soil sample data, only soils in the saturated zone require remediation. Therefore, in the area northwest of Building 18, the air will be injected into the saturated zone at low enough flows to enhance biodegradation, but not to physically remove hydrocarbons.

5.1.1 *Design Basis and Conceptual Design*

Based on the September 1995 SVE pilot test data and previous enhanced in-situ biodegradation and SVE pilot test data, the radius of influence for both air sparging and soil venting has been estimated to be 30 feet. Using the expanded extent of soil and groundwater to be remediated (Figure 15) and the AS radius of influence (30 feet), the number of AS wells required has increased from 20 to 25 air sparge wells. One of the 25 AS wells will be used to influence the area northwest of Building 18. The layout of the AS wells and their areas of influence are shown in Figure 16.

Twelve horizontal SVE wells (versus nine originally), typically 65 feet in length, will be employed to extract vapors from the unsaturated zone. The proposed locations of the horizontal SVE wells and their areas of influence, assuming a 30 foot radius of influence, is shown in Figure 17. Piping will be routed from a centrally located treatment compound to the AS wells. To minimize trenching, the horizontal SVE wells and the piping from the SVE wells to the treatment compound will be installed in the same trenches as the AS piping. The proposed trench and well locations are shown in Figure 18.

5.1.2 *Well Construction, Trenching and Piping*

Based upon the results of the September 1995 SVE pilot test, the horizontal SVE wells can be constructed of 2-inch diameter, continuously screened, schedule 40 PVC. Each horizontal well would be routed back to the treatment compound via 2-inch diameter schedule 40 PVC pipe. The horizontal SVE wells would be surrounded with sand or pea gravel, covered with plastic to prevent short circuiting, and backfilled.

The layout of AS and SVE trench locations is shown in Figure 18. The number of feet of trenching has been increased from 970 feet for the original system to 1,250 feet for the expanded system. Depending on the location, one to twelve pipe runs will be installed in each section of trench.

5.1.3 *AS/SVE System Components*

The air sparge system components will be essentially the same as was proposed in the Revised RAW. The AS blower size will need to increase from a 20 horsepower to a 30 horsepower blower. This increase in size is required to deliver the higher flow (300 CFM) associated with 25 (versus 20) wells.

The September 1995 SVE pilot test confirmed the air flow rate from each horizontal well to be approximately 100 CFM. However, the vacuum applied to obtain this flow rate was significantly lower than anticipated, approximately 5 inches of water. The increase from nine to twelve horizontal SVE wells increases the total flow of the system to approximately 1,200 CFM. Consequently, a 30 horsepower SVE blower will be required. Due to the lower required applied vacuum, a heat exchanger may not be necessary after the blower.

5.1.4 *SVE Mass Removal and Off-gas Treatment*

The mass removal rates calculated from the September 1995 SVE pilot test data ranged from 0.6 to 2.6 pounds per hour. Assuming an average mass removal of 1.5 pounds per hour per well, approximately 15 pounds per hour will initially be removed from all twelve wells. At these high mass removal rates treatment with granular activated carbon is not cost effective. Consequently, other off-gas treatment methods will be considered including catalytic and thermal oxidation.

Four air samples were collected during the September 1995 SVE pilot test and were analyzed for VOCs by USEPA Method 8240. The results of the analyses indicate that the extracted vapors contain primarily toluene with lesser amounts of benzene, ethylbenzene, and xylenes.

5.2 Enhanced In-situ Biodegradation System

Enhanced in-situ biodegradation was proposed to remediate groundwater in the southwest corner of the site. The proposed system would address adsorbed and dissolved phase benzene, toluene, and phenol in the saturated zone, and would help to prevent off-site migration. The primary components of this system are two horizontal air injection wells and a blower to deliver air to the wells. The design of this system remains unchanged from that which was specified in the Revised RAW.

5.3 Air Curtain

Tenneco proposes to use an air curtain to address adsorbed and dissolved phase benzene, toluene, and phenol in the saturated zone, and to help prevent off-site migration. The air curtain would overlap with the enhanced in-situ biodegradation system located to the west and with the AS/SVE system located to the east (Figure 14). The air curtain would deliver sufficient air to the saturated zone to biodegrade the contaminants prior to migrating off-site, but would not cause the release of fugitive emissions.

The air curtain system supplies air to the saturated zone to aerate the soil and groundwater to stimulate biological activity and to promote the natural degradation of petroleum constituents. Benzene, toluene, and phenol (the three primary compounds of concern at the site) are generally considered to be biodegradable by naturally occurring microorganisms within the soil and groundwater, providing there is an adequate supply of oxygen and basic nutrients. The air curtain will provide the necessary oxygen, and laboratory analyses have indicated that there are sufficient quantities of basic nutrients naturally occurring in the soil.

5.3.1 *Design Basis and Conceptual Design*

The enhanced in-situ biodegradation pilot test conducted in the toluene spill area (and reported in Section 8.0 of the Revised RAW) demonstrated the feasibility of aerating the saturated zone and biodegrading site petroleum constituents. Using pilot test data, the air curtain system was designed to inject air at pressure of 10 psi and at a flow of 12 CFM. At this flow, the effective radius of influence was estimated to be 30 feet.

Tenneco proposes to install two rows of air curtain wells, with overlapping areas of influence, to address the area between the AS/SVE system and the enhanced in-situ biodegradation system. The approximate location of these wells are shown on Figure 19. Based upon this design and an assumed radius of influence of 30 feet, groundwater will flow through the air curtain for approximately 90 feet.

Assuming a conservative groundwater velocity of 1.5 ft/day, this would result in a retention time of 60 days, approximately twice the time necessary to degrade the compounds of concern.

5.3.2 *Well Construction*

The air curtain wells, ACW-1 through ACW-10, will be installed at ten locations along the southern boundary of the site (Figure 19). The wells will be constructed to a depth of 30 feet, and will be constructed with 28 feet of 2.0-inch diameter schedule 40 PVC casing and two feet of 0.020-inch slotted PVC well screen. The annulus around the wells will be completed with number 2 Morie sand extending from 27 to 30 feet below grade, followed by a fine sand (number 00 Morie or equivalent) from 26 to 27 feet below grade, followed by a cement/bentonite grout from one to 27 feet below grade.

The wellheads will be completed with an 8- to 12-inch diameter flush mounted well vault surrounded by a two foot square concrete pad. The tops of the well casings will be fitted with a removable cap to enable well gauging.

5.3.3 *Trenching and Piping*

Based on the location of the air curtain wells and the location of the equipment compound (to be located approximately 40 feet north of the air curtain), there will be approximately 400 feet of trenching. Individual piping will be installed from the equipment compound to each well. Consequently, the number of pipes in each section of trench will vary between one and ten. The trench depth will be approximately 3.5 feet below grade. The trenches will be hand dug at the wellheads and at any locations where the trench will cross sub-surface utilities. The piping will be surrounded in all directions by six inches of sand or pea gravel to prevent damage. The remainder of the trench will be backfilled with native soil in eight to twelve inch compacted lifts.

5.3.4 *Equipment Compound*

The piping from the ten wells will be stubbed up approximately 40 feet north of the air curtain. Each stubbed up pipe will be fitted with a pressure gauge and a ball valve. The ten lines will then be manifolded together to a single line.

The equipment required to supply the air to the wells will be located inside a small shed or steel cargo container. The equipment compound will be situated on asphalt or a 6-inch thick layer of crushed stone. The air curtain system equipment components will be assembled in the equipment compound. The equipment compound will be modified to include active or passive vents, utility outlets and lighting.

5.3.5 *Air Injection System Components*

Ambient air will be drawn through an inlet filter and silencer and into a 15 horsepower blower. The air injection blower will be capable of delivering 120 CFM at a pressure of 12 psi. Downstream of the blower there will be a pressure indicator, a second silencer, a pressure relief valve, a bleed valve and silencer, and a temperature indicator. The air will then be routed through a heat exchanger which will lower the temperature to a level that is below the melting point of the PVC piping. Downstream of the heat exchanger there will be temperature, flow and pressure indicators. The pipe will then connect to the manifold. Each of the ten lines will have pressure gauges and ball valves prior to being routed below grade to the air curtain wells. The air supply blower and the heat exchanger blower will have on/off hand switches. The air supply blower will be controlled to shutdown if the internal blower temperature is too high or if the heat exchange exit temperature is too high.

5.3.6 *System Operation and Maintenance*

The air curtain system operation and maintenance will be performed on a bi-weekly basis. The supply air flow rate, pressures, and temperatures will be monitoring to ensure proper system operation. The ball valves on each line and the bleed valve will be adjusted as required. The inlet filter will be inspected to determine if it requires cleaning or replacement. Additionally, the air supply blower and the heat exchanger blower will be inspected and maintained on a regular basis.

Periodic monitoring will be performed at nearby wells to assess the effectiveness of the system and to ensure that the injection of air is not causing any fugitive emissions. Consequently, the following parameters will be measured on a monthly basis at MW-1, MW-10, and MW-11: depth to water, wellhead pressure, VOC concentration in the head space of the well, and dissolved oxygen concentration.

5.3.7 *Remediation Criteria*

The main objective of the air curtain system will be to remediate dissolved and adsorbed phase benzene, toluene, and phenol in the saturated zone, and to help prevent off-site migration along the southern border of the site. Tenneco proposes to operate the air curtain system until the benzene and toluene concentrations have been reduced to 512 ppb and 53,400 ppb, respectively, in the area wells in the toluene source area (see Section 6.2.3 of the Revised RAW).

5.4 Groundwater Recovery and Treatment System

A groundwater recovery and treatment system was proposed to remediate groundwater located off-site to the south of Hudson Street. The system would be employed to reduce dissolved and adsorbed phase benzene and toluene concentrations, and would help to prevent the dissolved phase plume from migrating further south.

5.4.1 *Design Basis and Conceptual Design*

Only minor changes were made to the conceptual design of the groundwater recovery system. Tenneco still proposes to install four recovery wells at the locations shown on Figure 14. The wells were located in the area of highest dissolved concentrations to maximize mass removal, while providing some degree of containment to prevent the further spread of dissolved compounds. The four recovery wells will be pumped at approximately 3 gallons per minute (gpm) for a combined recovery rate of 12 gpm. The four recovery wells will be equipped with pneumatic pumps and connected to PVC piping which will run to a treatment compound located on-site.

Once the groundwater recovery system is installed, a pump test will be performed to provide more accurate data on the concentration of hydrocarbons in the recovered groundwater and the groundwater recovery rate. The treatment system will be designed based upon data collected during the pump test and the final discharge point of the recovered groundwater.

5.4.2 *Well Construction and Subgrade Piping*

The groundwater recovery wells will be installed to a depth of 27 to 37 feet below grade, and be constructed with approximately 20 feet of 6-inch diameter Channel Pack^R galvanized well screen set from the water table to 20 feet below the water table. Channel Pack^R is a double well screen containing filter sand between the two screens. The Channel Pack^R well screen design was selected over the more conventional method of installing gravel pack around a single screen due to the presence of very fine sediments observed at the site during drilling activities conducted in the past year.

Based upon the proposed recovery well and treatment compound locations, there will be approximately 450 feet of trenching. The recovery wells will be manifolded to a PVC pipe which will run back to the treatment compound. Additional PVC piping will be installed in the trench to supply compressed air to operate the pneumatic pumps.

5.4.3 *Recovery and Treatment System Components*

The recovery wells will be equipped with Hammerhead^R pneumatic submersible pumps manufactured by QED Environmental Systems of Ann Arbor, MI. The Hammerhead^R pumps are controller-less and will maintain the desired drawdown in the well regardless of fluctuations in well yield. Pump cycle counters will be located at each recovery well vault to determine individual well pumping rates. The submersible pumps will be manifolded to PVC pipe and the recovered groundwater will be pumped to the treatment compound. A flowmeter will be located at the treatment compound to measure total flow rate of the recovery system. As stated in the Revised RAW and above, the treatment system will be designed after installation and testing of the groundwater recovery system and determination of the treatment requirements.

5.5 Engineering Controls

As discussed in Section 2.3.7, concentrations of beryllium exceeding the NJDEP's remediation criterion of 1.0 ppm have been detected in soil around boring B-47 in AEC-15. In accordance with Section 35.h(1) of N.J.A.C. 13:1K, Tenneco proposes to implement an engineering control by covering this portion of the site with asphalt. As indicated on Figure 20, an area measuring approximately 1,100 ft^2 will be covered. The inspection and up-keep of the asphalt cover will be incorporated into the routine operation and maintenance program for the soil and groundwater remediation systems.

5.6 Declaration of Environmental Use Restriction

Tenneco intends to apply a Declaration of Environmental Use Restriction (DER) to the entire Kalama facility, specific to the site related compounds of concern. The DER will be completed once active remediation as been completed.

SOVEREIGN CONSULTING INC.

Remedial Action Progress Report

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

12 June 2003

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APPENDICES

ATTACHMENTS (under separate cover)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this *Remedial Action Progress Report* (RAPR) for investigation and remediation activities conducted at the Kalama Chemical Inc. facility in Garfield, New Jersey (Figure 1). During a telephone conversation with Sovereign in January 2003, the New Jersey Department of Environmental Protection (NJDEP) requested that EPI reduce the number of submissions to the Department by attempting to combine the results of field activities and/or responses to NJDEP letters into each quarterly RAPR. Therefore, this RAPR contains the results of the following activities:

- Quarterly groundwater sampling conducted between 14 and 17 January 2003;
- Soil sampling conducted in September 2002 to investigate the possible presence of a "smear zone" beneath Hudson Street, Bloomingdale Avenue, and Cambridge Avenue;
- Soil sampling conducted in September 2002 to delineate the extent of the separate phase hydrocarbons (SPH) present in MW-9;
- Routine operation and maintenance of the existing remediation systems; and,
- A well search to obtain information on possible industrial, public, or domestic supply wells within a one-half mile radius of the site.

2.0 GROUNDWATER MONITORING PROGRAM

A groundwater monitoring program was originally proposed to the NJDEP in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan had not been approved by the NJDEP, a monitoring program was implemented in June 1997 to establish a base-line against which remediation progress could be compared. The monitoring program started in June 1997 has subsequently been modified to include additional compounds of concern.

The January 1995 groundwater sampling event identified three areas of the site requiring remediation and/or monitoring: 1) the Northeast Phenol Hot Spot (Former Building 10/36); 2) the Northwest Phenol Hot Spot (Former Building 33-B); and, 3) the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14). In addition, benzene, toluene, phenol, benzoic acid, methanol, and formaldehyde were identified as the six primary compounds of concern in groundwater, although the distribution of these compounds varied across the site. The Northeast and Northwest Phenol Hot Spot areas were subsequently combined, and are now collectively referred to as the Northern Phenol Area.

Based on the results of grab groundwater samples collected following the demolition of the Building 10/36 complex, salicylic acid (or 2-hydroxybenzoic acid) was added to the list of analytical parameters for the monitoring wells in the Northeast Phenol Hot Spot area. Based on the quarterly sampling results from June 1997 through October 1998, phenol and benzoic acid are no longer considered to be compounds of concern in the Toluene Spill Area and have been eliminated from the monitoring program for the wells addressing this AEC.

In response to comments in the NJDEP's letter dated 26 June 2000, 1,1'-biphenyl and diphenyl ether were added to the monitoring program for wells addressing the Toluene Spill Area during the July 2000 sampling event. In response to the NJDEP's letter dated 26 June 2000, a groundwater monitoring program for AEC-14 was submitted as part of the 3 August 2001 *Remedial Investigation Report Addendum* (RIRA). The NJDEP approved the monitoring program for AEC-14 in their letter dated 15 October 2001. A groundwater monitoring program for the Northeast and Northwest Phenol Hot Spot areas was included in Section 7.0 of the 1 May 2002 *Remedial Investigation Report Addendum No. 2* (RIRA-2). The NJDEP approved this monitoring program in their letter dated 30 July 2002.

On 9 August 2001, all of the remediation systems at the site were shut down in response to the NJDEP's 6 August 2001 letter. Due to low groundwater levels, EPI requested permission to re-start the soil vapor extraction (SVE) system in the southeast corner of the site in November 2001. The NJDEP verbally approved EPI's request, and the SVE system was re-started on 15 November 2001. The off-site SVE system and the vertical and horizontal components of the air curtain were re-started on 5 March 2002, following the construction of a new equipment compound to replace the one that had been located in Building 32-B[1].

2.1 Groundwater Quality Standards

The groundwater quality standards (GWQS) for the six original compounds of concern identified at the Kalama site are summarized below.

Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Benzene	1.0
Toluene	1,000
Phenol	4,000
Benzoic Acid	30,000
Methanol	50,000
Formaldehyde	100

The benzene, toluene, and phenol standards are from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The standards for benzoic acid, methanol, and formaldehyde are from the "Interim Specific & Generic Groundwater Quality Criteria" initially posted on the NJDEP's Bureau of Freshwater & Biological Monitoring (BF&BM) web page on 30 January 2002 (and last up-dated on 15 April 2003).

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[1] The Building 32/32-A/32-B complex had been demolished by Goodrich Corporation as part of their site restoration plans.

Groundwater at the site has been found to also contain salicylic acid, 1,1'-biphenyl, and diphenyl ether. However, since the NJDEP does not have any established groundwater quality standards for these compounds, a generic value of 100 parts per billion (ppb) would be applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believes the generic 100 ppb criterion is too conservative, since it does not incorporate toxicological data specific to each compound. Since none of these compounds of concern are volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the NJDEP's 100 ppb criterion is based, acceptable groundwater concentrations at the site should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request to establish alternate groundwater quality standards for methyl salicylate[2], salicylic acid, 1,1'-biphenyl, and diphenyl ether. In their letter dated 24 June 2002, the NJDEP responded to EPI's 17 April 2001 correspondence, and listed Interim Groundwater Standards for these compounds that had been posted on the NJDEP-BF&BM web page:

Interim Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Methyl Salicylate	4,000
Salicylic Acid	80.0
1,1'-Biphenyl	400
Diphenyl Ether	100

Give the disparity between the alternate groundwater standards proposed by EPI for salicylic acid and diphenyl ether (5,600 ppb and 21,000 ppb, respectively), and the Interim Groundwater Quality Standards (IGWQS) established by the NJDEP, EPI believes further discussions are required before these values are formally adopted for the Kalama Chemical site. However, for comparison purposes, the results of

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[2] Although methyl salicylate (oil of wintergreen) had not previously been detected in groundwater, an alternate standard had been requested since this compound had been detected in the soil of AEC-30 at concentrations requiring remediation (i.e., excavation and off-site disposal).

the January 2003 groundwater sampling event have been evaluated using both sets of groundwater quality standards.

2.2 Groundwater Sampling Procedures

A total of 60 monitoring wells were able to be sampled between 14 and 17 January 2003. In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". However, in accordance with the NJDEP's letter dated 6 August 2001, and as discussed during the 6 December 2001 conference call, wells that exhibit poor recharge or excessive drawdown were purged and sampled using Low Flow methodology.

2.2.1 *Standard Purging & Sampling Methodology*

Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of light non-aqueous phase liquids (LNAPLs) and DNAPLs using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rates did not exceed approximately two gallons per minute (gpm). In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

Before Purging

- Date, time, and weather conditions
- Well number
- Head space reading immediately after well cap is removed
- Product thickness, if any

- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

Well purging information for the January 2003 sampling event is summarized on the tables included in Appendix A.

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for VOC analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling. At the end of each day, the samples for benzene, toluene, phenol, salicylic acid, methyl salicylate, 1,1'-biphenyl, diphenyl ether, and methanol were either delivered to the analytical laboratory (Accutest) or returned to the office where they were picked up by an Accutest courier the following morning. The formaldehyde samples were shipped via overnight courier to Severn Trent Laboratories (STL) in Tallahassee, Florida. Copies of the analytical data packages for the January 2003 groundwater samples (including the electronic data disk deliverables) are included under separate cover as Attachment I.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

2.2.2 *Low Flow Purging & Sampling Methodology*

As discussed above, the NJDEP has approved the use of low flow purging and sampling for collecting samples from wells that exhibit poor recharge or excessive drawdown during purging. After reviewing the historical well purging data, EPI has identified the following 14 wells on which the low flow methodology is to be used:

Wells Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-1	Poor Recharge
MW-4	Poor Recharge
MW-22	Very Poor Recharge
MW-25	Very Poor Recharge
MW-28D	Excessive Drawdown (>10 feet)
MW-31	Very Poor Recharge
MW-32D	Excessive Drawdown (>10 feet)
MW-40	Poor Recharge
MW-47D	Poor Recharge
MW-47D2	Excessive Drawdown (>10 feet)
MW-48D	Excessive Drawdown (>10 feet)

Wells Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-51D	Excessive Drawdown (>10 feet)
MW-53D	Poor Recharge
MW-57D	Excessive Drawdown (>10 feet)

The low flow purging and sampling procedures used were taken from the USEPA Region II's *Groundwater Sampling Procedure - Low Stress (Low Flow) Purging and Sampling* document that was provided by the NJDEP following the 6 December 2001 conference call. A description of the methodology used and the completed data forms for each well are included in Appendix B.

3.0 GROUNDWATER SAMPLING RESULTS

Groundwater samples were collected from 60 wells between 14 and 17 January 2003. Monitoring well MW-9 was not sampled due to the presence of LNAPL. None of the monitoring wells gauged during the January 2003 monitoring event contained detectable amounts of DNAPL. Monitoring well MW-1 contained excessive amounts of sediment (due to the operation of the air curtain) and could not be purged by either low flow or standard techniques. Therefore, a sample was not collected from this well. Although MW-3D was gauged, samples from this monitoring well were accidently not collected during this monitoring event. As indicated in Section 1.0, the SVE system in the Toluene Spill Area, the off-site SVE system, and the vertical and horizontal components of the air curtain were in operation during this sampling event.

As stated in EPI's letter to the NJDEP dated 18 July 2002, the Northeast and Northwest Phenol Hot Spot Areas have been combined. Starting with the 4 September 2002 RAPR, these two areas are now referred to as the Northern Phenol Area. The monitoring program and sampling results for the two source areas are discussed separately, below.

3.1 Groundwater Elevations

Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 1 and were used to prepare the groundwater elevation contour maps shown on Figure 2 and Figure 3. MW-9 contained 0.86 feet of SPH during this monitoring event.

Figure 2 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. As indicated in Section 1.0, the air sparging system in the southeast corner of the site was shut down, but the vertical and horizontal injection wells of the air curtain in the southwest corner of the site were in operation at the time of sampling. Consistent with historical site conditions, a water table mound was present in the northeast corner of the site. A smaller water table mound was also observed around MW-4 and MW-17 in the southeast corner of the site. A slight water table mound was observed around upgradient, off-site well MW-34. This feature is considered to be anomalous, since a mound has never been detected in this well before.

Groundwater elevation contours for the deep overburden zone are shown on Figure 3. Although a slight mound was present in up-gradient, off-site well MW-34D, the direction of groundwater flow in the deep overburden zone continues to be to the west. This mound has never been detected in this or any other deep overburden zone well at the site, and is considered to be anomalous.

3.2 Northern Phenol Area

Although at one time the Northeast and Northwest Phenol Hot Spots appeared to be distinct areas, current groundwater sampling results suggest that they completely overlap and cannot be differentiated. Therefore, both areas are now referred to as the combined Northern Phenol Area.

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-21D, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, MW-62, WP-1R

Each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015 - Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315. In addition, the groundwater samples from MW-21D and MW-51D were also analyzed for methyl salicylate by USEPA Method 8270. The results of these analyses are summarized on Table 2 and are presented on Figure 4 (shallow overburden zone) and Figure 5 (deep overburden zone). Concentration vs. Time graphs summarizing historical data for each well are included in Appendix C.

3.2.1 *Shallow Overburden Zone*

The shallow overburden zone wells within the source area include WP-2R and MW-58. As shown on Figure 4, phenol was detected at 41,100 ppb in WP-2R and at 1,930 ppb in MW-58. Salicylic acid was detected at 22,900 ppb and 1,480 ppb in WP-2R and MW-58, respectively. WP-2R also contained 2,010 ppb of methanol; no detectable concentrations of formaldehyde were found in these two wells. The concentrations of phenol, salicylic acid, formaldehyde, and methanol were either not detectable or below their respective GWQS or IGWQS in monitoring points MW-21, MW-51, MW-59, MW-62, and WP-1R.

Vertical delineation well WP-2D contained 14.5 ppb of phenol, but no detectable concentrations of salicylic acid, methanol or formaldehyde.

3.2.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-51D, MW-55D, ORC-4D, and WP-3R (Figure 5). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (184,000 ppb), MW-48D (189,000 ppb), MW-50D (12,200 ppb), MW-51D (13,100 ppb), MW-55D (41,000 ppb), and ORC-4D (95,300 ppb). MW-47D was the only well that contained methanol at a concentration (477,000 ppb) exceeding its IGWQS of 50,000 ppb. This is the lowest methanol concentration ever detected in MW-47D, and represents the seventh consecutive quarter that concentrations of this compound have decreased in this well. Salicylic acid was detected in three source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in seven of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (88.2 ppb), MW-47D (583,000 ppb), MW-48D (563,000 ppb), MW-50D (1,460 ppb), MW-51D (5,280 ppb), MW-55D (1,070 ppb), and ORC-4D (258,000 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb only in MW-47D (450 ppb). Methyl salicylate was detected in MW-51D at a concentration of 2.3 ppb, well below its IGWQS of 4,000 ppb. The methyl salicylate concentration in MW-51D confirms the results from this well in October 2002 (59.9 ppb), and suggests that the methyl salicylate in soil is not impacting groundwater quality. The high concentration of methyl salicylate seen in the July 2002 groundwater sample from temporary well point TWP-2 was probably caused by globules of product in the sample. In order to confirm that the low concentrations of methyl salicylate are not due to problems related to the analytical method, matrix spike and matric spike duplicate samples will be collected from MW-51D during the April 2003 and July 2003 monitoring events.

The concentrations of the phenol, salicylic acid, methyl salicylate, methanol and formaldehyde were either not detectable or below their respective GWQS or IGWQS in all of the monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-21D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-57D, MW-58D, and MW-59D) except MW-2DR, which contained 113 ppb of salicylic acid. Vertical delineation well MW-47D2 contained no detectable concentrations of phenol, salicylic acid, formaldehyde or methanol during this sampling event.

Item 1 of the NJDEP's 15 January 2003 letter required that a vertical delineation well be installed adjacent to MW-57D due to the elevated concentrations of phenol and salicylic acid that had been detected in this well. In Section 5.0 of the 26 February 2003 RAPR, EPI responded that this deeper well was not required since the concentrations of phenol and salicylic acid had been decreasing over the last two sampling events. As indicated above, no detectable concentrations of phenol or salicylic acid were found in MW-57D during the January 2003 sampling event, further supporting EPI's belief that a vertical delineation well is not required at this location.

3.3 Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14)

In order to monitor the effectiveness of the AS/SVE, air curtain, and the off-site SVE systems, groundwater samples were to be collected from 34 wells. As per the NJDEP's letters dated 15 October 2001 and 20 June 2002, the monitoring wells addressing this AEC have been re-characterized as "source area", "fringe", "sentinel", or "background" wells as follows:

<u>Source Area Wells</u>: MW-4, MW-5, MW-D5, MW-E5, MW-9, MW-17, MW-33, MW-45, and OW-3

Fringe Wells:	MW-1, MW-10, MW-11, MW-14R, MW-23, MW-25, MW-31, MW-36, MW-40, MW-41, MW-42, MW-46, MW-56, OW-1, OW-2, OW-4, and OW-5
Sentinel Wells:	MW-6, MW-22, MW-30, MW-37, MW-38, and MW-61
Background Well:	MW-16 and MW-60

As indicated at the start of this Section, MW-1 contained excessive amounts of sediment and could not be purged, and MW-9 contained 0.86 feet of LNAPL; neither of these wells were sampled during this monitoring event. The groundwater samples collected from the remaining wells addressing this area of environmental concern were analyzed for benzene and toluene by USEPA Method 624, and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. The analytical results for these samples are summarized on Table 3 and are presented on Figure 6. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix D.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in nine of the 32 wells sampled. In the source area wells, benzene was detected in five of the eight wells sampled, including MW-D5 (74.5 ppb), MW-17 (38.0 ppb), MW-33 (1,000 ppb), MW-45 (15.9 ppb), and OW-3 (3.4 ppb). The benzene concentration in MW-D5 is the lowest ever detected in this well. In the fringe area wells, benzene was detected at concentrations exceeding the GWQS of 1.0 ppb in four of the 16 wells sampled, including MW-23 (1.1 ppb), MW-25 (1.1 ppb), MW-36 (198 ppb), and OW-1 (1.7 ppb). Benzene was either not detected or present at a concentration below its GWQS in all six sentinel and two background monitoring wells.

Benzene concentrations decreased in MW-4, MW-D5, MW-14R, MW-33, MW-40, and MW-45 from 2.06 ppb (MW-4) to 1,460 ppb (MW-33), relative to the October 2002 sampling event. Benzene concentrations only increased significantly in MW-17 (34.7 ppb) and MW-36 (170 ppb) relative to October 2002. No detectable concentrations of benzene were found in MW-40 for the first time since the well was first sampled in June 1997. Additionally, benzene concentrations were below the GWQS of 1.0 ppb in MW-4, MW-5, MW-E5, MW-6, MW-10, MW-11, MW-14R, MW-16, MW-22, MW-30, MW-31, MW-37, MW-38, MW-40, MW-41, MW-42, MW-46, MW-56, MW-60, MW-61, OW-2, OW-4, and OW-5.

Table 4 presents a comparison of the January 2003 benzene concentrations to i) the maximum concentration ever detected in a well; ii) the last four quarters of data for each well before the remediation systems were shut down in August 2001; iii) the October 2001 groundwater results (no remediation systems running); and, iv) the April, July, and October 2002 groundwater results (the air curtain, the on-site SVE system, and the off-site SVE system in operation). The summary on Table 4 shows that even with the spike in concentration in MW-36, there has been an average reduction of 82.6% in the levels of benzene in the monitoring wells that address the Toluene Spill Area of the site (excluding MW-E5 and MW-46 which have never contained more than 1.0 ppb of benzene). If the data from MW-36 is excluded, the average reduction in benzene concentrations increases to 96.6%.

Toluene was detected at concentrations above the GWQS of 1,000 ppb in only two of the 32 wells sampled. In the source area, toluene exceeded the GWQS in two of the eight wells sampled, including MW-D5 (8,510 ppb) and MW-33 (100,000 ppb). These are the lowest toluene concentrations ever detected in these wells. Toluene concentrations were below the GWQS of 1,000 ppb in all of the fringe area, sentinel, and background wells during the January 2003 sampling event.

Table 5 shows that as of January 2003, the number of wells that contain over 1,000 ppb of toluene has been reduced from 22 to two, and that there has been an average reduction in toluene concentrations of 99.3% in the wells addressing the Toluene Spill Area (excluding those wells that have never contained toluene at a concentration exceeding the GWQS of 1,000 ppb).

1,1'-Biphenyl concentrations did not exceed the NJDEP's proposed IGWQS of 400 ppb in any of the source area, fringe, sentinel, or background wells. Diphenyl ether was detected at concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb, but below EPI's proposed alternate GWQS of 21,000 ppb, in seven of the 32 wells sampled, including MW-4 (181 ppb), MW-14R (629 ppb), MW-17 (595 ppb), MW-23 (140 ppb), MW-33 (703 ppb), MW-36 (101 ppb), and OW-3 (155 ppb).

3.4 Distribution of Compounds of Concern

The distributions of toluene and benzene in the shallow overburden zone using the January 2003 groundwater sampling results are shown on Figure 7 and Figure 8, respectively. The highest concentrations of toluene (greater than 10,000 ppb) are limited to the area around MW-D5 and MW-33. No concentrations over 100,000 ppb were detected during this monitoring event. Concentrations of toluene exceeding the GWQS of 1,000 ppb are also limited to the southeast corner of the site. As shown on Table 6, the areal extent of the portions of the toluene plume in January 2003 that contained greater than 100,000 ppb, 10,000 ppb and 1,000 ppb decreased to 0 ft^2, 921 ft^2, and 5,346 ft^2, respectively (relative to October/November 2002). The areal extent of the toluene plume in January 2003 is the smallest observed since the baseline groundwater sampling event in June 1997. The overall size of the toluene plume (as defined by the 1,000 ppb isoconcentration line) has been reduced by approximately 96%, while the size of the source area (i.e., greater than 100,000 ppb) has been reduced 100%.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 100 ppb) being found around MW-D5 and MW-33. Benzene concentrations exceeding 100 ppb were also found in MW-36. Benzene concentrations exceeding 1.0 ppb were found in the south-central (MW-25, OW-1) portion of the site, and to the southwest of the site in MW-23 (1.1 ppb). As shown on Table 7, the portions of the benzene plume in January 2003 that contained greater than 1,000 ppb and 100 ppb decreased in areal extent to approximately 0 ft^2 and 3,767 ft^2, respectively, while the 10.0 ppb and 1.0 ppb portions of the plume increased in size to 45,040 ft^2 and 181,508 ft^2, respectively. The areal extent of the source area for the benzene plume in January 2003 is the smallest observed since the baseline groundwater sampling event in June 1997. Although the overall size of the benzene plume (as defined by the 1.0 ppb isoconcentration line) increased relative to October/November 2002, it is still slightly less than in July 2002, and is still 60% smaller than the June 1997 baseline conditions.

The distributions of 1,1'-biphenyl and diphenyl ether in the shallow overburden zone are shown on Figures 9 and 10, respectively. Concentrations of 1,1'-biphenyl did not exceed the NJDEP's proposed IGWQS of 400 ppb in any wells during this monitoring event. Diphenyl ether concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb were found in the southeast (MW-4, MW-17, MW-33, MW-45, OW-3), and southwest (MW-14R, MW-23, MW-36) portions of the site.

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 11 and 12, respectively. The area with the highest concentration of phenol in the shallow overburden zone is limited to beneath former Building 33-B (41,100 ppb in WP-2R). The area containing salicylic acid at concentrations exceeding the NJDEP's proposed IGWQS of 80.0 ppb encompasses WP-2R (22,900 ppb) and MW-58 (1,480 ppb).

The concentrations of formaldehyde and methanol in the shallow overburden zone did not exceed their respective IGWQS' of 100 ppb and 50,000 ppb during the January 2003 sampling event.

The distribution of phenol in the deep overburden zone is depicted on Figure 13. Phenol concentrations over 100,000 ppb were found around MW-47D and MW-48D, with concentrations exceeding 10,000 ppb also encompassing MW-50D, MW-51D, MW-55D, and ORC-4D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-28D, MW-49D, MW-52D, MW-53D, MW-54D, MW-58D, and MW-59D.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 14. The areal extent of salicylic acid in the deep overburden zone is larger than that of phenol, with the highest concentrations (exceeding 100,000 ppb) being found in ORC-4D, MW-47D, and MW-48D. The area of the salicylic acid plume as defined by the NJDEP's proposed IGWQS of 80.0 ppb extends from the north-central (MW-2DR, MW-55D) to northwest corner of the site (MW-51D), and southward to MW-53D and MW-54D.

As shown on Figure 15, formaldehyde concentrations exceeding the GWQS of 100 ppb in the deep overburden zone were limited to the area around MW-47D (450 ppb). The distribution of methanol in the deep overburden zone is shown on Figure 16. Methanol only exceeded the NJDEP's IGWQS of 50,000 ppb in MW-47D (477,000 ppb).

4.0 SMEAR ZONE INVESTIGATION

The following sections discuss the results of soil sampling activities conducted in Hudson Street, Bloomingdale Avenue, and Cambridge Avenue. This sampling was conducted to comply with the NJDEP's 26 June 2000 letter, which required EPI to perform an investigation into the presence of a possible "smear zone" that may exist beneath Hudson Street and Bloomingdale Avenue. The NJDEP required that the presence or absence of this "smear zone" be confirmed and actively remediated, if necessary.

4.1 Scope of Work

The following scope of work was originally proposed to the NJDEP in Section 5.2 of the 3 August 2001 *Remedial Investigation Report Addendum* (RIRA). Following receipt of the NJDEP's comments in their letter dated 15 October 2001, and following the 6 December 2001 conference call between EPI, Sovereign, and the NJDEP, the original scope of work was expanded to include additional soil samples around MW-33 and in Cambridge Avenue. EPI proposed to investigate the possible presence of a smear zone beneath Hudson Street and Bloomingdale Avenue by collecting soil samples adjacent to monitoring wells that had previously contained SPH, or that had recently exhibited changes in dissolved concentrations that mirrored fluctuations in the water table (i.e., concentrations increased when the water table rose and decreased when the water table fell). Final approval of the proposed sampling program was included in the NJDEP's letter dated 20 June 2002. Approval from the City of Garfield to install the required soil borings in Hudson Street, Bloomingdale Avenue, and Cambridge Avenue was received on 31 July 2002.

As shown on Figure 17, a total of 15 soil borings (SZ-1 through SZ-15) were installed in Hudson Street, Bloomingdale Avenue, and Cambridge Avenue. Soil borings were located adjacent to monitoring wells MW-23, MW-33, MW-40, MW-41, and OW-3 in Hudson Street, adjacent to MW-25, MW-42, OW-1, and OW-2 in Bloomingdale Avenue, and adjacent to MW-46 in Cambridge Avenue. An additional soil boring was located near passive magnetic resonance anomaly mapping (PMRAM) vertical profile PS#5 to close the gap between MW-23 and MW-40. As per the NJDEP's requirements, soil borings were also located adjacent to on-site wells MW-D5 (SZ-16) and MW-9 (SZ-17). As summarized on the following Table, the investigation intervals at each monitoring well location were based on historical water table fluctuations that had been observed in each well.

Depth to Water Summary and Investigation Intervals				
Well ID / Sample Location	Shallowest Historical DTW (feet)	Deepest Historical DTW (feet)	DTW on Day of Sampling (feet)	Investigation Interval (feet)
MW-D5	4.54	8.74	8.21	3.5 - 11.0
MW-9	3.30	10.47	Not Recorded	2.0 - 12.5
MW-23	6.21	9.25	8.41	5.0 - 11.0
MW-25	8.81	13.34	12.68	7.5 - 15.5
MW-33	15.28	19.32	18.66	14.0 - 21.0
MW-40	10.98	14.68	14.14	10.0 - 16.0
MW-41	10.70	16.88	15.80	9.5 - 19.0
MW-42	11.56	14.17	13.40	10.5 - 16.0
MW-45	17.22	19.72	19.02	16.0 - 22.0
MW-46	19.38	21.91	21.09	18.0 - 24.0
OW-1	13.26	15.18	14.68	12.0 - 17.0
OW-2	9.08	14.27	13.81	8.0 - 16.0
OW-3	15.32	18.00	17.00	14.0 - 20.0
PS#5				12.0 - 19.0*

Notes:
DTW = Depth to water from ground surface.
* = Based on intervals identified in PMRAM survey.
Depth intervals are in feet below grade.

In addition, soil borings were also located midway between MW-33 and OW-3 in Hudson Street (SZ-10), and on the northwest (SZ-13) and southwest (SZ-14) corners of the intersection of Hudson Street and Cambridge Avenue (to the east and southeast of MW-33, respectively). In order to delineate the horizontal extent of the SPH in MW-9, five soil borings (SZ-18 through SZ-22) were installed to the

the interval exhibiting the highest field screening results or obvious signs of staining. If the interval to be analyzed was the same as the one that was used to screen for SPH, a duplicate sample (not the soil which was screened in the field) was retained for laboratory analysis. Soil samples for VOC analyses were collected from undisturbed soil following the NJDEP's Methanol Preservation Procedures.

Soil samples were placed directly into laboratory-provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. Each sample was analyzed for total petroleum hydrocarbons (TPH) by USEPA Method 418.1, volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260), and base neutral acid extractable compounds (including calibrations for 1,1'-biphenyl and diphenyl ether) plus an NBS library search (BNA+25; USEPA Method 8270). In order to collect data required for calculating the Classification Exception Area (CEA), the soil samples collected from below the water table were also analyzed for total organic carbon. At the end of the day, the samples were returned to Sovereign's office, where they were picked up the following day by a courier and delivered to Accutest in Dayton, New Jersey (Certification No. 12129) for analysis. For QA/QC purposes, one trip blank sample was also submitted for each day of sampling and analyzed for VOC+10.

Copies of the analytical data packages (along with the Electronic Data Deliverables diskette) for all of the soil samples collected as part of this investigation are included under separate cover as Attachment II.

5.0 SMEAR ZONE INVESTIGATION RESULTS

The results of the investigations conducted to the south of the site (i.e., Hudson Street, Bloomingdale Avenue, and Cambridge Avenue) and around on-site monitoring well MW-9 are discussed separately, below.

5.1 Smear Zone Investigation

As shown on Figure 17, 15 soil borings (SZ-1 through SZ-15) were installed in either Hudson Street, Bloomingdale Avenue, or Cambridge Avenue, and two borings (SZ-16 & SZ-17) were installed on-site as part of the smear zone investigation. Due to the rainy weather conditions all day on 16 September 2002, and part of the day on 17 September 2002, the soil from borings SZ-1 through SZ-9, SZ-12, and SZ-15 could not be screened for VOCs using the PID.

5.1.1 *Soil Lithologies & Field Screening Results*

Soil boring SZ-1 was installed adjacent to monitoring well MW-23, located at the west end of Hudson Street. A clayey sand was encountered from 1.0 - 2.5 feet below grade, followed by 1.5 feet of poorly graded sand with clay. Well graded sand was encountered from 4.0 feet below grade to the completion depth of the boring at 11.0 feet. Groundwater in MW-23 was measured at 8.41 feet below grade on the day of sampling. Since field screening did not indicate the presence of soil contamination above the water table, sample SZ-1A was collected from 7.0 - 7.5 feet below grade. Soil sample SZ-1B was collected at 10.5 - 11.0 feet below grade, from an interval that exhibited a chemical odor; the shake tests and paint filter tests on soil from this interval were negative.

In boring SZ-2 (80.0 feet to the east of MW-23 at the location of PMRAM vertical profile PS#5), the soil consisted of a clayey sand to 3.5 feet below grade, followed by a lean clay to 6.5 feet below grade. A well graded sand was encountered from 6.5 to 12.0 feet below grade, with saturated soil conditions being found at 12.0 feet. A clayey sand with gravel was found at 12.0 - 14.0 feet, followed by 2.0 feet of well graded sand with gravel, and then 3.0 feet of lean clay to the completion depth of 19.0 feet below grade. No signs of contamination were observed in the unsaturated zone soils, so sample SZ-2A was collected from 9.5 - 10.0 feet. Sample SZ-2B was collected from an interval of stained soil at 15.5 - 16.0 feet below grade; the results of the paint filter and shake tests on the soil from this interval were negative.

Boring SZ-3 was located adjacent to monitoring well MW-40, and had a completion depth of 16.0 feet below grade. Groundwater was measured at 14.14 feet below grade in MW-40 at the time of sampling. The soil at this location consisted of silty sand to a depth of 8.0 feet below grade, followed by sandy lean clay to 14.0 feet below grade. The remainder of the boring consisted of lean clay from 14.0 - 15.0 feet, and clayey sand from 15.0 - 16.0 feet. No signs of contamination were observed in the unsaturated zone soils, so sample SZ-3A was collected from 13.0 - 13.5 feet. Sample SZ-3B was collected from an interval of stained soil at 15.5 - 16.0 feet below grade; the results of the paint filter and shake tests on the soil from this interval were negative.

Soil boring SZ-4 was installed adjacent to monitoring well OW-2 near the corner of Hudson Street and Bloomingdale Avenue. Clayey sand was encountered from 1.0 - 4.0 feet below grade, followed by 8.0 feet of clayey gravel. Sandy lean clay was encountered from 12.0 feet below grade to the completion depth of the boring at 16.0 feet. Groundwater in OW-2 was measured at 13.81 feet below grade on the day of sampling. Since field screening did not indicate the presence of soil contamination above the water table, sample SZ-4A was collected from 12.5 - 13.0 feet below grade. Soil sample SZ-4B was collected at 15.0 - 15.5 feet below grade from an interval that exhibited a chemical odor; the shake tests and paint filter tests on soil from this interval were negative.

Boring SZ-5 was installed adjacent to monitoring well MW-25, approximately 30.0 feet to the south of SZ-4, and also had a completion depth of 16.0 feet below grade. Groundwater in MW-25 was measured at 12.68 feet below grade at the time of sampling. The soil at this location consisted of clayey sand from 1.0 - 8.0 feet below grade, underlain by clayey sand with gravel to 14.0 feet below grade. From 14.0 to 16.0 feet below grade, the soil consisted of sandy lean clay. No signs of contamination were observed in the unsaturated zone soils, so sample SZ-5A was collected from 11.5 - 12.0 feet. Sample SZ-5B was collected from an interval of stained soil at 15.0 - 15.5 feet below grade; the results of the paint filter and shake tests on the soil from this interval were negative.

Soil boring SZ-6 had a total depth of 20.0 feet, and was installed adjacent to monitoring well OW-1 in Bloomingdale Avenue. A silty sand was encountered from 1.0 - 8.0 feet below grade, underlain by 4.0 feet of silty sand with gravel. Lean clay was encountered from 12.0 - 16.0 feet below grade, followed by poorly graded sand to the completion depth of the boring at 20.0 feet. Groundwater in OW-1 was measured at 14.68 feet below grade on the day of sampling. Since field screening did not indicate the presence of soil contamination above the water table, sample SZ-6A was collected from 13.5 - 14.0 feet below grade. Soil sample SZ-6B was collected at 15.5 - 16.0 feet below grade, from an interval below the water table that exhibited a chemical odor; the shake tests and paint filter tests on soil from this interval were negative. A second interval of soil exhibiting an odor was encountered from 16.0 - 17.0 feet below. A sample for laboratory analysis was not collected from this interval, but the paint filter and shake tests performed in the field were negative.

Boring SZ-7 was located adjacent to monitoring well MW-42 in Bloomingdale Avenue, and had a completion depth of 16.0 feet below grade. Groundwater was measured at 13.40 feet below grade in MW-42 at the time of sampling. The soil at this location consisted of clayey sand from 1.0 - 6.5 feet below grade, followed by lean clay from 6.5 - 8.0 feet below grade. Clayey gravel was encountered from 8.0 - 12.0 feet, followed by lean clay from 12.0 - 15.5 feet. Poorly graded sand was present in the bottom 0.5 feet of the boring. No signs of contamination were observed in the unsaturated zone soils, so sample SZ-7A was collected from 12.0 - 12.5 feet. Sample SZ-7B was collected at 15.5 - 16.0 feet below grade, from an interval soil exhibiting an odor; the results of the paint filter and shake tests on the soil from this interval were negative.

Soil boring SZ-8 was installed adjacent to monitoring well MW-41, just to the east of the corner of Hudson Street and Bloomingdale Avenue. Clayey sand was encountered from 1.0 - 8.0 feet below grade, followed by an additional 2.5 feet of clayey sand with gravel. Lean clay was encountered from 10.5 - 12.0 feet below grade, followed by clayey sand from 12.0 - 16.0 feet, and then sandy lean clay from 16.0 feet to the completion depth of the boring at 19.0 feet below grade. Groundwater in MW-41 was measured at 15.80 feet below grade on the day of sampling. Since field screening did not indicate the presence of soil contamination above the water table, sample SZ-8A was collected from 14.5 - 15.0 feet below grade. Soil sample SZ-8B was collected at 18.0 - 18.5 feet below grade, from an interval that exhibited a slight odor; the shake tests and paint filter tests on soil from this interval were negative.

Boring SZ-9 was located adjacent to monitoring well OW-3 in Hudson Street, and had a completion depth of 20.0 feet below grade. Groundwater was measured at 17.00 feet below grade in OW-3 at the time of sampling. The soil at this location consisted of clayey sand from 1.0 - 12.0 feet below grade, followed by lean clay from 12.0 - 16.0 feet below grade. The remainder of the boring consisted of poorly graded sand with sandstone fragments from 16.0 - 20.0 feet. No signs of contamination were observed in either the unsaturated or saturated zone soils, so sample SZ-9A was collected from 15.5 - 16.0 feet, while sample SZ-9B was collected from the bottom of the boring (19.5 - 20.0 feet below grade).

Boring SZ-10 was installed 30.0 feet east of SZ-9 in Hudson Street, approximately mid-way between monitoring wells OW-3 and MW-33. SZ-10 had a total depth of 20 feet, and saturated soil conditions were observed at 18.0 feet below grade. The soil at this location consisted of clayey fine sand from 1.0 - 8.0 feet below grade, underlain by poorly graded sand with clay to the completion depth of the boring at 20.0 feet below grade. No signs of contamination were observed in either the unsaturated or saturated zone soils, so sample SZ-10A was collected from 16.5 - 17.0 feet, while sample SZ-10B was collected from 19.0 - 19.5 feet below grade.

Boring SZ-11 was installed adjacent to monitoring well MW-33 in Hudson Street, and had a completion depth of 22.0 feet below grade. Groundwater was measured at 18.66 feet below grade in MW-33 at the time of sampling. The soil at this location consisted of poorly graded sand from 1.0 - 22.0 feet below grade. No signs of contamination were observed in either the unsaturated or saturated zone soils, so sample SZ-11A was collected from 17.0 - 17.5 feet, while sample SZ-11B was collected from 20.5 - 21.0 feet below grade.

Soil boring SZ-12 was installed adjacent to monitoring well MW-45, on the south side of Hudson Street and across from SZ-11 and MW-33. Groundwater was measured at 19.02 feet below grade in MW-45 at the time of sampling. The soil at this location consisted of poorly graded sand with cobbles from 1.0 - 20.0 feet below grade (the completion depth of the boring). Geoprobe refusal was encountered at 20.0 feet below grade. No signs of contamination were observed in either the unsaturated or saturated zone soils, so sample SZ-12A was collected from 17.5 - 18.0 feet, while sample SZ-12B was collected from the bottom of the boring (19.5 - 20.0 feet below grade).

Soil boring SZ-13 was installed 40.0 feet to the east of SZ-11, at the northwest corner of Hudson Street and Cambridge Avenue. Clayey sand was encountered from the surface to 4.0 feet below grade, followed by 8.0 feet of silty sand. Silty sand with pebbles and sandstone fragments was encountered from 12.0 feet below grade to the completion depth of the boring at 22.0 feet. Saturated soil conditions were encountered at approximately 19.0 feet below grade in this soil boring. Since field screening did not indicate the presence of soil contamination either above or below the water table, sample SZ-13A was collected from 17.0 - 17.5 feet below grade, while sample SZ-13B was collected at 20.0 - 20.5 feet below grade.

Soil boring SZ-14 was installed 32.0 feet east of SZ-12, at the southwest corner of Hudson Street and Cambridge Avenue. Sandstone fragments and cobbles with clay and sand were encountered from 1.0 - 12.0 feet below grade, followed by 8.0 feet of clayey sand to the completion depth of the boring at 20.0 feet. Geoprobe refusal was encountered at 20.0 feet below grade. Saturated soil conditions were encountered at approximately 19.0 feet below grade in this soil boring. Since field screening did not indicate the presence of soil contamination either above or below the water table, sample SZ-14A was collected from 17.5 - 18.0 feet below grade, while sample SZ-14B was collected at 19.5 - 20.0 feet below grade.

Boring SZ-15 was located adjacent to monitoring well MW-46 in Cambridge Avenue, and had a completion depth of 23.0 feet below grade. Groundwater was measured at 21.09 feet below grade in MW-46 at the time of sampling. The soil at this location consisted of poorly graded sand with clay from 1.0 - 23.0 feet below grade. No signs of contamination were observed in the unsaturated or saturated zone soils, so sample SZ-15A was collected from 19.5 - 20.0 feet below grade, and sample SZ-15B was collected from 22.0 - 22.5 feet.

Soil boring SZ-16 was installed adjacent to monitoring well MW-D5 in the southeast corner of the site. Fill material comprised of fine sand was encountered from 1.0 - 4.0 feet below grade, followed by 2.5 feet of lean clay. The remainder of the boring (to the completion depth of 11.0 feet below grade) was comprised of silty sand. Groundwater in MW-D5 was measured at 8.21 feet below grade on the day of sampling. Odors and staining were observed from 8.0 - 11.0 feet below grade. The paint filter and shake tests conducted on soil from 8.0 feet and 9.0 feet were negative, but a sheen was observed following tests on soil from 10.0 feet and 11.0 feet. Since field screening did not indicate the presence of soil contamination above the water table, sample SZ-16A was collected from 7.0 - 7.5 feet below grade. Soil sample SZ-16B was collected at 10.25 - 10.75 feet below grade, from an interval that exhibited a sheen following the shake test.

5.1.2 *Soil Sampling Results*

The analytical results for the soil samples collected from borings SZ-1 through SZ-16 are summarized on Table 10 are presented on Figure 18. The concentrations of TPH, VOCs, and BNAs were below all of the most restrictive, applicable remediation criteria in every soil sample except SZ-4B and SZ-16B. Sample SZ-4B (collected from 15.0 - 15.5 feet below grade adjacent to off-site monitoring well OW-2) contained 848 parts per million (ppm) of toluene, which exceeds its Impact to Groundwater Cleanup Criterion (IGWCC) of 500 ppm. Sample SZ-16B (collected from 10.25 - 10.75 feet below grade adjacent to on-site well MW-D5) contained 184 ppm of 1,1'-biphenyl and 96.9 ppm of diphenyl ether; the NJDEP approved, site specific IGWCC for these compounds are 12.0 ppm and 19.0 ppm, respectively.

5.2 SPH Delineation Around MW-9

A total of six soil borings were installed around MW-9 as part of this investigation (see Figure 17). Boring SZ-17 was installed adjacent to MW-9 as part of the smear zone investigation. Borings SZ-18 through SZ-22 were installed around MW-9 for the purposes of delineating the SPH present in this well.

5.2.1 *Soil Lithologies & Field Screening Results*

Boring SZ-17 was located adjacent to monitoring well MW-9, and had a completion depth of 12.5 feet below grade. The depth to groundwater was not measured in MW-9, but saturated soil conditions were observed in boring SZ-17 at 8.0 feet below grade at the time of sampling. The soil at this location consisted of fill material (comprised of gravel, brick fragments, poorly sorted sand, and clay) to 4.0 feet below grade, followed by lean clay with sand to the completion depth of the boring. Staining was observed from 5.0 - 12.5 feet below grade, and free product was observed at 12.0 - 12.5 feet. A sheen was observed following the paint filter and shake tests on all the soil tested from 5.0 to 12.0 feet below grade. Field screening with a PID indicated VOC concentrations of 39.2 ppm to 155 ppm. Soil sample SZ-17A was collected from 7.0 - 7.5 feet below grade (the interval above the water table with the highest PID reading), while sample SZ-17B was collected from 12.0 - 12.5 feet below grade (the interval that exhibited free product).

Soil boring SZ-18 was installed 25.0 feet west of MW-9, at the approximate western edge of the former tank pit excavation. Fill material consisting of gravel, brick fragments, poorly sorted sand, and clay was present to 4.0 feet below grade, underlain by lean clay with sand to the completion depth of the boring at 12.5 feet. Saturated soil conditions were encountered at approximately 8.0 feet below grade in this soil boring. Paint filter and shake tests were conducted on soil from the 6.0 to 12.0 feet intervals, but all test results were negative. Field screening with a PID indicated VOC concentrations of 8.4 to 23.3 ppm. Since field screening did not indicate the presence of soil contamination either above or below the water table, sample SZ-18A was collected from 6.5 - 7.0 feet below grade (the interval with the highest PID reading above the water table), and sample SZ-18B was collected from 11.5 - 12.0 feet (the interval with the highest PID reading below the water table.

Soil boring SZ-19 had a total depth of 12.5 feet, and was installed 15.0 feet to the north of MW-9. Sandy lean clay was present to 7.0 feet below grade, followed by 5.5 feet of lean clay to the completion depth of the boring. Saturated soil conditions were encountered at 7.0 feet below grade during sampling. Stained soil was encountered from 6.0 - 8.0 feet below grade, but the results of the shake and paint filter tests on the soil from this interval were negative. Field screening using a PID indicated VOC concentrations of 0.1 to 6.8 ppm. Since field screening did not indicate the presence of soil contamination above or below the water table, sample SZ-19A was collected from 6.0 - 6.5 feet below grade, and sample SZ-19B was collected at 7.5 - 8.0 feet below grade.

Soil boring SZ-20 was installed an additional 15.0 feet to the north of SZ-19 (for a total of 30.0 feet from MW-9), and had a total depth of 12.5 feet. As in boring SZ-19, sandy lean clay was present to 7.0 feet below grade, followed by 5.5 feet of lean clay to the completion depth of the boring. Saturated soil conditions were encountered at 7.0 feet below grade during sampling. No stained soil was encountered at this location, although field screening using a PID indicated VOC concentrations of 0.6 to 6.3 ppm. Since field screening did not indicate the presence of soil contamination above or below the water table, sample SZ-20A was collected from 5.5 - 6.0 feet below grade, and sample SZ-20B was collected at 8.0 - 8.5 feet below grade. However, based on the analytical results for the samples from boring SZ-19 (see Section 5.2.2, below), the samples from SZ-20 did not need to be analyzed.

Soil boring SZ-21 was installed 15.0 feet east of MW-9, at the approximate eastern edge of the former tank pit excavation. Sandy lean clay was present to 7.0 feet below grade, underlain by lean clay to the completion depth of the boring at 12.5 feet. Saturated soil conditions were encountered at approximately 6.0 feet below grade in this soil boring. Paint filter and shake tests detected sheens from the soil from the 8.0 to 12.0 feet intervals. Field screening with a PID indicated VOC concentrations of 9.4 to 174 ppm. Sample SZ-21A was collected from 4.0 - 4.5 feet below grade (from the interval exhibiting the highest PID reading above the water table). Sample SZ-21B was collected from 12.0 - 12.5 feet (an interval exhibiting a sheen and the highest PID reading below the water table).

Soil boring SZ-22 was installed 15.0 feet to the south of MW-9, and had a total depth of 12.5 feet. A sandy lean clay was present to 7.0 feet below grade, followed by 5.5 feet of lean clay to the completion depth of the boring. Saturated soil conditions were encountered at 7.0 feet below grade during sampling. No stained soil was encountered at this location, although field screening using a PID indicated VOC concentrations of 27.5 to 9,054 ppm. Sample SZ-22A was collected from above the water table at 5.0 - 5.5 feet below grade, while sample SZ-22B was collected from 9.0 - 9.5 feet below grade (the interval exhibiting the highest PID reading).

5.2.2 *Soil Sampling Results*

The analytical results for the soil samples collected from borings SZ-17 through SZ-22 are summarized on Table 11 and are presented on Figure 19. TPH was detected in each sample except SZ-19B, at concentrations ranging from 37.0 ppm (SZ-19A) to 5,850 ppm (SZ-21A). The NJDEP's generic remediation criterion for TPH in soil is 10,000 ppm. Benzene was detected at concentrations exceeding its IGWCC of 1.0 ppm in SZ-22A (2.0 ppm; 5.0 - 5.5 feet below grade) and SZ-22B (5.15 ppm; 9.0 - 9.5 feet below grade). No other VOCs were detected in the soil samples around MW-9 at concentrations exceeding their respective remediation criteria.

The polynuclear aromatic hydrocarbons (PAHs) benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene were detected at concentrations above their Residential Direct Contact Cleanup Criteria (RDCCC) and/or Non-Residential Direct Contact Cleanup Criteria (NRDCCC) in samples from borings SZ-17, SZ-18, and SZ-21. Benzo(a)anthracene exceeded its RDCCC of 0.90 ppm in samples SZ-17A (0.93 ppm), SZ-17B (1.35 ppm), and SZ-18A (1.15 ppm). Benzo(a)pyrene was detected at concentrations above its RDCCC and NRDCCC of 0.66 ppm in SZ-17A (1.0 ppm), SZ-17B (1.26 ppm), SZ-18A (1.05 ppm), and SZ-21A (0.73 ppm). Samples SZ-17B and SZ-18A contained 1.10 ppm and 1.02 ppm, respectively, of benzo(b)fluoranthene, which exceeds its RDCCC of 0.90 ppm. Benzo(k)fluoranthene only exceeded its RDCCC of 0.90 ppm in sample SZ-17B (1.05 ppm).

1,1'-Biphenyl was detected at concentrations above its site specific IGWCC of 12.0 ppm in samples SZ-21A (421 ppm; 4.0 - 4.5 feet below grade), SZ-21B (306 ppm; 12.0 - 12.5 feet below grade), and SZ-22B (107 ppm). Diphenyl ether exceeded its site specific IGWCC of 19.0 ppm in samples SZ-17A (92.8 ppm; 7.0 - 7.5 feet below grade), SZ-17B (101 ppm; 12.0 - 12.5 feet below grade), SZ-18A (85.1 ppm; 6.5 - 7.0 feet below grade), SZ-21A (383 ppm), SZ-21B (193 ppm), SZ-22A (118 ppm), and SZ-22B (118 ppm).

5.3 Conclusions

The analytical results for the soil samples collected off-site indicate that a smear zone does not exist beneath Hudson Street, Bloomingdale Avenue, or Cambridge Avenue. As discussed in Section 7.0, below, EPI proposes to collect additional soil samples to complete the vertical and horizontal delineation of the toluene detected in sample SZ-4B (located off-site adjacent to monitoring well OW-2), and the 1,1'-biphenyl and diphenyl ether detected in sample SZ-16B (located on-site adjacent to monitoring well

MW-D5). EPI will evaluate the need for any enhancements to the existing remediation system once the delineation around SZ-4B and SZ-16B has been completed.

EPI believes the results of the soil samples collected from around MW-9 indicate that the extent of the SPH in this well has been successfully completed, and demonstrate that SPH has not migrated outside of the former tank pit excavation. EPI proposes to remediate the area around MW-9 through excavation and off-site disposal (see Section 7.0, below).

6.0 REMEDIAL ACTIONS

The following Sections discuss the performance of the AS/SVE, off-site SVE, and air curtain remediation systems for the period of January 2003 through April 2003. The SVE component of the AS/SVE system, the off-site SVE system, and the horizontal and vertical components of the air curtain were in operation during this reporting period. In their letter dated 30 July 2002, the NJDEP indicated that the performance evaluation of the AS/SVE system that had been included in the 1 May 2002 RIRA-2 was acceptable. During a telephone conversation in August 2002, the NJDEP's Case Manager indicated that it would be acceptable for EPI to re-start the air sparging component of the AS/SVE system. However, as was reported in the 24 October 2002 RAPR, the AS system has not yet been re-started due to the presence of DNAPL in air sparge well AS-12.

6.1 January 2003

All three remediation systems were in operation in January 2003.

6.1.1 *AS/SVE System*

The SVE component of the AS/SVE system operated continuously at optimum flow and vacuum during the January reporting period. The SVE system was operated at an inlet vacuum of 26 to 30 inches of water (i.w.) and corresponding extraction flow rates of 1,076 to 1,215 cubic feet per minute (cfm). Monthly observation well monitoring was conducted during the January 2003 groundwater sampling event. SPH was only detected in MW-9 (0.86 feet) during this gauging event.

A total of 3.36 inches of rain fell during January 2003, resulting in groundwater levels rising approximately 0.5 - 1.0 feet across the remediation area. Approximately 39.0 pounds of non-methane hydrocarbons were recovered by the SVE system during the January reporting period (for an average of 7.8 pounds per week), which is comparable to the mass recovered in December 2002. Approximately 32,944 pounds of non-methane hydrocarbons had been recovered by the AS/SVE system as of 30 January 2003 (see Appendix F).

6.1.2 *Offsite SVE System*

The extraction blower for the off-site SVE system operated at an average inlet vacuum of approximately 29 i.w. and a maximum extraction rate of approximately 360 cfm. The system operated consistently with no reported downtime during the January 2003 reporting period. No vapor phase hydrocarbons were recovered by the off-site SVE system during this reporting period (see Appendix G).

6.1.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the January 2003 reporting period and no shutdowns were reported. Flow rates on the horizontal well system were balanced at 28 to 37 cfm on each of the two lines; the total flow into the formation via the vertical injection wells averaged approximately 37 cfm (see Appendix H). All injection flow rates were in proportion to the hydrostatic pressures yielded by the groundwater table. The air curtain equipment was operated at maximum obtainable pressure (20 pounds per square inch [psi]).

Monthly observation well monitoring was conducted during the January 2003 groundwater sampling event. Surging groundwater conditions were observed in MW-1D, MW-10, MW-11, OW-2, OW-4, and OW-5. MW-1 has become completely filled with sediment (due to the operation of the air curtain) and cannot be gauged. In addition, slight churning was observed in replacement monitoring well MW-14R. No VOCs were detected in the on-site vapor monitoring points (VMPs).

6.2 February 2003

All three remediation systems were in operation during February 2003. However, due to significant snowfall during this month which made most wells inaccessible, no well gauging could be performed.

6.2.1 *AS/SVE System*

The SVE component of the AS/SVE system was operated at optimum flow and vacuum during the February 2003 reporting period. A total of 14 days of downtime were experienced due to three separate power failures, coupled with the extreme weather conditions. The SVE system operated at an inlet vacuum of 25 to 28 i.w. and a corresponding extraction flow rate of 1,076 cfm. Approximately 3.83 inches of water-equivalent precipitation fell during the February reporting period, although no well gauging was performed to determine changes in groundwater elevations.

Only 10.0 pounds of non-methane hydrocarbons were recovered by the SVE system during the February 2003 reporting period (entirely during the first week of the month). This low mass removal rate continues the decreasing trend that has been observed since February 2002. Approximately 32,954 pounds of non-methane hydrocarbons have been recovered by the AS/SVE system as of 27 February 2003 (see Appendix F).

6.2.2 *Off-Site SVE System*

The extraction blower for the off-site SVE system operated at an inlet vacuum of approximately 28 i.w. and a maximum extraction air flow rate of 350 to 360 cfm. The system was down for a total of 14 days during the reporting period. No vapor phase hydrocarbons were recovered by the off-site SVE system as of 27 February 2003 (see Appendix G).

6.2.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the February 2003 reporting period. However, as with the other two remediation system, the air curtain was down for 14 days during this reporting period. Flow rates on the horizontal well system were balanced at approximately 32 cfm on each of the two lines. All injection flow rates were operating at levels in proportion to the hydrostatic pressures yielded by the groundwater table. The equipment for the vertical air curtain wells was operated at maximum obtainable pressure (18 psi) yielding an average total flow of approximately 47 scfm into the formation. VOC readings from the on-site VMPs were collected on 20 February 2003; no detectable concentrations of VOCs were recorded during this monitoring event.

6.3 March 2003

All three remediation systems were in operation during March 2003. However, due to continued snow cover at the site, monthly well gauging could not be performed during this reporting period.

6.3.1 *AS/SVE System*

The SVE component of the AS/SVE system operated continuously at optimum flow and vacuum during the March 2003 reporting period. The SVE system operated at an average inlet vacuum of 26 i.w. and a corresponding average extraction flow rate of 1,085 cfm. Approximately 4.24 inches of water-equivalent precipitation fell during the reporting period.

No vapor phase hydrocarbons were recovered by the SVE system during the March 2003 reporting period, consistent with the last three weeks of February 2003. The low mass removal rate may be related, in part, to the elevated groundwater conditions. However, the trend of decreasing mass removal rates dates back to February 2002, which is prior to the end of the drought and when water levels were still low. Therefore, the absence of recoverable vapor phase hydrocarbons may also suggest that minimal amounts of VOCs remain in the vadose zone soils. Approximately 32,954 pounds of non-methane hydrocarbons have been recovered by the AS/SVE system as of 27 March 2003 (see Appendix F).

6.3.2 *Off-Site SVE System*

The extraction blower for the off-site SVE system operated at an inlet vacuum of approximately 29 i.w. and a maximum extraction air flow rate of 360 cfm. No vapor phase hydrocarbons were recovered by the off-site SVE system during this reporting period. Approximately 4,252 pounds of non-methane hydrocarbons have been recovered by the off-site SVE system as of 27 March 2003 (see Appendix G).

6.3.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the March 2003 reporting period with no periods of downtime. Flow rates on the horizontal well system were balanced at 22.0 to 32.0 cfm on each of the two lines. All injection flow rates were operating at levels in proportion to the hydrostatic pressures yielded by the groundwater table. The equipment for the vertical air curtain wells was operated at maximum obtainable pressure (20 psi) yielding an average total flow of approximately 38.0 scfm into the formation. No VOCs were detected in the on-site VMPs during this reporting period.

6.4 April 2003

All three remediation systems were in operation during April 2003. However, as discussed below, the NJDEP gave verbal approval to shut down the SVE component of the AS/SVE system due to the low mass removal rates being achieved and the cost of running the thermal oxidizer under these conditions.

6.4.1 *AS/SVE System*

The SVE component of the AS/SVE system operated continuously at optimum flow and vacuum during the April 2003 reporting period until it was shut down on 17 April 2003. The SVE system operated at an average inlet vacuum of 26 i.w. and a corresponding average extraction flow rate of 1,019 cfm. Monthly well gauging was conducted as part of the April 2003 quarterly groundwater monitoring event. SPH was only detected in MW-9, at a thickness of 0.91 feet. Approximately 2.47 inches of water-equivalent precipitation fell during the reporting period. Groundwater elevations in the southeast corner of the site were found to be 0.23 to 1.12 feet higher in April 2003 relative to the January 2003 gauging event.

No vapor phase hydrocarbons were recovered by the SVE system during the first three weeks of April 2003, consistent with the last seven weeks of operation of the system. Approximately 32,954 pounds of non-methane hydrocarbons have been recovered by the AS/SVE system as of 17 April 2003 (see Appendix F). As indicated above, the SVE system was shut down on 17 April 2003 following receipt of verbal approval from the NJDEP. EPI will periodically re-evaluate site conditions to determine if re-starting the SVE system is warranted.

6.4.2 *Off-Site SVE System*

The extraction blower for the off-site SVE system operated at an inlet vacuum of approximately 27 i.w. and a maximum extraction air flow rate of 360 cfm. No vapor phase hydrocarbons were recovered by the off-site SVE system during this reporting period. Approximately 4,252 pounds of non-methane hydrocarbons have been recovered by the off-site SVE system as of 17 April 2003 (see Appendix G).

6.4.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the April 2003 reporting period with no periods of downtime. Flow rates on the horizontal well system were balanced at 30.0 to 38.0 cfm on each of the two lines. All injection flow rates were operating at levels in proportion to the hydrostatic pressures yielded by the groundwater table. The equipment for the vertical air curtain wells was operated at maximum obtainable pressure (20 psi) yielding an average total flow of approximately 38.0 scfm into the formation. VMP-1 contained 0.20 ppm of VOCs during the 10 April 2003 monitoring event.

6.5 DNAPL Recovery

Between July and August 2002, DNAPL was discovered in the southeast and northwest corners of the site. The DNAPL in the southeast corner of the site has been identified by laboratory analysis to be Dowtherm, a heat transfer oil that was used in this area of the facility. Based on its distinctive smell, the DNAPL in the northwest corner of the site is believed to be methyl salicylate (i.e., synthetic oil of wintergreen), which used to be manufactured and handled in former Buildings 3 and 4.

6.5.1 *Dowtherm*

EPI has implemented a manual recovery program for the DNAPL in AS-12. During each weekly operation & maintenance (O&M) visit for the SVE system and thermal oxidizer, AS-12 is gauged to determine the presence of DNAPL, and a surface mounted centrifugal pump is used to remove any accumulated product. Approximately 3.5 gallons of DNAPL were recovered from AS-12 during this reporting period, for a total of approximately 30.1 gallons. The results of the recovery program are summarized on Table 8.

The last DNAPL recovery event from AS-12 was conducted on 30 January 2003. While sealing the borings associated with the DNAPL investigation that was conducted during the first week of February 2003, grout from one or more of the boreholes migrated into AS-12, and effectively sealed the well to a depth of 18.0 feet below grade. Attempts to remove the grout were unsuccessful, since it was not discovered until several days after it had entered the sparge well. EPI intends to completely seal AS-12 (using a licensed New Jersey well driller), and will replace it with a monitoring well so that manual DNAPL recovery efforts can continue.

6.5.2 *Methyl Salicylate*

Monitoring well MW-51D was installed at the same location as the temporary well point (TWP-2) in which DNAPL appeared to be present in July 2002. As shown on Table 9, MW-51D has been gauged six times since it was installed on 17 October 2002, and no measurable amounts of DNAPL have been detected. MW-51D will continue to be included in the monthly monitoring program for the site.

7.0 PROPOSED REMEDIAL INVESTIGATIONS AND ACTIONS

As discussed in Section 5.3 of this report, EPI proposes to collect additional soil samples to complete the vertical and horizontal delineation of toluene in sample SZ-4B, and 1,1'-biphenyl and diphenyl ether in sample SZ-16B. In addition, EPI proposes to remediate the SPH in MW-9 through excavation and off-site disposal.

7.1 Delineation Soil Borings

The locations of the proposed delineation soil boring locations around SZ-4 and SZ-16 are shown on Figure 20. Vertical delineation soil samples would be collected from borings adjacent to the original sampling locations. The depths of the vertical delineation samples will be determined based on field screening results. Horizontal delineation samples would be collected from 15.0 - 15.5 feet below grade to the north, east, and west of SZ-4; delineation to the south has been completed by soil samples SZ-5B and SZ-6B. Horizontal delineation samples would be collected to the north, south, east, and west of SZ-16, at depths of 10.25 - 10.75 feet below grade.

Soil samples would be collected following the same methodology discussed in Section 4.2 of this report. The soil samples from around SZ-4 would be analyzed for toluene by USEPA Method 8260, while the soil samples from around SZ-16 would be analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

7.2 MW-9 Area Excavation

Due to the presence of SPH in MW-9 that cannot be remediated by the existing AS/SVE system, EPI proposes to remediate this area through excavation and off-site disposal. Excavation in this area would serve to remove any product saturated soils that exist within the former tank pit, and should eliminate the SPH present in MW-9. As shown on Figure 21, an area measuring approximately 2,000 square feet will be excavated to 1.5 feet below sample SZ-17B (approximately 14.0 feet below grade). The limits of the excavation are defined to the north, south, east, and west by borings SZ-19, SZ-22, SZ-21, and SZ-18, respectively. Although benzene, 1,1'-biphenyl, and/or diphenyl ether were present in the soil samples from these locations, the concentrations of these compounds were not indicative of the presence of SPH. Since the purpose of excavating soil from around MW-9 is solely to eliminate the SPH that is present at this location, the analytical results from borings SZ-18, SZ-19, SZ-21, and SZ-22 are sufficient to define the limits of the excavation. Approximately 1,040 yards of soil would be excavated for off-site disposal (i.e., recycling).

Prior to initiating excavation activities, MW-9 would be abandoned by a licensed New Jersey well driller. Once the excavation has been completed, a replacement well would be installed to confirm that the SPH has been successfully remediated (see Section 7.2.2, below). Every effort will be made to preserve air sparge wells AS-20 and AS-21, which would be on the eastern and western sides of the excavation, respectively. If it is determined that these sparge wells cannot be retained, they would be abandoned by a licensed New Jersey well driller.

7.2.1 *Post-Excavation Sampling*

In accordance with N.J.A.C. 7:26E-6.4 *et seq*., up to six post-excavation soil samples will be collected from the east, west, and south side walls to document the effectiveness of the remediation program. Samples from the northern sidewall will not be required based on the analytical results from samples SZ-19A and SZ-19B. Depending on the depth to groundwater at the time the excavation is performed, samples would be collected from the same depth intervals as for the samples from borings SZ-18, SZ-21, and SZ-22. Each post-excavation sample would be analyzed for base neutral compounds plus an NBS library search (including calibrations for 1,1'-biphenyl and diphenyl ether) by USEPA Method 8270. In addition, the samples from the southern sidewall would be analyzed for VOC+10 by USEPA Method 8260.

7.2.2 *Area Restoration*

Once the excavation has been completed and post-excavation samples collected, it would be backfilled with certified clean material, compacted, and re-surfaced with asphalt. The horizontal SVE line that ran through the excavation would be replaced prior to re-paving the excavation. Replacement monitoring well MW-9R would be installed adjacent to the original well location. MW-9R would have a total depth of 25.0 feet, and would be constructed with 20.0 feet of 4.0-inch diameter, Sch. 40 PVC screen and 5.0 feet of PVC casing (i.e., the same construction as MW-9). The well head would be protected with a flush mount, water tight manhole and locking cap.

8.0 WELL SEARCH

As per Item 7 on page 20 of the NJDEP's letter dated 15 October 2001, EPI conducted a new well search to update the original one performed by Geraghty & Miller between 1992 and 1993. The goal of the well search was to identify any industrial, public, or domestic supply wells within a one-half mile radius of the site, whose operation may have contributed to the water table fluctuations noted during the 1998 pump tests. In addition, the NJDEP requested that specific information be obtained on the following wells identified in the 1992-1993 well search:

1. A public supply well (NJDEP Permit No. 26-5331) located southeast of the site on Hobart Street in the City of Garfield (original map ID No. 17);
2. A public supply well (NJDEP Permit No. 26-4010) located north of the site on Grand Street in the City of Garfield (original map ID No. 19);
3. A product recovery well (NJDEP Permit No. 26-5149) located north of the Site near Grand Street and Cambridge Avenue in the City of Garfield (original map ID No. 18);
4. An industrial supply well owned by Tender Brand Frozen Foods (NJDEP Permit No. 26-205) located south of the site at 176 Saddle River Avenue in South Hackensack (original map ID No. 24); and,
5. A private well owned by Most Holy Name Church (NJDEP Permit No. 26-3410) located southeast of the site at 99 Marsellins Place in the City of Garfield (original map ID No. 16).

In April 2002, Sovereign obtained the results of a five mile computer data base well search and a one-half mile manual well search for industrial, public, and domestic supply wells from the NJDEP's - Bureau of Water Allocations. No new supply wells were identified by the April 2002 well search, therefore, the focus of the investigation shifted to gathering additional information on each of the wells listed above. Sovereign contacted the following agencies for information regarding these wells:

- NJDEP Bureau of Water Allocations;
- Garfield Water Department;
- Garfield Health Department;
- Garfield Tax Assessors Office;
- Garfield City Managers Office;
- South Hackensack Tax Assessment;
- South Hackensack Construction Official;
- South Hackensack Police Department;

- Boswell Engineering (Engineers for Garfield);
- NJDEP Site Remediation;
- NJDEP Bureau of Safe Drinking Water; and,
- NJDEP - Open Public Records Act (OPRA) for any information pertaining to these wells.

The locations of the five supply wells identified by the NJDEP are shown on Figure 22. The construction details and current status of these wells (as could be determined by Sovereign), are summarized on Table 12.

Sovereign contacted Mr. Mike Sferruzzo of the Garfield Water Department for information regarding the public supply wells located in the City of Garfield. Mr. Sferruzzo stated that the Grand Street and Hobart Street public supply wells are sealed and that any records regarding these wells were destroyed in a flood. Further, Mr. Sferruzzo stated that the City of Garfield has not utilized water from their well fields since 1990. All City of Garfield well fields were shut down due to volatile organic compound contamination. Garfield currently receives drinking water from Elmwood Park well fields and the Passaic Valley Water Commission.

The Hobart Street Well (No. 1 on Figure 22) was installed approximately 2,200 feet southeast of the site in February 1982 and listed as a public supply well. The well was 400 feet deep, and was constructed with 37.5 feet of 18.0-inch diameter steel casing set into red sandstone, followed by 58.0 feet of 12.0-inch diameter steel casing set into red sandstone or shale. The well had a yield of approximately 300 gallons per minute (based on a 74 hour pump test). A copy of the well record is included in Appendix I. Mr. Sferruzzo stated that the Hobart Street Well was a test well which was never utilized due to a high water hardness content. The well was sealed and never used as a supply well. The well was not replaced once sealed. The NJDEP did not have a copy of the Well Abandonment permit for this well. However, Sovereign located a 1998 NJDEP letter stating that well permit # 26-5331 (Hobart Street Well) was abandoned and needed to be sealed. No other information was available.

The Grand Street Well (No. 2 on Figure 22) was installed approximately 700 feet north of the site in April 1967. The well was 276 feet deep, and it was constructed with 61.5 feet of 10.0-inch diameter steel casing. The Grand Street Well was sealed in June 1992. Copies of the well record and well abandonment report are included in Appendix I.

The Grand Street and Cambridge Avenue well (No. 3 on Figure 22) is owned by the NJDEP and is located approximately 700 feet north of the Site. This product recovery well was installed in March 1981. The well is 26.0 inches in diameter and has a reported total depth of 21.0 feet, but is reportedly constructed with 5.0 feet of steel casing and 17.0 feet of screen. A copy of the well record for this well is included in Appendix I. Sovereign could find no other information pertaining specifically to this well (nor could the site it was associated with be identified). However, after filing an OPRA request with the NJDEP, Mr. Matt Coefer and Mr. Mark Herzberg of the NJDEP informed Sovereign that the product recovery well may be associated with an Amoco Station at 45 Monroe Street (located near the northeast corner of the site at Monroe Street and Cambridge Avenue).

According to NJDEP records, a leaking underground storage tank at the Amoco gas station resulted in on-site and off-site soil and groundwater contamination. The leak was discovered in 1993 after a plume of contaminated ground water migrated to a nearby 13-unit apartment building and caused gasoline fumes to build up in the basement of the building. In 1993, the NJDEP placed a ventilation system in the basement of the apartment building, installed a perimeter soil vapor extraction system, and installed groundwater monitoring wells to track the movement of the contaminant plume. The apartment building is located in the area of Grand Street and Cambridge Avenue. Mr. Coefer and Mr. Herzberg did not know if the product recovery well was part of the Amoco Station investigation, however, both assumed that given the location of the apartment building and the location of the product recovery well, that they are related. However, it is not clear how the recovery well and the Amoco station are related, given that the well was installed 12 years before the release at the station was discovered.

The Tender Brand Frozen Foods (TBFF) well (No. 4 on Figure 22) was located approximately 1,250 feet south of the site at 176 Saddle River Avenue in South Hackensack. The TBFF well was drilled as an industrial supply well in October 1950, and had a total depth of 230 feet. As indicated on the well record in Appendix I, the well was constructed 76.0 feet of 8.0-inch diameter steel casing, and had a reported yield of 100 gpm after eight hours of pumping. Sovereign contacted the South Hackensack Police Department and the South Hackensack Tax Assessment Office. The Police Department informed Sovereign that TBFF no longer existed at the address on the well record, and that there are a number of other units currently located at that address. Additionally, Sovereign contacted Mr. Frank Recanati, the South Hackensack Construction Official. Mr. Recanati informed Sovereign that TBFF occupied the property address from the early 1950s until the late 1960s. Mr. Recanati stated that a well does not currently exist at the property. He stated that if a well did exist, a sewage discharge meter would be located at the property. Mr. Recanati stated that there is no monitoring meter on the discharge line for that property, which indicates that there are no private wells at that location. Mr. Recanati further stated that according to the South Hackensack records, there hasn't been a well at that property since at least prior to 1980.

The Most Holy Name Church well (No. 5 on Figure 22) was located approximately 1,700 feet southeast of the site at 99 Marsellins Place in the City of Garfield. The well was drilled in September 1945 and utilized for sprinkling. The well was 130 feet deep, and was constructed 30.0 feet of 6.0-inch diameter steel casing. The well had a reported yield of 40.0 gpm. A copy of the well record for this well is provided in Appendix I. No other information regarding this well was available. Sovereign contacted a representative of Most Holy Name Church and was informed that to their knowledge, a well does not currently exist at the property. This confirms the findings of the 1992-1993 well search conducted by Geraghty & Miller.

Based on the results of the original 1992-1993 well search, and the results of the April 2002 well search, there do not appear to be any active industrial, public, or domestic supply wells within a one-half mile radius of the site.

SOVEREIGN CONSULTING INC.

FEB 27 REC'D

FEB 27 2003

FEB 27 2003

27 February 2003

Mr. Andrew Dillman
New Jersey Department of Environmental Protection
Bureau of Environmental Evaluation Cleanup & Responsibility Assessment
Division of Responsible Party Site Remediation
401 E. State Street, 5th Floor
P.O. Box 432
Trenton, New Jersey 08625-0432

RE: Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

Hand Delivered

Dear Mr. Dillman:

Attached please find an original and two copies of the *Remedial Investigation and Remedial Actions Report* for activities associated with former Building 17 and the former process waste sewer lines at the above referenced site. This report has been prepared by Sovereign Consulting Inc. (Sovereign) on behalf of EPEC Polymers Inc. (EPI). In addition, one copy of Attachments I through VI (Analytical Data Packages; 21 Volumes total) and eight computer diskettes containing the required electronic data deliverables are also being provided.

If you should have any questions or require additional information, please feel free to contact me at (609) 259-8200 or Ms. Bridget Hamann of El Paso Corporation (EPC) at (713) 420-5093.

Sincerely,
Sovereign Consulting Inc.

Paul I. Lazaar
Principal Project Manager

c: Project File
B. Hamann, EPC
B. Amig, Goodrich Corp.
R. Smith, Belkorp Industries

SOVEREIGN CONSULTING INC.

Remedial Investigation and Remedial Actions Report
Building 17 & Former Sewer Lines

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

26 February 2003

Prepared For:

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Houston, Texas 77002

Prepared By:

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Paul I. Lazaar, P.G.
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APPENDICES

ATTACHMENTS (Under Separate Cover)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this *Remedial Investigation and Remedial Actions Report* for activities conducted at the Kalama Chemical Inc. facility in Garfield, New Jersey (Figure 1). In July and August 2001, Building 17 was demolished as part of the property owner's (i.e., Goodrich Corporation's) plans for re-developing the site. Due to the soil contamination found once the building was demolished, Building 17 has been designated as area of environmental concern (AEC) 32. Between March and September 2002, three former process waste sewer lines were investigated and removed as part of the redevelopment plans. The Building 17 sewer line (AEC-33) was approximately 130 feet long and ran from north to south to the Hudson Street line. The sewer line that serviced the Building 32/32-A/32-B complex (AEC-34) was approximately 270 feet long and ran from the north end of the former building complex to the Hudson Street line. The Hudson Street sewer line (AEC-35) was approximately 330 feet long and ran parallel to Hudson Street along the southern property line from near former Building 22 to the southwest corner of the site (near MW-14). The locations of these new AECs are shown on Figure 2.

1.1 Sampling Methodology

The majority of the soil samples discussed in this report were collected using Geoprobe methodology. The Geoprobe was operated by a New Jersey licensed driller from Summit Drilling Co., Inc. under the supervision of a Sovereign geologist. Soil samples from the required depths were collected into acetate liners within a stainless steel sampler. Each liner was removed from the sampler, slit open, and screened for volatile organic compounds (VOCs) using a photo-ionization detector (PID) equipped with a 10.6 eV bulb. Soil samples for VOC analyses were collected from undisturbed soil following the NJDEP's Methanol Preservation Procedures. The descriptions of soil lithologies, results of PID screening, and the depths of the samples collected were recorded in the field. Copies of all soil boring logs are included in Appendix A.

Some of the samples discussed below were collected from test pits that were dug using the on-site track-hoe excavator. As each test pit was excavated, the soils were screened for VOCs using a PID. Samples were collected from soil at the base of each test pit. At the completion of sampling, the test pit was backfilled with the excavated material.

Post-excavation soil samples were either collected directly from the base and sidewalls of the excavation using a shovel or trowel, or were collected from soil within the bucket of the excavator. The excavator was used to obtain soil only when health and safety considerations precluded entering the excavation to collect the samples.

2.0 BUILDING 17 (AEC-32)

When the Kalama Chemical facility was in operation, Building 17 (located in the southwest corner of the site) was used as a laboratory (from 1928 to 1993) and as a pilot plant (from the 1940s to 1969). The laboratory was used for quality assurance/quality control purposes to check raw materials and finished products. The pilot plant was used to test new manufacturing processes to possibly be used at the Garfield, New Jersey plant, or at Kalama Chemical facilities in other parts of the country.

Due to the operations that were conducted in Building 17, this area of the site has been designated AEC-32. Following the demolition of the building in August 2001, a total of four sub-AECs were identified, including a concrete basin (AEC-32A), fill material beneath the floor of the building (AEC-32B), a concrete trough (AEC-32C), and the loading dock located between Building 16 and Building 17 (AEC-32D). The investigative and remedial activities (if warranted) conducted for each of these AECs are discussed separately, below.

2.1 AEC-32A - Concrete Basin

AEC-32A consists of a concrete basin measuring 47 feet long x 33 feet wide x 5.0 feet deep that was uncovered at the north end of Building 17 (see Figure 2). According to facility plans, this basin was used to collect water from the sinks in the laboratory. The basin had no outlet (i.e., it did not connect to a sewer line), but vents near the top of the basin allowed the collected water to evaporate. At the time the basin was uncovered, it was found to contain several inches of mud and water.

2.1.1 *Water Sampling*

A sample of the standing water in the basin (BLDG17-W) was collected on 6 August 2001 and analyzed for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260) and base neutral/acid extractable compounds plus an NBS library search (BNA+25; USEPA Method 8270). The analytical results for BLDG17-W are summarized on Table 1. A copy of the analytical data package for this sample (including the electronic data deliverables [EDD] diskette) is included under separate cover as Attachment I.

A total of seven targeted VOCs were detected in the water sample, including acetone (80.6 parts per billion [ppb]), benzene (0.88 ppb), 2-butanone (10.0 ppb), chloroform (15.4 ppb), 2-hexanone (2.6 ppb), methylene chloride (1.7 ppb), and toluene (1.3 ppb). The concentrations of these VOCs were below their respective Groundwater Quality Standards (GWQS) except for chloroform, which exceeded its standard of 6.0 ppb. A nontargeted VOC (ethanol) was detected at 9.4 ppb, well below the NJDEP's Interim Generic GWQS of 100 ppb for individual Synthetic Organic Compounds (SOCs) and 500 ppb for total SOCs. Targeted BNAs detected in the water sample included 18.9 ppb of butylbenzyl phthalate, 3.9 ppb of carbazole, 7.5 ppb of 2-methylphenol, 23.8 ppb of 3&4-methylphenol, 1.5 ppb of phenanthrene, and 802 ppb of phenol. None of these compounds exceeded their respective groundwater quality criteria. Nontargeted BNAs (primarily benzyl alcohol, benzoic acid compounds, and unknown compounds) were detected at a total concentration of 3,548 ppb.

On 14 August 2001, approximately 2,370 gallons of water were removed from the basin using a vacuum truck and transported to S&W Waste, Inc. in South Kearny, New Jersey for disposal. A copy of the waste manifest for this load of water is included in Appendix B.

2.1.2 *Soil Sampling*

Due to the mud that covered the floor of the basin it was not possible to evaluate its structural integrity. Therefore, a test pit was dug through the middle of the basin on 14 August 2001, and one soil sample (17S-1) was collected; one sample of the mud (17M-1) in the basin was also collected. On 17 August 2001, four additional test pits were dug through the southwest (17S-2), northwest (17S-3), southeast (17S-4), and northeast (17S-5) corners of the basin (see Figure 3). The floor of the basin was found to be approximately 14.0 inches thick and was constructed of reinforced concrete containing a layer of tar in the middle. The soil beneath the basin consisted of a brown, medium to coarse grained sand. No VOCs were detected while screening the soil using a PID. Soil samples 17S-1 through 17S-5 were collected from 1.0 - 1.5 feet below the bottom of the concrete, and each sample (plus 17M-1) was analyzed for total petroleum hydrocarbons (TPH; USEPA Method 418.1), VOC+10, and BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, and salicylic acid). The analytical results for these samples are summarized on Table 2, and are presented on Figure 4. A copy of the analytical data package for these samples (including the EDD diskette) is included under separate cover as Attachment I.

As shown on Table 2, no detectable concentrations of TPH or VOCs were found in the mud sample from the concrete basin. However, sample 17M-1 did contain 6.1 parts per million (ppm) of benzo(a)anthracene, 4.45 ppm of benzo(b)fluoranthene, 3.04 ppm of benzo(k)fluoranthene, and 4.42 ppm of benzo(a)pyrene. These concentrations exceed their respective Residential Direct Contact Cleanup Criteria (RDCCC) and/or Non-Residential Direct Contact Cleanup Criteria (NRDCCC). No other BNAs were found in sample 17M-1 at concentrations exceeding their respective remediation criteria. The concentrations of TPH, VOCs, and BNAs in samples 17S-1 through 17S-5 were either not detectable or were below the most restrictive soil remediation criteria.

Due to the polynuclear aromatic hydrocarbons (PAHs) present in sample 17M-1, the mud was removed from the basin pending off-site disposal. The basin was subsequently backfilled with fill material that had been under Building 17. Based on the analytical results from samples 17S-1 through 17S-5, EPI proposes no further action for this AEC.

2.2 AEC-32B - Building 17 Fill Material

Prior to the demolition of Building 17, it had been assumed that a crawl space existed beneath the ground floor of the building. However, once the floor of the building had been removed, it was found that the space within the foundation walls contained fill material (poorly sorted sand and gravel, brick fragments, and cinders). Since the fill material within the foundation walls extended two to three feet above surface grade, it needed to be removed as part of the site restoration process.

2.2.1 *Investigation Activities*

On 6 August 2001, soil samples were collected from the fill material for waste characterization purposes. The soil samples were collected from test pits TP-1 through TP-5 at the locations shown on Figure 5. Each sample was collected from 1.5 - 2.0 feet below grade (i.e., the top of the fill material), and analyzed for TCLP VOCs, TCLP Semi-VOCs, TCLP metals, TPH, polychlorinated biphenyls (PCBs; USEPA Method 8082), flashpoint, reactive cyanide, reactive sulfide, and corrosivity. On 3 October 2001, based on observations made while collecting post-excavation samples around TP-1 (see Section 2.2.2, below), test pit locations TP-2 through TP-5 were also sampled for VOC+10 and BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate). The analytical results for these samples are summarized on Table 3 and are presented on Figure 6. Copies of the analytical data packages (along with the EDD diskette) for all of the soil samples collected from this AEC are included under separate cover as Attachment II.

With the exception of 15.8 ppm of PCBs (Aroclor 1260) in sample TP-1, none of the other analytical parameters for samples TP-1 through TP-5 exceeded their applicable Maximum Contaminant Level (for the waste characterization analyses) or their most restrictive NJDEP remediation criteria; the NJDEP's RDCCC and NRDCCC for total PCBs in soil are 0.49 ppm and 2.0 ppm, respectively.

On 17 August 2001, test pit samples TP-1A through TP-1E were collected to complete the horizontal and vertical delineation of the PCBs detected in sample TP-1. Sample TP-1A was collected from 3.5 - 4.0 feet below grade at the location of test pit TP-1, while samples TP-1B through TP-1E were collected from 1.5 - 2.0 feet below grade. Each sample was analyzed for PCBs. The analytical results for these samples are summarized on Table 4, and are presented on Figure 7. No detectable concentrations of PCBs were found in the five delineation soil samples.

2.2.2 *Remediation Activities*

On 11 September 2001, an area measuring 19.0 feet x 27 feet was excavated to a depth of 4.0 feet around test pit TP-1 for the purposes of remediating the PCBs detected in the fill material at this location. The excavation extended from north to south to include test pit samples TP-1C and TP-1D, and from west to east from the foundation sidewall to TP-2. However, due to the events that occurred on 11 September 2001, field work at the site was suspended for several days, and post-excavation samples were not collected until 18 September 2001.

Post-excavation samples 17PE-1, 17PE-2, and 17PE-3 were collected from the northern, eastern, and southern sidewalls, while 17PE-4 was collected from the base of the excavation (Figure 8). Since the excavation extended to the western foundation sidewall of Building 17, a post-excavation sample was not collected from this location. The sidewall samples were collected from 1.5 - 2.0 feet below grade, while the base sample was collected from 4.0 - 4.5 feet below grade. Since the vertical and horizontal extent of the PCBs had already been defined by test pit samples TP-1A through TP-1D, the post-excavation samples did not need to be analyzed for this parameter. However, due to a chemical odor that was noted during field activities on 11 September 2001, the post-excavation samples were analyzed for VOC+10 by USEPA Method 8260 and BNA+25 by USEPA Method 8270 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate).

The analytical results for post-excavation samples 17PE-1 through 17PE-4 are summarized on Table 5 and are presented on Figure 9. The concentrations of targeted and nontargeted VOCs and BNAs were below their applicable remediation criteria in all three sidewall samples. However, base sample 17PE-4 contained 2,418 ppm of nontargeted VOCs (primarily chloride compounds related to the production of benzaldehyde), which exceeded the NJDEP's generic remediation criterion of 1,000 ppm for total VOCs in soil. In addition, 17PE-4 contained 5.58 ppm of hexachlorobenzene, which exceeded its RDCCC and NRDCCC of 0.66 ppm and 2.0 ppm, respectively; the NJDEP's Impact to Groundwater Cleanup Criterion (IGWCC) for hexachlorobenzene in soil is 100 ppm.

Based on the analytical results from sample 17PE-4, additional soil was removed from the excavation on 2 October 2001. As shown on Figure 10, an area around 17PE-4 measuring 7.0 feet x 7.0 feet was excavated an additional 1.5 feet (to 5.5 feet below grade), and five new post-excavation samples were collected. Samples 17PE-5 through 17PE-8 were collected from the sidewalls of the excavation at 4.0 - 4.5 feet below grade (the same interval as 17PE-4), and 17PE-9 was collected from the base of the excavation (5.5 - 6.0 feet). Each sample was analyzed for VOC+10 and BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate).

The analytical results for the second round of post-excavation samples are summarized on Table 6 and are presented on Figure 11. Targeted VOCs were not detected in post-excavation samples 17PE-5 through 17PE-9. Nontargeted VOCs were detected at total concentrations of 10.1 ppm in 17PE-9, 97.7 ppm in 17PE-5, 934 ppm in 17PE-8, 947 ppm in 17PE-6, and 2,133 ppm in 17PE-7. Hexachlorobenzene was detected at concentrations above its RDCCC and/or NRDCCC in 17PE-5 (0.98 ppm), 17PE-6 (3.56 ppm), 17PE-7 (6.7 ppm), and 17PE-8 (6.4 ppm). Sample 17PE-6 also contained benzo(a)anthracene (1.94 ppm), benzo(b)fluoranthene (2.47 ppm), and indeno(1,2,3-cd)pyrene (1.02 ppm) at concentrations exceeding their RDCCC of 0.90 ppm, and benzo(a)pyrene (0.70 ppm) at a concentration exceeding its RDCCC and NRDCCC of 0.66 ppm. Sample 17PE-7 contained 77.6 ppm of 1,2,4-trichlorobenzene, which exceeded its RDCCC of 68.0 ppm; the NJDEP's IGWCC for 1,2,4-trichlorobenzene in soil is 100 ppm. The total concentrations of nontargeted BNAs ranged from 50.1 ppm in 17PE-9 to 1,697 ppm in 17PE-7, well below the NJDEP's generic remediation criterion of 10,000 ppm for total organic compounds in soil.

Based on the analytical results for sidewall samples 17PE-5 through 17PE-8, a third phase of excavation and sampling was conducted. As shown on Figure 12, the base of the excavation was extended to 5.5 feet below grade, and an additional one foot of soil was removed from the northern, eastern, and southern sidewalls. Samples 17PE-10, 17PE-11, and 17PE-12 were collected from the sidewalls of the excavation at 4.0 - 4.5 feet below grade (the same interval as samples 17PE-5 through 17PE-8); a base sample was not collected since the concentrations of VOCs and BNAs in 17PE-9 were all below their respective remediation criteria. Each sample was analyzed for BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate), while sample 17PE-11 was also analyzed for VOC+10.

The analytical results for the third round of post-excavation samples are summarized on Table 7 and are presented on Figure 13. No detectable concentrations of VOCs were found in sample 17PE-11. None of the post-excavation samples contained detectable concentrations of hexachlorobenzene, and the other

BNAs detected in these samples were present at concentrations below their most restrictive remediation criteria.

Approximately 203 tons of soil were ultimately excavated and disposed off-site for recycling at Clean Earth of Philadelphia, Inc. Copies of the disposal documentation for the excavated soil are included in Appendix C. Following receipt of the third round of post-excavation sample results, the excavation was partially backfilled with approximately 77.0 tons of certified clean fill material from Passaic Crushed Stone Co., Inc. in Pompton Lakes, New Jersey. Copies of the weight tickets for the fill material, along with the clean fill certification documentation, are also included in Appendix C. The remainder of the excavation was backfilled using some of the remaining fill material from beneath Building 17. Based on the findings of the post-excavation sample results, EPI proposes no further action relative to this area of environmental concern.

2.3 AEC-32C - Concrete Trough

In early November 2001, a concrete trough was uncovered in the southeast corner of Building 17. The trough measured approximately 1.0 foot x 1.0 foot and was approximately 40.0 feet long (see Figure 14). The concrete below the trough extended to approximately three feet below grade. At the time it was uncovered, the trough contained large pieces of a crushed white rock (believed to be either quartz or quartzite), and the interstices between the rocks were partially filled with a dried, filter cake-like material.

2.3.1 *Investigation Activities*

A sample of the filter cake material (S-1) and a sample of the soil below the trough (S-2) were collected on 13 November 2001. Since the filter cake material appeared to be either dried sludge or a similar form of waste, each sample was analyzed for TPH, VOC+15, BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate), priority pollutant metals (PPM; USEPA Method 6010), PCBs, total cyanide (USEPA Method 9012), and total phenolics (USEPA Method 9066) to comprise a priority pollutant plus 40 additional compounds (PP+40) suite of analyses. The analytical results for these samples are summarized on Table 8, and are presented on Figure 15. Copies of the analytical data packages (along with the EDD diskette) for all of the samples collected from this AEC are included under separate cover as Attachment III.

The waste sample from the concrete trough was found to contain metals, nontargeted VOCs, and targeted BNAs at concentrations exceeding the applicable remediation criteria. TPH, targeted VOCs, PCBs, total cyanide, and total phenolics were either not detected, or were present at concentrations below their most restrictive remediation criteria. Antimony (26.2 ppm), lead (594 ppm), and mercury (100 ppm) were detected in sample S-1 at concentrations above the RDCCC for each metal of 14.0 ppm, 400 ppm, and 14.0 ppm, respectively. Although no targeted VOCs were detected in sample S-1, the total concentration of nontargeted VOCs (1,827 ppm, primarily chloride compounds related to benzaldehyde production) exceeded the NJDEP's generic remediation criterion of 1,000 ppm of total VOCs in soil. For the targeted BNAs, benzo(a)anthracene (4.58 ppm) exceeded its NRDCCC of 4.0 ppm, bis(2-ethylhexyl)phthalate (131 ppm) exceeded its Impact to Groundwater criterion of 100 ppm, and hexachlorobenzene (5.68 ppm) exceeded its NRDCCC of 2.0 ppm.

In soil sample S-2, all of the analytical parameters were either not detected, or were present at concentrations below their most restrictive remediation criteria.

2.3.2 *Remediation Activities*

Due to the elevated concentrations of metals, nontargeted VOCs, and targeted BNAs present in the filter cake material, the concrete trough was removed to prevent this material from serving as a potential future source of contamination. On 9 & 10 January 2002, an area measuring 12.5 feet x 60.0 feet was excavated around the concrete trough to a depth of 5.0 feet below grade. On 18 January 2002, post-excavation samples S-3, S-4, S-5, and S-6 were collected from the base of the excavation (6.0 - 6.5 feet below grade) at 15.0 feet spacings along the center line of the trough (Figure 16); due to the time lapse between completing the excavation and collecting the samples, an additional one foot of soil was removed at each location before collecting each sample. Sidewall samples were not collected due to 1) the presence of concrete foundation walls to the south and east, and 2) the presence of previously documented clean fill to the north and west. Based on the analytical results from sample S-1, each post-excavation sample was analyzed for PPM, VOC+10, and BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate).

The analytical results for post-excavation samples S-3 through S-6 are summarized on Table 9 and are presented on Figure 17. No metals, VOCs, or BNAs were detected at concentrations exceeding their applicable remediation criteria.

Approximately 216 tons of soil were excavated and disposed off-site for recycling at Clean Earth of Philadelphia, Inc. Copies of the disposal documentation for the excavated soil are included in Appendix D. The excavation was backfilled using some of the remaining fill material from beneath Building 17. Based on the findings of the post-excavation sample results, EPI proposes no further action relative to this area of environmental concern.

2.4 AEC-32D - Loading Dock

Following the excavation of the concrete trough (AEC-32C), purple staining was noted on the concrete that formed the west wall of the loading dock between Building 16 and Building 17. Due to this staining, an investigation was conducted to determine soil quality beneath the loading dock. Copies of the analytical data packages (along with the EDD diskette) for all of the samples collected from this AEC are included under separate cover as Attachment IV.

2.4.1 *Investigation Activities*

As shown on Figure 18, five soil borings (LD17-1 through LD17-5) were installed along the centerline of the loading dock. The soil borings were installed using Geoprobe methodology. The loading dock was found to be generally constructed as follows:

- 6.0-inches of concrete
- 2.0 - 2.5 feet of void space (containing rocks and wood)
- 3.0 - 6.0-inches of concrete
- 1.5 - 2.0 feet of void space (empty)
- 6.0-inches of concrete
- fill material

Due to this construction, soil samples could not be collected until 4.0 to 4.5 feet below the top of the loading dock. The fill material was approximately one foot thick, and was comprised of crushed rock, brick, wood chips, and glass. The native soil below the fill was comprised of a reddish brown, fine sandy silt. Soil samples for laboratory analysis were collected from the fill material (6.5 - 7.0 feet to 7.0 - 7.5 feet below the surface of the loading dock) and from the native soil (7.5 - 8.0 feet below the top of the loading dock). Based on the analytical results for the waste sample collected from the adjacent concrete trough, the samples from borings LD17-1, LD17-2, and LD17-3 were analyzed for PPM, VOC+10, and BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate). The samples from borings LD17-4 and LD17-5 were collected for contingency purposes from the native soil and ultimately did not need to be analyzed.

The analytical results for the loading dock samples are summarized on Table 10 and are presented on Figure 19. No detectable concentrations of VOCs were found in the fill material or in the native soil. The fill material in boring LD17-1 contained 0.69 ppm of benzo(a)pyrene, which exceeds the NJDEP's RDCCC and NRDCCC of 0.66 ppm. No other targeted BNAs were found in the fill material samples from LD17-1, LD17-2, and LD17-3 at concentrations exceeding their respective remediation criteria. No detectable concentrations of targeted BNAs were found in the native soil below the loading dock. Lead was detected at 42,000 ppm in the fill material sample from LD17-2, which exceeds its NRDCCC of 600 ppm. The fill material sample from LD17-3 contained 40.3 ppm of arsenic, which exceeds its RDCCC and NRDCCC of 20.0 ppm. No metals exceeded their most restrictive remediation criteria in the fill material sample from LD17-1, or in the native soil samples in all three borings.

2.4.2 *Remediation Activities*

In March 2002, the loading dock and underlying fill material were removed due to the concentrations of lead and arsenic present in samples LD17-2 and LD17-3. Since the benzo(a)pyrene detected in LD17-1 was present at a concentration comparable to that seen in the fill material that is present across the site, no remedial actions were taken specific to this compound. The extent of the loading dock excavation is shown on Figure 20. The stained concrete that was observed following the excavation of AEC-32C was also removed at this time. Approximately 166 tons of soil were ultimately excavated and disposed off-site for recycling at Clean Earth of Philadelphia, Inc. Copies of the disposal documentation for the excavated soil are included in Appendix E.

On 3 April 2002, post-excavation samples were collected from the south (LD17-6) and north (LD17-7) ends of the loading dock excavation. A post-excavation sample was not collected to the east due to the foundation wall of Building 16, or to the west due to the presence of clean fill material from the AEC-32C excavation. Each post-excavation sample was collected from 6.5 - 7.0 feet below the top of the former loading dock (as were fill samples LD17-2 and LD17-3) and analyzed for PPM. The analytical results for LD17-6 and LD17-7 are summarized on Table 11 and are presented on Figure 21. No metals were detected in these samples at concentrations exceeding their most restrictive remediation criteria.

The Building 17 loading dock excavation was backfilled with approximately 241 tons of certified clean fill material from Passaic Crushed Stone Co., Inc. Fill material documentation is also included in Appendix E. Additional fill material was needed to restore the excavation to a level comparable to the surrounding grade. Based on the findings of the post-excavation sample results, EPI proposes no further action relative to the Building 17 loading dock.

3.0 BUILDING 17 SEWER LINE (AEC-33)

As shown on Figure 2, the Building 17 sewer line was approximately 130 feet long and ran from north to south to the Hudson Street line. Approximately 65 feet of this line was removed during the demolition/excavation of the loading dock between Building 16 and Building 17. Copies of the analytical data packages for the soil samples collected from this AEC (along with the electronic data deliverables) are provided under separate cover as Attachment V.

3.1 Investigation Activities

In accordance with the *Technical Requirements for Site Remediation*, six borings were installed adjacent to the sewer line (one boring for every 15 linear feet of pipe). Soil samples were collected following the procedures outlined in Section 1.1 of this report. The locations of soil borings SL-17-1 through SL-17-6 are shown on Figure 22. Based on an inspection of a manhole along the line, the invert of the sewer pipe was determined to be 2.5 feet below grade. Therefore, a soil sample was collected from 2.5 - 3.0 feet below grade from each boring. Based on the analytical results for the soil samples collected following the demolition of Building 17, each sample from along the sewer line was analyzed for VOC+10, BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, benzoic acid, and salicylic acid), PCBs, and PPM. The analytical results for these samples are summarized on Table 12 and are presented on Figure 23.

The concentrations of BNAs and PCBs were either not detectable or were below all of their most restrictive cleanup criteria in all six samples collected along the Building 17 sewer line. The concentrations of PPM were below their most restrictive cleanup criteria in all samples except SL-17-1, which contained 15.5 ppm of mercury; the NJDEP's RDCCC for mercury is 14.0 ppm. The concentrations of targeted and nontargeted VOCs were below their respective IGWCC in all samples except SL-17-2, which contained benzene (1.97 ppm), chloroform (1.05 ppm), and 1,2-dichloroethane (4.68 ppm); the NJDEP's IGWCC for all three of these compounds is 1.0 ppm. The soil along the sewer line consisted of 2.5 to 3.0 feet of crushed stone/slag fill material, underlain by sand, slit, and silty sands.

3.2 Remedial Actions

Based on the soil sampling results discussed above, only a limited volume of soil appeared to have been impacted by leaks from the former Building 17 sewer line. However, since the sewer line was known to be filled with sludge, it was decided that it should be removed to prevent the material inside the pipe from serving as a potential future source of contamination. The excavation of the Building 17 sewer line was conducted during the first week of June 2002.

The soil covering the sewer line was first removed and staged for use as backfill material. Between borings SL-17-3 and SL-17-5, the sewer line was removed, along with approximately 2.0 feet of soil below the line. However, between borings SL-17-1 and SL-17-3, the excavation extended to three feet below the pipe (or approximately six feet below grade) and approximately 10.0 feet to the east (up to the wall and footings for Building 16). In order to minimize the volume of waste, the soil from above the sewer line in this expanded excavation area was also staged for use as backfill material. Approximately 110 tons of soil were ultimately excavated and disposed off-site for recycling at Clean Earth of Philadelphia, Inc. Copies of the disposal documentation for the excavated soil are included in Appendix F.

Post-excavation sample PX17-1 was collected from the base of the excavation (below sample SL-17-2) and analyzed for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260) and mercury by USEPA Method 6010/7000. The initial characterization samples from borings SL-17-1 and SL-17-3 served as post-excavation sidewall samples to the south and north, respectively. In addition, only clean fill existed to the south of SL-17-1 due to the remediation of the loading dock (AEC-32D). Since the excavation extended from the wall of Building 16 to the wall of Building 17, post-excavation samples were not required from the east and west sidewalls, respectively.

The analytical results for post-excavation sample PX17-1 are summarized on Table 13 and are presented on Figure 24. Mercury was detected at 0.24 ppm, which is below the NJDEP's RDCCC of 14.0 ppm for this metal in soil. Toluene was detected at 0.35 ppm, which is below the NJDEP's IGWCC of 500 ppm for this compound in soil. No detectable concentrations of benzene, chloroform, or 1,2-DCA were found in sample PX17-1.

The Building 17 sewer line excavation was backfilled with approximately 156 tons of certified clean fill material from Passaic Crushed Stone Co., Inc. in Pompton Lakes, New Jersey; a copy of the clean fill documentation is also included in Appendix F. Based on the findings of the post-excavation sample results, EPI proposes no further action relative to the former Building 17 sewer line.

4.0 BUILDING 32 SEWER LINE (AEC-34)

As shown on Figure 2, the former Building 32 sewer line was approximately 270 feet long and ran from the north end of the former building complex to the Hudson Street line. Similar to the Building 17 sewer line sampling, the purpose of collecting samples along this line was to determine if any soil remediation was required. Copies of the analytical data packages for the soil samples collected from this AEC (along with the electronic data deliverables) are provided under separate cover as Attachment V.

4.1 Investigation Activities

A total of 18 soil borings were installed (one for every 15 linear feet of pipe) following the procedures discussed in Section 1.1 of this report. The locations of borings SL-32-1 through SL-32-18 are shown on Figure 22. Based on an inspection of one of the manholes, the invert of the sewer line was determined to be approximately 6.0 feet below grade. Therefore, most of the samples were collected from either 6.0 - 6.5 feet below grade (SL-32-1 through 5, 7, 8, and 17) or 6.5 - 7.0 feet below grade (SL-32-6 and 9 through 16). The sample from boring SL-32-18 was collected from 6.25 - 6.75 feet below grade. Each sample was analyzed for VOC+10 and BNA+25 (including calibrations for 1,1'-biphenyl, diphenyl ether, benzoic acid, and salicylic acid).

The analytical results for these samples are summarized on Table 14 and are presented on Figure 25. The concentrations of targeted and nontargeted VOCs were below their respective IGWCC in all 18 samples. Benzene (0.15 ppm in SL-32-15), carbon disulfide (0.25 ppm in SL-32-5), and toluene (0.13 ppm to 7.78 ppm in 10 of the samples) were the only targeted VOCs detected in these samples. Targeted and nontargeted BNAs were also below their most restrictive cleanup criteria in 13 of the 18 samples. The polynuclear aromatic hydrocarbon (PAH) compounds benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and benzo(k)fluoranthene were found at concentrations exceeding their RDCCC and/or NRDCCC in samples SL-32-2, SL-32-3, and/or SL-32-7. These compounds are related to the fill material at the site and do not require further action. However, 1,1'-biphenyl, diphenyl ether, and phenol were also detected in three samples along this sewer line. In addition to the PAHs cited above, sample SL-32-2 also contained 12.1 ppm of 1,1'-biphenyl and 51.4 ppm of phenol; the NJDEP's IGWCC for phenol is 50.0 ppm. Phenol was also detected at 500 ppm in sample SL-32-5. Finally, 1,1'-biphenyl and diphenyl ether were detected in sample SL-32-18 at concentrations of 83.0 ppm and 259 ppm, respectively. Due to the proximity of sample SL-32-18 to the Hudson Street sewer line, the 1,1'-biphenyl and diphenyl ether found in this sample can be attributed to that line.

4.2 Remedial Actions

Based on the soil sampling results discussed above, only a limited volume of soil appeared to have been impacted by leaks from the former Building 32 sewer line. However, since the sewer line was known to be filled with sludge, it was decided that it should be removed to prevent the material inside the pipe from serving as a potential future source of contamination. The excavation of the Building 32 sewer line was conducted during the first week of June 2002.

With the exception of around SL-32-2 (12.1 ppm of 1,1'-biphenyl and 51.4 ppm of phenol) and SL-32-5 (500 ppm of phenol), no additional post-excavation sampling was required. The 83.0 ppm of 1,1'-biphenyl and 259 ppm of diphenyl ether detected in sample SL-32-18 were addressed as part of the Hudson Street sewer line excavation (see Section 5.3, below).

The soil covering the sewer line was first removed and staged for use as backfill material. Between borings SL-32-3 and SL-32-4, and SL-32-6 through SL-32-18, the sewer line was then removed, along with approximately 7.0 feet of soil. Between borings SL-32-1 and SL-32-3, and SL-32-4 and SL-32-6, the excavation extended to three feet below the pipe (or approximately 10 feet below grade) and 15 feet to the west. In order to minimize the volume of waste to be generated, the soil from above the sewer line in these expanded excavation areas was also staged for use as backfill material. Approximately 756 tons of soil were ultimately excavated and disposed off-site at Clean Earth of Philadelphia, Inc. Copies of the disposal documentation for the excavated soil are included in Appendix G.

Post-excavation samples were collected from the base (PX32-2 and PX-32-4) and western sidewall (PX-32-1 and PX32-3) of each excavation area, and analyzed for BNA+25 (including calibrations for 1,1'-biphenyl and diphenyl ether). The analytical results for the post-excavation samples PX32-1 through

PX32-4 are summarized on Table 15 and are presented on Figure 26. No detectable concentrations of BNAs were found in the PX32-1 and PX32-3 (the two sidewall samples). Low concentrations of PAHs were found in base samples PX32-2 and PX32-4, but none exceeded their respective RDCCC. No detectable concentrations of 1,1'-biphenyl or phenol were found in these samples.

The Building 32 sewer line excavation was backfilled with approximately 748 tons of certified clean fill material from Passaic Crushed Stone Co., Inc. in Pompton Lakes, New Jersey. Copies of the clean fill documentation are also included in Appendix G. Based on the findings of the post-excavation sample results, and since boring location SL-32-18 was addressed as part of the Hudson Street sewer line excavation, EPI proposes no further action relative to the former Building 32 sewer line.

5.0 HUDSON STREET SEWER LINE (AEC-35)

The Hudson Street sewer line was approximately 330 feet long and ran from near former Building 22 to the southwest corner of the site (near MW-14). The approximate location of this line is shown on Figure 2. The eastern half to two thirds of the sewer line was removed in late 1997 or early 1998, but no post-excavation samples were ever collected.

On 11 March 2002, stained soils and strong odors were encountered while excavating the former process waste sewer line in the southwest corner of the site. On 14 March 2002, one soil sample was collected from immediately below the sewer pipe (HS-1A; 7.0 - 7.5 feet below grade), and a second sample was collected for vertical delineation purposes (HS-1B; 8.5 - 9.0 feet below grade). Each sample was analyzed for TPH, PPM, VOC+10, and BNA+25 (included calibrations for 1,1'-biphenyl, diphenyl ether, salicylic acid, and methyl salicylate). The location of samples HS-1A and HS-1B are shown on Figure 22. The analytical results for these samples are summarized on Table 16 and are presented on Figure 27.

The concentrations of TPH, PPM, and targeted VOCs were below their respective remediation criteria in both soil samples. Nontargeted VOCs (primarily cycloalkanes/alkenes) were detected in sample HS-1A at a concentration of 1,714 ppm, which exceeds the NJDEP's remediation criterion of 1,000 ppm for total VOCs in soil. In the deeper sample, nontargeted VOCs were detected at a total concentration of 123 ppm. In the BNA analyses, 1,1'-biphenyl and diphenyl ether were detected in sample HS-1A at 2,730 ppm and 6,220 ppm, respectively, which exceed their site specific, Impact to Groundwater remediation criteria of 12.0 ppm and 19.0 ppm. In sample HS-1B, 1,1'-biphenyl and diphenyl ether were detected at 651 ppm and 3,350 ppm, respectively. Although no other targeted BNAs were detected in HS-1A or HS-1B at concentrations exceeding their respective remediation criteria, the total concentration of targeted BNAs (8,992 ppm) and nontargeted BNAs (4,025 ppm) in HS-1A exceeded the NJDEP's general remediation criterion of 10,000 ppm for total organic compounds in soil.

Given the concentrations of 1,1'-biphenyl and diphenyl ether that were detected in the soil samples below the sewer line, and since elevated concentrations of these compounds had also been detected in groundwater in several wells along the southern property line, EPI determined that the remaining portions of the Hudson Street sewer line needed to be removed. The following Sections discuss the two phase of soil sampling conducted along the Hudson Street sewer line, and subsequent remedial actions. Copies of the analytical data packages for the soil samples collected from this AEC (along with the electronic data deliverables) are provided under separate cover as Attachment VI.

5.1 Phase I Soil Samples

Based on the poor condition of the sewer pipe and the results from soil samples HS-1A and HS-1B, the investigation of the sewer line proceeded under the assumption that contaminated soil would be found beneath most (if not all) of the sewer line. Since EPI had already decided that the sewer line was to be removed, soil samples were collected for the purposes of defining the vertical extent of the contamination, rather than to characterize soil quality to determine the integrity of the sewer. These "pre-excavation" results would then be used to document that a sufficient amount of soil had been excavated during the removal of the sewer line. Soil samples were also collected to the north and south of the sewer line for the purposes of defining the horizontal extent of the future excavation.

On 4 & 8 April 2002, a total of 21 soil borings (SL-HS-1, 1N, 2, 3N, 4, 5, 5N, 5S, 6, 7, 7N, 7S, 8, 9, 9N, 9S, 10, 11, 11N, 11S, and 12) were installed and sampled along the Hudson Street sewer line (see Figure 22). Since soil from two feet below the sewer line was already known to be impacted, samples were collected from three to four feet below the line (10.5 - 11.0 feet below grade). Due to the slight pitch of the line, sample depths were consistent when moving along the sewer line from east to west. Samples for horizontal delineation (SL-HS-1N, 3N, 5N, 5S, 7N, 7S, 9N, 9S, 11N, and 11S) were collected from a depth equivalent to the six inch interval immediately below the sewer line (generally 7.0 - 7.5 feet below grade). Due to the proximity of the sewer to the southern property line, borings SL-HS-1S and SL-HS-3S would have been located off-site and were therefore not installed. As discussed below, this data gap was addressed during the second round of sampling (se Section 5.2). Based on the results from samples HS-1A and HS-1B, each sample was analyzed for VOC+10 by USEPA Method 8260 and BNA+25 by USEPA Method 8270 (including calibrations for 1,1'-biphenyl, diphenyl ether, benzoic acid, and salicylic acid).

The analytical results for the soil samples collected along the Hudson Street sewer line are summarized on Table 16 and are presented on Figure 27. Benzene and toluene were the only targeted VOCs detected in the Phase I soil samples. Benzene was detected at 0.18 ppm in sample SL-HS-11; the NJDEP's IGWCC for benzene is 1.0 ppm. Toluene was detected in sample SL-HS-10 (6.26 ppm) and sample SL-HS-11N (6.37 ppm); the IGWCC for toluene is 500 ppm. Nontargeted VOCs were found in samples SL-HS-5, SL-HS-7, SL-HS-7N, SL-HS-8, SL-HS-11, and SL-HS-12 at total concentrations ranging from 15.3 ppm to 120 ppm. The NJDEP's generic remediation criterion for total VOCs in soil is 1,000 ppm.

The concentrations of individual targeted BNAs were below their most restrictive cleanup criteria in 16 of the 21 samples collected. 1,1'-Biphenyl was detected at concentrations exceeding its site specific IGWCC of 12.0 ppm in samples SL-HS-5 (259 ppm), SL-HS-7 (605 ppm), SL-HS-10 (355 ppm), and SL-HS-12 (254 ppm). Diphenyl ether was detected at concentrations exceeding its site specific IGWCC of 19.0 ppm in samples SL-HS-4 (37.6 ppm), SL-HS-5 (901 ppm), SL-HS-7 (1,780 ppm), SL-HS-10 (1,040 ppm), and SL-HS-12 (713 ppm). Each sample was collected from 10.5 - 11.0 feet below grade. In borings SL-HS-4 and SL-HS-5, the soil at 10.5 - 11.0 feet below grade was comprised of a well graded, fine to medium grained sand. In boring SL-HS-7, the soil at 10.5 - 11.0 feet below grade consisted of a poorly graded sand with some silt. The soil at depth in borings SL-HS-10 and SL-HS-12 consisted of silty/clayey sand and silty sand, respectively.

5.2 Phase II Soil Samples

Although none of the soil samples collected to the north and south of the Hudson Street sewer line (at 7.0 to 8.0 feet below grade) contained VOCs or BNAs at concentrations exceeding their most restrictive soil remediation criteria, additional soil samples needed to be collected to complete the vertical and horizontal delineation of the 1,1'-biphenyl and diphenyl ether present at 10.5 - 11.0 feet below grade at locations SL-HS-4, SL-HS-5, SL-HS-7, SL-HS-10, and SL-HS-12. In addition, soil samples needed to be collected along the fence line near locations SL-HS-1S and SL-HS-3S to close the data gap in the southwest corner of the site.

The following Phase II soil samples were collected from along the Hudson Street sewer line on 11 & 12 July 2002.

Sample ID	Depth (feet)
SL-HS-1S	7.0 - 7.5
SL-HS-3S	7.0 - 7.5
SL-HS-4	11.5 - 12.0
SL-HS-4N	10.5 - 11.0
SL-HS-4S	10.5 - 11.0
SL-HS-5	11.5 - 12.0
	12.5 - 13.0
SL-HS-5N	10.5 - 11.0
SL-HS-5S	10.5 - 11.0
SL-HS-7	11.5 - 12.0
SL-HS-7N	10.5 - 11.0
SL-HS-7S	10.5 - 11.0
SL-HS-10	11.5 - 12.0
SL-HS-10N	10.5 - 11.0
SL-HS-10S	10.5 - 11.0
SL-HS-12	11.5 - 12.0
SL-HS-12N	10.5 - 11.0
SL-HS-12S	10.5 - 11.0

Based on the results of the initial characterization soil sampling, each sample was only analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270.

The analytical results for the Phase II soil samples collected along the Hudson Street sewer line are also summarized on Table 16 and are presented on Figure 27. The concentrations of 1,1'-biphenyl and diphenyl ether in soil were below the site specific IGWCC 12.0 ppm and 19.0 ppm, respectively, in all of the horizontal and vertical delineation samples except SL-HS-12S. The 10.5 - 11.0 feet sample from boring SL-HS-12S (located approximately 5.0 feet to the south of the eastern end of the sewer line) contained 14.0 ppm of 1,1'-biphenyl and 37.4 ppm of diphenyl ether. The final horizontal delineation of this location was completed through post-excavation sampling.

5.3 Remedial Actions

Based upon the results of the soil sampling discussed above, EPI elected to excavate the remains of the former sewer line and the soil beneath the line that contained 1,1'-biphenyl and diphenyl ether at concentrations exceeding their respective site specific Impact to Groundwater Criteria of 12.0 ppm and 19.0 ppm. The activities associated with implementing the selected remediation program for the Hudson Street sewer line were conducted between 17 September 2002 and 19 November 2002, and included 1) excavating and disposing of approximately 1,312 tons of non-hazardous soil; 2) removing and disposing of 30 gallons of contaminated water; 3) collecting post-excavation soil samples; 4) backfilling the excavation with approximately 1,282 tons of certified clean stone materials; and, 5) restoring a portion of the excavation area with asphalt pavement. The following sections discuss these tasks in more detail.

5.3.1 *Limits of the Excavation*

On 17 September 2002; the defined remediation area was marked out and excavation activities commenced. The limits of the excavation were defined to the north and south of the sewer line by soil samples from borings SL-HS-1N, 1S, 3N, 3S, 4N, 4S, 5N, 5S, 7N, 7S, 9N, 9S, 10N, 10S, 11N, 11S, 12N, and 12S, to the east by a manhole located at the end of the sewer line (the approximate location of SL-HS-12), and to the west by a concrete railroad bollard in the southwest corner of the site (see Figure 28). Due to their proximity to the sewer line, it was necessary to abandon monitoring well MW-14, two of Geraghty & Miller's old soil vapor extraction pilot test wells (SVE-2 and SVE-5), and two of the vapor monitoring points for the air curtain (VMP-2 and VMP-5). The locations of these wells and points are shown on Figure 28. Copies of the abandonment forms for these wells and points are included in Appendix H. Although air curtain wells ACW-11 and ACW-12 were located along the northern sidewall of the excavation, each well was able to be preserved and was not damaged during the removal of the sewer line.

5.3.2 *Soil Excavation and Disposal*

On 17 September 2002, EPI's excavation contractor (F. Di Girolamo & Son Inc. of Wayne, New Jersey), under the supervision of a Sovereign engineer, began excavation activities at the extreme southwestern end of the former sewer line utilizing a Caterpillar 225 BLC Excavator with a 1.75 cubic yard bucket. The top 5.0 feet of soil from above the sewer line consisted of fill material (i.e., clay, silt, sand, gravel, brick fragments, cinders, and concrete rubble). Clean soils were set aside and later re-used within the same excavation cell. Any concrete or debris was segregated for off-site disposal. The soil excavated from along the sewer line was placed into a dump truck and transported to a temporary staging area in a secure portion of the site pending off-site disposal.

Based upon visual observations of the soil below the sewer line (predominantly sand and silt), Di Girolamo determined the appropriate sloping and benching requirements to minimize the potential for cave-ins. When the excavation reached approximately 11.5 - 12.0 feet below grade adjacent to the southwest corner of Building 16, an undetermined volume of oil entered the trench from beneath the building. Sovereign collected samples of the product and determined in the field that the material was heavier than water. It appears that this product could possibly have come from a small section of pipe that connected a bathroom in Building 16 to the Hudson Street sewer line. Based upon information from Figure J-1 of Geraghty & Miller's December 1993 *ECRA Investigation Report and Proposed Remedial Action Plan*, this line had been plugged at the junction with the Hudson Street line in February 1981.

A sample of the apparent dense non-aqueous phase liquid (DNAPL) was analyzed by Accutest for VOC+10 by USEPA Method 8260, BNA+25 by USEPA Method 8270, and density. The analytical results for this sample are summarized on Table 17. The Building 16 DNAPL has a density of 1.11 g/ml, and was found to contain 288,000 ppm of 1,1'-biphenyl (approximately 30% of the total concentration) and 612,000 ppm of diphenyl ether (approximately 64% of the total concentration), which is consistent with the composition of Dowtherm. The remaining 6% of the sample was composed primarily of toluene

(0.36%), nontargeted VOCs (2.9%) and nontargeted BNAs (2.0%). No chlorinated compounds were found in the DNAPL sample.

Due to the instability of the sidewalls, it was not feasible to leave the excavation open. Therefore, a temporary sump consisting of 5.0 feet of 2.0-inch diameter 20-slot well screen and 10 feet of PVC casing was installed in the area where the DNAPL entered the excavation; the screened interval was surrounded by crushed stone, with the remainder of the excavation filled with quarry process material.

On 18 September 2002, a vacuum truck from EISCO-NJ was mobilized to the site to begin total fluids extraction from the sump. Prior to beginning the total fluids extraction, the sump was gauged and found to contain approximately two feet of water, but no measurable amounts of either light non-aqueous phase liquid (LNAPL) or DNAPL. After two extraction periods totaling 2.5 hours, approximately 30.0 gallons of water (but no measurable amounts of product) were recovered. The recovered liquid was transferred to a drum and staged on site pending off-site disposal at Cyclechem, Inc. in Elizabeth, NJ. A separate manifest for this liquid does not exist, as it was ultimately disposed of with the purge water from the October 2002 groundwater sampling event.

On 20 September 2002, the sewer line excavation reached the Water Utility Building located along the southern property line (see Figure 28). For health and safety reasons, it was decided not to re-excavate soil from in front of this building due to 1) the proximity of the water lines located within the building; 2) the instability of the soils matrix; and, 3) no as-built foundation drawings were available for the building to assure safe removal of the soil. EPI does not believe that this small section of soil needs to be excavated since the sewer pipe had previously been removed during the initial work conducted in late 1997, and since the analytical results from soil samples SL-HS-9, 9N, and 9S (collected near the west side of the building) indicate that the concentrations of 1,1'-biphenyl and diphenyl ether were below their most stringent remediation criteria.

On 24 September 2002, the sump near Building 16 was removed and a 10' x 15' area was excavated an additional 3.0 feet in depth (to approximately 15.0 feet below grade) in the vicinity of where the DNAPL entered the trench. During the removal of the sump, it was observed that the materials used to backfill the initial excavation on 17 September 2002 from below the water table appeared to be stained.

However, the soils excavated from approximately 12.0 to 15.0 feet below grade on 24 September 2002 did not appear to be stained. Since the excavation extended several feet below the water table, it was not possible to visually inspect the soils remaining in place.

All excavation activities were completed on 24 September 2002. After receiving approval from the disposal facility, the excavated soil was transported from the site between 18 and 22 November 2002. Approximately 1,312 tons of soil were ultimately shipped off-site for disposal (recycling) at Clean Earth of Philadelphia, Inc. Copies of the disposal documentation for the excavated soil are included in Appendix I.

5.3.3 *Post-Excavation Sampling Results*

The vertical and horizontal limits of the excavation were primarily defined by the soil samples collected between April and July 2002 as part of the characterization of this AEC. However, three post-excavation sidewall samples were required to be collected to document that the limits of the 1,1'-biphenyl and diphenyl ether in soil had been defined. Sample SL-HS-12SA was collected approximately 5.0 feet south of soil boring SL-HS-12S at a depth of 10.5 - 11.0 feet below grade. Sample SL-HS-13 was collected from the end wall of the excavation, approximately 10.0 feet to the east of SL-HS-12; the sample from this location was collected from 10.5 - 11.0 feet below grade. Sample SL-HS-7A was collected near the point where the Building 32 sewer line joined the Hudson Street sewer line. SL-HS-7A was collected from 7.0 - 7.5 feet below grade to document that the 1,1'-biphenyl and diphenyl ether that had been detected in sample SL-32-18 had been remediated.

Each post-excavation sample was analyzed for 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. The analytical results for these samples are summarized on Table 18 and are presented on Figure 29. No detectable concentrations of 1,1'-biphenyl and diphenyl ether were found in samples SL-HS-12SA and SL-HS-13, while only a trace amount (0.06 ppm) of diphenyl ether was found in sample SL-HS-7A. These results indicate that the excavation activities were successful in remediating the compounds of concern present in samples SL-HS-12, SL-HS-12S, and SL-32-18.

In order to document the concentrations of 1,1'-biphenyl and diphenyl ether that remained at the base of the excavation near the southwest corner of Building 16, one post-excavation sample (SL-HS-2A) was collected and analyzed for base neutral compounds plus an NBS library search (BNC+15; USEPA Method 8270). The analytical results for this sample are also summarized on Table 16 and presented on Figure 29. Sample SL-HS-2A contained 549 ppm of 1,1'-biphenyl and 1,270 ppm of diphenyl ether, both of which exceed their Impact to Groundwater soil remediation criteria of 12.0 ppm and 19.0 ppm, respectively.

5.3.4 *Backfilling and Surface Restoration*

The approximate 4,100 square foot excavation was backfilled using approximately 1,282 tons of certified clean quarry process material (see Appendix I for documentation) and the top 5.0 feet of soil from above the sewer line. The backfill was placed in lifts in a cell like manner and compacted with the Caterpillar 225 BLC Excavator bucket. In order to assure adequate compaction, 3/4-inch crushed stone was placed near the water table and ground surface. In the area of the soil vapor extraction system in the southeast corner of the site, the surface of the excavation was restored with 4.0-inch thick asphalt pavement. All other disturbed areas were re-graded with quarry process stone. Grading activities for the site were completed on 8 November 2002.

5.3.5 *Replacement Wells*

Monitoring well MW-14 was located in the southwest corner of the site, near the corner of Hudson Street and River Drive. Given its proximity to the former sewer line, MW-14 was abandoned prior to starting excavation activities. Due to the need to continue monitoring the concentrations of benzene, toluene, 1,1'-biphenyl and diphenyl ether in groundwater in the southwest corner of the site, EPI installed replacement well MW-14R approximately seven feet from the location of MW-14 on 17 October 2002.

Monitoring well MW-14R was installed using a hollow-stem auger drill rig operated by a licensed New Jersey well driller (Summit Drilling Co., Inc.). Since MW-14R was installed through the fill material of the Hudson Street sewer line excavation, only a limited number of split spoon samples were collected to characterize native soil at the bottom of the borehole. In order to be consistent with the construction of MW-14, replacement well MW-14R is 18.0 feet deep, and is constructed with 15.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 3.0 feet of PVC casing. The annulus around the well screen was filled with No. 2 Morie sand to two feet above the top of the screened interval. The remainder of the borehole was then sealed with a cement/bentonite grout to grade, and the well head was completed with a locking steel standpipe. Well construction details are shown on the boring log in Appendix J.

The first 14.0 feet of soil at the location of MW-14R consisted of the quarry process fill material used to backfill the sewer line excavation. Silt containing a little fine sand and trace amounts of clay was encountered at 14.0 feet, and continued to the completion depth of the boring at 18.0 feet below grade. Groundwater was first encountered at approximately 10.0 feet below grade; no VOC readings could be recorded due to a malfunctioning PID.

The location and elevation of MW-14R was measured by a New Jersey Licensed Professional Land Surveyor. The latitude and longitude were measured to the nearest one-tenth (0.10) of a second, and its elevation was measured to the nearest one-hundredth (0.01) of a foot. Certification Form A (As-Built) and B (Location Certification) for MW-14R are also included in Appendix J.

Replacements for vapor monitoring points VMP-2 and VMP-5 are scheduled to be installed in Spring 2003, after allowing sufficient time for the fill material within the excavation to settle.

5.3.6 *Conclusions*

The post-excavation results indicate that with the exception of near the southwest corner of Building 16, the levels of 1,1-biphenyl and diphenyl ether along the Hudson Street sewer line have been remediated to below their site specific Impact to Groundwater Cleanup criteria. Therefore, EPI requests that No Further Action be required relative to soil in AEC-35. EPI will be conducting a soil boring program to determine the extent of the impacted soil that resulted from the Dowtherm entering the excavation from the pipe beneath Building 16. This new area of environmental concern will be designated AEC-36.

State of New Jersey
Department of Environmental Protection

James E. McGreevey
Governor

Bradley M. Campb
Commissioner

JAN 15 2003

Bruce C. Amig
Goodrich Corporation
Four Coliseum Centre
2730 West Tyvola Rd
Charlotte, NC 28217

Re: Administrative Consent Order (ACO) In The Matter of
Former Kalama Chemical Facility
Ordered Party: El Paso Corporation (EPI)
290 River Drive, Garfield City, Bergen County
ISRA Case #E86B73
Remedial Investigation Report (RIR) Dated October 24, 2002

Dear Mr. Amig:

The New Jersey Department of Environmental Protection (NJDEP) has reviewed the referenced RIR and has the following comments:

1. The proposed well locations and construction of MW-21D, MW-51D and MW-62 are conditionally acceptable. Deeper zone monitoring wells shall also be installed at the following two locations:

- Northern Phenol Area; in the vicinity of existing well MW-57D and proposed well MW-51D, to be screened as a D2 zoned well from 45 to 50 feet bgs,

- Benzoic Acid/Benzaldehyde Plant and Toluene Area; to be paired with existing well MW-8 as a deep overburden monitoring well and possible deeper D2 zone well if additional vertical delineation is necessary.

2. The seven new installed monitoring wells are acceptable. Proposed overburden wells MW-60 and MW-61 at the corner of Hudson and Cambridge Street reportedly were installed and sampled.

3. AS-12 and MW-9 both contain free phase product and are located approximately 100 feet apart. The operation of the air sparge (AS) system, soil vapor extraction (SVE) and air curtain shall be suspended within the distance of 100-feet radially from site wells AS-12 and MW-9 due to the DNAPL. The proposed excavation of an area confined 90 feet by 90 feet around AS-12 shall increase in a northern direction to include well MW-9.

4. EPI shall submit a Remedial Action Workplan for both the Northern Phenol Area (Phenol and Salicylic Acid) and dense non aqueous phase liquid (DNAPL) in the southeast portion of site monitoring wells AS-12 and MW-9.

5. Based on the additional installed wells, EPI shall revise the vertical plume depth of the classification exception area (CEA). The CEA information shall include all contaminants exceeding the applicable ground water quality criteria (GWQC). EPI shall revise the enclosed CEA Fact Sheet.

6. Trichloroethylene (TCE) in ground water is present primarily in the eastern site well. The highest TCE concentrations were 803 ppb in deep overburden western ("background") well MW-35D and 286 ppb in shallow overburden southern (down gradient) well OW-1. EPI shall conduct a background study to address the potential off-site source. The background study shall include the potential for on-site downward migration of the contaminant due to documented ground water elevation mounding in the eastern portio

eastern ground water flow component. The locations of the background well(s) shall be far enough away from the site seasonal influences.

7. EPI shall clarify the amount of product removed on 9/25/02 which was recorded to be 4.0 gallons versus 0.4 gallons, because the recorded DNAPL thickness and historic daily product removal does not appear to be accurately reflect the amount removed.

8. The borings installed July 12, 2002 (TWP-6 and TWP-7) shall be shown on the site map.

9. Electronic Data Submittal (EDS).

The electronic data submission is not acceptable. There are several data errors in the submission. The diskette will be returned under separate cover. Please correct the errors and resubmit the diskette.

10. Analytical Data QA/QC.

The data are acceptable.

If you have any questions regarding this letter, please do not hesitate to contact the case manager, Andrew Dillman at (609) 633-1447.

Sincerely,

Michael Buriani

Michael Buriani, Supervisor
Bureau of Environmental Evaluation,
Cleanup and Responsibility Assessment

enclosure

c: Kris Geller, NJDEP
David Haymes, NJDEP
David Morrow, NJDEP
Roger Towe, El Paso Corp.
Ravi Gupta, Sovereign Consulting
Garfield Health Dept.
Mid-Bergen Regional Health Comm.

This shell can be sent to the regulated community to assist them in preparing a CEA\WRA. When a CM establishes the CEA they must generate the CEA fact sheet from the CEA database.

CLASSIFICATION EXCEPTION AREA
AND
WELL RESTRICTION AREA
FACT SHEET

Site Name: **DATE:**
Location: (Include Address Municipality and County):
Block(s) : **Lot(s):**

See Exhibit A (Site Location Map)

Block(s) and Lot(s) of off site properties within the CEA (if any):

Site Contact Person:
Address:
Phone Number:

Case Number:Site Identification # (if applicable - i.e. ISRA or UST Case #, NJPDES permit #, etc.)

DEP Lead Program (Include Phone Number):

DEP (Remedial Action Workplan, No Further Action, or other) Approval Document dated:

DESCRIPTION OF CEA

1) Identification of impacted aquifer

Pursuant to N.J.A.C. 7:9-6.5, this area is presently designated as Class II-A. The primary designated use for Class II-A ground water is potable water; secondary uses include agricultural and industrial water. Any proposed ground water use within the CEA will require NJDEP review for feasibility of well installation and modifications that would be protective of any impacts from these contaminants for the duration of the CEA.

2) Contaminants of Concern

This CEA/WRA applies only to the contaminants listed in the table below. The ground water quality criteria/ primary drinking water maximum contaminant levels for these contaminants are listed in parts per billion (ppb). All constituent standards (N.J.A.C. 7:9-6) apply at the designated boundary.

Contaminant	Max.* (ppb)	GWQC** (ppb)	MCL*** (ppb)	Duration (years)

* Maximum Concentration Detected at the time of CEA establishment
** Ground Water Quality Criteria
*** Safe Drinking Water Maximum Contaminant Level

3) CEA Boundary

Horizontal Boundary - See attached Exhibit B (CEA/WRA Location Map)

Vertical Boundary - Depth of CEA is ____________ feet.
Comments:

DURATION OF CEA: ____________ years, based upon the maximum duration in the above table.

Note: Since groundwater quality data indicates exceedance of contaminants above the Maximum Contaminant Levels of the Primary Drinking Water Standards, and the designated uses of Class IIA aquifers include potable use, the CEA established for this site is also a Well Restriction Area. The extent of Well Restriction Area shall coincide with the boundaries of the CEA.

WELL RESTRICTIONS:

With the exception of monitoring wells installed into the first water bearing zone, any proposed wells to be installed within the CEA/WRA boundary shall be double cased into the appropriate confining layer in order to prevent any vertical contaminant migration pathways. Any proposed production wells in the immediate vicinity of the CEA/WRA should be pre-evaluated to determine if pumping from these wells would draw a portion of the contaminant plume into the cone of influence of the production wells or alter the configuration of the contaminant plume.

SITE IS____\IS NOT_____ WITHIN AN ACTUAL POTABLE USE AREA.

SOVEREIGN CONSULTING INC.

RECEIVED
DEC 23 2002

19 December 2002

Mr. Andrew Dillman
New Jersey Department of Environmental Protection
Bureau of Environmental Evaluation Cleanup & Responsibility Assessment
Division of Responsible Party Site Remediation
401 E. State Street, 5th Floor
P.O. Box 432
Trenton, New Jersey 08625-0432

RE: **Kalama Chemical Inc. Facility**
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

CERTIFIED MAIL - RETURN RECEIPT REQUESTED

Dear Mr. Dillman:

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this response to the New Jersey Department of Environmental Protection's (NJDEP's) letter dated 9 December 2002, which provided comments on EPI's 4 September 2002 *Remedial Action Progress Report for the January and April 2002 Groundwater Sampling Events*, and on the Schedule of Activities included with the 22 November 2002 correspondence. This letter has been formatted to match the structure of the NJDEP's letter.

1. The NJDEP acknowledged that EPI proposed to investigate the presence of dense non-aqueous phase liquids (DNAPLs) that had been found in air sparge well AS-12 and in the vicinity of monitoring well MW-51.

   EPI Response

   The investigation into the distribution DNAPL around AS-12 and MW-51 is on-going. The preliminary results of these investigations were submitted to the NJDEP in 24 October 2002 *Remedial Action Progress Report* [RAPR] *for the July 2002 Groundwater Sampling Event.*

2. The NJDEP is requesting clarification as to why monitoring wells WP-1R, WP-2R, and MW-21 were not included in the April 2002 groundwater sampling event.

EPI Response

WP-1R, WP-2R, and MW-21 were included in the April 2002 sampling event. The data for these wells can be found in the 4 September 2002 RAPR on Table 10, Figures 18, 21, 27, 28, and 29, and in Appendix D.

3. The NJDEP indicated that well logs and Certification Forms A & B needed to be submitted for monitoring wells MW-47D2, MW-57D, MW-58, MW-58D, MW-59, MW-59D, and WP-2D.

EPI Response

The information requested by the NJDEP was included in Appendix A of the 24 October 2002 RAPR.

4. The NJDEP is requiring that the source of the trichloroethene (TCE) detected in background monitoring well MW-35D be evaluated. In addition, the NJDEP is requiring that TCE be included as an analytical parameter in future quarterly groundwater sampling events.

EPI Response

Information on the distribution of TCE in groundwater around the site is not new, and it has been known since at least 1992 that the highest concentrations of TCE have been present in wells upgradient from the site. In response to the NJDEP's letter dated 6 September 1995, a detailed discussion on the source and distribution of chlorinated volatile organic compounds (VOCs) in groundwater was included in Section 3.3.2 of the 29 February 1996 *Revised Remedial Action Work Plan Addendum* (RAWA). Following their review of the Revised RAWA, the NJDEP indicated in their letter dated 30 August 1996 that "...Tenneco was not responsible for the chlorinated VOC contaminants present in groundwater".

Recent analytical results indicate that chlorinated VOCs are not present in the DNAPL in AS-12. In addition, TCE concentrations in MW-35D (located to the east of the site, not to the west as indicated in the NJDEP's 9 December 2002 letter) have decreased from 1,900 parts per billion (ppb) in September 1993 to 803 ppb in April 2002. In the 34 other wells in which historical data exists that can be compared to the April 2002 results, TCE concentrations either remained the same (i.e., not detected) or decreased from 47% to 100%. EPI believes that there has been no change in site conditions to warrant a new evaluation/investigation into the source of the TCE in groundwater around the site. In addition, EPI does not believe performing quarterly monitoring for TCE is necessary, and that the current monitoring program that calls for sampling wells at the site annually (in April) for VOCs by USEPA Method 624 is sufficient to monitor for the presence and distribution of TCE in groundwater.

5. The NJDEP included a copy of their letter dated 24 June 2002, which had been prepared in response to EPI's 17 April 2001 request for alternate groundwater quality standards for methyl salicylate, salicylic acid, 1,1'-biphenyl, and diphenyl ether.

   EPI Response

   EPI had received the NJDEP's 24 June 2002 letter; the statement in Section 1.1 of the 4 September 2002 RAPR was an error. However, the NJDEP's 24 June 2002 correspondence provided only a partial response to EPI's 17 April 2001 letter that had proposed site specific remediation criteria for methyl salicylate, salicylic acid, 1,1'-biphenyl, and diphenyl ether in soil and groundwater. EPI is confused by the Interim Groundwater Quality Criteria included in the NJDEP's letter, and by the calculations used to develop the soil cleanup criteria. EPI is in the process of preparing a separate response to the NJDEP's 24 June 2002 letter that will outline their questions and concerns with regard to the assumptions and technical basis used by the Department in developing the alternate soil and groundwater criteria.

6. The NJDEP is requiring EPI to initiate product recovery from wells that exhibit free product.

   EPI Response

   EPI agrees to this requirement. Between 7 August 2002 and 10 December 2002, approximately 26.0 gallons of DNAPL have been recovered from AS-12 through weekly pump-outs. The floating separate phase hydrocarbons (SPH) present in MW-9 (highly weathered fuel oil) can no longer be practically recovered via pumping or bailing due to its tar-like consistency. EPI's proposal to address the SPH in MW-9 will be included in the up-coming Remedial Investigation Report on the smear zone and SPH delineation soil sampling that was conducted in September 2002.

Laboratory Analytical Data QA/QC

No response necessary.

Electronic Data Submittal (EDS)

The NJDEP indicated that the EDS diskette was not acceptable. EPI will amend the data on the diskette once it has been received from the NJDEP.

Remedial Schedule

No response necessary.

If you should have any questions or require additional information, please feel free to contact me at (609) 259-8200 or Mr. Roger Towe of El Paso Corporation (EPC) at (713) 420-4755.

Sincerely,
Sovereign Consulting Inc.

Paul I. Lazaar
Principal Project Manager

c: Project File
R. Towe, EPC
B. Amig, Goodrich Corp.
R. Smith, Belkorp

State of New Jersey
Department of Environmental Protection

James E. McGreevey
Governor

Bradley M. Campbell
Commissioner

Bruce C. Amig
Goodrich Corporation
Four Coliseum Centre
2730 West Tyvola Rd
Charlotte, NC 28217

DEC 09 2002

Re: Administrative Consent Order (ACO) In The Matter of
Former Kalama Chemical Facility
Ordered Party: El Paso Corporation (EPI)
290 River Drive, Garfield City, Bergen County
ISRA Case #E86B73

1) Remedial Investigation Report (RIR) sent via cover letter dated September 4, 2002 for the January 2002 and April 2002 ground water sample collection events.
2) Remedial Schedule dated November 22, 2002.

Dear Mr. Amig:

The New Jersey Department of Environmental Protection (NJDEP) has reviewed the referenced RIR and has the following comments:

In August 2001, all of the remediation systems at the site were shut down in response to the NJDEP's August 6, 2001 letter. Due to low ground water levels, EPI requested permission to re-start the soil vapor extraction (SVE) system in the southeast corner of the site in November 2001. The off-site SVE system and the air curtain were re-started on March 5, 2002, following the construction of a new equipment building to replace the one that had been located in Building 32-B.

NJDEP COMMENTS:

1. EPI proposes to investigate the dense non aqueous phase liquid (DNAPL) in soil identified at well AS-12, and methyl salicylic next to well MW-51. This is acceptable.

2. EPI shall clarify why the Northwest Phenol Hot Spot monitoring wells WP-2R, WP-1R, and MW-21 were not sampled during the April 6-19, 2002 sampling event.

3. The A and B well certification forms and well logs for the April 2002 installed monitoring wells MW-47D2, MW-57D, MW-58, MW-58D, MW-59, MW-59D, and WP-2D shall be submitted.

4. The TCE concentration during the April 2002 sampling event has been identified above the GWQS in primarily deep wells and "background" western site wells. The highest TCE concentration at 803 ppb was identified at western well MW-35D. The source for the TCE contamination, which appears to be in the general vicinity and offsite area of the Benzoic Acid/Benzaldehyde Plant and Toluene Area, shall be evaluated. TCE analysis shall be added as a quarterly sampling parameter.

5. EPI states that the NJDEP has not responded to EPI's request to establish alternate ground water quality standards for methyl salicylate, salicylic acid, 1,1'-biphenyl, and diphenyl ether.

The NJDEP responded to EPI's request in the letter dated June 24, 2002. A copy is enclosed for reference.

6. EPI shall initiate product recovery from wells that exhibit free product.

Laboratory Analytical Data QA/QC.

The formaldehyde data for the January 2002 ground water sampling is qualified since the samples were preserved with sulfuric acid.

The remaining data are acceptable.

Electronic Data Submittal (EDS).

The electronic data submission on disk is not acceptable. The submission dates for each sampling event must not be the same. Additionally, each submission must have a unique SRPID and Directory combination in the DTST (dataset) file. The disks will be returned under separate cover.

Remedial Schedule.

The NJDEP has reviewed the proposed schedule, under cover letter dated November 22, 2002, for the proposed remedial activities at the above referenced Industrial Establishment. Based on that review, the proposed schedule is acceptable. Therefore, according to that schedule, the next document is due on January 17, 2003.

If you have any questions regarding this letter, please do not hesitate to contact the case manager at (609) 633-1447.

Sincerely,

Michael Buriani

Michael Buriani, Supervisor
Bureau of Environmental Evaluation,
Cleanup and Responsibility Assessment

enclosure

c: Kris Geller, NJDEP
David Haymes, NJDEP
David Morrow, NJDEP
Roger Towe, El Paso Corp.
Ravi Gupta, Sovereign Consulting
Garfield Health Dept.

State of New Jersey
Department of Environmental Protection

James E. McGreevey
Governor

Bradley M. Campb
Commissioner

Bruce C. Amig
Goodrich Corporation
Four Coliseum Centre
2730 West Tyvola Rd
Charlotte, NC 28217

JUN 24 2002

Re: Administrative Consent Order (ACO) In The Matter of
Former Kalama Chemical Facility
Ordered Party: El Paso Corporation (EPI)
290 River Drive, Garfield City, Bergen County
ISRA Case #E86B73
Remedial Investigation Reports (RIR) Dated: April 17, 2001 – Request for Alternate Soil & Ground Water Criteria.

Dear Mr. Amig:

The New Jersey Department of Environmental Protection (NJDEP) has completed its review of the above referenced document and has the following comments:

The NJDEP calculates the impact to ground water (IGW) criteria for salicylic acid at 0.134 ppm, and methyl salicylate at 30 ppm. Both the residential and non-residential direct contact cleanup criteria for methyl salicylate are the semi volatile cap value of 10,000 ppm.

Impact to Ground Water SCC.

Both salicylate acid and methyl salicylate are semi volatile compounds. As such IGW criteria were developed using the simple partitioning model, with compound specific Kocs and Henry's Law Constants, and default New Jersey values for other parameters, The GWQS used to develop the IGW were 80 ppb for salicylic acid and 3500 ppb for methyl salicylate.

Methyl Salicylate Direct Contact SCC.

Using the Rfd of 0.5 mg/kg/day, ingestion pathway criteria were calculated using standard assumptions. The calculated RDCSCC is 39,100 ppm. The calculated NRDSCC is 511,000 ppm. However, both values default to the NJDEP semi volatile cap value of 10,000 ppm.

Direct contact criteria based on the inhalation pathway were not calculated since there is not data on Rfcs for these compounds. An OSHA (8 hr) value exists for salicylic acid but no Rfc. There is no data on methyl salicylate.

TABLE 1

Summary of site contaminant Cleanup Criteria for the former Kalama Chemical site.

	RDCSCC	NRDCSCC	IGWSCC	GWQC
Salicylic Acid	980	10,000	0.134	0.080
Methyl Salicylate	10,000	10,000	30	4.0
1,1' – Biphenyl	3,900	10,000	12	0.4
Diphenyl Ether	390	5,100	19	0.1
Formaldehyde	1,173	15,330	4.26	0.100
Formaldehyde - Inhalation	15.5	26	——	——

All Criteria are in parts per million (ppm)
RDCSCC = Residential Direct Contact Soil Cleanup Criteria
NRDCSCC = Non Residential Direct Contact Soil Cleanup Criteria
IGWSCC = Impact to Ground Water Soil Cleanup Criteria
GWQC = Ground Water Quality Criteria

If you have any questions, please contact the Case Manager, Andrew Dillman, at (609) 633-1447.

Sincerely,

Andrew Dillman for

Maurice Migliarino, Section Chief
Bureau of Environmental Evaluation,
Cleanup and Responsibility Assessment

enclosure

c: Kris Geller, NJDEP
David Haymes, NJDEP
David Morrow, NJDEP
Roger Towe, El Paso Energy Corp.
Ravi Gupta, Sovereign Consulting
Garfield Health Dept.

SOVEREIGN CONSULTING INC.

24 October 2002

Mr. Andrew Dillman
New Jersey Department of Environmental Protection
Bureau of Environmental Evaluation Cleanup & Responsibility Assessment
Division of Responsible Party Site Remediation
401 E. State Street, 5th Floor
P.O. Box 432
Trenton, New Jersey 08625-0432

RE: Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

Hand Delivered

Dear Mr. Dillman:

Attached please find an original and two copies of the *Remedial Action Progress Report* for the July 2002 groundwater sampling event conducted at the above referenced site. This report has been prepared by Sovereign Consulting Inc. (Sovereign) on behalf of EPEC Polymers Inc. (EPI). In addition, one copy of Attachments I , II, and III (Analytical Data Packages) and three computer diskettes containing the required electronic data deliverables are also being provided.

If you should have any questions or require additional information, please feel free to contact me at (609) 259-8200 or Mr. Roger Towe of El Paso Corporation (EPC) at (713) 420-4755.

Sincerely,
Sovereign Consulting Inc.

Paul I. Lazaar
Principal Project Manager

c: Project File
R. Towe, EPC
B. Amig, Goodrich Corp.
R. Smith, Belkorp Industries

111-A N. Gold Drive • Robbinsville, NJ 08691 • Tel: 609-259-8200 • Fax: 609-259-8288

SOVEREIGN CONSULTING INC.

Remedial Action Progress Report for the July 2002 Groundwater Sampling Event

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

24 October 2002

Prepared For:

EPEC Polymers, Inc.
1001 Louisiana Street
Houston, Texas 77002

Prepared By:

Sovereign Consulting Inc.
111-A North Gold Drive
Robbinsville, New Jersey 08691

Paul I. Lazaar, P.G.
Principal Project Manager

Ravi Gupta
Principal Engineer

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APPENDICES

ATTACHMENTS (under separate cover)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this *Remedial Action Progress Report* for the groundwater sampling event conducted from 16 to 19 July 2002 at the Kalama Chemical Inc. site in Garfield, New Jersey (Figure 1). A groundwater monitoring program was originally proposed to the New Jersey Department of Environmental Protection (NJDEP) in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan had not been approved by the NJDEP, a monitoring program was implemented in June 1997 to establish a base-line against which remediation progress could be compared. The monitoring program started in June 1997 has subsequently been modified to include additional compounds of concern.

The January 1995 groundwater sampling event identified three areas of the site requiring remediation and/or monitoring: 1) the Northeast Phenol Hot Spot (Former Building 10/36); 2) the Northwest Phenol Hot Spot (Former Building 33-B); and, 3) the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14). In addition, benzene, toluene, phenol, benzoic acid, methanol, and formaldehyde were identified as the six primary compounds of concern in groundwater, although the distribution of these compounds varied across the site. The Northeast and Northwest Phenol Hot Spot areas were subsequently combined, and are now collectively referred to as the Northern Phenol Area.

Based on the results of grab groundwater samples collected following the demolition of the Building 10/36 complex, salicylic acid (or 2-hydroxybenzoic acid) was added to the list of analytical parameters for the monitoring wells in the Northeast Phenol Hot Spot area. Based on the quarterly sampling results from June 1997 through October 1998, phenol and benzoic acid are no longer considered to be compounds of concern in the Toluene Spill Area and have been eliminated from the monitoring program for the wells addressing this AEC.

In response to comments in the NJDEP's letter dated 26 June 2000, 1,1'-biphenyl and diphenyl ether were added to the monitoring program for wells addressing the Toluene Spill Area during the July 2000 sampling event. In response to the NJDEP's letter dated 26 June 2000, a groundwater monitoring program for AEC-14 was submitted as part of the 3 August 2001 *Remedial Investigation Report Addendum* (RIRA). The NJDEP approved the monitoring program for AEC-14 in their letter dated 15

October 2001. A groundwater monitoring program for the Northeast and Northwest Phenol Hot Spot areas was included in Section 7.0 of the 1 May 2002 Remedial Investigation Report Addendum No. 2 (RIRA-2). The NJDEP approved this monitoring program in their letter dated 30 July 2002.

On 9 August 2001, all of the remediation systems at the site were shut down in response to the NJDEP's 6 August 2001 letter. Due to low groundwater levels, EPI requested permission to re-start the soil vapor extraction (SVE) system in the southeast corner of the site in November 2001. The NJDEP verbally approved EPI's request, and the SVE system was re-started on 15 November 2001. The off-site SVE system and the vertical and horizontal components of the air curtain were re-started on 5 March 2002, following the construction of a new equipment compound to replace the one that had been located in Building 32-B[1].

1.1 Groundwater Quality Standards

The groundwater quality standards (GWQS) for the six original compounds of concern identified at the Kalama site are summarized below.

Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Benzene	1.0
Toluene	1,000
Phenol	4,000
Benzoic Acid	30,000
Methanol	50,000
Formaldehyde	100

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[1] The Building 32/32-A/32-B complex had been demolished by Goodrich Corporation as part of their site restoration plans.

The benzene, toluene, and phenol standards are from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The standards for benzoic acid, methanol, and formaldehyde are from the "Interim Specific & Generic Groundwater Quality Criteria" posted on the NJDEP's Bureau of Freshwater & Biological Monitoring (BF&BM) web page on 30 January 2002.

Groundwater at the site has been found to also contain salicylic acid, 1,1'-biphenyl, and diphenyl ether. However, since the NJDEP does not have any established groundwater quality standards for these compounds, a generic value of 100 parts per billion (ppb) would be applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believes the generic 100 ppb criterion is too conservative, since it does not incorporate toxicological data specific to each compound. Since none of these compounds of concern are volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the NJDEP's 100 ppb criterion is based, acceptable groundwater concentrations at the site should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request to establish alternate groundwater quality standards for methyl salicylate[2], salicylic acid, 1,1'-biphenyl, and diphenyl ether. Although the NJDEP has not yet responded to EPI's 17 April 2001 letter, the following Interim Groundwater Standards for these compounds have been posted on the NJDEP-BF&BM web page:

Interim Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Methyl Salicylate	4,000
Salicylic Acid	80.0
1,1'-Biphenyl	400
Diphenyl Ether	100

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[2] Although methyl salicylate (oil of wintergreen) had not previously been detected in groundwater, an alternate standard had been requested since this compound had been detected in the soil of AEC-30 at concentrations requiring remediation (i.e., excavation and off-site disposal).

Give the disparity between the alternate groundwater standards proposed by EPI for salicylic acid and diphenyl ether (5,600 ppb and 21,000 ppb, respectively), and the Interim Groundwater Quality Standards (IGWQS) established by the NJDEP, EPI believes further discussions are required before these values are formally adopted for the Kalama Chemical site. However, for comparison purposes, the results of the July 2002 groundwater sampling event have been evaluated using both sets of groundwater quality standards.

2.0 NORTHERN PHENOL AREA DELINEATION

In their letter dated 6 August 2001, the NJDEP required that a work plan be submitted for completing the horizontal and vertical delineation of the phenol, salicylic acid, methanol, and/or formaldehyde that are present in groundwater in the Northeast Phenol and Northwest Phenol Hot Spot areas of the site. Due to their proximity to each other, one work plan was developed for investigating both areas concurrently. The following scope of work was submitted to the NJDEP on 27 September 2001. Draft comments approving the scope of work were received from the NJDEP on 13 November 2001; final comments were included in the NJDEP's letter dated 18 July 2002.

2.1 Well Installation Procedures

Monitoring wells MW-47D2, MW-57D, MW-58, MW-58D, MW-59, MW-59D, and WP-2D were installed at the site between 8 and 17 April 2002. Monitoring wells MW-47D2 and WP-2D were installed to vertically delineate the compounds of concern present in MW-47D and WP-2R, respectively. Monitoring well MW-57D was installed approximately 60 feet to the west of MW-2DR to horizontally delineate the compounds of concern present in this well and in MW-55D. MW-58 and MW-58D were installed approximately 60 feet to the west of WP-2R to horizontally delineate both the shallow (for WP-2R) and deep (for MW-55D) overburden zones. In order to complete the horizontal delineation of the compounds of concern present in WP-2R and MW-55D, MW-59 and MW-59D were installed on the north side of Monroe Street (approximately 70 feet away from WP-2R). The locations of the new and existing monitoring wells in the northwest corner of the site are shown on Figure 2. The construction details for each well are shown on the following Table.

Well ID	Diam. (in.)	Depth (feet)	Screened Interval (feet)	Zone Monitored
MW-47D2	2.0	50.0	45.0 - 50.0	Glacial Till
MW-57D	4.0	33.0	23.0 - 33.0	Deep Overburden
MW-58	4.0	18.0	8.0 - 18.0	Shallow Overburden
MW-58D	4.0	33.0	23.0 - 33.0	Deep Overburden

Well ID	Diam. (in.)	Depth (feet)	Screened Interval (feet)	Zone Monitored
MW-59	2.0	15.0	5.0 - 15.0	Shallow Overburden
MW-59D	2.0	33.0	23.0 - 33.0	Deep Overburden
WP–2D	2.0	45.0	40.0 - 45.0	Glacial Till

With the exception of the total depth for MW-47D2, and the screen length for MW-47D2 and WP-2D, each well was installed and constructed as was originally proposed in the 27 September 2001 work plan. Due to the presence of weathered bedrock, the total depth of MW-47D2 was reduced from the proposed depth of 63.0 feet to 50.0 feet. In order to maximize the distances between the bottoms of shallow wells MW-47D and WP-2R and the tops of the screened intervals for the deeper wells, MW-47D2 and WP-2D were each constructed with only 5.0 feet of screen.

Monitoring wells MW-57D, MW-58, MW-58D, MW-59, and MW-59D were installed using hollow-stem auger drilling techniques. Due to the need to double case the deep wells, MW-47D2 and WP-2D were installed using air rotary/water rotary drilling techniques. The borehole for each well was advanced to the target depth (when possible), and split spoon soil samples were collected for lithologic characterization. Since MW-59 and MW-59D were located beneath overhead power lines, these wells were installed with a half-derrick for health and safety reasons. Since split spoon sample could not be collected with the hollow stem auger drill rig in this configuration, the soil lithologies for MW-59 and MW-59D were logged from the drill cuttings.

In order to keep the borehole from collapsing, 10.0-inch diameter steel casing was advanced during the installation of MW-47D2 and WP-2D. After advancing the boring approximately 5.0 feet into the glacial till, 6.0-inch diameter steel casing was installed through the outer casing and grouted into place. The 6.0-inch steel casing was allowed to sit for approximately 24 hours before attempting to advance the boring to the completion depth. At the initial location for WP-2D (approximately 5.0 feet from WP-2R), the 6.0-inch steel casing began to spin while advancing the boring to set the well materials. Attempts to re-grout the steel casing were unsuccessful, so the 6.0-inch and 10-inch casings were removed and the borehole was sealed to grade with a cement/bentonite grout. WP-2D was successfully installed in a new borehole located approximately 15.0 feet south of WP-2R. The 10.0-inch casing could not be removed from the boring for MW-47D2 or from the second boring for WP-2D. Therefore, the 6.0-inch steel casing was installed through the outer casing and was grouted into place.

For all seven wells, the annulus around the well screen was filled with No. 2 Morie sand to two feet above the top of the screened interval. The remainder of the borehole was then sealed with a cement/bentonite grout to grade. The well heads for MW-47D2, MW-57D, MW-58, MW-58D, and WP-2D were completed with steel standpipes, while MW-59 and MW-59D were completed with flush-mounted manholes. Well construction details are shown on the boring logs for each well in Appendix A.

2.1.1 *Soil Lithologies*

Due to its proximity to MW-47D, split spoon samples were not collected during the installation of MW-47D2 from the first 33.0 feet of soil. Split spoon samples could not be collected from below 33.0 feet due to the presence of glacial till (which extended to 43.0 feet below grade). A weathered sandstone bedrock was encountered at 43.0 feet, and continued to the completion depth of the boring at 50.0 feet below grade.

At the location of MW-57D, located 130 feet to the west of MW-47D, the top 12.0 feet of soil consisted of fill material (comprised primarily of concrete, brick, rock, and asphalt) with some sand and silt. A well graded sand was encountered from 12.0 to 14.0 feet below grade, followed by a 10 feet thick clay layer. The clay layer was underlain by a silty sand to the completion depth of the boring at 33.0 feet below grade.

Monitoring wells MW-58 and MW-58D were installed through the basement of former Building 33-A. As such, the first 15.0 feet of material encountered consisted of the crushed concrete and brick used to backfill the basement. Once the boring advanced through the basement, split spoon samples could be collected. A well graded sand with silt was encountered from 15.0 to 16.0 feet below grade, followed by a seven feet thick clay layer. Silty sand was found from 23.0 to 25.0 feet below grade, underlain by another two feet of clay, and then six feet of well graded sand with silt to the completion depth of 33.0 feet below grade.

As indicated earlier, the soil lithologies at the location of MW-59 and MW-59D were logged from the drill cuttings, since split spoon samples could not be collected with the half-derrick drill rig configuration. The first 10.0 feet of soil at this location consisted of a silty sand, followed by a well graded sand and silt to the completion depth of 33.0 feet below grade. The clay layer that was observed during the installation of MW-58D and WP-2D was not encountered at the location of MW-59 or MW-59D on the north side of Monroe Street.

Split spoon samples were not collected during the installation of WP-2D. However, since the well is located within the footprint of former Building 33-B, the top 16.0 feet of soil would be expected to consist of the poorly sorted sand, silt, and gravel fill material noted during the installation of WP-2R. Based on drill cuttings, the clay layer that had been observed in other wells in the Northern Phenol area was encountered from 16.0 to 25.0 feet below grade. The clay layer was underlain by 8.0 feet of sandy silt and clay, followed by glacial till from 33.0 to 42.0 feet below grade. Weathered sandstone bedrock was encountered from 42.0 feet to the completion depth of 45.0 feet below grade.

2.2 Well Survey

The locations and elevations of the seven new monitoring wells were measured by a New Jersey Licensed Professional Land Surveyor. The latitude and longitude of each well was measured to the nearest one-tenth (0.10) of a second, and elevations were measured to the nearest one-hundredth (0.01) of a foot. Elevation measurements were taken from each well casing with the inner protective cap removed. Certification Forms A (As-Built) and B (Location Certification) for each well are included in Appendix A.

2.3 Groundwater Sampling Results

The first round of groundwater samples from MW-47D2, MW-57D, MW-58, MW-58D, MW-59, MW-59D, and WP-2D was collected on 1 May 2002. Groundwater sampling procedures are discussed in Section 3.1, below. As per the approved work plan, each sample was analyzed for phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015-DAI, and formaldehyde by USEPA Method 8315. The analytical results for the 1 May 2002 sampling event are summarized on Table 1 and are presented on Figure 3. A copy of the analytical data package for these samples (including the electronic data disk deliverables) is included under separate cover as Attachment I.

Methanol and formaldehyde were either not detected or were present in concentrations below the NJDEP's IGWQS in all seven wells. Phenol was detected at concentrations above its GWQS of 4,000 ppb in MW-57D (19,900 ppb) and MW-58 (9,230 ppb). Salicylic acid was detected at concentrations above the IGWQS of 80.0 ppb, but below the proposed site specific standard of 5,600 ppb, in MW-47D2 (231 ppb), MW-58 (1,890 ppb), and WP-2D (567 ppb). Salicylic acid was also detected at 119,000 ppb in MW-57D, which exceeds both groundwater quality standards.

The analytical results for MW-59 and MW-59D indicate that delineation to the north of WP-2D and MW-55D in the shallow and deep overburden zones has been completed. In addition, the results from MW-58D indicate that the horizontal delineation of the phenol and salicylic acid in MW-55D has been completed to the west. However, the phenol and salicylic acid present in MW-57D (deep overburden zone) and MW-58 (shallow overburden zone) still need to be delineated to the west.

A second round of samples from these wells was collected as part of the July 2002 groundwater monitoring event (see Section 4.2, below).

2.4 Temporary Well Point Installation & Sampling

Based on the results of the 1 May 2002 groundwater samples from the new monitoring wells, EPI collected grab groundwater samples from temporary well points to horizontally delineate the phenol and salicylic acid detected in shallow overburden well MW-58 and deep overburden well MW-57D. As shown on Figure 4, temporary well point TWP-2[3] was located adjacent to MW-51 (approximately 45.0 feet west of MW-57D) and TWP-3 was installed approximately 45.0 feet west of MW-58. Contingency

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[3] The designation TWP-1 had previously been used for the temporary well point used to collect a groundwater sample from AEC-29 (the former underground storage tank beneath Building 1).

groundwater samples were also collected from TWP-4 (located adjacent to MW-21) and from TWP-5 (located near Building 35). Although the contingency samples were collected across River Drive, they were still located on property that is part of the site. Therefore, no off-site access issues were involved.

2.4.1 *Sampling Methodology*

The installation of the temporary well points described above was performed using direct push (e.g., Geoprobe) methodology. The Hurricane drill rig was operated by a New Jersey licensed driller from Summit Drilling Co., Inc. under the supervision of a Sovereign geologist. Soil samples (for lithologic description purposes only) were collected into acetate liners within a stainless steel sampler. Each liner was removed from the sampler, slit open, and screened for VOCs using a photo-ionization detector (PID) equipped with a 10.6 eV bulb. The descriptions of soil lithologies and results of PID screening were recorded in the field. VOCs were not detected by the PID in any of the borings installed as part of this investigation. Once the completion depth of each boring had been reached, a temporary well point constructed with 10.0 feet of 1.0-inch diameter PVC screen was installed in the borehole. Groundwater samples were collected using a small diameter bailer. Once the groundwater samples had been collected, the PVC well material was removed and the borehole was sealed to grade with a cement/bentonite grout. Copies of the boring logs for the temporary well points are included in Appendix A.

The groundwater samples were placed directly into laboratory-provided sample containers, labeled, logged onto a chain of custody form, and placed on ice in a cooler. At the end of the day, the samples were delivered to Accutest in Dayton, New Jersey (Certification No. 12129) for analysis. Each sample was originally proposed to be analyzed for phenol and salicylic acid by USEPA Method 8270. However, due to observations made during the installation of TWP-2 (see below for further discussion), each sample was also analyzed for methyl salicylate by USEPA Method 8270. The samples from TWP-2 and TWP-3 were analyzed using a 72-hour turn around time so as not to exceed the holding times for the contingency samples. A copy of the analytical data package for these groundwater samples (including the electronic data disk deliverables) is included under separate cover as Attachment II.

2.4.2 *Soil Lithologies and Well Point Construction*

Well point TWP-2 was installed adjacent to monitoring well MW-51, through the area where methyl salicylate contaminated soil had been excavated for off-site disposal. This area had been designated AEC-30 (Building 4 - Methyl Salicylate Area) in the 17 September 2001 *Remedial Investigation and Remedial Actions Report*. Previous groundwater samples from MW-51 had indicated that the concentrations of phenol and salicylic acid in the shallow overburden zone were below their respective groundwater quality standards. The soil boring for TWP-2 was advanced to 34.0 feet below grade, and the screened interval for the well point was set at 24.0 - 34.0 feet below grade. The initial 14.0 feet of soil consisted of the crushed stone used to backfill the excavation. This material was underlain by a coarse sand and poorly graded gravel to 17.5 feet below grade. An oil of wintergreen (i.e., methyl salicylate) odor was first noted in these native soils, and this odor persisted throughout the remainder of the boring. Multiple changing lithologies were noted, including silt and very fine sand (17.5 - 20.0 feet), coarse sand and gravel (20.0 - 22.0 feet), coarse sand and silt (22.0 - 24.0 feet), silt (24.0 - 27.0 feet), very fine sand (27.0 - 28.0 feet), rock fragments and silt (30.0 - 31.0 feet), and very fine to fine sand (31.0 - 34.0 feet); no soil was recovered from 28.0 - 30.0 feet. At 32.5 - 33.5 feet below grade, the soil appeared to be saturated with product.

Sovereign conducted a shake test on a soil sample from the 32.5 - 33.5 feet interval in TWP-2. Soil was placed in a jar, water was added, and the contents were shaken for 20 to 30 seconds. The jar was then allowed to sit to see if a separate phase had been flushed from the soil. Although only a slight sheen was observed at first, with time (on the order of several days), the sediment settled out of the water, and a layer of product accumulated on top of the soil, but below the top of the water in the jar. These results indicate that a dense non-aqueous phase liquid (DNAPL) is present at the location of TWP-2. Based on the odor observed during sampling, and the previous environmental conditions in this area of the site, the DNAPL is most likely methyl salicylate. It should be noted that methyl salicylate is heavier than water, with a density of 1.18.

TWP-3 was installed through the basement of former Building 33. As such, the first 12.0 feet of material encountered in this boring consisted of the crushed brick and concrete fragments used to backfill the basement. Native soil consisting of coarse to medium sand was encountered at 12.0 feet below grade, and continued to the completion depth of the boring at 20.0 feet below grade.

At the location of TWP-4, located next to monitoring well MW-21 on the west side of River Drive, the first 16.0 feet of soil consisted of fill material comprised of silt, sand, gravel, and cinders. From 16.0 - 20.0 feet below grade, a fine to medium sand was encountered, followed by a silt with very fine sand to the completion depth of 34.0 feet. In boring TWP-5 (located on the west side of River Drive near the northeast corner of Building 35), 11.0 feet of the same fill material as in TWP-4 was underlain by a fine to coarse sand and gravel to 20.0 feet below grade (the completion depth of the boring).

On 12 July 2002, Sovereign installed two additional borings (TWP-6 and TWP-7) in an attempt to delineate the product saturated soil observed at 32.5 - 33.5 feet below grade in TWP-2. Boring TWP-6 was located approximately 45.0 feet to the west of TWP-2 (near the property line) and was advanced to 35.0 feet below grade. The top 14.0 feet of soil at this location consisted of fill material comprised of sand, gravel, brick fragments, rock fragments, and ash. Beneath the fill material, the lithologies in TWP-6 were very similar to those in TWP-2, consisting of alternating layers of sand, gravel, and silt. A fine to medium sand was encountered between 28.0 - 32.0 feet below grade, followed by a fine sand to the completion depth of 35.0 feet. Starting at 14.0 feet below grade, an oil of wintergreen odor was noted and which persisted throughout the rest of the soil boring. However, no product saturated soils were observed in boring TWP-6.

TWP-7 was installed approximately 45.0 feet to the south of TWP-2 and was advanced to 32.0 feet below grade. Crushed stone fill material was encountered to a depth of 16.0 feet below grade. From 16.0 - 31.0 feet, the soil consisted of fine sand with varying amounts of gravel, rock fragments, and silt. A silt layer was encountered at 31.0 feet, so the boring was terminated at 32.0 feet below grade. No product saturated soils were observed in boring TWP-7.

An attempt was made to install a boring to the north of TWP-2, but refusal was encountered at 4.0 feet below grade. Since no product saturated soil was encountered during the installation of monitoring well MW-57D, an additional soil boring was not installed to the east of TWP-2.

2.4.3 *Groundwater Sampling Results*

Groundwater samples from the temporary well points were collected using disposable, small diameter polyethylene bailers. The analytical results for temporary well points TWP-2, TWP-3, and TWP-4 are summarized on Table 2 and are presented on Figure 5. TWP-2 contained 86,100 ppb of phenol, 186,000 ppb of salicylic acid, and 786,000 ppb of methyl salicylate. Based on the physical property data in the *Hand Book of Environmental Data on Organic Chemicals*, the reported solubility of methyl salicylate in water (at 30°C) ranges from 740 parts per million (ppm) to 5,000 ppm. The actual solubility would most likely be lower since the temperature of groundwater is typically below 30°C. The dissolved concentration of methyl salicylate in TWP-2 exceeded its low end solubility, which is further evidence to suggest that DNAPL is present.

TWP-3 contained 21.2 ppb of methyl salicylate, but no detectable concentrations of phenol or salicylic acid. Due to the concentrations found in TWP-2, contingency sample TWP-4 was also analyzed. No detectable concentrations of phenol were found in TWP-4, while salicylic acid and methyl salicylate were present at 61.3 ppb and 64.7 ppb, respectively. Since the concentrations of all three compounds of concern in TWP-3 were below their respective groundwater quality standards, the sample from TWP-5 was not analyzed.

2.5 Proposed Monitoring Wells

Based on the results from the temporary well points, EPI intends to install three additional wells in the northwest corner of the site. As shown on Figure 6, monitoring wells MW-21D, MW-51D, and MW-62 are to be installed at the locations of TWP-4, TWP-2, and TWP-3, respectively. Each monitoring well would be installed using a hollow-stem auger drill rig operated by a licensed New Jersey well driller. MW-21D and MW-51D would each have a total depth of approximately 34.0 feet, and would be constructed with 10.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 24.0 feet of PVC casing. MW-62 would have a total depth of approximately 20.0 feet, and would be constructed with 10.0 feet of 4.0-inch diameter, 20-slot Sch. 40 PVC screen and 10.0 feet of PVC casing. All three wells would be completed with steel standpipes with locking caps. The locations and elevations of MW-21D, MW-51D and MW-62 would be measured by a New Jersey licensed surveyor, and Well Certification Forms A & B would be completed.

EPI is developing a work plan for delineating and identifying the source area of the DNAPL detected in temporary well point TWP-2. This investigation would be independent of the installation of monitoring well MW-51D.

3.0 GROUNDWATER SAMPLING PROCEDURES

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". However, in accordance with the NJDEP's letter dated 6 August 2001, and as discussed during the 6 December 2001 conference call, wells that exhibit poor recharge or excessive drawdown were purged and sampled using Low Flow methodology.

3.1 Standard Purging & Sampling Methodology

Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of separate phase hydrocarbons (SPH) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rates did not exceed approximately one gallon per minute (gpm). In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

Before Purging

- Date, time, and weather conditions
- Well number
- Head space reading immediately after well cap is removed
- Product thickness, if any
- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

Well purging information for the July 2002 sampling event is summarized on the tables included in Appendix B.

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for VOC analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling. At the end of each day, the samples for benzene, toluene, phenol, salicylic acid, 1,1'-biphenyl, diphenyl ether, and methanol were either delivered to the analytical laboratory (Accutest) or returned to the office where they were picked up by an Accutest courier the following morning. The formaldehyde samples were shipped via overnight courier to Severn Trent Laboratories (STL) in Tallahassee, Florida. Copies of the analytical data packages for the July 2002 groundwater samples (including the electronic data disk deliverables) are included under separate cover as Attachment III.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

3.2 Low Flow Purging & Sampling Methodology

As discussed above, the NJDEP has approved the use of low flow purging and sampling for collecting samples from wells that exhibit poor recharge or excessive drawdown during purging. After reviewing the historical well purging data, and based on observations made during the 1 May 2002 sampling event from the seven new wells in the Northern Phenol Area, EPI has identified the following 13 wells on which the low flow methodology is to be used:

Wells Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-1	Poor Recharge
MW-4	Poor Recharge
MW-22	Very Poor Recharge
MW-25	Very Poor Recharge
MW-28D	Excessive Drawdown (>10 feet)
MW-31	Very Poor Recharge
MW-32D	Excessive Drawdown (>10 feet)
MW-40	Poor Recharge
MW-47D	Poor Recharge
MW-47D2	Excessive Drawdown (>10 feet)
MW-48D	Excessive Drawdown (>10 feet)
MW-53D	Poor Recharge
MW-57D	Excessive Drawdown (>10 feet)

The low flow purging and sampling procedures used were taken from the USEPA Region II's *Groundwater Sampling Procedure - Low Stress (Low Flow) Purging and Sampling* document that was provided by the NJDEP following the 6 December 2001 conference call. A description of the methodology used and the completed data forms for each well are included in Appendix C.

4.0 GROUNDWATER SAMPLING RESULTS - JULY 2002

Groundwater samples were collected from 55 wells between 16 and 19 July 2002. Monitoring well MW-9 was not sampled due to the presence of SPH. Monitoring well MW-1 contained excessive amounts of sediment (due to the operation of the air curtain) and could not be purged by either low flow or standard techniques. Therefore, a sample was not collected from this well. As indicated in Section 1.0, the SVE system in the Toluene Spill Area, the off-site SVE system, and the vertical and horizontal components of the air curtain were in operation during this sampling event.

As stated in EPI's letter to the NJDEP dated 18 July 2002, the Northeast and Northwest Phenol Hot Spot Areas have been combined. Starting with the 4 September 2002 RAPR, these two areas are now referred to as the Northen Phenol Area. The monitoring program and sampling results for the two source areas are discussed separately, below.

4.1 Groundwater Elevations

Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 3 and were used to prepare the groundwater elevation contour maps shown on Figure 7 and Figure 8. The deep overburden wells to the south of the site (i.e., MW-25D, MW-36D, MW-37D, and MW-38D) were accidently omitted from the July 2002 gauging event. MW-9 contained 1.91 feet of SPH during this monitoring event.

Figure 7 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. As indicated in Section 1.0, the air sparging system in the southeast corner of the site was shut down, but the vertical and horizontal injection wells of the air curtain in the southwest corner of the site were in operation at the time of sampling. Consistent with historical site conditions, a water table mound was present in the northeast corner of the site. A smaller water table mound was also observed around MW-4 in the southeast corner of the site.

Groundwater elevation contours for the deep overburden zone are shown on Figure 8. The direction of groundwater flow in the deep overburden zone is to the west.

4.2 Northern Phenol Area

Although at one time the Northeast and Northwest Phenol Hot Spots appeared to be distinct areas, current groundwater sampling results suggest that they completely overlap and cannot be differentiated. Therefore, both areas are now referred to as the combined Northern Phenol Area.

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the shallow and deep overburden zones, groundwater samples were collected from the following wells:

Source Area Wells:	MW-28D, MW-47D, MW-47D2, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-2R, WP-2D, WP-3R
Monitoring Points:	MW-2DR, MW-3D, MW-12D, MW-21, MW-32D, MW-51, MW-52D, MW-53D, MW-54D, MW-57D, MW-58, MW-58D, MW-59, MW-59D, WP-1R

Each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015 - Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315. The results of these analyses are summarized on Table 4 and are presented on Figure 9 (shallow overburden zone) and Figure 10 (deep overburden zone). Concentration vs. Time graphs summarizing historical data for each well are included in Appendix D.

The formaldehyde sample bottle for MW-2DR broke while in transit to the analytical laboratory. Therefore, MW-2DR was not analyzed for this parameter during the July 2002 monitoring event.

4.2.1 *Shallow Overburden Zone*

The shallow overburden zone wells within the source area include WP-2R and MW-58. As shown on Figure 9, phenol was detected at 90,700 ppb in WP-2R and at 9,880 ppb in MW-58. Salicylic acid was detected at 48,700 ppb and 379 ppb in WP-2R and MW-58, respectively. WP-2R also contained 300 ppb of formaldehyde and 10,800 ppb of methanol, while MW-58 contained 62.0 ppb of formaldehyde but no detectable concentration of methanol. The concentrations of phenol, formaldehyde, and methanol were either not detectable or below their respective groundwater quality standards in monitoring points MW-21, MW-51, MW-59, and WP-1R. Salicylic acid only exceeded its IGWQS of 80.0 ppb in WP-1R (145 ppb).

Vertical delineation well WP-2D contained 380 ppb of phenol and 293 ppb of salicylic acid, but no detectable concentrations of methanol or formaldehyde.

4.2.2 *Deep Overburden Zone*

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, MW-57D, ORC-4D, and WP-3R (Figure 10). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-47D (228,000 ppb), MW-48D (119,000 ppb), MW-50D (53,700 ppb), MW-55D (57,700 ppb), and ORC-4D (30,300 ppb). MW-47D was the only well that contained methanol at a concentration (2,930,000 ppb) exceeding its IGWQS of 50,000 ppb. Salicylic acid was detected in five source area wells at concentrations exceeding EPI's proposed alternate GWQS of 5,600 ppb, and in nine of the source area wells at concentrations exceeding the NJDEP's IGWQS of 80.0 ppb, including MW-28D (116 ppb), MW-47D (684,000 ppb), MW-48D (164,000 ppb), MW-49D (756 ppb), MW-50D (13,000 ppb), MW-55D (4,320 ppb), MW-57D (295,000 ppb), ORC-4D (112,000 ppb), and WP-3R (90.7 ppb).

Formaldehyde was detected in the source area at a concentration exceeding its IGWQS of 100 ppb only in MW-47D (360 ppb).

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all of the monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-47D2, MW-52D, MW-53D, MW-54D, MW-58D, and MW-59D) except MW-2DR, which contained 295 ppb of salicylic acid.

Vertical delineation well MW-47D2 contained 14.5 ppb of phenol, 56.1 ppb of salicylic acid, and no detectable concentrations of formaldehyde or methanol.

4.3 Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14)

In order to monitor the effectiveness of the AS/SVE, air curtain, and the off-site SVE systems, groundwater samples were to be collected from 31 wells. As per the NJDEP's letters dated 15 October 2001 and 20 June 2002, the monitoring wells addressing this AEC have been re-characterized as "source area", "fringe", "sentinel", or "background" wells as follows:

Source Area Wells: MW-4, MW-5, MW-D5, MW-E5, MW-9, MW-17, MW-33, MW-45, and OW-3

Fringe Wells: MW-1, MW-10, MW-11, MW-14, MW-23, MW-25, MW-31, MW-36, MW-40, MW-41, MW-42, MW-46, OW-1, OW-2, OW-4, and OW-5

Sentinel Wells: MW-6, MW-22, MW-30, MW-37, and MW-38

Background Well: MW-16

As indicated at the start of this Section, MW-1 contained excessive amounts of sediment and could not be purged, and MW-9 contained 1.91 feet of SPH; neither of these wells were sampled during this monitoring event. The groundwater samples collected from the remaining wells addressing this area of environmental concern were analyzed for benzene and toluene by USEPA Method 624, and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. The analytical results for these samples are summarized on Table 5 and are presented on Figure 11. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix E.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 12 of the 29 wells sampled. In the source area wells, benzene was detected in six of the eight wells sampled, including MW-4 (13.3 ppb), MW-D5 (1,340 ppb), MW-17 (46.6 ppb), MW-33 (548 ppb), MW-45 (3,980 ppb), and OW-3 (2.1 ppb). In the fringe area wells, benzene was detected at concentrations exceeding the GWQS of 1.0 ppb in six of the 15 wells sampled. Benzene concentrations of approximately 5.0 ppb or less were found in MW-23 (3.7 ppb), MW-25 (1.6 ppb), and OW-2 (3.9 ppb). In the three remaining wells containing elevated concentrations, benzene was detected in MW-14 (30.8 ppb), MW-36 (34.6 ppb), and MW-40 (19.0 ppb). No detectable concentrations of benzene were found in the five sentinel and one background monitoring wells.

Benzene concentrations increased more than 10% in MW-4, MW-17, and MW-36 relative to the April 2002 sampling event. The increases in these wells ranged from 11.5 ppb in MW-4, to 34.6 ppb in MW-36, to 35.3 ppb in MW-17. Benzene concentrations decreased at least 10% in nine wells (MW-10, MW-23, MW-25, MW-33, MW-40, MW-42, MW-45, OW-2, and OW-3), with the decreases ranging from 1.4 ppb (MW-10) to 6,220 ppb (MW-45). Additionally, benzene concentrations were below the GWQS of 1.0 ppb in MW-5, MW-E5, MW-6, MW-10, MW-11, MW-16, MW-22, MW-30, MW-31, MW-37, MW-38, MW-41, MW-42, MW-46, OW-1, OW-4, and OW-5.

Table 6 presents a comparison of the July 2002 benzene concentrations to i) the maximum concentration ever detected in a well; ii) the last four quarters of data for each well before the remediation systems were shut down in August 2001; iii) the October 2001 groundwater results (no remediation systems running); and, iv) the April 2002 groundwater results (the air curtain, the on-site SVE system, and the off-site SVE system in operation). The summary on Table 6 shows that even with the increased benzene concentrations observed in MW-4, MW-17, and MW-36 between April 2002 and July 2002, there has still been an average reduction of 93% in the levels of benzene in the monitoring wells that address the Toluene Spill Area of the site (excluding MW-E5 and MW-46 which have never contained more than 1.0 ppb of benzene).

Toluene was detected at concentrations above the GWQS of 1,000 ppb in three of the 29 wells sampled. In the source area wells, toluene exceeded the GWQS in three of the eight wells sampled, including MW-D5 (97,700 ppb), MW-33 (169,000 ppb), and MW-45 (136,000). The toluene concentration in MW-33 is the lowest ever detected in this well. Toluene concentrations were below the GWQS of 1,000 ppb in all of the fringe area, sentinel, and background wells.

Table 7 shows that as of July 2002, the number of wells that contain over 1,000 ppb of toluene has been reduced from 22 to three, and that there has been an average reduction in toluene concentrations of 95% in the wells addressing the Toluene Spill Area (excluding those wells that have never contained toluene at a concentration exceeding the GWQS of 1,000 ppb).

1,1'-biphenyl was detected at concentrations above the NJDEP's proposed IGWQS of 400 ppb in on-site wells MW-D5 (479 ppb), MW-10 (1,240 ppb), and MW-14 (1,570 ppb), and in off-site well MW-33 (603 ppb). Diphenyl ether was detected at concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb, but below EPI's proposed alternate GWQS of 21,000 ppb, in 10 of the 29 wells sampled, including MW-4 (848 ppb), MW-D5 (848 ppb), MW-10 (3,350 ppb), MW-14 (630 ppb), MW-17 (606 ppb), MW-23 (477 ppb), MW-33 (1,160 ppb), MW-40 (129 ppb), MW-45 (284 ppb), and OW-3 (200 ppb).

4.4 Distribution of Compounds of Concern

The distributions of toluene and benzene in the shallow overburden zone using the July 2002 groundwater sampling results are shown on Figure 12 and Figure 13, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to the area around MW-33 and MW-45. Concentrations of toluene exceeding the GWQS of 1,000 ppb are also limited to the southeast corner of the site. As shown on Table 8, the portions of the toluene plume in July 2002 that contained greater than 100,000 ppb, 10,000 ppb and 1,000 ppb decreased in areal extent (relative to April 2002) by approximately 1,980 ft^2, 3,580 ft^2 and 8,034 ft^2, respectively. The areal extent of the toluene plume in July 2002 approximately 4.5 months after re-starting the air curtain is the smallest observed since the baseline groundwater sampling event in June 1997.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found around MW-D5 and MW-45. Benzene concentrations exceeding

10.0 ppb were found in the southwest (MW-14) and south-central (MW-40) portions of the site, and to the south of the site in MW-36. As shown on Table 9, the portions of the benzene plume in July 2002 that contained greater than 1,000 ppb, 100 ppb, and 10.0 ppb decreased in areal extent by approximately 5,004 ft^2, 8,511 ft^2, and 2,473 ft^2 respectively, while the areal extent of the 1.0 ppb benzene plume increased by approximately 17,098 ft^2. This increase can be attributed to the spike in the benzene concentration observed in MW-36. The areal extent of the benzene plume in July 2002 is therefore comparable to that in July 2000[4].

The distributions of 1,1'-biphenyl and diphenyl ether in the shallow overburden zone are shown on Figures 14 and 15, respectively. Concentrations of 1,1'-biphenyl exceeded the NJDEP's proposed IGWQS of 400 ppb in the southeast (MW-D5, MW-33), south-central (MW-10), and southwest (MW-14) areas of the site. Diphenyl ether concentrations exceeding the NJDEP's proposed IGWQS of 100 ppb were found in the southeast (MW-4, MW-D5, MW-33, MW-45, OW-3), south-central (MW-10, MW-40), and southwest (MW-14, MW-23) portions of the site.

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 16 and 17, respectively. The area with the highest concentration of phenol in the shallow overburden zone is limited to beneath former Building 33-B (90,700 ppb in WP-2R). The area containing salicylic acid at concentrations exceeding the NJDEP's proposed IGWQS of 80.0 ppb (but below EPI's proposed alternate GWQS of 5,600 ppb) extends westward from WP-2R (48,700 ppb) to WP-1R (145 ppb).

As shown on Figure 18, formaldehyde concentrations exceeding the GWQS of 100 ppb in the shallow overburden zone are limited to around WP-2R. Methanol did not exceed its IGWQS of 50,000 ppb in the shallow overburden zone during the July 2002 sampling event.

The distribution of phenol in the deep overburden zone is depicted on Figure 19. Phenol concentrations over 100,000 ppb were found around MW-47D and MW-48D, with concentrations exceeding 10,000 ppb also encompassing MW-50D, MW-55D, and ORC-4D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-28D, MW-49D, MW-52D, MW-53D, MW-54D, MW-58D, and MW-59D.

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[4] Excluding April 2001 which was skewed due to an anomalous benzene concentration in MW-37.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 20. The distribution of salicylic acid in the deep overburden zone is similar to that of phenol, with concentrations exceeding 100,000 ppb encompassing ORC-4D, MW-47D, MW-48D, and MW-57D. Salicylic acid concentrations exceeding 10,000 ppb extend eastward to MW-50D. The area of the salicylic acid plume as defined by the NJDEP's proposed IGWQS of 80.0 ppb extends from the northeast to northwest corners of the site, and southward to MW-53D and MW-54D.

As shown on Figure 21, formaldehyde concentrations exceeding the GWQS of 100 ppb in the deep overburden zone were limited to the area around MW-47D.

The distribution of methanol in the deep overburden zone is shown on Figure 22. Methanol only exceeded the NJDEP's IGWQS of 50,000 ppb in MW-47D (2,930,000 ppb).

5.0 REMEDIAL ACTIONS

The following Sections discuss the performance of the AS/SVE, off-site SVE, and air curtain remediation systems for the period of July 2002 through September 2002. The SVE component of the AS/SVE system, the off-site SVE system, and the horizontal and vertical components of the air curtain were in operation during this reporting period.

5.1 July 2002

All three remediation systems were in operation in July 2002.

5.1.1 *AS/SVE System*

The SVE component of the AS/SVE system was operated at optimum flow and vacuum during the July reporting period. The system was down for approximately six days due to an unreported power outage. The SVE system was operated at an inlet vacuum of 27 inches of water (i.w.) and a corresponding extraction flow rate of 1,181 to 1,215 cubic feet per minute (cfm). Monthly observation well monitoring was conducted on 16 July 2002. SPH was only detected in MW-9 (1.91 feet) during this gauging event.

Although only 1.65 inches of rain fell during July 2002, groundwater levels only experienced a slight decrease. Approximately 265 pounds of non-methane hydrocarbons were recovered by the SVE system during the July 2002 reporting period (for an average of 66.0 pounds per week). The low removal rate can be attributed, in part, to the down time experienced at the beginning of the month. Approximately 32,455 pounds of non-methane hydrocarbons have been recovered by the AS/SVE system as of 25 July 2002 (see Appendix F).

5.1.2 *Offsite SVE System*

The extraction blower for the off-site SVE system operated at an average inlet vacuum of approximately 24 i.w. and a maximum extraction rate of approximately 350 cfm. The system operated consistently with no reported downtime during the July 2002 reporting period. No vapor phase hydrocarbons were recovered by the off-site SVE system during this reporting period (see Appendix G).

5.1.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the July 2002 reporting period and no shutdowns were reported. Flow rates on the horizontal well system were balanced at 36 to 38 cfm on each of the two lines; the total flow into the formation via the vertical injection wells was approximately 46.0 cfm (see Appendix H). All injection flow rates were in proportion to the hydrostatic pressures yielded by the groundwater table. The air curtain equipment was being operated at maximum obtainable pressure (19 to 20 pounds per square inch [psi]).

Monthly observation well monitoring was conducted on 16 July 2002. Surging groundwater conditions were observed in MW-1, MW-1D, MW-11, OW-2, OW-4, and OW-5. VOCs were detected in VMP-4 (2.72 ppm) and VMP-6 (5.10 ppm).

5.2 August 2002

All three remediation systems were in operation during August 2002.

5.2.1 *AS/SVE System*

The SVE component of the AS/SVE system was operated at optimum flow and vacuum during the August 2002 reporting period. Downtime during the period was attributed to power outages prior to the 8 & 22 August 2002 routine maintenance visits. The hour meters on the system were found to be inoperable during the 8 August 2002 inspection, although the system was able to be restarted and was running upon departure. Control fuses in the thermal oxidizer control panel were found blown on the 22 August 2002 monitoring event, which prevented restarting the SVE system. Replacement and back-up panel fuses were ordered, and the system was restarted on the 29 August 2002. Manual logging of operational hours was conducted while replacement hour meters were ordered.

The SVE system operated at an inlet vacuum of 27 i.w. and a corresponding extraction flow rate of 1,181 cfm. Monthly observation well monitoring was conducted on 15 August 2002. Approximately 5.19 inches of rain fell during the August 2002 reporting period, although no significant change in groundwater elevations occurred. MW-9 contained 1.89 feet of SPH during this gauging event.

Due in part to the reduced period of operation, only 85.0 pounds of non-methane hydrocarbons were recovered by the SVE system during the August 2002 reporting period (for an average of 17.0 pounds per week). This low mass removal rate continues the decreasing trend that has been observed since February 2002. Approximately 32,541 pounds of non-methane hydrocarbons have been recovered by the AS/SVE system as of 29 August 2002 (see Appendix F).

5.2.2 *Off-Site SVE System*

The extraction blower for the off-site SVE system operated at an inlet vacuum of approximately 22 i.w. and a maximum extraction air flow rate of 350 cfm. Downtime during the August 2002 reporting period was caused by power interruptions recorded on the 8 and 22 August 2002 maintenance events. The system was restarted without incident on each visit and optimum operation was resumed. Monthly observation well monitoring was conducted on 15 August 2002. No VOCs were detected using a PID in the head spaces of the off-site monitoring wells (with the exception of 35.0 ppm in OW-2), or in the air samples from the off-site vapor monitoring points.

Approximately 5.0 pounds of non-methane hydrocarbons were recovered by the off-site SVE system during this reporting period. This represents the first time since the 19 October 2000 monitoring event that detectable concentrations of VOCs have been found in the influent air stream. Approximately 4,247 pounds of non-methane hydrocarbons have been recovered by the off-site SVE system as of 29 August 2002 (see Appendix G).

5.2.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the August 2002 reporting period. Both systems (horizontal and vertical) were found to be down on the 8 August 2002 maintenance event; the equipment was restarted on the same day. Normal operation was resumed with the shutdown being attributed to a power outage at the site affecting all systems. Flow rates on the horizontal well system are balanced at 38 to 42 CFM on each of the two lines. All injection flow rates are operating at levels in proportion to the hydrostatic pressures yielded by the groundwater table. The equipment for the vertical air curtain wells is being operated at maximum obtainable pressure (19 psi) yielding a total flow of approximately 42 scfm into the formation.

Monthly observation well monitoring was conducted on 15 August 2002. Surging groundwater conditions were observed in MW-1, MW-1D, MW-11, MW-44, OW-2, and OW-5. VOC readings from the on-site vapor monitoring points (VMPs) were also collected on 15 August 2002. Approximately 4.4 ppm of VOCs were recorded in both VMP-1 and VMP-9.

5.2.4 *Other Activities*

In their letter dated 30 July 2002, the NJDEP indicated that the performance evaluation of the AS/SVE system that had been included in the 1 May 2002 RIRA-2 was acceptable. During a telephone conversation in August 2002, the NJDEP's Case Manager indicated that it would be acceptable for EPI to re-start the air sparging component of the AS/SVE system. However, as is discussed in further detail in Section 6.0 of this report, the AS system has not yet been re-started due to the presence of DNAPL in air sparge well AS-12.

5.3 September 2002

All three remediation systems were in operation during September 2002.

5.3.1 *AS/SVE System*

The SVE component of the AS/SVE system was operated at optimum flow and vacuum during the September 2002 reporting period. Downtime during the period was limited to four days due to failing thermocouples in the oxidizer. New thermocouples were installed on 26 September 2002 and consistent system operation was resumed. The hour meters were replaced on the SVE system and thermal oxidizer control panels on 26 September 2002. During the same maintenance event, the pitot tube and connections were replaced on the process flow stream.

The SVE system operated at an inlet vacuum of 25 i.w. and a corresponding extraction flow rate of 1,112 cfm. Limited observation well gauging was conducted as part of the DNAPL groundwater investigation on 4 & 5 September 2002. Approximately 4.88 inches of rain fell during the September 2002 reporting period, although most of this precipitation fell after the gauging event was conducted. Therefore, no evaluation can be made of changes in groundwater levels during this reporting period.

Approximately 133 pounds of non-methane hydrocarbons were recovered by the SVE system during the September 2002 reporting period (for an average of 33.0 pounds per week). Approximately 32,674 pounds of non-methane hydrocarbons have been recovered by the AS/SVE system as of 26 September 2002 (see Appendix F).

5.3.2 *Off-Site SVE System*

The extraction blower for the off-site SVE system operated at an inlet vacuum of approximately 22 i.w. and a maximum extraction air flow rate of 350 to 360 cfm. The off site SVE system was shut down from 11 to 25 September 2002 to allow for the excavation of the former process waste sewer line than runs parallel to Hudson Street along the southern property line. The off-site SVE system was inspected, tested for leaks, and re-started without incident on 25 September 2002.

Approximately 2.0 pounds of non-methane hydrocarbons were recovered by the off-site SVE system during this reporting period. Approximately 4,249 pounds of non-methane hydrocarbons have been recovered by the off-site SVE system as of 26 September 2002 (see Appendix G).

5.3.3 *Air Curtain System*

The horizontal and vertical air curtain wells ran at the full capacity of the sparging equipment during the September 2002 reporting period. Both systems were shut down between 11 and 25 September 2002 to allow for the excavation of the Hudson Street sewer line. Normal operations were resumed on 25 September 2002 following line inspections, repairs to the well head for air curtain well ACW-12, and pressure testing.

Flow rates on the horizontal well system are balanced at 38.0 cfm on each of the two lines. All injection flow rates are operating at levels in proportion to the hydrostatic pressures yielded by the groundwater table. The equipment for the vertical air curtain wells is being operated at maximum obtainable pressure (18 psi) yielding a total flow of approximately 39.0 scfm into the formation. VOC readings from the on-site VMPs were collected on 26 September 2002. Approximately 1.3 ppm of VOCs were recorded in VMP-9. Vapor monitoring points VMP-2 and VMP-5 were abandoned (by excavation) during the remediation of the Hudson Street sewer line. The excavation of these VMPs was witnessed by a licensed New Jersey well driller; copies of the abandonment reports for these VMPs will be included with the next RAPR.

6.0 PRELIMINARY DNAPL INVESTIGATION RESULTS

Following the receipt of the NJDEP's 31 July 2002 letter that allowed the air sparge component of the AS/SVE system to be re-started, and approved the DNAPL investigation program that had been proposed in Section 5.4 of the 1 May 2002 *Remedial Investigation Report Addendum No. 2*, Sovereign gauged the total depth of each air sparge well to determine which points needed to be re-developed to remove accumulated sediments. On 8 August 2002, an estimated 14.8 feet of DNAPL was measured (using an interface probe) in well AS-12. DNAPL was not detected in any of the other 24 air sparge wells located in the southeast corner of the site. On 14 August 2002, approximately 50 gallons of water were removed from AS-12 during its re-development. On 16 August 2002, the drum containing the development water from AS-12 was gauged and was found to contain approximately 0.37 feet (or approximately 8.0 gallons) of DNAPL; AS-12 was also gauged and was found to contain 0.88 feet of DNAPL.

EPI has implemented a manual recovery program for the DNAPL in AS-12. During each weekly operation & maintenance (O&M) visit for the SVE system and thermal oxidizer, AS-12 is gauged to determine the presence of DNAPL, and a submersible pump is used to remove any accumulated product. The following table summarizes the results of the recovery program.

Summary of DNAPL Recovery from AS-12

Date	Depth to Bottom of Well (feet)	Depth to Top of DNAPL (feet)	DNAPL Thickness (feet)	Estimated Volume of DNAPL Recovered (gal.)
8/7/02	28.92	14.08	14.84	0
8/14/02				8.0
8/16/02	29.2	28.32	0.88	0.14
8/22/02	29.2	28.25	0.95	0.15
8/29/02	29.3	28.45	0.85	0.14
9/5/02	29.2	27.80	1.40	0.22
9/11/02	29.2	27.95	1.25	0.20
9/18/02	29.2	28.08	1.12	0.18

Summary of DNAPL Recovery from AS-12				
Date	Depth to Bottom of Well (feet)	Depth to Top of DNAPL (feet)	DNAPL Thickness (feet)	Estimated Volume of DNAPL Recovered (gal.)
9/25/02	29.65	28.35	1.30	4.0
10/3/02	29.2	27.74	1.46	0.23
▨	▨	▨	▨	**Total: 13.3**

A sample of the DNAPL was collected and analyzed by Accutest for volatile organic compounds plus an NBS library search (VOC+10; USEPA Method 8260), base neutral/acid extractable compounds (including calibrations for 1,1'-biphenyl, diphenyl ether, benzoic acid, and salicylic acid) plus an NBS library search (BNA+25; USEPA Method 8270), and density. The analytical results for this sample are summarized on Table 10. The DNAPL from AS-12 has a density of 1.07 g/ml (density of water = 1.0 g/ml), and was found to contain 223,000 parts per million (ppm) of 1,1'-biphenyl (approximately 33% of the total concentration) and 420,000 ppm of diphenyl ether (approximately 63% of the total concentration), which is consistent with the composition of Dowtherm. The remaining 4% of the sample was composed primarily of toluene (0.96%), polynuclear aromatic hydrocarbons (PAHs; 0.01 to 0.61% each), nontargeted VOCs (0.33%) and nontargeted BNAs (0.57%).

Between 4 & 6 September 2002, Sovereign conducted the DNAPL investigation groundwater sampling program that had been approved by the NJDEP. This program consisted of three stages, including:

1. Using a transparent, bottom-loading, double check valve bailer to retrieve a water sample from the bottom of monitoring wells MW-4, MW-4D2, MW-5, MW-5D, MW-5D2, MW-D5, MW-17, MW-17D, MW-33, and MW-33D, and air sparge wells AS-6, AS-7, AS-8, AS-9, AS-11, AS-13, AS-15, AS-16, and AS-17 and visually inspecting the recovered fluid for DNAPL;

2. Checking for the presence of DNAPL using Sudan IV, an oleophilic/hydrophobic (i.e., soluble in oil, insoluble in water) dye; and,

3. Collecting and analyzing groundwater samples from each of the above wells for 1,1'-biphenyl and diphenyl ether using low flow purging and sampling methodology.

The results from Steps 1 & 2 indicated that none of the wells included in the sampling program contained DNAPL. Although the water from MW-4 contained a slight sheen that turned red when the Sudan IV dye was added, this well historically contained light non-aqueous phase liquids (LNAPLs). Therefore, EPI believes the initial screening results from MW-4 are inconclusive.

The analytical results for the DNAPL investigation groundwater samples are summarized on Table 11 and are presented on Figure 23. 1,1'-Biphenyl only exceeded its IGWQS of 400 ppb in MW-4 (770 ppb). Diphenyl ether was detected at concentrations exceeding its IGWQS of 100 ppb in MW-4 (1,690 ppb), MW-D5 (1,040 ppb), MW-17 (728 ppb), and MW-33 (265 ppb). These results are consistent with those from previous quarterly groundwater sampling events. 1,1'-Biphenyl and diphenyl ether were either not detected or were present at concentrations below their respective IGWQS in MW-4D2, MW-5, MW-5D, MW-5D2, MW-17D, MW-33D, AS-6, AS-7, AS-8, AS-9, AS-11, AS-13, AS-15, AS-16, and AS-17.

The results of the well gauging and groundwater sampling program suggest that the DNAPL present in AS-12 is limited to the 90' x 90' box defined by the surrounding air sparge wells. EPI is developing a soil boring work plan for completing the vertical delineation of the DNAPL, as well as for better defining its horizontal extent and distribution through the soil column. The results of this investigation will be submitted to the NJDEP as a separate Remedial Investigation Report (RIR). Supporting documentation and copies of the analytical data packages for the DNAPL investigation groundwater sampling will also be included in the RIR.

SOVEREIGN CONSULTING INC.

RECEIVED
FEB 05 200

6 February 2002

Mr. Andrew Dillman
New Jersey Department of Environmental Protection
Bureau of Environmental Evaluation Cleanup & Responsibility Assessment
Division of Responsible Party Site Remediation
401 E. State Street, 5th Floor
P.O. Box 432
Trenton, New Jersey 08625-0432

RE: **Kalama Chemical Inc. Facility**
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

Hand Delivered

Dear Mr. Dillman:

Attached please find an original and two copies of the *Quarterly Groundwater Sampling Results* report for the monitoring event conducted from 23 to 25 October 2001 at the above referenced site. This report has been prepared by Sovereign Consulting Inc. (Sovereign) on behalf of EPC Polymers Inc. (EPI). In addition, one copy of Attachment I (Analytical Data Packages) and one computer diskette containing the required electronic data deliverables are also being provided.

If you should have any questions or require additional information, please feel free to contact me at (609) 259-8200 or Mr. Roger Towe of El Paso Corporation (EPC) at (713) 420-4755.

Sincerely,
Sovereign Consulting Inc.

Paul I. Lazaar
Principal Project Manager

c: Project File
R. Towe, EPC
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R. Smith, Belkorp Industries

111-A N. Gold Drive • Robbinsville, NJ 08691 • Tel: 609-259-8200 • Fax: 609-259-8288

SOVEREIGN CONSULTING INC.

Quarterly Groundwater Sampling Results
October 2001

Kalama Chemical Inc. Facility
290 River Drive
Garfield, Bergen County, New Jersey
ISRA Case No. 86B73

4 February 2002

Prepared For:

EPEC Polymers, Inc.
1001 Louisiana Street
Houston, Texas 77002

Prepared By:

Sovereign Consulting Inc.
111-A North Gold Drive
Robbinsville, New Jersey 08691

Ravi Gupta

Paul I. Lazaar, P.G.
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ATTACHMENTS (under separate cover)

Attachment I - Analytical Data Package for the October 2001 Groundwater Samples (3 Volumes)

1.0 INTRODUCTION

On behalf of EPEC Polymers Inc. (EPI), Sovereign Consulting Inc. (Sovereign) has prepared this *Quarterly Monitoring Report* for the groundwater sampling event conducted from 23 to 25 October 2001 at the Kalama Chemical Inc. site in Garfield, New Jersey (Figure 1). A groundwater monitoring program was originally proposed to the New Jersey Department of Environmental Protection (NJDEP) in the March 1995 *Revised Remedial Action Work Plan* (Revised RAW). Although this plan has not yet been approved by the NJDEP, a monitoring program was implemented in June 1997 to establish a base-line against which remediation progress could be compared. The monitoring program started in June 1997 has subsequently been modified to include additional compounds of concern.

The January 1995 groundwater sampling event identified three areas of the site requiring remediation and/or monitoring: 1) the Northeast Phenol Hot Spot (Former Building 10/36); 2) the Northwest Phenol Hot Spot (Former Building 33-B); and, 3) the Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14). In addition, benzene, toluene, phenol, benzoic acid, methanol, and formaldehyde were identified as the six primary compounds of concern in groundwater, although the distribution of these compounds varied across the site.

Based on the results of grab groundwater samples collected following the demolition of the Building 10/36 complex, salicylic acid (or 2-hydroxybenzoic acid) was added to the list of analytical parameters for the monitoring wells in the Northeast Phenol Hot Spot area. Based on the quarterly sampling results from June 1997 through October 1998, phenol and benzoic acid are no longer considered to be compounds of concern in the Toluene Spill Area and have been eliminated from the monitoring program for the wells addressing this AEC.

In response to comments in the NJDEP's letter dated 26 June 2000, 1,1'-biphenyl and diphenyl ether were added to the monitoring program for wells addressing the Toluene Spill Area during the July 2000 sampling event.

In response to the NJDEP's letter dated 26 June 2000, a groundwater monitoring program for AEC-14 was submitted as part of the 3 August 2001 Remedial Investigation Report (RIR) Addendum. The

NJDEP approved the monitoring program for AEC-14 in their letter dated 15 October 2001. A groundwater monitoring program for the Northeast and Northwest Phenol Hot Spot areas will be provided as a stand alone document in accordance with the comments in the NJDEP's 15 October 2001 letter.

On 9 August 2001, all of the remediation systems at the site were shut down in response to the NJDEP's 6 August 2001 letter. Therefore, the results of the October 2001 groundwater sampling event can be used to evaluate concentration rebounds under static conditions.

1.1 Groundwater Quality Standards

The groundwater quality standards (GWQS) for the six original compounds of concern identified at the Kalama site are summarized below.

Site Specific Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Benzene	1.0
Toluene	1,000
Phenol	4,000
Benzoic Acid	30,000
Methanol	3,500
Formaldehyde	110

The benzene, toluene, and phenol standards are from N.J.A.C. 7:9-6 et seq. (Groundwater Quality Standards). The standard for methanol was proposed in the March 1995 Revised RAW and was approved by the NJDEP in their letter dated 6 September 1995. The values for benzoic acid and formaldehyde were established by the NJDEP in their 30 August 1996 letter following the submission of proposed standards in the Revised RAW Addendum.

Groundwater at the site has been found to also contain salicylic acid, 1,1'-biphenyl, and diphenyl ether. However, since the NJDEP does not have any established groundwater quality standards for these compounds, a generic value of 100 parts per billion (ppb) would be applied (Table 2 of N.J.A.C. 7:9-6 et seq.). EPI believes the generic 100 ppb criterion is too conservative, since it does not incorporate toxicological data specific to each compound. Since none of these compounds of concern are volatile, and groundwater in the vicinity of the site is not used for beneficial purposes, there are few, if any, complete exposure pathways relevant to groundwater. In the absence of the exposure pathway upon which the NJDEP's 100 ppb criterion is based, acceptable groundwater concentrations at the site should be much higher than the generic value.

On 17 April 2001, EPI submitted a formal request for the following alternate groundwater quality standards for salicylic acid, 1,1'-biphenyl, and diphenyl ether.

Proposed Alternate Groundwater Quality Standards
Kalama Chemical Inc. Facility
Garfield, Bergen County, New Jersey

Compound of Concern	GWQS (in ug/L)
Salicylic Acid	5,600
1,1'-Biphenyl	1,800
Diphenyl Ether	21,000

In their 6 August 2001 letter, the NJDEP indicated that until the Department completes its review of EPI's proposed alternate groundwater quality standards, the Interim Generic Groundwater Quality Standard (IGWQS) of 100 ppb would apply for salicylic acid, 1,1'-biphenyl, and diphenyl ether. For comparison purposes, the results of the October 2001 groundwater sampling event have been evaluated using both sets of groundwater quality standards.

2.0 GROUNDWATER SAMPLING PROCEDURES

In accordance with the NJDEP's "Technical Requirements for Site Remediation", groundwater sampling was performed following the procedures outlined in the May 1992 "Field Sampling Procedures Manual". Prior to sampling, each well was gauged to measure the depth to groundwater and to determine the presence/absence of separate phase hydrocarbons (SPH) using an interface probe capable of detecting separate phase liquid layers as thin as 0.01 feet. Approximately three well volumes were then purged from each well to remove stagnant water and ensure that the sample collected was representative of the water quality in the shallow and deep overburden zones. If three well volumes could not be purged due to poor recharge, the water level in the well was allowed to recover to within two feet of static conditions (or sufficiently to allow sample collection) prior to sampling.

Well purging was performed using a submersible 12 volt, PVC and stainless steel, electric pump and dedicated vinyl tubing. During purging, the flow rates generally ranged from 1.0 to 1.5 gallons per minute (gpm). In accordance with the "Field Sampling Procedures Manual", the following information was recorded during the purging and sampling of each well:

Before Purging

- Date, time, and weather conditions
- Well number
- Head space reading immediately after well cap is removed
- Product thickness, if any
- pH, dissolved oxygen, temperature, specific conductivity
- Total depth of well from top of casing (TOC)
- Depth from TOC to top of screen
- Depth to water from TOC
- Estimated volume of water in well

After Purging

- Start and end time of purging
- Purge method
- Purge rate(s)
- Total volume purged
- Depth to water after purging
- pH, dissolved oxygen, temperature, specific conductivity

Before Sampling

- Depth to water from TOC

After Sampling

- Start and end time of sampling
- pH, dissolved oxygen, temperature, specific conductivity
- Sampling method

Well purging information for the October 2001 sampling event is summarized on the tables included in Appendix A.

Approximately three well volumes of water were purged from all wells except MW-4, which went dry after one volume, and MW-47D, which went dry after two well volumes; neither well recharged sufficiently to allow for continued purging. All wells were sampled within two hours of completing purging except MW-4 and MW-25. The water levels in these two wells took over two hours to recover sufficiently to allow samples to be collected. As discussed in Section 3.0 below, all of these wells contained one or more compounds of concern at concentrations exceeding the applied groundwater quality standards. Therefore, these purging anomalies do not appear to have biased the groundwater sampling results.

In accordance with the NJDEP's letter dated 6 August 2001, and as discussed during the 6 December 2001 conference call, wells that exhibit poor recharge or excessive drawdown will be purged and sampled during future monitoring events using Low Flow methodology (see Section 4.0 for further discussion).

Groundwater samples were collected using a disposable Teflon bailer and dedicated nylon string. The samples for VOC analyses were collected from the first bailer of water recovered from each well. Each sample container was labeled, logged on a chain-of-custody form, and placed on ice in a cooler. One trip blank (prepared by the analytical laboratory) and one field blank (rinsate of an un-used Teflon bailer) was collected for each day of sampling. At the end of each day, the samples for benzene, toluene, phenol, salicylic acid, 1,1'-biphenyl, diphenyl ether, and methanol were either delivered to the analytical laboratory (Accutest in Dayton, New Jersey; Certification No. 12129) or returned to the office where they were picked up by an Accutest courier the following morning. The formaldehyde samples were shipped via overnight courier to STL/Savannah Laboratories (STL/SL) in Tallahassee, Florida. Copies of the analytical data packages for the October 2001 groundwater samples (including the electronic data disk deliverables) are included under separate cover as Attachment I.

The submersible pumps used during groundwater sampling were decontaminated between each well. The pump and electric cord were first placed in a bucket with a non-phosphate detergent solution and allowed to operate for several minutes; any sediment on the outside of the pump was also removed during this stage. The pump was then transferred to a second bucket containing potable water and allowed to run for several minutes. Finally, the outside of the pump was rinsed with potable water prior to re-use. Since the Teflon bailers and vinyl tubing were disposed between well locations, it was not necessary to decontaminate this material.

3.0 GROUNDWATER SAMPLING RESULTS

Groundwater samples were collected from 47 wells between 23 and 25 October 2001. Monitoring well MW-9 was not sampled due to the presence of SPH. Monitoring well MW-12D was covered by debris from the demolition of Building 31 and Building 32 and could not be sampled. As with the April and July 2001 sampling events, shallow overburden zone wells MW-2, MW-3, MW-18, MW-28, MW-32, ORC-2, WP-5, and WP-6 in the Northeast Phenol Hot Spot area were not sampled during this monitoring event[1]. The monitoring program and sampling results for the three source areas are discussed separately, below.

3.1 Groundwater Elevations

Prior to sampling, each well was gauged to determine the presence/absence of SPH and to measure the depth to water. Well gauging data for this sampling event are summarized on Table 1 and were used to prepare the groundwater elevation contour maps shown on Figure 2 and Figure 3. MW-9 contained 2.10 feet of SPH during this monitoring event.

Figure 2 shows the groundwater elevation contours for the shallow overburden zone. The overall direction of groundwater flow continues to be towards the west-southwest. As indicated in Section 1.0, the air sparging system in the southeast corner of the site and the vertical and horizontal injection wells of the air curtain in the southwest corner of the site were not in operation at the time of sampling. The water table mound present in the northeast corner of the site is most likely due to low permeability silts and clays that underlie this area. The absence of a mound around MW-4 in the southeast corner of the site is most likely due to the low water table conditions that have resulted from the lack of precipitation dating back to the Summer of 2001. The mound in the southeast corner of the site has always been of limited extent (primarily around MW-4), and would therefore be affected by drought conditions to a greater degree than the mound in the northeast corner of the site (which is caused by a much larger low

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[1] Wells MW-2, MW-3, MW-18, MW-28, MW-32, ORC-2, WP-5, and WP-6 were not sampled during this monitoring event since the concentrations of phenol, salicylic acid, methanol, and formaldehyde in the shallow overburden zone of the Northeast Phenol Hot Spot area have been below their respective groundwater quality standards since at least July 1999 (with the exception of salicylic acid in ORC-2 in April 2000).

permeability layer). Since the presence of a water table mound around MW-4 was first identified in 1988, (thereby pre-dating the installation and operation of the AS/SVE system by many years), its absence during the October 2001 monitoring event cannot be attributed to the fact that the air sparging system was not in operation.

Groundwater elevation contours for the deep overburden zone are shown on Figure 3. The direction of groundwater flow in the deep overburden zone is generally westward.

3.2 Northeast Phenol Hot Spot (Former Building 10/36)

In order to monitor the natural degradation of the phenol, salicylic acid, methanol, and formaldehyde present in the deep overburden zone (i.e., below the clay layer) in the area of former Building 10/36 in the northeast corner of the site, groundwater samples were collected from the following wells:

Source Area Wells	MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, WP-3R
Monitoring Points	MW-2DR, MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, MW-54D

Each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270, methanol by USEPA Method 8015 - Direct Aqueous Injection (DAI), and formaldehyde by USEPA Method 8315. The results of these analyses are summarized on Table 2 and are presented on Figure 4. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix B.

The deep overburden zone wells within the source area are MW-28D, MW-47D, MW-48D, MW-49D, MW-50D, MW-55D, ORC-4D, and WP-3R (Figure 4). Phenol was detected at concentrations exceeding the GWQS of 4,000 ppb in MW-28D (15,600 ppb), MW-47D (179,000 ppb), MW-48D (34,000 ppb), MW-50D (11,500 ppb), and MW-55D (113,000 ppb). MW-47D was the only well that contained methanol (8,280,000 ppb) and formaldehyde (620 ppb) at concentrations exceeding their GWQS' of 3,500 ppb and 110 ppb, respectively. Salicylic acid was detected in five source area wells at concentrations exceeding the proposed alternate GWQS of 5,600 ppb, and in six of the source area wells at concentrations exceeding the NJDEP's IGWQS of 100 ppb, including MW-28D (17,000 ppb), MW-47D (568,000 ppb), MW-48D (251,000 ppb), MW-49D (6,960 ppb), MW-50D (2,680 ppb), and MW-55D (79,900 ppb).

The concentrations of the phenol, salicylic acid, methanol and formaldehyde were either not detectable or below their respective GWQS in all of the side and downgradient monitoring points in the deep overburden zone (MW-3D, MW-12D, MW-32D, MW-52D, MW-53D, and MW-54D), with the exception of MW-2DR, which contained 1,540 ppb of salicylic acid and 140 ppb of formaldehyde.

3.3 Northwest Phenol Hot Spot (Building 33-B)

In order to monitor the natural degradation of phenol in the shallow overburden zone beneath former Building 33-B, groundwater samples were collected from the following wells:

Source Area Well	WP-2R
Monitoring Points	WP-1R, MW-21

Each groundwater sample was analyzed for phenol and salicylic acid by USEPA Method 8270. The analytical results for these samples are summarized on Table 3 and are presented on Figure 5. Concentration vs. Time graphs summarizing historical data for all three wells are included in Appendix C.

Phenol and salicylic acid were detected at 101,000 ppb and 59,300 ppb, respectively, in WP-2R during the October 2001 sampling event. Downgradient monitoring point WP-1R contained 32.4 ppb of phenol and no detectable concentration of salicylic acid. Consistent with previous sampling events, no detectable concentrations of phenol or salicylic acid were found in MW-21.

3.4 Benzoic Acid/Benzaldehyde Plant and Toluene Spill Area (AEC-14)

In order to monitor the effectiveness of the AS/SVE, air curtain, and the off-site SVE systems, groundwater samples were to be collected from the following wells:

Source Area Wells: MW-1, MW-4, MW-5, MW-D5, MW-E5, MW-6, MW-9, MW-10, MW-11, MW-14, MW-17, MW-23, MW-25, MW-30, and MW-33

Monitoring Points: MW-16, MW-22, MW-31, MW-36, MW-37, MW-38, MW-40, MW-41, MW-42, MW-45, MW-46, OW-1, OW-2, OW-3, OW-4, and OW-5

As per the NJDEP's 15 October 2001 letter, the monitoring wells addressing this AEC have been re-characterized as "source area", "fringe", or "sentinel" wells as follows:

Source Area Wells: MW-4, MW-5, MW-D5, MW-E5, MW-9, MW-17, MW-33, MW-45, and OW-3

Fringe Wells: MW-1, MW-10, MW-11, MW-14, MW-23, MW-25, MW-31, MW-36, MW-40, MW-41, MW-42, MW-46, OW-1, OW-2, OW-4, and OW-5

Sentinel Wells: MW-6, MW-16, MW-22, MW-30, MW-37, and MW-38

As indicated in Section 3.1, MW-9 contained 2.10 feet of SPH during this monitoring event and was not sampled. The groundwater samples collected from the remaining wells addressing this area of environmental concern were analyzed for benzene and toluene by USEPA Method 624, and 1,1'-biphenyl and diphenyl ether by USEPA Method 8270. The analytical results for these samples are summarized on Table 4 and are presented on Figure 6. Concentration vs. Time graphs summarizing historical data for each well are included in Appendix D.

In their 6 August 2001 letter, the NJDEP requested clarification of the term "surging" water that was used to describe conditions in several monitoring wells at the site. During the 6 December 2001 conference call with the NJDEP, EPI explained that the "surging" water that had been observed in several of the wells within the area of influence of the air curtain represented injected air that was migrating to the surface through the monitoring well. Due to the ease at which the air could migrate to the surface, the water in the well would vigorously bubble and churn. As was agreed during the conference call, the wells and the monitoring events when this "surging" action were observed are summarized on the following Table.

Wells Influenced by "Surging" Water from Air Curtain Injection Wells	
Well	Sampling Events
MW-1	April 1998 through July 2001
MW-10	January 2000, October 2000 through July 2001
MW-11	January 1999 through July 2001
MW-22	April 1998, July 1998
OW-2	January 2000 through July 2001
OW-4	January 2000 through July 2001
OW-5	January 2000 through July 2001

The data for each of these sampling events have been identified on the tables included in Appendix D, and have been removed from the Concentration vs. Time graphs. It should be noted that "surging" water has never been observed in wells within the area of influence of the AS/SVE system in the southeast corner of the site.

Benzene was detected at concentrations above the GWQS of 1.0 ppb in 12 of the 30 wells sampled. In the source area wells, benzene was detected in six of the eight wells sampled, including MW-4 (20.7 ppb), MW-D5 (919 ppb), MW-17 (22.0 ppb), MW-33 (1,600 ppb), MW-45 (5,910 ppb), and OW-3 (13.7 ppb). In the fringe area wells, benzene was detected at concentrations exceeding the GWQS of 1.0 ppb in 10 of the 17 wells sampled. Benzene concentrations of approximately 10.0 ppb or less were found in MW-10 (5.9 ppb), MW-23 (10.8 ppb), MW-31 (3.4 ppb), MW-41 (2.8 ppb), OW-1 (1.7 ppb), and OW-4 (2.9 ppb). In the four remaining wells containing elevated concentrations, benzene was detected in MW-14 (56.0 ppb), MW-25 (579 ppb), MW-40 (81.5 ppb), and OW-2 (1,110 ppb). No detectable concentrations of benzene were found in the five sentinel monitoring wells.

Benzene concentrations increased in several wells (MW-4, MW-10, MW-14, MW-17, MW-25, MW-31, MW-40, MW-41, MW-45, OW-1, OW-2, and OW-4) relative to the July 2001 sampling event (as was anticipated since all the remediation systems had been shut down in August 2001). Most of these increases were minor (ranging from 1.7 ppb to 37.7 ppb) and were within the normal range of fluctuations that have been observed while the remediation systems were in operation. Significant increases relative to July 2001 were only observed in MW-25 (up 561 ppb), MW-45 (up 5,645 ppb), and OW-2 (up 1,108 ppb). Benzene concentrations decreased in six wells (MW-D5, MW-23, MW-33, MW-36, MW-42, and OW-3), with the decrease ranging from 0.52 ppb to 330 ppb. Additionally, benzene concentrations remained below the GWQS of 1.0 ppb in MW-1, MW-5, MW-E5, MW-6, MW-11, MW-16, MW-22, MW-30, MW-36, MW-37, MW-38, MW-46, and OW-5.

Table 5 presents a comparison of the October 2001 benzene concentrations to the maximum concentration ever detected in a well, and to the last four quarters of data for each well before the remediation systems were shut down in August 2001. The summary on Table 5 shows that even with the slight rebound in benzene concentrations that were observed between July 2001 and October 2001, there has still been an average reduction of 90% in the levels of benzene in the monitoring wells that address the Toluene Spill Area of the site (excluding MW-E5 and MW-46 which have never contained more than 1.0 ppb of benzene).

Toluene was detected at concentrations above the GWQS of 1,000 ppb in seven of the 30 wells sampled. In the source area wells, toluene exceeded the GWQS in three of the eight wells sampled, including MW-D5 (48,500 ppb), MW-33 (314,000 ppb), and MW-45 (287,000). In the fringe area wells, toluene was detected at concentrations exceeding the GWQS in four of the 17 wells sampled, including MW-14 (1,380 ppb), MW-25 (89,400 ppb), MW-40 (6,890 ppb), and OW-2 (196,000 ppb). Toluene concentrations in the sentinel wells were all below the GWQS of 1,000 ppb, and ranged from not detected in MW-16 to 32.5 ppb in MW-30.

Unlike with the benzene results, shutting off the remediation systems did not result in an increased number of wells containing toluene at concentrations exceeding the GWQS. Only two wells (MW-25 and OW-2) contained higher toluene concentration in October 2001 than had been detected over the previous four quarters of sampling. Although toluene concentrations increased relative to July 2001 in MW-14 (up 520 ppb), MW-33 (up 10,000 ppb), MW-40 (up 1,400 ppb), and MW-45 (up 152,000 ppb), these results are consistent with those from the last four quarters of sampling, and are still lower than the maximum concentrations that have ever been detected in each well (see Table 6). In MW-D5, the toluene concentration in October 2001 decreased 16,500 ppb relative to July 2001 and represents the lowest level ever detected in this well. Table 6 shows that as of October 2001, the number of wells that contain over 1,000 ppb of toluene have been reduced from 22 to seven, and that there has been an average reduction in toluene concentrations of 88% in the wells addressing the Toluene Spill Area (excluding those wells that have never contained toluene at a concentration exceeding the GWQS of 1,000 ppb).

1,1'-biphenyl was detected at concentrations above the proposed alternate GWQS of 1,800 ppb in on-site well MW-D5 (2,130 ppb), and at concentrations above the NJDEP's interim generic groundwater quality standard of 100 ppb in on-site wells MW-4 (741 ppb) and MW-14 (1,390 ppb). In the off-site wells, 1,1'-biphenyl was detected at 236 ppb in MW-46 and 294 ppb in MW-33. Diphenyl ether was detected at concentrations exceeding the interim generic GWQS of 100 ppb, but below the proposed alternate GWQS of 21,000 ppb, in 18 of the 30 wells sampled, including MW-4 (2,580 ppb), MW-5 (101 ppb), MW-D5 (5,120 ppb), MW-10 (931 ppb), MW-11 (154 ppb), MW-14 (5,480 ppb), MW-17 (679 ppb), MW-22 (226 ppb), MW-23 (732 ppb), MW-25 (221 ppb), MW-31 (261 ppb), MW-33 (616 ppb), MW-40 (1,040 ppb), MW-45 (176 ppb), MW-46 (405 ppb), OW-1 (144 ppb), OW-2 (147 ppb), and OW-3 (376 ppb).

3.5 Distribution of Compounds of Concern

The distribution of toluene and benzene in the shallow overburden zone using the October 2001 groundwater sampling results is shown on Figure 7 and Figure 8, respectively. The highest concentrations of toluene (greater than 100,000 ppb) are limited to the area around MW-33 and MW-45, and in the vicinity of OW-2. Concentrations of toluene exceeding the GWQS of 1,000 ppb are also found in the vicinity of MW-14 and MW-40. As shown on Table 7, the portions of the toluene plume in October 2001 that contained greater than 100,000 ppb, 10,000 ppb, and 1,000 ppb increased in areal extent by approximately 675 ft^2, 3,260 ft^2, and 8,200 ft^2, respectively. The areal extent of the toluene plume in October 2001 following a rebound in concentrations is therefore comparable to that in October 2000.

The benzene affected area roughly mirrors the toluene affected area, with the highest concentrations (greater than 1,000 ppb) being found around MW-D5 and MW-33, and OW-2. Benzene concentrations exceeding 10.0 ppb were also found in the southeast corner of the site (MW-14 and MW-23), and in the area of MW-25 and MW-40. As shown on Table 8, the portions of the benzene plume in October 2001 that contained greater than 1,000 ppb, 100 ppb,, 10.0 ppb, and 1.0 ppb increased in areal extent by approximately 2,120 ft^2, 7,370 ft^2, 28,920 ft^2, and 55,200 ft^2, respectively. The areal extent of the benzene plume in October 2001 following a rebound in concentrations is also comparable to that in October 2000[2].

The distributions of 1,1'-biphenyl and diphenyl ether in the shallow overburden zone are shown on Figures 9 and 10, respectively. The concentration of 1,1'-biphenyl exceeded the proposed alternate GWQS of 1,800 ppb in the vicinity of MW-D5. However, concentrations of 1,1'-biphenyl exceeding the interim generic GWQS of 100 ppb were also found encompassing MW-4, MW-D5, and MW-33, and in the vicinity of MW-14 and MW-46. Diphenyl ether concentrations exceeding the interim Generic GWQS of 100 ppb were found in the southeast corner of the site encompassing MW-4, MW-5, MW-D5, MW-17, MW-45, MW-46, and OW-3; in the south-central portion of the site around MW-10, MW-11, MW-25, MW-40, OW-1, and OW-2; and in the southwest corner of the site around MW-14, MW-22, MW-23, and MW-31.

No detectable concentrations of benzene, toluene, 1,1'-biphenyl, and diphenyl ether were found in upgradient monitoring well MW-16. These results confirm previous analytical data which indicated that the area affected by the toluene spill did not extend off-site to the east.

The distributions of phenol and salicylic acid within the shallow overburden zone are shown on Figures 11 and 12, respectively. The area with the highest concentration of phenol is limited to beneath former Building 33-B (101,000 ppb in WP-2R). The area containing salicylic acid at concentrations exceeding the proposed alternate GWQS of 5,600 ppb and the NJDEP's interim generic GWQS of 100 ppb is also limited to the area of WP-2R.

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[2] Excluding April 2001 which was skewed due to an anomalous benzene concentration in MW-37.

The distribution of phenol in the deep overburden zone is depicted on Figure 13. Phenol concentrations over 100,000 ppb were found between MW-47D and MW-55D, with concentrations exceeding 10,000 ppb also encompassing MW-28D, MW-48D, and MW-50D. Phenol concentrations decrease rapidly to below the GWQS of 4,000 ppb, as evidenced by the levels seen in MW-2DR, MW-49D, MW-52D, MW-53D, and MW-54D.

As shown on Figure 14, formaldehyde concentrations exceeding the GWQS of 110 ppb in the deep overburden zone were found in a lenticular area encompassing MW-2DR and MW-47D.

The distribution of salicylic acid in the deep overburden zone is shown on Figure 15. The distribution of salicylic acid in the deep overburden zone is similar to that of phenol, with concentrations exceeding 10,000 ppb encompassing MW-28D, MW-47D, MW-48D, and MW-55D. Salicylic acid concentrations exceeding 100,000 ppb were limited to MW-47D and MW-48D. The area of the salicylic acid plume as defined by the NJDEP interim GWQS of 100 ppb is only slightly larger than that defined by the proposed alternate GWQS of 5,600 ppb.

The distribution of methanol in the deep overburden zone is shown on Figure 16. Methanol only exceeded the GWQS of 3,500 ppb in MW-47D (8,280,000 ppb).

4.0 PROPOSED LOW FLOW PURGING & SAMPLING METHODOLOGY

As discussed in Section 2.0, the NJDEP has approved the use of low flow purging and sampling for collecting samples from wells that exhibit poor recharge or excessive drawdown during purging. After reviewing the historical well purging data, EPI has identified the following 11 wells on which the low flow methodology will be used in future groundwater monitoring events:

Wells to be Purged & Sampled using Low Flow Methodology	
Well	Reason for Selection
MW-1	Poor Recharge
MW-4	Poor Recharge
MW-22	Very Poor Recharge
MW-25	Very Poor Recharge
MW-28D	Excessive Drawdown (>10 feet)
MW-31	Very Poor Recharge
MW-32D	Excessive Drawdown (>10 feet)
MW-40	Poor Recharge
MW-47D	Poor Recharge
MW-48D	Excessive Drawdown (>10 feet)
MW-53D	Poor Recharge

EPI proposes to follow the purging and sampling procedures from the USEPA Region II's *Groundwater Sampling Procedure - Low Stress (Low Flow) Purging and Sampling* document that was provided by the NJDEP following the 6 December 2001 conference call. A description of the methodology to be used and an example form for recording the data in the field are included in Appendix E.

WEEKLY SUMMARY OF INSPECTIONS BY INSPECTORS

Week of April 30 to May 4, 1956, Inc.

May 2, Progress Report - Interchemical Corp., Wagaraw Road, Hawthorne, N
Cofrancesco Contractors, from the city of Paterson, were hired to make repairs. A shovel closed up the opening and this prevented the green liquid from flowing into the river. Pumps were installed to pump all liquid waste to the Hawthorne sewer from the ditch while repair work is taking place.

May 3, Progress Report - Interchemical Corp., Hawthorne, N. J.
Cofrancesco Contractors continue work and pumping liquid waste into the sanitary sewer.

May 4, Progress Report - Interchemical Corp., Hawthorne, N. J.
Several sewer joints were found to be leakin and it was decided to open the ground from manhol to repair all joints.

May 5, Progress Report - Interchemical Corp., Hawthorne, N. J.
On Saturday May 5, men were working all day excavating around the sewer line.

May 6, Progress Report - Interchemical Corp., Hawthorne, N. J.
On Sunday May 6, an inspection was made to observe the conditions.
A private detective was hired to prevent younsters from falling into the ground opening.

DISTRICT NO. 3 - Thomas J. Costello

Paterson Overflows - Twelve sewers overflowed this week. This will be reported on the monthly report.

May 1, Special Report - Public Service Electric & Gas Co., Paterson, N. J.
Murky looking water was discharging from one of the outlets in the rear of the above named company to the Passaic River. The maintenance man informed our inspector that they were washing sediment out of the condensers, the mud from the intake line being returned to the river.

DISTRICT NO. 4 - Robert Van Volkenburgh

May 2, Special Report - Heyden Chemical Co., 270 River Drive, Garfield.
Accompanying this report is an analysis made by the Heyden Chemical Company, of the discharge mentioned in the report of April 3. This discharge is black and foamy and runs about one hour.
Mr. Victor Coates, Chief Engineer, claims the discharge is not harmful to the river.

PASSAIC VALLEY SEWERAGE COMMISSIONERS
DEPARTMENT OF SANITATION CONTROL

LABORATORY REPORT

STANDARD METHODS OF ANALYSIS A.P.H.A.
MILLIGRAMS PER LITER (mg/l)
RESULTS EXPRESSED IN ~~PARTS PER MILLION (p.p.m.)~~

ATE OFSAMPLE June 15, 1972 TIME 2:00 P. M. SAMPLE NO. 218

MPLE OF Universal International Industries, 29 Riverside Ave., Newark, N. J. TAKEN BY J. K. Mc Laughlin

TAL SOLIDS:—		BIOCHEMICAL OXYGEN DEMAND (B.O.D.)	55 sl
TOTAL MINERAL		TURBIDITY	200 wp
TOTAL VOLATILE		CHLORINE RESIDUAL	
LUBLE SOLIDS:—		COLIFORM (~~B. coli per ml.) M.P.N.~~ BACTERIA per ml.	
SOLUBLE MINERAL		FLAMMABLE	
SOLUBLE VOLATILE		EXPLOSIMETER READING (PERCENT)	
SPENDED SOLIDS:—	174 vo	SETTLEABLE SOLIDS (mls. Per Liter)	
SPENDED MINERAL	59 vo	pH	10.9 dp
USPENDED VOLATILE	115 - vo	PHOSPHATE (ORTHO)	
GANIC NITROGEN		PHOSPHATE (TOTAL)	
MMONIA NITROGEN		TEMPERATURE °F.	90° F.
TRITE NITROGEN		HEAVY METALS	
TRATE NITROGEN		CHROMATE CHROMIUM	16 mg/l er
TAL NITROGEN			
LORIDES AS CHLORINE	45 wp		
KALINITY AS CaCO3			
YGEN CONSUMED (C.O.D.)	310 wp		
SSOLVED OXYGEN (D.O.)			

DESCRIPTION

ale green translucent liquid.
race of brown suspended matter.
ndustrial odor. (melted wax)
Br ish sediment.

REMARKS:

FID000007

APPRO
Director of Sanitation Control