OFF-SITE GROUNDWATER
PREDESIGN INFORMATION REPORT

HOOKER CHEMICAL/RUCO POLYMERS SUPERFUND SITE
HICKSVILLE, NEW YORK

Prepared by:
Conestoga-Rovers
& Associates

651 Colby Drive
Waterloo, Ontario
Canada N2V 1C2

Office: (519) 884-0510
Fax: (519) 884-0525

web: http://www.CRAworld.com

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

Page

LIST OF FIGURES
(Following Text)

LIST OF FIGURES
(Following Text)

LIST OF TABLES
(Following Text)

LIST OF APPENDICES

APPENDIX A	STRATIGRAPHIC AND INSTRUMENTATION LOGS
APPENDIX B	ISOFLOW PURGING AND ANALYTICAL RESULTS
APPENDIX C	WELL DEVELOPMENT SUMMARY
APPENDIX D	INJECTION TESTING INFORMATION AND PROGRESS MEMOS
APPENDIX E	EFFECT OF CARBON SUPPLEMENTATION ON ENHANCEMENT OF VINYL CHLORIDE DEGRADATION IN GROUNDWATER LABORATORY TREATABILITY STUDY
APPENDIX F	ESTIMATION OF TOTAL OXYGEN DEMAND

LIST OF ACRONYMS

1,1-DCE	1,1-Dichloroethylene
1,2-DCE	1,2-Dichloroethylene (total)
AMSL	Above Mean Sea Level
ARCADIS	ARCADIS Geraghty & Miller
BGS	Below Ground Surface
BOD	Biological Oxygen Demand
BRP	Beyond Ruco Property
BWD	Bethpage Water District
c-1,2-DCE	cis-1,2-Dichloroethylene
CI	Controls and Instrumentation
CLP	Contract Laboratory Protocols
CRA	Conestoga-Rovers & Associates
DAP	Diammonium Phosphate
DCE	Dichloroethylene
DEC	New York State Department of Environmental Conservation
DO	Dissolved Oxygen
EPA	United States Environmental Protection Agency
FS	Feasibility Study
GPM	gallons per minute
GSHI	Glenn Springs Holdings, Inc.
Hooker/Ruco Site	Hooker Chemical/Ruco Polymers Superfund Site
IRM	Interim Remedial Measure
LFP	Low Flow Purging
MS/MSD	Matrix Spike/Matrix Spike Duplicate
NA	Natural Attenuation
Navy	Naval Weapons Industrial Reserve Plant
Northrop	Northrop/Grumman Aerospace Corporation
NTU	Nephlometric Turbidity Unit
O&M	Operation and Maintenance
ORC	Oxygen Release Compound
ORP	Oxidation/Reduction Potential
OU-1	Operable Unit – 1
OU-2	Operable Unit - 2

LIST OF ACRONYMS

OU-3	Operable Unit – 3
OxyChem	Occidental Chemical Corporation
P&ID	Process & Instrumentation Diagram
PC	Personal Computer
PCE	Tetrachloroethylene
PID	Photoionization Detector
PLC	Programmable Logic Controller
PRAP	Proposed Remedial Action Plan
psi	Pounds per square inch
PVC	Polyvinyl Chloride
QA/QC	Quality Assurance/Quality Control
RD/RA	Remedial Design/Remedial Action
RI	Remedial Investigation
RM	Remedial Measure
ROD	Record of Decision
ROI	Radius of Influence
scfm	Standard Cubic Feet per Minute
SOW	Scope of Work
TCE	Trichloroethylene
TCL	Target Compound List
TICs	Tentatively Identified Compounds
TOC	Total Organic Carbon
TOD	Total Oxygen Demand
TVOC	Total Volatile Organic Compound
VCM	Vinyl Chloride Monomer
VOCs	Volatile Organic Compounds
WPCP	Water Pollution Control Plant

1.0 INTRODUCTION

The Hooker Chemical/Ruco Polymers Superfund Site (Hooker/Ruco Site) is a 14-acre polymer manufacturing facility located in Hicksville, New York as shown on Figure 1.1. A Site plan is shown on Figure 1.2. A Remedial Investigation (RI) and Feasibility Study (FS) were completed for the Hooker/Ruco Site (on-Site) in August 1992 and August 1993, respectively. In April 1994, Occidental Chemical Corporation (OxyChem) initiated a program to investigate groundwater conditions (off-Site) beyond the Ruco property (BRP).

The purpose of the BRP Study was to collect additional groundwater data around and primarily west of the Hooker/Ruco Site to complete the RI and to prepare a FS to address the off-Site vinyl chloride monomer (VCM) subplume in the Bethpage regional aquifer (i.e., Operable Unit-3 [OU-3]). The regional groundwater contains chemicals from the Hooker/Ruco Site, the adjacent aerospace manufacturing facility operated by the Northrop Grumman Aerospace Corporation (Northrop), and the Naval Weapons Industrial Reserve Plant (Navy) which is located on the Northrop property. Northrop has conducted an RI/FS for their site pursuant to a Consent Agreement with the New York State Department of Environmental Conservation (DEC). The Navy site was also the subject of an RI/FS under the Comprehensive Long-Term Environmental Active Navy Program. The RI's for the Northrop and Navy sites were completed in September 1994 and October 1993, respectively. Based on the findings of these RI's, Northrop implemented an Interim Remedial Measure (IRM) which included treatment at the Bethpage Water District (BWD) wells south (downgradient) of the Northrop site and the pumping and treatment of groundwater from Northrop on-site production wells GP-1 and GP-3, and IRM wells ONCT-1D, ONCT-2D, and ONCT-3D.

In addition to the data from the RI reports for these three sites, groundwater results obtained from Nassau County show extensive tetrachloroethylene (PCE) and trichloroethylene (TCE) presence a considerable distance west and north of these three facilities, indicating other unknown sources for PCE and TCE contribution to the regional aquifer. While these other sources are not the subject of this study, the chemicals from some of these other sources are present in the regional Total Volatile Organic Compound (TVOC) plume that is being addressed by Northrop, the Navy, and Hooker/Ruco. The TVOC plume extends immediately west of the Hooker/Ruco facility. The TCE/PCE farther to the west is sourced by others and is not included as part of the TVOC plume. The VCM subplume is located in the northwest corner of the TVOC plume.

Because the impacts on the Bethpage regional aquifer by the three adjacent facilities have intermingled to some degree, it was agreed by all parties in the spring of 1995 that a regional evaluation and remedy be developed to address the combined TVOC conditions created. However, in order to expedite the program, a decision was made in November 1998 to separate the RI/FS process into two parts. The DEC is working with Northrop and the Navy to address the overall TVOC plume while the EPA is working with OxyChem/Glenn Springs Holdings Inc. (GSHI)/Hooker/Ruco to address the VCM subplume.

The DEC, Northrop, and Navy prepared a Groundwater FS (dated November 2000) which addressed the regional TVOC groundwater plume. A Proposed Remedial Action Plan (PRAP) was issued by the DEC in November 2000 and the Record of Decision (ROD) for the regional TVOC groundwater plume (designated as Operable Unit-2 for the Northrop/Navy sites by the DEC) was issued on April 24, 2001. The Remedial Measure (RM) described in the Northrop/Navy OU-2 ROD included continued operation of the IRM groundwater extraction and treatment system and the wellhead treatment of impacted public water supply wells. Northrop and the Navy are continuing to investigate the areal and vertical extent of the TVOC plume further to the south of the RM using vertical profile borings. The data from these borings have been provided to OxyChem to assist in the understanding of the regional conditions.

Computer simulations presented in the OU-3 RI Report for the Hooker/Ruco Site showed that the Northrop RM fully contains the VCM subplume, a portion of the TVOC plume. Thus, any remedial actions that will be implemented by OxyChem to address the VCM subplume as a separate component of the TVOC plume would be an enhancement to an already effective remedy.

Data from the various studies that have been performed provided the additional data on the regional groundwater conditions that were necessary to evaluate effective remedial action alternatives for the VCM subplume. The evaluation of remedial action alternatives was presented in the document entitled "Feasibility Study for Operable Unit-3" (OU-3 FS Report), dated July 2000.

The objective of the OU-3 FS Report was to develop, evaluate, and select potential remedial alternatives that can be implemented to protect human health and the environment from risks associated with the groundwater containing elevated VCM as well as any other chemicals in the VCM subplume that are attributable to the Hooker/Ruco Site. As discussed in the OU-3 RI Report, OxyChem believes that the downgradient edge of the VCM subplume is the maximum areal extent to which chemicals from the Hooker/Ruco Site could have migrated. For the purposes of the FS, reference to the VCM subplume is intended to include all of the chemicals within the VCM subplume that are attributed to the Hooker/Ruco Site.

Based on the evaluation presented in the OU-3 FS Report, the EPA issued a PRAP for the VCM subplume on July 25, 2000. The PRAP's preferred remedial action incorporates the use of biosparging within the VCM subplume with the contingency of a pump and treat system if biosparging is shown not to be able to achieve the remedial action objectives in a reasonable time frame. The Record of Decision for OU-3 was finalized by the EPA on September 29, 2000. The selected remedial action incorporates the use of in situ bioremediation treatment of the VCM subplume using biosparging (with supplemental nutrient addition, if necessary). Furthermore, the OU-3 ROD retained the contingency pumping remedy (if needed) as described in the OU-3 PRAP. The Administrative Order for the Remedial Design and Remedial Action (RD/RA) for the VCM subplume (i.e., Index No. II-CERCLA-02-2001-2018) was received by GSHI on May 4, 2001.

To obtain the information needed to assist in the design of the OU-3 biosparge remedy, OxyChem has aggressively undertaken a number of predesign activities. These predesign activities include:

i) groundwater sample collection from 26 wells in May and June 2001 for natural attenuation (NA) parameters;
ii) groundwater sample collection from 19 wells in October 2001 for NA parameters;
iii) injection testing of 8 existing wells to obtain technical information regarding the physical aspects of implementing the biosparging technology;
iv) installation of new monitoring wells at 8 locations to refine the delineation of the VCM subplume;
v) groundwater sample collection and analyses of the newly installed wells and 3 existing well nests. The newly installed wells were also sampled and analyzed for NA parameters; and
vi) performance of a laboratory study involving microcosm slurry testing to examine the effect of supplementation of air, inorganic nutrients, and carbon sources on the VCM biodegradation rate.

The scope for the predesign work was primarily outlined in the document entitled "OU-3 Predesign Activity Scope of Work" (OU-3 Predesign SOW), originally submitted in June 1999. A revised Scope of Work was submitted on January 23, 2002 and approved by the EPA on February 8, 2002.

1.1 PURPOSE OF THIS REPORT

The information obtained during performance of the RI activities identified the need to collect additional information to assist in the design of the selected remedy. The purposes of the predesign activities were to:

i) refine the delineation of natural attenuation conditions in the vicinity of the VCM subplume;

ii) refine the delineation of the VCM subplume;

iii) refine the geologic and hydrogeologic conditions in the area of the VCM subplume;

iv) obtain additional information regarding the technical implementability of the biosparging technology; and

v) assist in determining long-term access requirements for the VCM subplume remedy.

This report presents a description of the predesign activities performed, a summary of the findings of the activities, and the proposed scope and timing of the biosparge remedy.

1.2 REPORT ORGANIZATION

This report is organized as described below:

1.0 Introduction;
2.0 Predesign Activities;
3.0 Natural Attenuation Processes;
4.0 Geology, Hydrogeology, and Chemical Data Summary;
5.0 Injection Testing;
6.0 Microcosm Study;
7.0 Proposed Biosparge Remedy;
8.0 Full Scale System; and
9.0 Schedule.

2.0 PREDESIGN ACTIVITIES

The purpose of this section is to present a description of the predesign field activities conducted in association with the VCM subplume refinement and groundwater conditions assessment.

2.1 NATURAL ATTENUATION GROUNDWATER SAMPLE COLLECTION

Groundwater samples were collected in the vicinity of the Hooker/Ruco Site to determine whether natural attenuation (NA) is contributing to the reduction of groundwater chemical concentrations in both on-Site (OU-1) and off-Site (OU-3) areas.

Groundwater samples were collected between May 30 and June 7, 2001 from 26 wells and in October 2001 from 19 wells for NA parameters. The locations of the wells sampled are shown on Figure 2.1. These data were collected to determine whether biodegradation was contributing to the natural attenuation of PCE, TCE, and VCM in the groundwater. The groundwater samples were analyzed for volatile organic compounds (VOCs) and NA parameters. The groundwater samples were also analyzed for the VCM degradation products ethane and ethene. Total organic carbon (TOC) in groundwater was analyzed to provide data regarding the availability of a primary substrate that is necessary for the reductive dechlorination of VOCs in the groundwater.

Sampling was performed by CRA personnel, who were escorted by personnel from ARCADIS Geraghty & Miller (ARCADIS) during their routine quarterly groundwater monitoring program. The samples for NA parameters collected in May and June and on October 2 and 3, 2001 were obtained after ARCADIS had completed their sample collection from the wells. ARCADIS supplied all of the purging equipment and performed all of the well purging in the selected wells. ARCADIS also escorted CRA during the period October 10 to 12, 2001. However, CRA performed the purging of these wells because they were not included in ARCADIS's routine sampling program. Several of the wells purged by CRA had dedicated ARCADIS pumps in them which were used for purging and sampling. Eleven of the 45 wells were purged and sampled using dedicated bladder pumps with packers. The remaining wells were purged and sampled using either a clean non-dedicated Redi-flo submersible pump or a clean non-dedicated bladder pump. All of the non-dedicated pumps were decontaminated between wells. All of the wells except 9921 and MW1GF had either dedicated polyethylene or teflon tubing stored inside of the well. CRA supplied new dedicated polyethylene tubing to purge and sample these two wells. A list of the wells sampled and the pumps used is presented in Table 2.1a (May 30 to June 7) and Table 2.1b (October 2 to 12).

All decon water and well purge water that ARCADIS generated was collected into 55-gallon drums for disposal into the sanitary sewer system.

All purge and decon water generated by CRA was collected and stored in two 55-gallon drums at the Hooker/Ruco Site pending analysis to determine appropriate treatment/disposal.

Rinse blanks and all other QA/QC associated protocols were followed as per the approved plans.

All of the wells were purged using the low flow purging (LFP) method at pumping rates ranging from 100 to 500 mL per minute (mL/min) with the exception of the eleven wells that contained packers and wells GM17SR and GM16SR. These wells were purged of three volumes as per the ARCADIS sampling program protocols. After ARCADIS collected their samples from these wells, the flow rate was decreased to between 400 and 450 mL/min, and upon stabilization of the field parameters, CRA collected the NA parameter samples from the well. A summary of the final stabilization parameters is presented in Table 2.2. Stabilization parameters were measured using a flow-through cell. All of the wells achieved stabilization.

The maximum suggested sampling protocol drawdown of 0.3 feet was maintained for all the wells sampled for NA parameters with the exception of wells HN-29I, MW-50D1, and MW-50D2. It was not possible to dial the Redi-flo pump in well NH-29I down below 300 mL/min because the pump would stop pumping at flows below the 300 mL/min rate. The well was purged and sampled at 300 mL/min, which caused the drawdown in this well to drop approximately 1.7 feet from the initial static level. Wells MW-50D1 and MW-50D2 had a large amount of sediment in them. At flow rates on the order of 100 mL/min, several feet of drawdown occurred.

The following NA parameters were analyzed by the H2M laboratory located in Melville, New York: dissolved manganese, nitrate, nitrite, ammonia, phosphorus, sulfate, sulfide, chloride, dissolved gases, total organic carbon, and alkalinity. The dissolved manganese was field-filtered through a 0.45 µm filter cartridge before being collected in the appropriate sample container. Parameters measured in the field included: redox potential, pH, temperature, dissolved oxygen (DO), and ferric (+3) iron. Field parameters were measured for the samples collected using the EPA LFP method, which were then run through a sample cell. The one exception to this was ferric iron, which was collected at the end of sampling and analyzed using a Hach field test kit.

In addition to the 2001 groundwater monitoring, there are some NA groundwater monitoring from other previous years that provide useful data. In 1998, OxyChem collected groundwater samples from seven wells associated with the VCM subplume using LFP sampling techniques and analyzed them for DO, oxidation/reduction potential (ORP), nitrate, iron (II), sulfate, and methane. Details of the sampling are provided in the OU-3 RI Report. Subsequently, Northrop collected groundwater samples from nine wells in the VCM subplume, in the PCE/TCE plume, and downgradient of the PCE/TCE plume in the third quarter of 2000 and analyzed them for DO and ORP. The results were provided to OxyChem in a letter to Syed Quadri (USEPA) and Stephen Whyte (GSHI) from ARCADIS, dated March 15, 2001. All of these data have also been included in Table 2.2.

The QA/QC reviews and analytical results for the May/June and October sampling were submitted to the EPA on July 30, 2001 and January 29, 2002, respectively. Based on the review, the data were acceptable for their intended use with the few qualifications described in the QA/QC reviews.

The evaluations of the NA parameter results is presented in Section 3.0.

2.2 BOREHOLE AND MONITORING WELL INSTALLATIONS

In order to further refine the understanding of the VCM subplume, OxyChem has installed additional groundwater monitoring wells in eight locations. Seven of the locations were planned and one extra location was added.

The first group of wells were installed between February 4 and June 19, 2002. The locations of the wells are shown on Figure 2.2. Typical details of the monitoring wells are shown on Figure 2.3 and well installation details are shown on the stratigraphic and well installation logs included in Appendix A.

The boreholes and wells were installed pursuant to the procedures described in the OU-3 Predesign SOW with the following EPA approved modifications:

i) it was not necessary to perform geophysics in the boreholes because the selected method of borehole drilling (i.e., Rotosonic™) provided a continuous soil core;

ii) bentonite chips were used for the monitoring well seals; and

iii) the borehole groundwater samples were collected using the Isoflow method.

During installation of the wells at the first seven locations, VCM was detected in the Isoflow samples at MW-61 and was not detected in wells MW-58 and MW-59. To refine the delineation of the southern (downgradient) boundary of the VCM subplume, well MW-66 was added at approximately the mid-point between locations MW-61 and MW-58/59. One other minor modification that was made was that the location of MW-60 was moved slightly due to a request from Northrop, on whose property the well is located. Additional details regarding the well installations are presented in the following sections.

2.2.1 BOREHOLE INSTALLATION

At each location, the borehole was installed using the Rotosonic™ drilling method. Prior to the start of drilling, the upper 2 to 3 feet of material was excavated by hand to ensure that no underground utilities were present. Drilling was performed using a 4-inch diameter core barrel with a 6-inch diameter override steel casing. Additional override casings of larger diameter were used on some of the deeper installations where needed to overcome the friction on the 6-inch casing and allow drilling to continue.

A continuous 4-inch diameter soil core was retrieved from each borehole. Each soil core was scanned with a photoionization detector (PID) immediately following removal from the borehole. The soil stratigraphy is presented in the borehole logs included in Appendix A. Potable water was placed in the casings to prevent upwelling of the formation materials into the casings during drilling.

Isoflow sampling for VOC analysis commenced at a depth at which chemicals attributable to one or more of the three sites had been previously detected in the vicinity of the well. Isoflow sample collection was performed at 50±-foot intervals until the selected target depth was reached. The groundwater sample was collected using a Grundfos pump and polyethylene discharge tubing. Table 2.3 presents a summary of the Isoflow samples collected and the VOC analytical parameters detected. A complete listing of the Isoflow sampling results is included in Appendix B. After each 50±-foot interval was drilled, the core barrel was removed and the Isoflow assembly was lowered to the base of the borehole. The 6-inch override casing was then pulled back approximately 5 feet and the groundwater within the borehole was purged until pH, conductivity and temperature reached stabilization. A summary of the stabilized values for the final purge volume is shown in Appendix B. The Isoflow assembly was flushed with potable water prior to reinstallation to the top of the next sample depth.

2.2.2 WELL INSTALLATION

The screened intervals for the monitoring wells were chosen based on the Isoflow analytical results, interpretation of the stratigraphy, and the PID readings. Depending on these data, two to four intervals were chosen for monitoring at each location, with the concurrence of the EPA.

At four of the eight locations, the boring was used for the installation of all the selected monitoring intervals. At the other four locations (i.e., MW-60, MW-61, MW-62, and MW-66), a second borehole was drilled to accommodate the installation of some of the selected monitoring intervals to maintain the hydraulic separation provided by fine-grained (e.g., clay) layers between intervals with significantly different chemical concentrations in the groundwater. In some cases, the deepest selected monitoring interval was not at the bottom of the borehole. In these cases, the borehole was backfilled with bentonite chips to the bottom of the deepest selected monitoring interval and allowed to hydrate for approximately a 1/2 hour prior to installing the monitoring well.

Schedule 80 PVC screen and riser pipe was used in three of the wells. In the remaining wells, black steel riser with stainless steel screens were installed in the borehole to the desired monitoring depth. Steel was used for the deeper wells to prevent collapse of the well and for possible future use of the well as an injection well. After the well riser and screen were inserted in the borehole, the sandpack was washed down the tremie pipe using potable water directly into the annulus surrounding the well screen. The progress of the sandpack installation was continuously monitored using a weighted measuring tape lowered into the annulus between the well and the borehole wall.

After the sandpack for the lowest selected interval had been placed, bentonite chips were placed to the bottom of the next overlying selected monitoring interval. The sandpack and bentonite chip placement procedure continued until the sandpack for the uppermost selected monitoring interval had been installed. Thereafter, approximately five feet of bentonite chips were placed on top of the uppermost sandpack. Grout consisting of 94 percent cement and 6 percent bentonite was then placed in the annular space to the ground surface using the tremie method. The bentonite chips for each layer were allowed to hydrate for approximately 1/2 hour prior to placement of the overlying material to minimize intermixing of the overlying layers.

The wells were all completed with a locking flush-mount manhole-style cover. Table 2.4 presents a monitoring well construction summary.

2.2.3 WELL DEVELOPMENT

The monitoring wells were developed to remove sediments and potable water (used during the drilling process) from the screen and sandpack as well as to stabilize the surrounding formation.

Development was performed using the air-lift method. A small compressor (11 standard cubic feet per minute - scfm) was used to introduce air into the screened interval through 3/4-inch black polyethylene tubing. The compressor was equipped with an in-line filter to prevent the introduction of hydrocarbons into the well from the compressor motor. During well development, the rate of air injected into the well was rapidly varied to surge groundwater in the vicinity of the screen to remove the sediment and potable water from the sandpack.

Development was to be considered complete when 10 well volumes were removed. For those wells with multiple screened intervals, well development started at the deepest screened interval and progressed upwards. The volume removed at each screened interval was proportioned according to the number of screened intervals. For example, if a well had three screened intervals, approximately 1/3 of the 10 well volumes was removed from each screened interval by raising the outlet of the air lift pump tubing to approximately the bottom of the screened interval. Between development at each well, the air lift tubing was decontaminated with soap and potable water.

A summary of the measurements obtained during well development which include pH, temperature, and conductivity are included in Appendix C. The measurements presented in the table show that most of the wells were clearing by the time 10 well volumes had been removed.

2.2.4 GROUNDWATER SAMPLE COLLECTION

Pursuant to the OU-3 Predesign SOW, groundwater samples from monitoring wells MW-53, MW-56 through MW-64, and MW-66 were to be collected and analyzed. The wells were sampled between June 18 and July 11, 2002, with the exception of MW-56S, MW-56I, and MW-53DI. Wells MW-56S/I could not be located. The GSHI on-Site representative was informed by a U.S. Postal employee that the section of the road in which MW-56 was located was rebuilt (i.e., excavated and new sub-base and asphalt installed) in the fall of 2000. GSHI was not notified by the Town of Oyster Bay of such activity. Because of the excavation, it is believed that even if the wells could be located, they are likely damaged and/or infilled and unable to be sampled. Also, because of a subsurface bend in the pipe of MW-53D1, the sampling pump could not be lowered into the water within the well and the well could not be sampled.

Groundwater samples were collected for analysis of Target Compound List (TCL) VOCs, TOC, and NA parameters. Two blind duplicates, two equipment rinse blanks, and two matrix spike/matrix spike duplicate (MS/MSD) samples were submitted for analysis during the sampling. Nine trip blanks were submitted for analyses according to the protocols outlined in the report entitled "Quality Assurance Project Plan, OU-3 Predesign Activities", (OU-3 QAPP) dated November 2001. The well sampling was performed pursuant to the LFP procedures.

The wells were purged using the LFP techniques at pumping rates ranging from 100 to 500 mL per minute. A summary of the final field measured stabilization parameters is presented in Table 2.2. Stabilization parameters were measured using a flow-through cell. All of the wells stabilized pursuant to the QAPP guidelines with the exception of turbidity in samples from MW-58D2 and MW-64D. Also, drawdowns greater than 0.3 feet were created in wells MW-57I (0.60 feet), MW-62D2 (0.40 feet), and MW-62D (4.41 feet). These exceedances are not expected to impact the integrity of the data.

The QA/QC review and final results were submitted to the EPA on September 3, 2002. Based on the QA/QC review, the data were acceptable for their intended use with the qualifications described.

2.3 HANDLING OF GENERATED WASTES

Decontamination water and groundwater generated during the Isoflow sampling, monitoring well installation, well development, and groundwater sampling, were temporarily containerized in either drums or frac tanks. Excess soil generated during monitoring well installation was temporarily containerized in either drums or in roll-off dumpsters. The excess soils were segregated based on the soil core PID readings. Soils with less than or equal to 5 ppm PID readings were containerized separately from those with PID readings greater than 5 ppm. The containerized materials were sampled and analyzed to determine appropriate treatment/disposal. The analytical results and QA/QC review for the waters were submitted to the EPA and the Cedar Creek Water

Pollution Control Plant (WPCP) on July 18, 2002. The water results showed that the only compound exceeding its Class GA level (i.e., potable groundwater) was TCE at 9 μg/L (Class GA = 5 μg/L). WPCP approval was received on July 22, 2002 and the water was discharged on August 12 and 13, 2002. The analytical results and QA/QC review for the soils were submitted to the EPA on June 24, 2002. The results showed the soils to be non-hazardous. The soils were disposed at the Waste Management facility located in Tullytown, Pennsylvania on August 30, 2002.

3.0 NATURAL ATTENUATION EVALUATION

The purpose of this section is to present the results and an evaluation of all the NA samples collected to date. Included are: the data collected by OxyChem in December 1998, which were presented in the OU-3 RI Report; the data collected by Northrop in the third quarter of 2000 and in the second quarter of 2001; and the recent data collected by OxyChem in the second quarter of 2002. This evaluation provides a summary of the NA conditions throughout the TVOC plume. The locations of the wells sampled for NA parameters are shown on Figure 2.1.

A summary of the analytical results for the natural attenuation sampling including the chlorinated ethenes and the field-measured parameters are presented in Tables 3.2, 3.3, 3.4, 3.5, and 3.6.

3.1 NATURAL ATTENUATION BACKGROUND

The processes that control the NA of compounds in groundwater can be classified into two categories: non-destructive and destructive. Non-destructive processes result in reductions in compound concentrations over distance or time. Destructive processes destroy the compound's structure resulting in reductions in compound mass. Non-destructive NA processes include:

i) dispersion and diffusion;
ii) dilution;
iii) sorption; and
iv) volatilization.

Destructive NA occurs through degradation. Although degradation occurs by both non-biological (abiotic) and biological mechanisms (biotic), abiotic degradation rates typically are slow compared to those of biotic degradation. Biotic degradation is commonly known as biodegradation. Because it results in the destruction of chemical mass, biodegradation is frequently the most important NA mechanism in reducing chemical concentrations in groundwater and is the focus of this NA evaluation.

3.2 BIODEGRADATION

Microbial biodegradation involves the utilization of carbon from an organic compound (the primary substrate) for microbial cell growth. As part of the biodegradation process, electrons are transferred from the primary substrate (electron donor) to an available electron acceptor. This transfer of electrons is defined as an oxidation-reduction (redox) reaction. Energy derived from this transfer of electrons is utilized by soil microorganisms for cellular respiration.

Microbial biodegradation will only occur if suitable quantities of the primary substrate and electron acceptors are available for the necessary redox reactions. Certain forms of organic matter (e.g., fuel hydrocarbons, landfill leachate, and natural organic matter) are readily utilized as primary growth substrates during microbial biodegradation. The biodegradation of a primary substrate often will result in the cometabolic biodegradation of a secondary substrate, which is defined as an organic compound that does not undergo direct biodegradation, but is fortuitously transformed to degradation products as a secondary reaction.

Typical electron acceptors available in groundwater, in the order of those that release the greatest energy to those that release the least energy, are: dissolved oxygen, nitrate, manganese and iron coatings on soil, dissolved sulfate, and carbon dioxide. The sequential use of these electron acceptors occurs as groundwater becomes increasingly reducing during the biodegradation of organic compounds.

When groundwater becomes depleted of dissolved oxygen and nitrate, the conditions are conducive to the reduction and subsequent dissolution of iron and manganese oxides. Ferric iron (Fe^{3+}) typically exists as an oxide coating on soil and is relatively insoluble in groundwater. Ferric iron is used as an electron acceptor during microbial biodegradation where it is reduced to ferrous iron (Fe^{2+}), which exists primarily in the dissolved phase. Manganese (Mn) oxides are similarly utilized as electron acceptors under the appropriate redox conditions, and are reduced from the relatively insoluble Mn^{4+} form to dissolved manganese (Mn^{2+}). These biochemical reactions result in the mobilization of ferrous iron (Fe^{2+}) and manganese (Mn^{2+}) in groundwater. The mobilization of manganese will begin prior to that of iron because dissolved manganese (Mn^{2+}) is stable over a larger range of redox conditions than ferrous iron (Fe^{2+}). However, the concentration of dissolved iron in groundwater is often higher than that of manganese because soils typically have a higher iron content (Hem, 1985). Increased concentrations of dissolved iron in groundwater are indicative of sufficiently reducing conditions for the reductive dechlorination of chlorinated ethanes and ethenes.

With the long-term migration of organic chemicals in groundwater, a sequence of geochemical (or redox) zones of increasing ORP will develop downgradient from the source area (Lyngkilde and Christensen, 1992b; Appelo and Postma, 1993). The sequence of these redox zones, in order of the closest to the farthest away from the source area, will be as follows:

i) methanogenic zone;
ii) sulfidogenic zone (sulfate-reducing);
iii) ferrogenic zone [Fe^{3+}-reducing];
iv) manganogenic zone [Mn^{4+}-reducing];
v) nitrate-reducing zone; and
vi) aerobic (oxic) zone.

The extent of each individual redox zone is site specific, and depends on substrate migration pathways, kinetics of redox processes, groundwater flow velocities, and the availability of various electron acceptors in groundwater. Ultimately, the site-specific distribution of redox zones downgradient from the source area will control the natural attenuation of organic chemicals in impacted groundwater (Lyngkilde and Christensen, 1992a).

3.3 <u>BIODEGRADABILITY OF CHLORINATED VOCs</u>

The chlorinated compound VCM is the VOC of prime interest in OU-3. PCE and TCE are of prime interest in the TVOC plume. Dichloroethenes (DCEs) are also present in the TVOC plume. The following section of the report briefly discusses the biodegradation of chlorinated VOCs in general, with emphasis on PCE, TCE, DCE, and VCM biodegradation.

As stated in Section 3.1, biodegradation of VOCs is mediated through a series of redox reactions, in which electrons are transferred between electron donors and electron acceptors. Biodegradation of chlorinated VOCs occurs through any one of the following three mechanisms:

i) the organic compound is used directly by microorganisms as an electron donor (i.e., primary substrate);
ii) the organic compound is used directly by microorganisms as an electron acceptor; or

iii) the organic compound undergoes biodegradation as a secondary reaction during microbial biodegradation of another organic compound.

3.3.1 PCE AND TCE BIODEGRADATION

PCE is the most oxidized of the chlorinated ethenes and is not susceptible to oxidation mechanisms (electron doner) for biodegradation (i.e., PCE cannot be used as a primary substrate) unless it is via a cometabolic pathway. However, reductive dechlorination is the only fully documented pathway for biodegradation of PCE. Therefore, PCE is biologically recalcitrant under aerobic conditions and typically requires an anaerobic environment in order to undergo biodegradation. The reductive dechlorination pathway for the chlorinated ethenes is summarized on Figure 3.1. This figure includes indicators of the relative speed of the degradation process through each of the steps.

TCE also is highly oxidized and is typically not susceptible to oxidation reactions. TCE is mainly biodegraded by reductive dechlorination under anaerobic conditions. Although the main biodegradation mechanism for TCE is reductive dechlorination, TCE may, in some cases, undergo aerobic cometabolism resulting in partial dechlorination.

3.3.2 DCE AND VCM BIODEGRADATION

DCE and VCM (the most reduced chlorinated ethenes) are susceptible to both aerobic degradation (through oxidation) and anaerobic degradation (through oxidation or reduction). DCE and VCM biodegradation has been documented to occur by each of the three principal biodegradation mechanisms (i.e., anaerobic, aerobic, and cometabolism).

VCM is the most susceptible of the chlorinated ethenes to electron donor reactions. DCE is also susceptible. Oxidation (also referred to as mineralization) of DCE and VCM is associated with the transformation of DCE and VCM to carbon dioxide, water, and chloride. Aerobic oxidation of DCE and VCM is characterized by a loss of mass and a decreasing molar ratio of DCE and VCM compared to that of other chlorinated VOCs. Anaerobic oxidation of VCM occurs under Fe^{3+}-reducing and methanogenic conditions (Bradley and Chapelle, 1996; Barrio-Lage et. al., 1990). Anaerobic degradation of VCM by a combination of mineralization and reductive dechlorination also has been documented, resulting in the production of both methane and ethene (Barrio-Lage et al., 1990). The degradation pathways for VCM are shown on Figure 3.1.

Because DCE and VCM are the most reduced forms of the chlorinated ethenes, they are the least susceptible to electron acceptor (i.e., reduction) reactions; therefore, reductive dechlorination of DCE and VCM is slow relative to other VCM degradation mechanisms. Reductive dechlorination of DCE and VCM has been documented in anaerobic environments, and is characterized by reductions in mass, increased concentrations of chloride ions, and production of the daughter products, which are VCM for DCE and ethene and ethane for VCM. The occurrence of reductive dechlorination relies on the presence of a primary substrate (i.e., electron donor).

As previously stated, DCE and VCM are susceptible to cometabolic degradation under aerobic conditions. The occurrence of cometabolic degradation is dependent on the availability of primary substrate to initiate the degradation reactions. Hartmans and deBont (1992) have documented a bacterial consortium of aerobic VCM oxidizers that can mediate the cometabolic biodegradation of VCM.

3.4 EVIDENCE FOR NATURAL ATTENUATION

Natural attenuation in the OU-1 and OU-3 groundwater and the Northrop PCE/TCE groundwater plume could occur due to both non-destructive and destructive processes. Non-destructive natural attenuation processes such as dispersion, diffusion, dilution, sorption, and volatilization generally apply to varying degrees to any site impacted by VOCs. The occurrence of destructive processes such as biodegradation is dependent on numerous environmental factors, and may or may not be significant at a given site.

The following indicators of destructive natural attenuation of organic compounds were evaluated:

i) redox and geochemical indicators of biodegradation;
ii) presence of degradation products in association with parent compounds; and
iii) presence of an organic carbon, nitrogen, and phosphorus supply to support microbial oxidation, reductive dechlorination, or cometabolic reactions.

This section of the report discusses these lines of evidence as they pertain to destructive natural attenuation, specifically biodegradation, of PCE, TCE, DCE, and VCM as observed in the TVOC plume and VCM subplume.

3.4.1 REDOX INDICATORS

The relative concentrations of redox indicator data were used to identify the dominating redox processes as expressed by either the electron donor being oxidized or the electron acceptor being reduced by the biodegradation of organic carbon. The groundwater data from the natural attenuation samples collected in December 1998 May/June/October 2001, and June/July 2002 provided analytical results for the following redox parameters: nitrate (NO_3^-)/nitrite (NO_2^-), dissolved manganese (Mn^{2+}), dissolved iron (Fe^{2+}), sulfate (SO_4^{2-}), sulfides (S^{2-}), methane (CH_4) and microbial counts. During collection of the groundwater samples, field measurements of DO, ORP, and Fe^{2+} were also taken.

The natural attenuation data for the majority of the groundwater samples indicated that aerobic conditions exist in the TVOC plume except in the core area of the VCM subplume. Aerobic conditions are indicated by the presence of substantial DO, sulfate, and nitrate/nitrite, high ORP, and low or non-detect values for Mn^{2+}, Fe^{2+}, sulfide, and CH_4 (see Table 3.1). These data suggest that groundwater in the Bethpage area is generally aerobic (see Figure 3.2). These conditions are conducive to the oxidation of VCM, but are not favorable for PCE biodegradation. The DO levels are generally between 5 and 10 mg/L, which suggests that oxidative degradation of any VCM that exists in the TVOC plume can occur and is not oxygen limited in the TVOC plume.

There are a few exceptions to the generally aerobic conditions. The most significant of these exceptions is in the vicinity of the VCM subplume. In the VCM subplume groundwater redox conditions generally exhibit reducing conditions ranging from mildly methanogenic to strongly methanogenic. The strong reducing nature of the monitoring wells in these areas is based on the low DO and ORP measurements, the absence of nitrate/nitrite, and elevated concentrations of Mn^{2+}, Fe^{2+}, and CH_4 in wells MW-50J1 and MW-50J2. The increased concentrations of CH_4 at these wells (16 to 13,000 μg/L) relative to background (non-detect at 1 μg/L) indicate that methanogenic conditions exist in the vicinity of these wells. Methanogenic conditions are conducive to the reductive dechlorination of PCE and VCM, and in some cases, to biological oxidation. Furthermore, the total aerobic microbial counts measured in samples from wells MW-50D1, MW-50D2, MW-50J1, MW-50J2, F-1, and F-2 showed that all the wells had aerobic colonies. Therefore, even though the other natural attenuation data suggested anaerobic conditions existed in wells MW-50J1, MW-50J2, and F-2, they still supported aerobic microbial populations.

The redox data from MW-52S indicate aerobic conditions at this location, based on the presence of DO and nitrate/nitrate, high ORP, and low or non-detect values for Mn^{2+}

and Fe^{2+}. However, methane and ethene concentrations at this well are elevated relative to background. These data suggest that anaerobic conditions were present at one time in this area of the VCM subplume but were not maintained and that conditions favorable to the faster aerobic degradation are reestablishing themselves. This may be the result of oxygenated surface water or groundwater recharge into the area from adjoining upgradient areas.

The other areas for which the redox data suggest anaerobic groundwater conditions at the time of sampling are in the vicinity of wells GM-34D, MW-58, MW-60, N10627, and N09921. The reasons for the presence of anaerobic conditions at these wells are not fully understood, but it appears to be a localized condition.

Visualization of the spatial distribution of redox conditions in the vicinity of the Hooker/Ruco Site also is presented through the use of radial diagrams produced using the computer visualization program SEQUENCE version 1.1 (Environmental Software Solutions, 1998). The spatial distributions of redox conditions in the groundwater using this visualization technique are presented on Figure 3.3 for the regional groundwater and on Figure 3.4 for the area of the VCM subplume. The redox indicator parameters DO, NO_3^-/NO_2^-, Fe^{2+}, SO_4^{2-}, and CH_4 are presented on each radial diagram. The redox radial diagram for each monitoring well location is overlaid with the radial diagram representative of background conditions. The axis for each redox indicator parameter is set up in such a manner that decreasing groundwater redox potential (i.e., conditions conducive to reductive dechlorination) is apparent when the area representing monitoring well groundwater conditions shrinks relative to background conditions (wells A-1 and R-1).

In summary, the redox conditions in the TVOC plume are generally aerobic. Aerobic conditions are conducive to the degradation of VCM. The few locations where redox conditions are conducive to reductive dechlorination are visually apparent because the area representing monitoring well conditions shrinks relative to the area representing background conditions. The redox radial diagrams presented on Figures 3.3 and 3.4 indicate that a change from the generally aerobic redox conditions to anaerobic (reducing) conditions is apparent in the vicinity of monitoring wells located within the core of the VCM subplume.

3.4.2 PRESENCE OF PCE, TCE, DCE, AND VCM DEGRADATION PRODUCTS

A key indicator of biodegradation is the presence of PCE, TCE, and VCM degradation products at monitoring wells associated with the current or historical presence of PCE, TCE, or VCM. TCE, DCE, and VCM are degradation products of PCE, and DCE and VCM are degradation products of TCE (see Figure 3.1). VCM and chloride are degradation products of DCE and chloride, ethene and ethane are degradation products of VCM. In order to assess whether degradation is occurring, the wells have been divided into the following five groups based on location:

- the first group of wells is located upgradient from the plumes (Table 3.2);
- the second group is located in the VCM subplume (Table 3.3);
- the third group is located in the PCE/TCE plume (Table 3.4);
- the fourth group is located on the boundary of the PCE/TCE plume (Table 3.5); and
- the fifth group is located downgradient of the PCE/TCE plume (Table 3.6).

The concentrations of PCE, TCE, and VCM parent compounds, and the degradation products TCE, DCE, VCM, chloride, ethene, and ethane, are summarized in the tables. Recent groundwater PCE, TCE, DCE, and VCM concentrations are shown on Figures 3.5, 3.6, 3.7, and 3.8, respectively. Data are presented for all monitoring wells included in the natural attenuation sampling where data are available.

It is not possible to determine which portions of the TCE and VCM concentrations are attributable to degradation, because TCE and VCM were also released to the groundwater from various sources. This is not the case with DCE, and consequently the relative ratios of DCE isomers can be used to provide information regarding the origin of DCE in groundwater. There are three DCE isomers: 1,1-DCE, cis-1,2-DCE, and trans-1,2-DCE. Cis-1,2-DCE and trans-1,2-DCE may be combined and reported as total 1,2-DCE. When DCE is released to the environment anthropogenically, the ratios of the three isomers typically are relatively equal. When DCE is produced as a result of TCE biodegradation, production of the cis-1,2-DCE isomer is favored over that of 1,1-DCE and trans-1,2-DCE. Although it was not possible to determine whether VCM was a source material or the result of degradation, it is possible to determine if degradation of VCM is occurring or has occurred. VCM may undergo various biodegradation pathways, resulting in different degradation products. When undergoing biological oxidation (i.e., electron donor reactions), VCM is transformed into carbon dioxide, water, and chloride. With the exception of chloride, these VCM degradation products are difficult to measure in groundwater. Also, it may be difficult to attribute these directly to VCM degradation. When undergoing anaerobic biological oxidation, the biodegradation of VCM may be indirectly monitored through the production of redox indicator parameters Fe^{2+} and methane. Reductive dechlorination of VCM is unequivocally identified by the presence of the degradation products ethene and ethane (see Figure 3.1). Even low concentrations of ethene are indicative of VCM degradation.

3.4.2.1 UPGRADIENT WELLS

As described in Section 3.4.1, the redox data for the upgradient wells (see Table 3.2), indicate that the background (upgradient) groundwater conditions are aerobic. The organic chemical data shows that only PCE and TCE were present in the groundwater at low concentrations. No PCE/TCE degradation products (DCE, VCM, ethene, ethane, and methane) were detected. The absence of degradation products is attributed to the aerobic conditions which inhibit PCE and TCE degradation and the low PCE/TCE concentrations that exist.

3.4.2.2 VCM SUBPLUME WELLS

The redox data for the wells located in the core of the VCM subplume (see Table 3.3), indicate that the groundwater conditions in the VCM subplume are anaerobic (i.e., strongly methanogenic). It is believed, based on the generally aerobic conditions of the regional TVOC plume, that the historic groundwater conditions within the VCM subplume were aerobic until the VCM migrated into the area. Aerobic degradation of the VCM occurred until the DO was consumed. Thereafter, the conditions became anaerobic (i.e., the current condition).

The organic chemical data show that PCE and TCE were present in the majority of the wells and that their degradation products 1,2-DCE and 1,1-DCE are also present. In the monitoring wells in which substantial DCE was detected, the cis-1,2-isomer was present in greater abundance relative to the 1,1-DCE and trans-1,2-DCE isomers (e.g., MW-52 and MW-61 well nests). This indicates that the DCE is most likely the result of reductive dechlorination of the PCE and TCE. Ethane and ethene were detected in the core of the VCM subplume and the chloride concentrations exceeded 20 mg/L in many VCM subplume wells. This provides confirmation that VCM was also undergoing reductive dechlorination under the current anaerobic conditions.

3.4.2.3 PCE/TCE PLUME WELLS

The redox data for the PCE/TCE plume wells (see Table 3.4), indicate that the groundwater conditions are aerobic except in the vicinity of MW-58 and the deeper wells in MW-60.

The organic chemical data show that PCE and TCE were present in the majority of the wells and that the degradation product DCE was also present. In those wells in which cis-1,2-DCE was analyzed for, this isomer was detected at concentrations similar to the other DCE isomers, except in the vicinity of well MW-58, in which the cis-1,2-DCE isomer was detected at greater concentrations relative to the other isomers. This indicates that reductive dechlorination of PCE and TCE to DCE was not occurring except in the MW-58 area and supports the redox data which show anaerobic conditions in the MW-58 area.

VCM was not detected in any of the PCE/TCE plume wells. Also, the degradation products methane, ethene, and ethane were not detected. The absence of these degradation products is attributed to the aerobic conditions. As shown on Figure 3.1, the aerobic degradation of DCE to CO_2, chloride, and water is quicker than the pathway for the anaerobic degradation of DCE to VCM followed by aerobic degradation of VCM to CO_2, chloride, and water. Thus, the absence of VCM may be attributable to aerobic degradation of DCE directly to CO_2, chloride, and water. The continued degradation of DCE is supported by the chloride concentrations which are greater than 20 mg/L for many of the wells.

3.4.2.4 PCE/TCE PLUME BOUNDARY WELLS

The redox data for the PCE/TCE plume boundary wells (see Table 3.5) indicate the groundwater condition in these wells is aerobic.

The organic chemical data show that PCE and TCE were present in the majority of the wells and that the degradation product DCE was also present. In those wells in which cis-1,2-DCE was analyzed for, this isomer was detected at concentrations similar to the other DCE isomers, except for wells MW-53D2 and MW-57S. This indicates that reductive dechlorination of PCE was likely not occurring and that degradation of TCE may be occurring very slowly. The slow rate is attributed to the aerobic conditions in these wells.

VCM was not detected in any of the boundary wells. Also, the degradation products methane, ethene, and ethane were not detected. The absence of these degradation products is attributed to the aerobic conditions. The chloride data are inconclusive regarding whether aerobic degradation of DCE directly to CO_2, chloride, and water is occurring because the chloride concentrations were all less than 20 mg/L.

3.4.2.5 DOWNGRADIENT WELLS

The redox data for the downgradient wells (see Table 3.6) indicates aerobic conditions except in the vicinity of wells GM-34D, N10627, and N09921.

The organic chemical data show that PCE and TCE were present in the majority of the wells and that low level concentrations of the degradation product DCE was also present. In those wells in which cis-1,2-DCE was analyzed for, this isomer was detected at concentrations similar to the other DCE isomers. This indicates that reductive dechlorination of PCE was likely not occurring and that degradation of TCE may have been occurring very slowly. The very slow rate is attributed to the aerobic conditions.

VCM was not detected in any of the downgradient wells. Also, the degradation products methane, ethene, and ethane were not detected. The absence of these degradation products is attributed to the aerobic conditions. The chloride data support the aerobic degradation of DCE directly to CO_2, chloride, and water because many of the wells had chloride concentrations greater than 20 mg/L.

3.4.3 PRESENCE OF AN ORGANIC CARBON, NITROGEN, AND PHOSPHORUS SUPPLY

Effective aerobic degradation requires some TOC (>10 mg/L) to be present in the groundwater. The biodegradation of PCE, and to some degree VCM, in the groundwater results from reductive dechlorination processes. Therefore, a direct carbon source would be required for this biodegradation pathway to occur. Groundwater samples for TOC were taken and analyzed along with the natural attenuation parameters. The TOC data indicate that the groundwater in the TVOC plume generally is deficient in TOC. Although the TOC concentrations may be somewhat understated due to the analytical procedure used, it is expected that the TOC concentrations are low. With the exception of six wells (MW-50J1, MW-61S, MW-61I, MW-61D1, MW-62D, and N10627), TOC was not detected above 2 mg/L in the Bethpage groundwater. The lack of sufficient TOC indicates that both aerobic and anaerobic degradation may be inhibited throughout the study area. The above wells, except N10627 are located within the VCM subplume.

Despite the lack of TOC in the groundwater, there is evidence that oxidative degradation is occurring in the VCM subplume as indicated by the redox conditions and the presence of chloride in the groundwater. There is also evidence that reductive dechlorination was occurring in the VCM subplume, as indicated by the redox conditions and the presence of ethene in the groundwater (see Section 3.4.2). This indicates that there was TOC present. Based on the upgradient data, the TOC was unlikely to be naturally occurring; however, potential sources of the TOC include the lower molecular weight VOC and SVOC tentatively identified compounds (TICs), and/or VCM. The occurrence of biological oxidation of VCM under anaerobic conditions has been documented (ref. Barrio-Lage et.al., 1990) to occur under ferrogenic and methanogenic conditions. As discussed in the previous section, methanogenic conditions exist in the vicinity of the VCM subplume.

Nitrogen and phosphorus are nutrients that are required for microbial growth. Nitrogen is present as nitrate in the majority of the Bethpage area wells at levels between 3 and 11 mg/L. Nitrite is generally non-detect and ammonia is present in about half the wells at concentrations between 0.1 and 2.1 mg/L. These nitrogen levels are sufficient to sustain microbial growth. The majority of phosphorus analyses were non-detect at 0.05 mg/L with a few levels detected between 0.13 and 0.4 mg/L. This level of phosphorus may be insufficient to sustain microbial growth.

3.5 EVALUATION

The data indicate that, in general, the groundwater in the Bethpage TVOC plume is aerobic and that conditions exist for the aerobic degradation of VCM, except in the central part of the VCM subplume, where anaerobic conditions have been created by the consumption of the originally available oxygen. Consequently, for the VCM degradation to continue occurring in the central portion of the VCM subplume, it must occur following the anaerobic processes. PCE and TCE in the central part of the VCM subplume will degrade more rapidly due to the anaerobic conditions created by the VCM consumption of the available oxygen. Anaerobic conditions that could continue to support degradation of additional PCE and TCE through DCE and VCM to produce ethene and ethane historically existed in the extreme northern part of the VCM subplume (near MW-50) but no longer exist due to the influx of upgradient aerobic water which has migrated into this area. The high dissolved oxygen concentrations throughout the majority of the TVOC plume suggest that the TVOC plume groundwater is not oxygen-limited in these areas (approximately 10 mg/L is the solubility of oxygen in water) and should be sufficient to support the natural aerobic microbial population. Biosparging will be used to resaturate the groundwater with oxygen in the anaerobic areas to enhance the degradation of VCM. The data suggest that it may also be necessary to increase the dissolved TOC concentration in the VCM subplume through the addition of a suitable carbon source in order to create the conditions necessary to stimulate an increase in the VCM degradation rate. A ratio of 100:10:1 for organic carbon:nitrogen:phosphorus is generally assumed to be adequate to sustain microbial growth. The data show that sufficient nitrogen is present in the aquifer, but there may also be a need to supplement the available phosphorus especially when biosparging of the VCM subplume begins as this may deplete the available phosphorous.

The natural attenuation data collected indicate that the groundwater in the area where the VCM subplume is currently located is anaerobic. As the VCM subplume continues to migrate in a southerly direction, the northern area (where the VCM subplume has left) is beginning to return to aerobic conditions. Furthermore, the TOC and nutrients (N and P) in the VCM subplume are low and have been consumed by the degradation that has already occurred. Because of these conditions, VCM degradation in the subplume has slowed. To start the aerobic degradation of the VCM subplume, the addition of oxygen (air), a carbon source, and nutrients will be needed.

In the remainder of the TVOC plume, the groundwater conditions are aerobic and degradation of the PCE and TCE will be slow. However, the aerobic conditions that exist in the peripheral edges of the VCM subplume (contact areas with TVOC plume) are conducive to VCM degradation. Unfortunately, once the VCM reaches these peripheral aerobic conditions, the oxygen is consumed and continued VCM degradation slows.

3.6 SUMMARY

A review of the data presented herein indicates that the groundwater in the regional TVOC plume is generally aerobic and natural attenuation of VCM in the groundwater is occurring. However, in the VCM subplume, the available oxygen has been depleted and needs to be replenished. In addition, continued degradation in the VCM subplume may become limited by the lack of carbon sources and potentially by a lack of phosphorus. Natural attenuation of VCM by biodegradation has occurred in the vicinity of monitoring wells MW-50J1, MW-50J2, MW-52S, and MW-52I. PCE and TCE biodegradation is limited, but has occurred historically as demonstrated by the presence of cis-1,2-DCE in the PCE/TCE plume wells, boundary wells, and downgradient wells. This slow degradation is likely due to the presence of aerobic conditions which inhibits

PCE degradation and retards TCE degradation. The PCE and TCE that have already degraded to DCE may have already further degraded directly to chloride, water, and carbon dioxide via aerobic processes available in the TVOC plume. Natural attenuation of VCM by the oxidation pathway will be enhanced by the addition of dissolved oxygen and carbon sources in the VCM subplume.

In summary, the data leads to the following key observations:

i) The distribution of redox parameters indicates that, in general, groundwater in the regional area is aerobic and oxidative biodegradation of VCM to chloride and carbon dioxide could be occurring;

ii) The redox parameters in the center of the VCM subplume indicate that the groundwater in this area is anaerobic;

iii) Natural attenuation of VCM by the oxidation pathway will be enhanced by the addition of dissolved oxygen and carbon sources in the VCM subplume;

iv) VCM anaerobic degradation products (ethane and ethene) were observed at monitoring wells MW-50J1, MW-50J2, MW-52S, and MW-52I, indicating that anaerobic biodegradation of VCM by reductive dehalogenation has occurred in the VCM subplume;

v) The PCE and TCE degradation product cis-1,2-DCE was observed in PCE/TCE plume wells and downgradient monitoring wells in association with the parent compounds, indicating that degradation of PCE and TCE is slowly occurring in the area due to the predominantly aerobic conditions; and

vi) The DCE may be degrading directly to CO_2, chloride, and water because of the aerobic conditions. This is likely why VCM is not being detected outside the limits of the VCM subplume.

The results of this natural attenuation evaluation indicate that destructive natural attenuation processes have contributed to the reductions in PCE, TCE, and VCM concentrations over time. They have resulted in the biotransformation of some PCE, TCE, and VCM to relatively innocuous compounds (i.e., ethene, ethane, methane, chloride, carbon dioxide and water). However, continued PCE and TCE degradation will be slow to occur due to the predominantly aerobic conditions in the TVOC plume. Similarly, continued VCM degradation in the VCM subplume will be slow to occur due to the predominantly anaerobic conditions therein. VCM degradation can be significantly enhanced by the addition of oxygen and may be further enhanced by the addition of carbon sources and nutrients into the VCM subplume.

4.0 GEOLOGY/HYDROGEOLOGY AND CHEMICAL DATA SUMMARY

This section provides a summary of the geologic, hydrogeologic, chemical, and groundwater conditions in the vicinity of the Hooker/Ruco Site.

4.1 GEOLOGY/HYDROGEOLOGY

The regional and Hooker/Ruco Site geology and hydrogeology were previously described in the OU-3 RI Report. The information obtained from the boreholes drilled in 2002, while refining the geologic/chemical characteristics within the vicinity of the VCM subplume, does not significantly change the description provided in the OU-3 RI Report.

In summary, the regional stratigraphy generally consists of unconsolidated overburden deposits of clay, silt, sand, and gravel overlying a shist and gneiss bedrock. The overburden units, in order of increasing depth, are:

i) Upper Glacial aquifer (medium to coarse sand, 75± feet thick);
ii) Magothy aquifer (fine to medium sand with interbedded discontinuous layers of coarse sand and silty clay, maximum thickness 650± feet);
iii) Raritan Confining Unit (silty clay, 175± feet thick); and
iv) Lloyd aquifer (fine to coarse sand, 300± feet thick).

In the vicinity of the Hooker/Ruco Site, the overburden stratigraphy consists of the same four units. The Upper Glacial Aquifer ranges in thickness from 30 to 70 feet. The Magothy Aquifer underlies the Upper Glacial Aquifer. The Magothy Aquifer is underlain by the Raritan Confining Unit, the top of which is the vertical extent of the hydrogeologic regime evaluated during the OU-3 RI and 2002 investigations. Two geologic cross-sections were developed, one with a north-south orientation through the middle of the VCM subplume and one with an east-west orientation north of Northrop Plant 5. The location of the geologic sections are shown on Figure 4.1. The geologic sections are shown on Figures 4.2 and 4.3. In general, the stratigraphic logs indicate the presence of coarse sand and gravel material to depths of approximately 70 feet to 100 feet BGS in the vicinity of the Hooker/Ruco Site. This material is representative of the coarse deposits of the Upper Glacial aquifer. Below this depth, interbedded layers of fine sands, silts, sandy clays, and clays become dominant although some layers of coarse material are evident. The finer deposits interbedded with clay layers or lenses are characteristic of the deposits that comprise the Magothy aquifer.

Below the Upper Glacial deposits, continuous fine-grained (e.g. clay layers can not be identified between more than two adjacent monitoring wells. In some cases, it is difficult to correlate the fine-grained layers between immediately adjacent wells. The intermittent nature of the fine-grained layers is expected to strongly influence groundwater flow paths in both the horizontal and vertical directions. The groundwater flow paths are expected to vary significantly around the discontinuous fine-grained lenses as the more permeable pathways are sought.

4.1.1 GROUNDWATER LEVELS

The water table generally is located near the base of the Upper Glacial aquifer and the Upper Glacial aquifer is largely unsaturated in the vicinity of the Hooker/Ruco Site. Groundwater in the Upper Glacial Aquifer and Magothy Aquifer generally flows from north to south with local variations due to the effect of pumping wells and recharge basins.

4.2 GROUNDWATER CHEMICAL RESULTS

The groundwater analytical results assessment presented in the following section focusses on the current extent of PCE, TCE, and VCM in the area south of the Hooker/Ruco Site. These three compounds are those most frequently detected although the VCM subplume is the primary topic of this report. The data presented include the information from the new wells installed in 2002 and further refines the understanding of the horizontal and vertical extent of the VCM subplume.

4.2.1 TETRACHLOROETHYLENE (PCE)

The PCE results from local monitoring well, Northrop RM wells, and Northrop production wells are shown on Figure 4.4. These show that PCE underlies the majority of the Hooker/Ruco, Northrop, and Navy sites. The PCE presence extends upgradient of the northern boundaries of the three sites indicating the presence of off-Site sources. As presented in the OU-3 RI Report, higher PCE concentrations were detected at Hicksville municipal wells H8-1/6192 and H8-8/9180 than at wells MW-56 and MW-57, which are located cross-gradient between the Hooker/Ruco Site and the municipal wells.

The highest PCE concentration in recent monitoring (820 µg/L), was detected in well GM-13D followed by 160 µg/L in MW-63S. The general pattern of PCE concentrations is that the zone of greater PCE concentrations occurs at a higher elevation (shallower depth) starting in the vicinity south of the Navy site and increases with depth in a southerly direction to the GP-1 area. The PCE concentrations are significantly lower in the area between GP-1 and the Northrop ONCT wells. This pattern of PCE concentrations is consistent with:

i) the southerly regional groundwater flow direction enhanced by the pumping from the Northrop RM wells;

ii) the downward flow direction created by surface recharge and the pumping of the Northrop RM wells, which have screened intervals in the range of 400 to 570 ft bgs; and

iii) the discontinuous lenses of fine-grained materials impeding vertical migration until the downgradient edge of a particular lens is reached, whereupon vertical migration occurs until the next lens is encountered. This process then repeats itself (i.e., stair step process).

4.2.2 TRICHLOROETHYLENE (TCE)

Recent TCE results from local monitoring wells, Northrop RM wells, and Northrop production wells are shown on Figure 4.5. These show that the TCE presence is much more extensive and of greater concentration than the PCE. Similar to PCE, the TCE presence extends upgradient of the northern boundaries of the three sites indicating the presence of off-Site sources. The highest recent TCE concentration (2700 µg/L) was detected in well MW-60D1 followed by 2000 µg/L in GP-3.

The general pattern of elevated TCE concentrations is similar to that of the PCE with greater concentration at shallower depths south of the Navy site which increase in depth as the groundwater flows south toward the Northrop RM wells.

4.2.3 VINYL CHLORIDE MONOMER (VCM)

The recent VCM results from monitoring wells, Northrop RM wells, and Northrop production wells are shown on Figure 4.6. These show that the VCM subplume is limited to an area extending from the southern portion of the Hooker/Ruco Site to Northrop RM well GP-3. The highest recent VCM concentration (9100 µg/L) was detected in well MW-61D2, followed by 2050 μg/L in MW-66D2, and 1700 μg/L in MW-52I.

The general pattern of elevated VCM concentrations is similar to that of PCE and TCE, with greater concentrations at shallower depths in the northern portion of the VCM subplume and increasing in depth towards GP-3 to the south.

The width of the VCM subplume is expected to be narrowing. Now that Northrop extraction wells GP-8 and GP-14 are no longer pumping, the VCM subplume migration will be following the natural southerly groundwater flow pattern. As the VCM subplume continues its southerly path, the groundwater modelling work performed for the Hooker/Ruco Site predicts that the VCM subplume will be converging on the location of GP-3. The pumping at GP-1 also helps draw the VCM subplume to the GP-3 extraction point. This flow phenomena is graphically presented in Figure 4.7 which also shows the current estimate of the areal extent of the VCM subplume.

With regard to the vertical extent of the VCM subplume, the recent data collected from the new well installations has been combined with the historic vertical data to provide a clearer picture of the vertical extent. The data show that the concentrated segment of the VCM subplume is flowing as a fairly thin wedge through the hydrogeologic regime. As shown on Figure 4.8, the thickness of the interval with elevated VCM concentrations ranges from 20 to 120 feet. Primarily, the elevated concentrations exist between adjacent low permeable layers and are predominantly more in the 20 to 50 foot thickness range.

Based on the concentrations and the geologic conditions, which include discontinuous fine-grained lenses in a matrix of more permeable materials, it appears that the VCM subplume is migrating downward in a cascading fashion. That is, it is migrating through one or two of the more permeable intervals along its southerly migration pathway. Vertical migration is partially restricted by the underlying fine-grained lenses until the downgradient edge of the lens is reached whereupon vertical migration resumes until the next fine-grained lens is encountered. This process is repeated as the VCM subplume migrates to depth, being drawn down by the pumping of GP-3 and GP-1 and being pushed down by the infiltration of clean water from precipitation and surface recharge basins.

It should be noted that the October 2001 results for well nest MW-52 were used on Figures 4.4 through 4.8 because the most recent results (i.e., June 2002) were obtained after air injection testing of this well nest and may have been impacted by the injections. The results were:

		Concentration (μg/L)		
Well	*Parameter*	*September 2000*	*October 2001*	*June 2002*
MW-52S	PCE	12J	8J	42
	TCE	6J	ND 40	19
	VCM	1900J	320	46
MW-52I	PCE	34J	32J	10J
	TCE	40J	21J	9J
	VCM	2000J	1700	150
MW-52D	PCE	13	20	30
	TCE	38	33	30
	VCM	ND 0.2	ND 0.2	ND 1

It is possible that the large decrease in VCM concentrations in MW-52I occurred because of the degradation that took place due to the air injection testing. Well nest MW-52 was sampled in October 2002 and analyzed by Northrop as part of their quarterly groundwater monitoring program. These results (when received) will help determine whether the VCM concentrations were impacted by the air injections or whether the VCM subplume has simply migrated further south.

Similarly, the VCM concentrations in the June 2002 samples from well nest MW-50 were all ND. Thus, it is possible that the low level VCM concentrations detected in the on-Site wells in December 1998 also may no longer be present as the VCM subplume continues to migrate to the south and the northern areas become restored. This is supported by analytical results for well F-1, which was sampled in August 2002. The results show that VCM was not detected at 2 μg/L whereas in December 1998 it was detected at 7 μg/L.

4.2.4 SUMMARY

As presented in the OU-3 RI Report, the pattern of VCM analytical results with time for GP-6, GP-8, and GP-14 showed that when these three wells were pumping, they reinforced the natural north to south groundwater gradient and drew VCM toward them from areas to the north and northwest of these wells. These pumping wells also helped draw the VCM to deeper portions of the aquifer. This pumping scenario resulted in the creation of two prongs of VCM migration, one to the area of GP-6 and the other to the area of wells GP-8 and GP-14. This occurred until 1992 when these wells were turned off. It is believed that chemicals potentially attributable to the Hooker/Ruco Site migrated to and were captured by these wells prior to 1992 and that the most southerly extent of the VCM subplume prior to 1992 was GP-6.

When pumping stopped at GP-6, GP-8, and GP-14 in 1992, the groundwater flow system returned to a more natural condition in the areas of these wells. However, the natural north to south gradient was still being maintained by the pumping of GP-1 and GP-3 which are located further downgradient. With the pumps at GP-6, GP-8 and GP-14 no longer drawing the VCM toward them, the chemicals in the VCM subplume have migrated with the natural southerly groundwater flow and are converging on the flow paths associated with the pumping of Northrop wells GP-1 and GP-3.

An evaluation was performed to determine if the current southerly extent of the VCM subplume is consistent with the conceptual understanding of the groundwater flow system. Using the hydraulic conductivities and porosities assigned to the groundwater flow model presented in the OU-3 RI Report and the gradients listed in Table 4.1, interstitial groundwater flow velocities were calculated for four intervals of the formation (shallow, intermediate, deep, and very deep). As shown on Figure 4.8, the VCM subplume from the area of GP-6 to GP-3 is located in the very deep interval. The rate of groundwater flow at this depth is on the order of 0.4 ft/day. For the time period from the end of 1992 to the middle of 2002 (9.5 years) the groundwater travel distance would be on the order of 1400 feet which is slightly less than the 1900 feet between GP-6 and GP-3. Given the increase in velocity as water approaches a pumping well, it is not unreasonable to expect that the leading edge of the VCM subplume may be approaching GP-3. This is consistent with the fact that VCM has been identified to be present at elevated concentrations at wells MW-61 (adjacent to GP-6) and MW-66 (just north of Plant 5), as shown on Figure 4.6.

5.0 SPARGING TESTS

One of the major components of the work performed this year involved the field testing of air injection as a remedial technology. The testing was performed to determine the physical practicability of injection and to provide insightful information that can be applied to the final design of the proposed bioremediation system for the VCM subplume.

Sparging pilot tests were conducted using existing monitoring wells from two areas, the Hooker/Ruco Site and Northrop Plant 12, in the summer of 2002. A trailer unit equipped with controls, instrumentation and gas addition capacity was constructed by CRA (CI trailer). A process and instrumentation diagram (P&ID) for the trailer is included in Appendix D. A second trailer equipped with a 200 psi – 400 scfm compressor was also delivered to the Site. The testing primarily consisted of air being delivered to one wellhead at a time, and injection capacity and impacts in injected and adjacent wells being monitored over several days in each test.

Well locations in the Hooker/Ruco test area are shown on Figure 5.1. The Hooker/Ruco area has no significant VCM in groundwater, but it has anaerobic conditions due to past microbial activity. Well locations in the Plant 12 test site are shown on Figure 5.2. The Plant 12 site has some VCM and some anaerobic intervals. The subsurface lithology and hydrogeological parameters are similar at the two locations.

5.1 TEST EQUIPMENT AND PROCEDURES

The large trailer mounted compressor had a nominal capability to deliver 400 scfm at 200 psi to the wellheads. The high pressure compressor was required to depress the water table to allow air flow in the deeper wells.

The air supply system included an oil trap at the compressor and a heat exchanger and a moisture trap in the CI trailer in order to deliver a relatively dry air at a temperature of less than 90°F. Digital and analog pressure gauges and a digital flow meter monitored the major flow parameters. Pressure, flow, and temperature data were recorded continually on a personal computer (PC). The heat exchanger and electric components in the CI trailer were powered by a small gasoline generator. The air discharge hose from the compressor was connected to the sparged wellhead by a threaded coupling, with a pressure gauge and a pressure relieving valve on one branch of a tee. The wellhead assembly was anchored by sand bags and/or chains to prevent flailing hoses in the event of a joint failure.

Gaseous amendments (helium, nitrous oxide, propane) were metered from compressed bottles staged inside the CI trailer. Helium was added at 1 to 2 percent of injected air as a tracer. Nitrous oxide and propane were injected together in one test to assess the concept of supplementing nitrogen and carbon sources for microbes, to stimulate biodegradation. Nutrients were added to the test well in the form of a 5 percent di-ammonium phosphate (DAP) solution, prior to the sparging test. The DAP solution was mixed on-site and introduced by gravity flow from the mixing tank.

Sparging tests consisted of air injection into a single well, and then monitoring the impacts in nearby wells and the sparged well. Most sparging events were conducted for four hours per day, with the flow stepped up on consecutive days at 100, 150, and 200 standard cubic feet per minute (scfm) nominal flows. In each test, pressure and flow tended to drift, and some adjustments were made to maintain flow near the nominal value. The remainder of each sparging day was spent in maintenance (fueling, gas bottle management) and monitoring groundwater and unsaturated zone gases in wells in the vicinity of the sparged well. Monitoring was typically performed prior to the start of injection, during the test, and then was also extended up to five days after each sparge event.

Health and safety procedures were compliant with the OU-3 Predesign HASP. The procedures included review by the on-Site workers, conducting daily meetings to discuss the day's tasks and potential hazards posed by them, and recording these meetings on daily forms and in a bound notebook. A summary of the daily activities was also recorded in the bound notebook. The sparge test procedures were completed with no incidents. However, a small grass fire occurred while welding the injection components on well K2.

5.2 DATA COLLECTION AND OBJECTIVES

Data was collected to determine air injection capacity and to assess impacts to groundwater quality. Air injection capacity was directly measurable as the injected air flow rate at a range of wellhead pressures. A wide range of monitoring was performed to assess the impacts of sparging, both in terms of spatial influence and modification of groundwater and vadose zone air chemistry. Table 5.1 summarizes the types and objectives of data collected.

Air injection flow rate and pressure were recorded continually by PC, and taken manually every 15 minutes during sparge events. Each well was tested at nominal flows of 100, 150, and 200 scfm, regulating the pressure to obtain the desired flow in each step. The injection capacity is discussed below in terms of an increase in flow rate achieved for a rise in applied pressure.

Groundwater field parameters were measured after each sparge event in the sparged well and in adjacent wells in which groundwater impacts might be expected (i.e., wells with screens above the sparged screen). Bladder pumps, decontaminated prior to each use, with Teflon tubing dedicated to each well, were set in the screen interval for sampling. Pumped discharge was directed through a flow cell with a single probe, instrumented with temperature, DO, pH, ORP, and turbidity measurement capabilities. Wells were purged of at least five gallons, and then until all parameters stabilized over at least three readings taken at five minutes intervals.

Groundwater samples for laboratory analysis were collected through the same bladder pump and dedicated tubing following purging. Water samples were labeled and stored on ice until delivered to the lab, typically the day after collection. At each site, water table wells (screened across the water table) were monitored for pressure, gas composition, and water parameters. Helium was metered into all sparged air as a tracer. A summary of the field data is presented in Appendix D.

5.3 SCHEDULE OF TESTS

A summary of the sparging periods for the tested wells is provided below.

Date	*Activity*	*Sparge Well*
4/16 – 4/18	Sparge 100, 150, 200 scfm nominal flows, 4 hours each	MW-52S
4/23 - -4/25	Sparge 100, 150, 200 scfm nominal flows, 4 hours each	MW-52I
5/8 – 5/10	Sparge 100, 150, 200 scfm nominal flows, 4 hours each	MW-50J2
5/21	Test MW-50D1; no flow; pneumatic slug test instead Step test MW-50D2, 3 x 1 hour steps 100, 150, 200 scfm	MW-50D1 & MW-50D2
5/30-6/1	Sparge 100, 150, 200 scfm nominal flows, 4 hours each	F2
6/18 6/19	Add DAP solution to MW-50D2 Sparge MW-50D2 8 hours ~ 200 scfm	MW-50D2
7/10	Sparge 1 hr 100, 1 hr 150, 6 hrs 200 scfm	K2
7/23 – 7/25	Sparge 100, 150, 200 scfm nominal flows with propane, nitrous oxide	MW-52D

Date	*Activity*	*Sparge Well*
8/7	Add sugar byproduct solution to MW-52D Sparge 1 hr 100, 1 hr 150, 6 hrs 300 scfm nominal flow	MW-52D
8/8	Add sugar byproduct solution to MW-52D Sparge 1 hr 100, 1 hr 150, 6 hrs 300 scfm nominal flow	MW-52D

Notes:
scfm = standard cubic feet per minute, or what flow would be at 70°F and 1 bar
DAP = diammonium phosphate (N, P nutrient amendment)

5.4 RESULTS

This section presents an overview of the air injection test results. Data are reported more fully in Appendix D.

5.4.1 AIR INJECTION CAPACITY

Pursuant to the scope of work, injection testing was to have been performed up to a maximum air flow rate of 300 scfm. One short-term flow rate of 330 scfm was tested in MW-52S, the first tested well. This test showed that once air flow started, large air flow rates could be achieved with small increases in the air injection pressure. Based on this observation, it was resolved that remedial sparging flows would be unlikely to exceed 200 scfm and nominal step test flows of 100, 150, and 200 scfm were decided upon to establish the air capacity over an expected operating range.

Air flow in most cases was initiated when the applied pressure reached that required to depress the water in the well to the top of the screen. Within a minute or two of flow beginning, a semi-steady flow/pressure setting was reached. After this setting was established, flow and pressure tended to drift somewhat as flowpaths developed in the aquifer. When flow deviated more than about 15 percent from the nominal rate in any one test, pressure was adjusted manually.

In each step test, flow tended to increase and pressure decrease and eventually stabilized. The air capacity lines, based on the stabilized end point data, are shown for all sparge tests on Figure 5.3. In this figure, the zero-flow point is estimated from the theoretical breakout pressure, based on the column of water that must be depressed before air reaches the top of the screen. All other data points are end points from the step tests. All air capacity lines on Figure 5.3 have similar gradients, and extrapolate back to the breakout pressure, except for MW-52I. The latter well is screened in a more silty interval, and required more pressure for an increment in air flow. The results showed that the sandy intervals accepted 40 to 50 scfm per psi increase in pressure, once air flow was initiated, except for MW-52I where an air flow at approximately 7 scfm/psi was observed.

The estimated breakout pressure for MW-50DI (screen interval is 235 – 255 feet bgs) was 75 psi. Air flow could not be established in this well even at a pressure of 110 psi. Slug tests were performed in this well and in MW-50D2 to compare the hydraulic properties of the two screened intervals. Slug test data and the solutions are given in Appendix D. These tests indicated the hydraulic conductivity of MW-50D1 was 3.0×10^{-5} cm/sec. This suggests that the screened lithology in MW-50D1 is silt. The air cannot penetrate the silt because the pore size is very small and capillary forces (surface tension) are high when the pores create a very tightly curved air/water interface. "Air entry pressure" increases as the pore size decreases.

Although air flow was not induced in MW-50D1, the ORP and DO did rise in this well four days after sparging the deeper MW-50D2, indicating that oxygen permeated upward into the silt, even if gaseous air could not be directly injected.

In the propane-amended injection test of MW-52D, the ability of the formation to accept air decreased between the step tests. The decrease in air capacity is believed to be due to silting caused by the frequent stop-starts of injection during adjustment of the propane addition. The capacity was recovered in the later injection test of MW-52D in which a liquid sugar byproduct solution was injected prior to air sparging. This supports that an injection of water can serve to redevelop air capacity if it decreases in a well.

5.4.2 GROUNDWATER IMPACTS

Groundwater impacts from sparging were monitored using a range of parameters to attempt to quantify the basis for a remedial sparging design. Parameters monitored in sparged wells and adjacent wells included:

Water levels
DO
pH
ORP
Specific conductance (SC)
Helium
C1 – C4 gases
Microbial assays

Water levels have been thought by some researchers in the early 1990s to indicate the area of influence above a sparging point, but this has now been shown to not be generally true. Some changes in levels were observed in monitoring wells close to sparge points in the 2002 tests, but these were small and irregular.

Dissolved oxygen concentrations were raised by sparging to concentration higher than the meter range (20 mg/L) in sparged well groundwater in all cases. The concentrations returned at various rates to sub-20 mg/L concentrations in most cases over the period of monitoring of the tests. In only a few cases was the DO affected in adjacent wells.

The solubility of oxygen increases with pressure. To a fair approximation, the solubility of oxygen in contact with air is 8 mg/L for each atmosphere pressure. For instance, at a screen 325 ft below the water table, water pressure is 10 atmospheres, and DO saturation achievable by sparging is 80 mg/L. When water samples from a screen at that depth is brought to surface after sparging, dissolved gases effervesce.

The intent of the injection testing was to determine the technical practicality of injecting air and the potential amendments. Thus, the air injection was performed for relatively short periods of time. These short time tests were not intended to be long enough to evaluate DO changes in adjacent wells. However, adjacent wells were monitored to determine if the short-term testing did have some impact.

DO response was not immediate in some wells adjacent to sparged wells. This is believed to be partly because air is slow to permeate finer sands, and partly because there is a certain oxygen demand in much of the VCM subplume that must be met before DO can rise. Figure 5.4 shows a correlation between DO and redox, or ORP. The data are from monitoring wells across the VCM subplume, sampled in June and July 2002. Where DO is above 2 mg/L (aerobic) the ORP is above +100 mV. These are described as oxidizing conditions. Where DO is less than 2 mg/L, ORP ranges from very reducing to mildly reducing (from -300 to +100 mV). Sparging groundwater with DO initially less than 2 mg/L may have to satisfy a considerable oxygen demand to move the ORP up to +100 mV before the DO concentration begins to rise. The oxygen demand in the anaerobic zones may consist of chemical oxygen demand of inorganic constituents such as Fe^{++} (aq), and biological oxygen demand.

DO measurements for the F2 and MW-50J2 sparge tests are shown on Figure 5.5 to illustrate the types of responses seen in sparging. Figure 5.7 shows DO and ORP in sparged wells F2 and MW-50J2, and DO in the overlying F1 and MW-50J1. The immediate impacts of sparging can be seen as DO spikes in F2 and MW-50J2. In F2, the initial ORP was negative, and the DO rose but quickly declined after sparging due to immediate chemical oxygen demand in the sparged well. In MW-50J2 the initial ORP was over +100 mV, and the DO peak declined more slowly, presumably due to aerobic microbial uptake. In both F2 and MW-50J2 tests, the F1 and MW-50J1 shallow wells failed to show any DO response to the sparging in the deeper wells. As noted above, the

DO and ORP both rose in MW-50D1 four days after sparging the deeper MW-50D2, although air flow could not be induced in MW-50D1. This confirms that DO will permeate silty zones that resist sparge air intrusion.

pH often is an indicator of microbial respiration, which typically ends in production of carbon dioxide, yielding carbonic acid and reducing the pH. Trends in DO and pH are often correlated, as consumption of DO leads to production of acidity. Figure 5.6 compares DO and pH responses in wells MW-52I and MW-52D.

Initially low DO in both wells in Figure 5.6 was raised to >20 mg/L when they were sparged. Both wells had ORP of approximately +100 mV, and both had slightly acidic pH, prior to sparging. After sparging, however, groundwater behaved quite differently in the two wells. In MW-52I, DO remained elevated and pH was little affected. In MW-52D, however, DO was rapidly consumed and pH dropped as CO_2 was produced. The difference between the two wells is that propane and sugar byproducts were injected into MW-52D, stimulating microbes. The lack of post-sparge DO consumption in MW-52I indicates that the existing BOD in this well was small.

ORP is mentioned above as an indicator of anaerobic oxygen demand. Some of the anaerobic oxygen demand is chemical demand, which will consume oxygen before the DO can be raised by sparging.

Specific conductance (SC) is typically used only to confirm parameter stability during purging prior to sampling. In some instances it confirms respiration, since generation of carbon dioxide raises the ionic content of the water.

Helium was injected as a tracer into sparge air, at 1 to 2 percent of the injected flow It was analyzed as a groundwater solute by MicroSeeps Lab. Helium gas was also monitored in water table wells with a helium gas detector, with a detection limit of 0.01 percent.

Methane was found to give false readings on the helium gas meter. Where the methane concentration was known, the helium meter was still of some use.

Dissolved helium data (analyzed by lab) were inconclusive in the 2002 tests. Reported concentrations of helium in the groundwater samples were always low, sometimes higher in samples prior to sparging than afterwards, indicating low reliability at low reported concentrations. The absence of higher helium concentrations in wells adjacent to deeper sparged wells shows that sparged air flow does not simply ascend in a cone at this site. Rather, air flow resembles an inverted water fall, flowing in cascades between silt or clay lenses, and flowing around those features, which can divert air flow laterally over some distance.

C1 – C4 gases include methane (C1), ethane, ethene (C2), propane (C3) and butane (C4), with the Cx number indicating the number of carbons in the molecule. Ethene in particular was found in 2002 samples from across the VCM subplume to correlate with VCM, indicating natural attenuation of VCM to ethene is occurring. This degradation can be described by:

$H_2.C{=}C.H.Cl$ (VCM) - >$H_2.C{=}C.H_2 + Cl^-$ (ethene, chloride)

Methane was reported at concentrations indicating methanogenic microbial activity over much of the VCM subplume.

Microbial assays were performed by plate counts on groundwater samples. The absolute numbers of cultivable microbes per mL of water were found to be low, but these increased significantly after sparging. Microbial assays on groundwater always under-count actual population densities because many or even most species do not readily multiply in the lab.

5.5 UNSATURATED (VADOSE) ZONE IMPACTS

The unsaturated zone is of concern mostly because of the question whether sparge gases will strip VCM and carry it above the water table (which is located approximately 60 feet bgs) and possibly even to the surface leading to vapor exposure. At the Hooker Ruco Site, six wells screened across the water table (E1, F1, I1, MW-50J1, K1, and P1), and MW-52V at Plant 12 allowed monitoring of vadose zone gases for sparging impacts.

Monitoring of water table gases consisted of purging and sampling by a vacuum pump through a sealable cap, and measuring oxygen, carbon dioxide, and methane percentages with a gas meter; organic vapors with a PID (10.6 eV); and helium with a helium detector. Unfortunately it was found that methane, which was widespread in the subsurface of the test areas, interferes with the helium detector (the He meter read 25 percent of the methane percentage, when no helium was present, prior to sparging).

Figure 5.7 illustrates some of the effects of sparging in the gases above the water table, as observed in F1. Initially, the zone just above the water table is quite anaerobic: methane was 20 percent, carbon dioxide 10 percent, and oxygen 0 percent. Methane and carbon dioxide are due to microbial respiration above and below the water table. As shown on

Figure 5.7, oxygen in the gas immediately reaches 20 percent in F1 after sparging the deeper F2 well, even though the DO in F1 groundwater did not rise above 0.5 mg/L. This shows that the sparge air was diverted away from F1 groundwater, but permeated into the air contained in the vadose zone immediately above the water table.

After the F2 sparging, methane in F1 stayed flat, while carbon dioxide rose as oxygen fell. The methane disappearance is believed to be due to displacement by fresh air. The mirror symmetry of the oxygen and carbon dioxide curves after sparging represent conversion from one to the other, by microbial respiration, and confirms that the vadose zone is biologically active. These phenomena, displacement and respiration, are seen, though less clearly, in other water table wells.

The above observations, just above the groundwater table, support that degradation of any VOCs that may migrate to the vadose zone will continue as the vapor migrates upwards through the vadose zone. While no quantitative data are available on near-surface vapors in long-term sparging, it is believed that the above observations support that no detectable vapors should reach the surface. Vadose zone gas monitoring in a prototype system will be performed to confirm this.

5.6 AREA OF INFLUENCE

Many early authors on air sparging refer to radius of influence (ROI) of sparging, which would appear, particularly by analogy with pumping hydraulics and soil vapor extraction, to be an important parameter. It is, however, not a very practical parameter, because sparged air flows are often highly heterogeneous, and not aptly described by a radius. A significant objective of the 2002 pilot tests was nonetheless to assess over what area the subsurface was impacted by sparging, with a view to establishing an effective well spacing.

Air flow through the aquifer occurs in sub-vertical tubes, until they are baffled by fine grained lithologies (silt and clay layers). The pattern of the air tubes in sand is conical, because the air expands up the pressure gradient and because of random walk dispersion of branching tubes. Silts and clays baffle air flow, and will cause "stepping" of an ascending air flow like an inverted water cascade.

The 2002 tests do not provide a lot of direct evidence for the effective lateral reach of sparging in the saturated zone. The observed groundwater impacts are summarized below:

Sparged well	*Observation well*	*Horizontal separation (feet)*	*Vertical separation (feet)*	*Observations*
MW-50J2	MW-50J1	8	52	DO rise <0.1 ppm; ORP rise 60 mV
MW-50D2	MW-50J1	40	282	No impact
MW-50D2	MW-50J2	48	120	No impact
MW-50D2	MW-50D1	35	95	DO rise 2 ppm 2 days after sparge
MW-50D2	F1	150	282	DO rise 0.2 ppm; ORP 60 mV rise
F2	F1	~ 0	22	DO rise 0.3 ppm to 0.6; ORP rise 60 mV
K2	K1	10	53	ORP rise 40 mV
MW-52I	MW-52S	14	80	DO rise from 11 to 20+ ppm
MW-52D	MW-52I	14	136	ORP rise 20 mV
MW-52D	MW-52S	15	231	Possible small rise in ORP

The effect in MW-52S from sparging in MW-52I is the best indication of influence. In other pairings, the factor that probably interrupts the impact to shallow wells is intervening fine-grained units (silts or clays), that divert the ascending air flow laterally. MW-50D1 is completed in a silty interval (shown by slug testing) that would not accept air flow, but it is evident that DO did slowly permeate to this well from the deep sparge point (MW-50D2).

In conclusion, the injection tests did not run long enough to establish an area of influence for an individual well. As stated in Section 5.4.2, this was not an objective of the testing performed. The design strategy is to install and operate one component of the full scale remedial system over a longer term, to refine the operational parameters for the remaining components of the full scale remedial system.

5.7 CHEMICAL AMENDMENTS

Chemical amendments were added to the sparging tests to prove the feasibility of supplementing carbon sources and nutrients, where these might be limiting microbial activity. Such circumstances might be indicated, for instance, where DO is higher than 2 mg/L (aerobic), VCM concentrations are low and not showing signs of ongoing attenuation, and total organics are low. The supplemental carbon sources tested were propane and sugar byproducts, both in MW-52D. Supplemental nitrogen was added with the propane sparge in MW-52D as nitrous oxide (N_2O) gas and a di-ammonium phosphate (DAP, $(NH_4)_2.PO4$) solution was injected prior to sparging MW-50D2.

Supplement	*Purpose*	*Form of Addition*	*Location Tested*
DAP	N, P nutrient	Solution, prior to sparge	MW-50D2
Propane	Carbon source	Gas, in air flow	MW-52D
Nitrous oxide	N nutrient	Gas, in air flow, concurrent with propane	MW-52D
Sugar Byproducts	Carbon source, some N nutrient	Solution, prior to sparge	MW-52D

The pilot tests did not show any technical difficulties with injection of either the sugar byproduct or DAP solutions.

Injection of hydrocarbon and nitrous oxide gases can deliver these constituents to the same places as the sparged air that carries them. Methane is a relatively simple hydrocarbon to add to an air stream, but there is already considerable methane in much of the VCM subplume. Propane has been shown in a number of studies to stimulate production of microbial enzymes more effective than methane-metabolizing bacteria in degrading VCM. Propane has the difficulty that it is a liquid at typical deep injection pressures. In the pilot tests, propane was heated with an electric blanket and temperature controls, to raise the vapor pressure to that in the injected air lines. So far as is known, this is the first instance of heated propane addition to deep sparge air. After set-up and calibration, the propane system performed as designed, without problems.

Nitrous oxide is available in 2,000 psi compressed gas bottles, and is simple to add to an injection air flow. It was added simultaneously with propane in the sparging of MW-52D.

5.8 INDIVIDUAL TEST DATA

In this section, individual sparging test data are summarized. Actual data are presented in Appendix D. Field progress reports are also included in Appendix D with some partial analyses.

5.8.1 MW-52S SPARGE, NORTHROP PLANT 12

Well MW-52S was the first sparged well for the 2002 pilot tests. It was here that the capacity of the formation was seen to be higher than expected, and the step test strategy was amended from the preliminary guidelines to the 100, 150, and 200 scfm steps used.

In initial testing, flow up to 330 scfm was achieved, before scaling back. The well was then sparged at:

i) 100 scfm for 4 hours on April 16, 2002;
ii) 150 scfm for 4 hours on April 17, 2002; and
iii) 200 scfm for 4 hours on April 18, 2002.

Area groundwater was monitored in wells MW-52S, MW-52I, and MW-52D through April 23, 2002.

The estimated and actual breakout pressures were 28 and 37 psi.

Impacts attributable to the MW-52S sparging were:

i) DO in MW-52S groundwater rose from 2 to >20 mg/L, and declined back to approximately 2 mg/L by July. ORP rose from 200 to 250 mV.

5.8.2 MW-52I SPARGE, NORTHROP PLANT 12

Well MW-52I showed a lower capacity than other wells, except MW-50D1 in which air flow was not achieved. MW-52I was sparged at:

ii) 100 scfm for 4 hours on April 23, 2002;
iii) 150 scfm for 4 hours on April 24, 2002; and
iv) 200 scfm for 4 hours on April 25, 2002.

Area groundwater was monitored in wells MW-52S, MW-52I and MW-52D through April 25, 2002.

The estimated and actual breakout pressures were 70 and 80 psi.

Impacts attributable to the MW-52S sparging were:

i) DO in MW-52I rose from approximately 5 to >20 mg/L, and did not decline. pH rose from 5 to 6.

5.8.3 MW-50J2 SPARGE, HOOKER-RUCO SITE

Well MW-50J2 was sparged at:

i) 111 scfm for four hours on May 9, 2002;
ii) 154 scfm for four hours on May 10, 2002; and
iii) 220 scfm for four hours on May 13, 2002.

Area groundwater and water table gases were monitored through May 16, 2002.

The estimated and actual breakout pressures were 26 and 39 psi. After injection was completed, the valve to the well was closed (shut-in). The shut-in well held 29.5 psi overnight. These slight discrepancies suggest that the top of the screen interval may be in a less permeable lithology, and flow initially exited from a point lower in the screen.

Impacts attributable to the MW-50J2 sparging were:

i) DO in MW-50J2 groundwater rose from <1 mg/L to 14 mg/L, and decreased back to 2 mg/L over two months;
ii) Methane rose in MW-50J1 gases, but not oxygen; presumably DO was consumed in the groundwater. Methane was either stripped from the groundwater into the vadose zone, or merely displaced within the vadose zone toward MW-50J1; and
iii) Oxygen rose to 8 percent in adjacent well K1 (and to 10 percent after the MW-50D2 sparge, perhaps a lagged impact from MW-50J2).

5.8.4 F2 SPARGE, HOOKER-RUCO SITE

Wells F1 and F2 were installed in the same borehole, and share a surface casing. F2 was sparged at:

i) 109 scfm for 4 hours on May 30, 2002;
ii) 156 scfm for 4 hours on May 31, 2002; and
iii) 195 scfm for 4 hours on June 1, 2002.

Area groundwater and water table gases were monitored through June 6, 2002.

The estimated and actual breakout pressures were 13 psi. The shut-in well leaked down to 8 psi overnight, indicating minor potential leakage through the well casing.

Impacts attributable to the F2 sparging were:

i) DO in F2 groundwater rose from <1 mg/L to 5 mg/L, and decayed back to <1 mg/L in just five days. F2 ORP rose from -100 to +100 mV;

ii) F1 groundwater ORP rose slightly, and F1 SC rose slowly over two months. F1 DO was unaffected; and

iii) Oxygen in F1 gas rose to 20 percent oxygen with 2 percent helium. The oxygen was converted to carbon dioxide over a month (see Figure 5.7).

5.8.5 K2 SPARGE, HOOKER-RUCO SITE

Well K2 is located across the south fence of the Hooker-Ruco Site, on Harold Levinson Associates (HLA) property. K2 was sparged at:

i) 102 scfm for 1 hour;

ii) 160 scfm for 1 hour; and

iii) 197 scfm for 6 hours all on July 9, 2002.

Area groundwater and water table gases were monitored through July 15, 2002. The sampling pump became stuck in K2 on July 14, 2002, and was left in place for later attempts at retrieval.

The estimated and actual breakout pressures were 25 and 26 psi. The shut-in well held 24 psi overnight.

Impacts attributable to the K2 sparging were:

i) DO in K2 groundwater rose from <1 mg/L to 2 mg/L, and decayed back to <1 mg/L in just five days. K2 ORP rose from -100 to +100 mV;

ii) K1 groundwater ORP rose from -100 to +100 mV, and DO rose to 2 mg/L; and

iii) Oxygen in F1 gas rose to 16 percent oxygen with 2 percent helium. The oxygen was converted to carbon dioxide over a week (see Figure 5.7).

5.8.6 MW-50D2 SPARGE, HOOKER-RUCO SITE

Well MW-50D2 is the deep well of the test cluster. It was tested at three flows on May 21, 2002 to verify it would allow later testing. The three flows were:

i) 60 scfm for 1 hour;

ii) 150 scfm for 1 hour; and

iii) 200 scfm for 1 hour.

Subsequently on June 19, 2002 it was sparged for eight hours at a nominal 200 scfm, after injecting DAP solution as a microbial nutrient. In all, 15,000 gallons of water with 200 lb DAP were injected in 300 gallon batches of water. Approximately 25 pounds of DAP was mixed into each of eight 300-gallon batches. Between injecting each 300-gallon batch into the well, potable water was injected into MW-50D2 and after injecting the final batch, potable water continued to be injected until a total of approximately 15,000 gallons had been injected. No slowing of the solution injection rate, which might indicate precipitation of phosphates in the screen, was observed. No precipitation was expected because the total dissolved solids content of the water is low (typically less than 200 mg/L).

Area groundwater and water table gases were monitored through May 25, 2002 after the first step tests, and through June 23, 2002 after the DAP injection.

The estimated and actual breakout pressures were 125 and 159 psi. The shut-in well held 150 psi overnight.

Both MW-50D1 and MW-50D2 showed high pH, believed due to cement contamination from grout invasion of the screen interval, that gradually decreased.

Impacts attributable to the MW-50D2 sparging were:

i) DO in MW-50D2 groundwater rose from 2 to >20 mg/L, and varied thereafter between 14 and >20 mg/L. The lower values may be due to degassing in the relatively long ascent up the tubing in this deeper well; and

ii) MW-50D1 groundwater ORP rose from 0 to +200 mV, and DO rose from 2 to 4 mg/L four days after the 8-hour sparge of MW-50D2.

5.8.7 MW-52D SPARGE, NORTHROP PLANT 12

Well MW-52D was sparged on July 17, 2002 for 15 minutes at 100, 150, and 200 scfm to verify the capacity prior to setting up for the two later tests, which included amendments. The well was sparged with nitrous oxide (N_2O) and propane mixed in the injected air from July 23, 2002 through July 25, 2002. Later, a sugar byproduct solution was added to the well on August 6 and 7, 2002, and it was sparged again on August 8, 2002.

The propane gas and sugar byproduct solution were meant to prove the concept that liquid amendment injection into groundwater in sparge wells can physically be done, to stimulate microbes with additional carbon sources. Nitrous oxide was intended to be a gaseous source of nitrogen. Propane and N_2O gases were added directly to the sparged air flow, while the sugar byproduct was injected as a liquid solution prior to sparging.

A propane bottle was enclosed in an insulation wrap with a heater cable and temperature controls, and heated to raise the vapor pressure to the level of the injection air. Some adjustments were required to start this system up, and thereafter performed according to plan. For the propane/nitrous oxide testing, MW-52D was sparged at:

i) 100 scfm for 4 hours on July 23, 2002;

ii) 150 scfm for 4 hours on July 24, 2002; and

iii) 200 scfm for 4 hours on July 25, 2002.

Injection capacity decreased in this well during the propane sparging, which is believed to be due to silting caused by the frequent stop-starts during adjustment of the propane addition. The capacity was recovered in the subsequent sparge test, after injection of the liquid sugar byproducts.

Sugar byproducts in the quantity of 80 lb were mixed, 20 lb per 200 gallon batch of water, with an additional 200 gallons of water following each sugar byproduct batch. This was poured by gravity down the well. Water was from the Hooker-Ruco plant, and was found to have 0.35 mg/L free chlorine residual, which may have temporarily decreased the microbial population.

Well MW-52D was then sparged on August 8, 2002 at:

i) 60-115 scfm for 1 hour;
ii) 150-170 scfm for 1 hour; and
iii) 200-310 scfm for 6 hours.

Area groundwater was monitored in wells MW-52S, MW-52I, and MW-52D through August 13, 2002.

The estimated and actual breakout pressures were 133 and 138 psi. Overnight the shut-in well held at 130 psi.

Impacts attributable to the MW-52D sparging were:

i) DO was raised from <5 to >20 mg/L. After the sugar byproduct injection, DO declined sharply, pH declined, and SC rose, indicating microbial conversion of DO and sugar byproducts to carbon dioxide. A similar decline in DO after the propane injections was not noted to occur; and
ii) Spikes in DO (from 18 to >20 mg/L) were detected in MW-52I.

5.9 OXYGEN DEMAND AND SPARGING REQUIREMENTS

The next step in the process is to use the data obtained during the field tests with the view toward how these data will affect the design of a full scale system. The following discusses the initial estimate of the oxygen demand and sparging requirements that must be met if a well spacing of 100 feet between adjacent injection wells is used to create a sparging system in the groundwater formation.

The objective of sparging is to oxygenate impacted groundwater to stimulate aerobic microbial degradation of VCM. There are various oxygen sinks in the VCM subplume, as suggested by the correlation between ORP and DO in the subplume monitoring wells which must be oxidized before aeration can raise the DO.

Estimation of the air flow required to match the TOD of reported analytes in groundwater in the VCM subplume is reported in Appendix F. It is calculated that 30-40 hours of sparging at 100 scfm is required per well for initial aeration, and 3-4 hours per month is required to keep up with groundwater inflow to the well from the upgradient portion of the aquifer. This assumes a 100 ft spacing, and a ten foot overlap of influence between the injection wells.

5.10 OPERATIONAL ISSUES

There are other operational issues regarding an injection system that have been considered in the proposed design. These are discussed in the following sections.

Silting of wells: This may be caused by the vibration of normal sparge operations or the too-rapid shutting on or off of the sparge system. In sparging MW-52D, a reduction in air injection capacity was seen at one stage, which was overcome by the sugar byproduct solution injection. Thus, it is expected that capacity may be recovered by injection of a slug of water which would force the sediment either out of the well or back into the formation. It may also be prudent to disinfect the water slug with hypochlorite to discourage biofouling of the screen.

Air plugging of the formation: Air or nitrogen residual after oxygen is consumed could occupy pore space in the aquifer even after sparging, and that such aerated areas could affect groundwater flow paths. This possibility is not supported by the test data and pragmatic experience.

Vertically continuous volumes of gaseous air will continue to rise even after sparging ceases, possibly forming transitory extended gas lenses under finer grained traps, but will not hang in place. As long as an air body is continuous in the sand, it will flow upward following the pressure gradient. If it breaks up into discontinuous bubbles where buoyancy is insufficient to overcome the air entry pressure (that is, to push into saturated pores), it can divert local water flow on the scale of the bubble, but not macro-scale water flow.

Sparged air flows in finger channels rather than continuous sheet structures, so that even in active sparging there is no damming of groundwater flow.

Possible stripping of volatiles to the surface: This is unlikely to occur, even if sparging is sustained for some time. To verify that this does not occur, vadose zone monitoring points will be installed. Data from the field tests suggest that vapors stripped from below the water table should not be detectable at the surface, but this will be demonstrated by monitoring.

5.11 SUMMARY

The principal results obtained from the injection testing were:

i) the formation has the capacity to easily accept the planned air flow rates;

ii) the addition of both liquid and gas amendments were practical;

iii) air plugging of the formation is unlikely to occur;

iv) DO can permeate into silty intervals that do not accept injected air directly;

v) water injection can be used to redevelop wells that decrease in air capacity;

vi) no detectable vapors should reach the ground surface; and

vii) the injection tests were not run long enough to establish an area of influence for an individual well. Such establishment was not an objective of the testing performed. The design strategy is to install and operate a pilot system over a longer term to determine an effective well spacing for a full scale remedial system.

6.0 MICROCOSM STUDY RESULTS

To complement the field program, a laboratory study involving microcosm slurry testing was performed to examine the effect of supplementation with air, inorganic nutrients, and carbon sources on the VCM biodegradation rate. A complete description of the laboratory study is provided in Appendix E and is summarized in the following.

Sugar byproducts, propane, and methane were selected as the supplemental carbon sources for the laboratory microcosm study. The additions of sugar byproducts and propane were expected to stimulate the growth and microbial activity of the heterotrophic microbial population. The addition of methane was expected to stimulate the biodegradation of VCM via a co-metabolic pathway where methane would be used as a co-carbon source by methylotrophic bacteria. Unamended microcosms were also included in the study to provide base case results.

The water used for the microcosm tests was collected from well MW-64 at a depth of 255 feet bgs and initially contained 6200 μg/L of VCM. The soil used to make up the slurry for the microcosm tests was also collected from well MW-64 from the 250 to 255-foot bgs interval. The act of blending of the water and soil to make up the batch of slurry for the microcosm tests reduced the VCM concentration from 6200 μg/L to on the order of 300 to 400 μg/L. This reduction provides some indication of how sensitive the VCM concentrations in the water are to simple manipulative processes such as mixing and oxygen injection. These are the exact sorts of conditions that the injection system is intended to create.

With respect to the actual microcosm results, both aerobic and anaerobic samples were tested.

The anaerobic microcosms had no headspace with which the microcosms had to equilibrate. For the time period from 2 to 20 weeks, the microcosms with no air (no headspace) showed 13 percent VCM degradation, suggesting that conditions were not optimal for the anaerobic pathway.

The aerobic microcosms showed an initial rapid decline of VCM concentration. This was observed in both the treatment microcosms (Sets #2 to 6) and the poisoned controls which had head space (Set #7). However, this initial rapid decline in VCM concentration was not observed in the microcosm which did not have head space (Set #1). This pattern suggests that the initial rapid decrease in VCM could have been caused by non-biological oxidative degradation mechanisms, such as photo-oxidation or other oxidative catalytic reactions involving the presence of oxygen and VCM in the vapor phase. Similar observations describing the rapid degradation of VCM in the head space in contact with Teflon and oxygen have been made by other researchers (Dr. R. Lewis, HSA). The preparation of the microcosms involved the use of teflon-lined stoppers to prevent VCM adsorption on the septum. The microcosm preparation involved shaking the microcosm bottles vigorously to ensure good mixing. It was performed in the laboratory under fluorescent lighting, which could possibly have enhanced these abiotic (non-biological) reactions leading to the rapid initial loss in VCM concentration shown in the two-week results. Subsequently, the microcosms were incubated upside down (no contact between the Teflon liner and the headspace) and in the dark (no photo-oxidation). The subsequent rate of VCM concentration reduction in Sets #2 to #6 is slightly higher than degradation rates in the poisoned control, reflecting the typical rate of VCM aerobic biodegradation process even under optimized nutrient and oxygen conditions. The important result of the microcosm study is that degradation was initiated, and continued throughout the 20-week test period. Given the conditions that were created, it is expected that the degradation process would have continued well beyond the 20 weeks of the test and shown that biodegradation of VCM is a viable alternative for implementation at the Hooker/Ruco Site.

The microcosms amended with carbon sources all showed significant VCM degradation, indicating that organic carbon supplementation enhances VCM degradation. Two percent methane amendment produced the largest VCM reduction (42 percent), followed by sugar byproducts and 0.4 percent propane (40 and 38 percent reduction, respectively), while 2 percent propane was less effective (16 percent reduction). Methane was not significantly reduced in the headspace in the methane-amended microcosms, suggesting that the methane cometabolic pathway may not have been occurring or that its acclimation period was longer than 20 weeks. VCM degradation in the microcosms amended with carbon was more significant after week 4, suggesting that there may be an acclimation period before aerobic degradation is enhanced. It is anticipated that the enhanced biodegradation of VCM would have continued after week 20 until either the carbon, nutrient, or oxygen sources were exhausted.

Based on the results of the laboratory study, it is recommended that carbon supplementation be included in the final air injection design. The most effective forms of carbon sources for supplementation were low concentrations of sugar byproducts and propane. The two sources were very similar in their ability to increase VCM degradation; therefore, the choice of the source can be made based on the ease of field addition and the need for lateral (sugar byproducts) vs. vertical (propane) distribution. There will likely be a acclimation period before VCM degradation begins to accelerate.

While the rate of VCM degradation in the microcosms were not limited by nutrients, (because DAP was added to each microcosm), it is believed that nutrients may become a limiting factor for degradation of the VCM subplume as those nutrients already present in the formation are consumed by the biodegradation processes, especially when it is accelerated. Thus, it is recommended that supplementation with minor amounts of nutrients also be performed.

7.0 PROPOSED BIOSPARGE REMEDY

7.1 REMEDIAL ACTION OBJECTIVES

In accordance with the OU-3 ROD, the objectives of the RA are:

i) protect human health from exposure (via injections, inhalation, and dermal contact) to VCM, TCE, PCE, and tentatively identified compounds (TICs) in groundwater at concentrations in excess of New York State groundwater standards and Federal MCLs; and

ii) to restore the aquifer to meet the standards and MCLs in a timely manner.

To achieve these objectives, it is believed that the biosparge remedy need only reduce the chemical concentrations to a level (target concentration) at which adverse impacts to the Northrop RM (e.g., exceedance of Air Guide/air discharge criteria of 0.02 $\mu g/m^3$ at Northrop's GP-1/GP-3 treatment system) do not occur. Nonetheless, once the conditions conducive to aerobic VCM degradation have been established in the groundwater formation, the degradation process will continue unabated until the VCM is consumed or one of the key components necessary of degradation is exhausted (either oxygen, nutrients, or carbon source). Consequently, given sufficient time and contact, the VCM concentrations should reach Class GA groundwater criteria.

The planned remedial action will focus on developing an injection system that is capable of delivering the necessary components (oxygen, nutrients, and carbon sources) to create conditions conducive to aerobic degradation of VCM. The remedy will primarily concentrate on the central core areas of the VCM subplume where elevated concentrations have been found to exist. Once the concentrated VCM areas have been remediated, the peripheral low concentrations are likely susceptible to the naturally occurring conditions in the groundwater.

7.2 DESIGN BASIS

The proposed remedy consists of the injection of air at a rate sufficient to convert the generally anaerobic conditions in the area downgradient of the injection wells located within the VCM subplume to aerobic conditions and then supply sufficient oxygen to maintain aerobic conditions as biodegradation of the chemical compounds, principally VCM, occurs. The remedy will also take into consideration the requirement that the air flow rate selected will not result in the release of VOCs to the atmosphere. To accelerate the rate of biodegradation, low level concentrations of a carbon source and inorganic nutrients will also be injected. The distance from the most downgradient injection wells to the groundwater extraction wells must be large enough to allow sufficient contact time between the VCM and the injected air/carbon source/nutrients to achieve biodegradation of the VCM to the selected target concentration before reaching GP-3. Furthermore, the location needs to be far enough upgradient of well GP-3 to insure that any injected materials are no longer present in concentrations that could adversely affect the Northrop GP-1/GP-3 treatment system. It is recognized that VCM degradation will continue to occur as long as there is sufficient oxygen, carbon source, and nutrients available in the groundwater. Therefore, it is expected that VCM degradation to non-detect concentrations is possible as long as the conditions conducive to degradation are maintained.

The designed remedy will also include a monitoring program to:

i) evaluate the effectiveness of the remedy; and
ii) evaluate potential discharges from the vadose zone to the atmosphere.

The predesign injection testing results showed that the permeable materials (e.g., sand) of the formation readily accepted air at a high flow rate with the application of pressure only a few pounds per square inch (psi) greater than that needed to depress the water in the well to the top of the well screen. Thus, the formation should have more than enough capacity to accept the air flow rates needed for the biosparge remedy. The groundwater analytical results showed that the portion of the VCM subplume with higher concentrations is anaerobic and that dissolved methane concentrations are elevated showing that anaerobic degradation is occurring. However, the VCM subplume is migrating at a rate quicker than anaerobic degradation can adequately address the VCM to achieve the target concentration before it reaches well GP-3. VCM degrades much more quickly under aerobic conditions. Therefore, the anaerobic conditions must be converted to aerobic conditions.

Based on the discussion presented in Section 5.10, nitrogen bridging and the generation of large air pockets did not appear to occur. Thus, groundwater flow diversion is not believed to be a significant issue and the injection of air is the preferred media for the delivery of oxygen to the formation. Should performance monitoring indicate that air injection is not effective enough, consideration of an alternate delivery media (e.g., oxygen, oxygen release compound (ORC)) may be considered. If an ORC is determined to be needed, one will be selected that will not adversely impact the formation or Northrop's RM.

7.3 PROPOSED INJECTION REMEDY

7.3.1 INJECTION WELL LAYOUT

Prior evaluations showed that an exceedance of the Air Guide 1 criteria for VCM could occur at the Northrop GP-1/GP-3 treatment system if the VCM concentrations in the influent to the system was on the order of 45 μg/L for a groundwater pumping rate of approximately 500 gpm (assuming no retention on the existing carbon treatment units). Thus, to ensure that the Air Guide 1 criteria is not exceeded, the areal and vertical extent of the remedy should address the VCM subplume near the leading edge where the VCM concentrations are still on the order of 20 to 40 μg/L in order to maintain the groundwater at these concentrations as the maximum allowable objective concentration.

A number of remedial injection well layouts were evaluated in order to determine which would be the most appropriate for the VCM subplume. The layouts included injection well "fence(s)" or line(s) of injection wells, individual injection wells installed throughout the VCM subplume, and combinations of injection fences and individual wells. Based upon the evaluation, it was determined that the use of multiple injection well fences provides the best solution for the VCM subplume. Each injection well fence will inject the air, carbon source, and nutrients into the concentrated VCM intervals in sufficient quantity to insure that the desirable aerobic degradation conditions are created. The duration of aerobic exposure is then the major component that allows the degradation to occur. As long as each necessary component is present in sufficient quantity, the aerobic degradation process will continue and will eventually degrade all of the VCM present. By using the injection fence method, the treated water from the upgradient injection fence will eventually migrate to the adjacent downgradient injection fence which will then allow the downgradient injection fence to cease operation.

The initial plan for the injection well layout will consist of three fences of injection wells as shown on Figure 7.1. The three lines will be spaced approximately 700 to 1100 feet apart (equivalent to approximately 5 to 7 years of groundwater travel time). This spacing is a reasonable compromise between the expenditure of capital costs to install an injection fence and the longer term Operation and Maintenance (O&M) costs that would be incurred on an ongoing basis. The most southerly fence will be located near the southerly extent of the VCM subplume where the concentrations generally range from 20 to 40 μg/L, to protect the GP-1/GP-3 treatment system. As shown on Figure 7.1, this fence of wells is adjacent to Northrop Plant 5. Only the most southerly injection fence is planned to be initially installed. It will be used as a full scale pilot system before the other injection well fences are installed. The installation of the other two injection well fences is expected to result in a substantial reduction in the overall length of time that the remedy must operate.

7.3.2 INJECTION WELL SPACING

7.3.2.1 HORIZONTAL

The injection wells along each fenceline will be initially installed at a spacing of 100 feet. The wells will be connected by an air supply forcemain. Should it be determined, based on performance monitoring, that a closer spacing is needed at select locations, additional wells can be installed and tied into the forcemain.

It is noted that as the groundwater flows towards GP-3, it is anticipated that the flow paths will merge together, thereby creating better contact of the injected materials with the VCM impacted groundwater that flowed between the effective radius of the individual injection wells. This is shown conceptually on Figure 4.7. In addition, the injected materials will disperse both horizontally and vertically as southerly migration continues. This natural distribution of injected materials with the converging VCM impacted groundwater will make the remedy more effective as the groundwater continues to flow south.

7.3.2.2 VERTICAL

The injection points need to be strategically placed so that either gases or liquids can be injected into or near the high concentration portion of the VCM subplume. The proposed method of air injection relies on the pressure gradient created by the air injection to distribute oxygen vertically above the point of injection. It is expected that it will be most effective to inject air in between the fine-grained lenses that define the high VCM concentration subplume and also into the interval beneath the underlying fine-grained unit. Thus, multiple injection points will be used at each individual well that make up the injection fence. Within the VCM subplume, the gases will be injected into the bottom of the defined permeable interval (the permeable zone containing elevated VCM concentrations that is sandwiched between two low permeability layers). Injecting into the bottom of the permeable zone will allow the gases to rise and disperse as much as possible throughout the entire permeable interval. The reason for also injecting gas below the fine-grained lenses is that by injecting air (or other gases) below the fine-grained lenses defining the high concentration plume, better areal distribution of the air will result and the air will find its own path around the lenses and bubble up through the high concentration portion of the VCM subplume. Bubbling up of the air will occur in a non-predictable pathway as it will be dictated by the slope of the underside of the discontinuous and randomly located clay lenses. Nonetheless, with the overlap of gaseous injections from neighboring injection wells along the fence, a continuous upward cascading curtain of gases is expected to develop which will contact the desired permeable unit.

For liquids, it is likely to be more effective injecting directly into the high concentration plumes. Mixing will be assisted by the air injection process and also more significantly by the natural flow/dispersion forces that exist in nature.

When injecting directly into the high concentration plume, it is recommended that the injections occur via screens set just above the bottom clay layer. Gases will bubble up through the high concentration plume (and be trapped under the overlying clay layer) and liquids will disperse more around the bottom of the flow interval (the VCM will have to pass through the injected liquids present in the bottom layer as it continues its downward migration to the lower depths of the screened intervals of GP-3/GP-1).

A schematic of the proposed vertical layout is shown on Figure 7.2. Each injection well is to be constructed of 1-inch diameter black steel pipe with one 5-foot long stainless-steel screen. Multiple wells may be installed in one borehole with a seal installed between each screened interval. Typical injection well details are shown on Figure 7.3.

The heterogeneity and the presence of discontinuous lenses of fine-grained soils in the formation necessitates the use of multiple injection points with depth. The actual depths of the injection points will be selected based on:

i) prior knowledge of the expected depth of the VCM subplume;

ii) the geologic conditions encountered; and

iii) PID readings.

Furthermore, to confirm that the screens are being installed in the correct intervals, groundwater samples will be collected during the installation process from every third well location in the fence alignment and analyzed for VOCs. The samples will be collected using either the Hydropunch or Isoflow method. Sample collection will start at a depth approximately 50 feet above the elevation that the top of the VCM subplume is anticipated and will continue at approximately 50-foot intervals to a depth approximately 50 feet below the anticipated bottom of the VCM subplume.

7.3.3 INJECTION SUPPLEMENTS

The results of the groundwater sampling and microcosm testing have identified that there may be components necessary for biodegradation, other than just oxygen, that may prove to be rate limiting. The first of these is a suitable carbon source. Although some carbon source is present in the groundwater, monitoring throughout the area identified that the groundwater carbon concentration (as measured by TOC) was very low and in many cases, non-detect at 1 mg/L. Thus, the low carbon content in the groundwater may become a rate limiting factor for the aerobic degradation of the VCM subplume. In addition, microcosm studies showed that aerobic biodegradation was enhanced considerably by supplementation with carbon sources. This shows that there may be a shortage of carbon source in the groundwater or at least that the addition of a carbon source is beneficial to VCM degradation. Thus, to accelerate the aerobic biodegradation of VCM, low level concentrations of a carbon source will be injected. Based on the microcosm results, the preferred carbon sources are sugar byproducts or propane. The field injection tests proved that injection of either carbon source is technically achievable.

The groundwater analytical results also suggest that nitrogen concentrations may be sufficient to support biodegradation but that phosphorus concentrations may be insufficient. Although no microcosms were tested without nutrient supplementation, it is believed prudent to ensure that sufficient nutrients are available for biodegradation to occur, especially once it becomes accelerated. This will insure that the nutrients do not become the rate limiting factor in the VCM degradation. The amount of nitrogen to be added will be limited to comply with New York State Class GA (potable water) standards of 10 mg/L for nitrate and nitrite expressed as nitrogen. The preferred nutrient source is DAP based on its ease of handling and injection.

7.3.4 OXYGEN MASS LOADING

The proposed air injection system is comprised of three injection well fences with 9, 12, and 13 injection locations for the southern, middle, and northern fences, respectively. Up to three injection wells will be installed at each injection location. Air injection will initially be performed for 40 hours (in ten-hour intervals cycling between the shallow and deep injection points). Thereafter, air injection will be initially performed at least twice monthly at the southern line (see Section 7.3.7 for details on the operating philosophy). It is believed that periodic stop/start of the injections will result in better distribution of the injected materials into the formation since a slightly different flow path will be created by each injection, thereby spreading through more of the formation. Continuous injection is not needed since the groundwater flows only at a rate of 0.4 ft/day (12 feet/month) and sufficient air can be injected in a short time period to saturate such a given volume of water (see Section 5.9). The semi-monthly injection will be evaluated during the early operations period and adjusted as necessary to ensure that the air distribution is sufficient to achieve the targeted VCM reductions. Air will be pulse injected into each well on a rotating basis cycling between the deeper and shallower injection points. Pursuant to the total oxygen demand calculated in Section 5.9 (details are presented in Appendix F), the design air flow rate for each well will be approximately 100 scfm for 4 hours per month following the initial oxygen saturation injection which is expected to take on the order of 40 hours. At this flow rate, approximately 9800 pounds of oxygen, at an efficiency of 10 percent, is anticipated to be delivered per month along the southerly injection fence. Once the southern injection fence has been installed and the operation and maintenance factors have been understood and perfected to the extent practical, construction of the middle injection fence will be initiated. The intent being that the southern injection fence will be used as a full scale pilot test that allows OxyChem to learn and improve upon the design features of the system. Thereafter, the improvements can be adopted into the middle injection fences and then the northern injection fence (which will follow the installation and initial O&M of the middle injection fence).

7.3.5 POTENTIAL VCM AIR STRIPPING

It is possible that the air injection will cause some of the VCM to be stripped and carried into the overlying saturated layers of the formation and possibly into the vadose zone. Given the thickness of the overlying saturated zone, which is on the order of 400, 300, and 200 feet for the southerly, middle, and northerly injection fences and of the vadose zone (typically on the order of 60 feet) it is anticipated that there will be no adverse effect on the surface use of the remedial area. The reasons for this belief are as follows:

i) the degradation of VCM is expected to continue as the VCM migrates upwards through the overlying saturated formation;

ii) the conditions in the overlying saturated formation are generally already aerobic and are expected to have the other necessary components (i.e., nutrients, carbon, and microbial population) which will support the aerobic degradation process;

iii) the degradation of VCM is expected to continue even if the VCM reaches the vadose zone since the moist conditions in the vadose zone are also amenable to the VCM degradation process;

iv) the vadose zone is on the order of 60 feet thick and provides a substantial retention time before stripped gases, if any, reach the surface; and

v) a large majroity of the surface use in the remedial area is commercial and does not include basements where gases may be more likely to enter.

A vadose zone monitoring program will be implemented, as described in Section 7.3.7, to confirm that discharges of VOCs to the atmosphere do not occur. Methods for controlling the amount of stripping that may occur include reducing the air injection rate and shortening the injection duration but increasing the frequency. These methods will be carefully evaluated during operation of the full scale southern injection fence should the need arise.

7.3.6 AIR DISTRIBUTION SYSTEM

The primary component of the biodegradation remedy is the air distribution system. Air distribution to the injection wells will consist of the following sub-systems:

i) air compressor;

ii) sparge control panel; and

iii) air distribution forcemains and control and power cables to the well points.

The air compressor and sparge control panel will be housed in a permanent structure. The structure will also house a tank for liquid amendment mixing and storage, a work station for the operator, a washroom, and an equipment cleaning station. The structure will be a prefabricated, insulated, and weathertight modular control building, with approximately 1000 square feet of space (e.g., 30 x 35 ft). The building will be placed on a compacted gravel base for support and will have a man-door for access and HVAC for heating and cooling.

The air from the compressor will be directly piped from the sparge control panel to each individual injection well head. The air supply forcemain will consist of a 3-inch diameter black steel pipe that will be connected to each individual injection point via a 1-inch diameter black steel pipe equipped with a solenoid valve. Any gas supplements will be injected via the same air lines. A 2-inch diameter black steel pipe will also be installed to supply any liquid supplements. The control and power cables will be housed in separate 2 or 3-inch diameter shielded conduits. Separate conduits are needed so that the power in the power cables do not create false signals in the control cables. The forcemains, conduits, and cables will be of sufficient capacity to allow for the installation of injection wells at 50-foot spacings along each fenceline, should the need for additional wells be determined.

The air flow to the injection wells will be controlled from one or more sparge panels contained in the permanent structure. The panel will control the flow rate and pressure to each individual injection point. The control instruments for each well will consist of flow and pressure indicators, flow switch, flow and pressure regulators, and indicator lights. Injection pressures will be maintained below the formation rupture pressure. Furthermore, to reduce silting of the well, injections will be applied and relaxed gradually over several minutes. Each panel will contain a Programmable Logic Controller (PLC) to control its operation. The PLC will allow interfacing with an operator from a personal computer (PC) running Allen-Bradley's RSView HMI software package (or equivalent). RSView is a graphical operator interface package that will operate under the Windows 2000 software operating system.

The electrical design will provide for the project electrical loads and conform to the latest requirements of the National Electrical Code and the National Electrical Safety Code.

The operator will start the injections from the PC and injection will continue until stopped from the PC or the controls measure an alarm condition (e.g., pressure too high) which will shut the system off. The PC will also allow the operator to be able to change the timing of the sparging sequence. The PC will be used to display injection header pressure, flow rates, temperature, sparging sequence status, and alarms. It will be connected to a phone line to allow for remote access of the control system.

A security system monitored 24 hours a day will be provided. The system will monitor power to the control room, fire/smoke detectors, entry detection sensors, and process alarms. In the event of an alarm or indication of a failure of the security system (security breach), the monitoring company will contact the appropriate personnel to take action.

7.3.7 OPERATION AND MAINTENANCE

7.3.7.1 LICENSING REQUIREMENTS

There are no known licensing requirements associated with the biosparge remedy.

7.3.7.2 OPERATION AND MAINTENANCE

Operator presence is only required on a periodic basis once the pilot injection system is in full-scale operation. The system is designed to operate unsupervised, with the PLC monitoring key parameters for proper operation. Should an operating parameter be out of range, the system will attempt to adjust for it or if necessary shut down safely, while notifying the operator of the shut down. The system cannot be started up remotely following a major alarm. The operator must go to the facility, evaluate the problem, and make corrections, prior to restarting the system. The operator will receive a summary of system operation from the PC HMI hooked up to the PLC. Information related to instrumentation readouts (i.e., process equipment and piping) and any alarms will be provided on the HMI. The operator will check the system's operation, log data, and sample as necessary. The PLC will be designed to assist in the accumulation, storage, and trending of operating data. The operator will also be responsible for the maintenance of the building and equipment.

The health and safety procedures for the operation and maintenance of the pilot system will be in accordance with those presented in the report entitled "Health and Safety Standard Operating Procedures for the Biosparging Predesign Activities, Operable Unit-3" dated April 2002.

7.3.7.3 PILOT SYSTEM OPERATING PHILOSOPHY

Air, nutrients, and a carbon source will be pulse-injected into the elevated concentration intervals of the VCM subplume where the injected materials will dissolve into groundwater and migrate downgradient from the injection wells via advection thus creating an aerobic treatment zone for enhanced biological degradation of VCM.

OPERATIONAL GOALS

The operating goals of the system are as follows:

i) To create an aerobic treatment zone at the southern boundary of the zone of elevated VCM concentration in the VCM subplume to aerobically treat VCM present in groundwater to the target concentration and below;

ii) To maintain a minimum dissolved oxygen concentration in the range of 2 to 5 mg/L in groundwater throughout the aerobic treatment zone;

iii) To maximize the volume within the aerobic treatment zone over which dissolved metals may precipitate to minimize clogging of the aquifer in one localized area, which could force groundwater to move around the treatment zone. It is expected that if groundwater is forced to move around a localized area, the injected air will also be diverted thereby enhancing the distribution of the air; and

iv) To minimize the formation of air/nitrogen gas pockets by optimizing the dissolution of oxygen gas into the groundwater.

7.3.7.4 OPERATIONAL SUMMARY

The proposed injection system is comprised of three fencelines of 9, 12, and 13 injection locations in the southern, middle, and northern area of the VCM subplume. Two or three injection wells will be installed at each injection location. Injection will be initially semi-monthly for the pilot system.

Air, nutrients, and a carbon source will be pulse injected cycling between the shallow and deep injection points. The design air flow rate for each well will be approximately 100 scfm. To satisfy the initial TOD, which is estimated to require 40 hours of injection at 100 scfm per injection point, the injections will cycle between the shallow and deep injection points at ten-hour intervals for four cycles. Thereafter, the continuing TOD as groundwater migrates past the injection points will be satisfied by cycling the injection between the shallow and deep injection points for four hours each, twice per month. Based on the TOD estimated in Section 9.5, injecting twice per month will supply twice the estimated TOD, thereby providing a safety factor to ensure oxygen is not a limiting condition to biological degradation of VCM.

7.3.8 PERFORMANCE MONITORING

Performance monitoring will include groundwater and vadose zone monitoring and process monitoring.

7.3.8.1 GROUNDWATER MONITORING

The proposed location of the groundwater monitoring wells are shown on Figure 7.1. The majority of the monitoring points are located at a distance of approximately 100 feet downgradient of the injection wells which is equivalent to approximately 8 months travel time. Thus, these wells will be monitored semi-annually. As shown on Figure 7.1, this layout results in 4, 6, and 6 monitoring locations for the southern, middle, and northern injection fence lines, respectively. The monitoring well nests will be installed at approximately the midpoint between every other pair of injection wells. The mid-point location was selected to monitor the groundwater expected to be least impacted by the injected materials. The well nests will typically consist of two wells in the groundwater and one vadose zone well. The screened intervals of the groundwater monitoring wells will be set at:

i) an elevation equal to the mid point between the injection intervals of adjacent injection wells; and
ii) in the next overlying sand unit above the adjacent injection wells.

The groundwater monitoring well screens will be 10 feet in length.

Furthermore, to provide an early indication of the impact of the biosparging system, groundwater monitoring wells will also be installed at two locations approximately 20 feet (2± months travel time) downgradient of each of the injection fences (see Figure 7.1). These wells will be monitored quarterly.

Existing wells, if located in the appropriate location (e.g., MW-62I and MW-62D for the northern fence), will be used.

Sample collection and analyses will be in accordance with the procedures presented in the OU-3 QAPP. All groundwater sampling will be performed using the LFP procedures included in Appendix A of the OU-3 QAPP.

Initially, the groundwater will be monitored for VOCs, TOC, N, P, and the NA parameters, DO, ORP, pH, temperature, and conductivity. In addition, heterotrophic microorganisms will be analyzed annually for the first 3 years.

7.3.8.2 VADOSE ZONE MONITORING

Vadose zone wells will be installed in the same locations and monitored at the same frequency as the groundwater monitoring wells.

The vadose zone wells will be installed at a depth of approximately 8 feet bgs. This depth was selected to be representative of a basement depth. The vadose zone wells will be constructed of 1/2-inch diameter tubing with screens 2 feet in length. The sandpack will extend 2 feet above the screen. The annulus above the sandpack will be sealed with cement grout containing 6 percent bentonite to prevent short-circuiting with the atmosphere. The well head will be airtight and include a stop cock that will allow direct connection of a gas sample monitor and/or container.

The vadose zone gases will be monitored using a PID. If an elevated PID reading is obtained, a gas sample will be collected for laboratory analysis of VOCs. Sample collection and analyses will be performed in accordance with the procedures presented in the OU-3 QAPP.

7.3.8.3 PROCESS MONITORING

Injection header pressure and temperature as well as injection on/off cycle times and quantities of materials injected will be monitored and stored by the HMI software on the PC. The data will be used to help optimize the timing, locations, and rate of material injection. The data will be used to assess the rate of VCM biodegradation, injection material distribution and migration, and monitor groundwater flow pathways.

In addition, the air immediately above the ground surface at each injection well will be periodically monitored using a PID to determine if short-circuiting up the well annulus is occurring.

8.0 FULL SCALE SYSTEM

The design basis and scope of the pilot system (i.e., southerly fence line of injection wells) were presented in Section 7.0. The information obtained during the first year of operation and monitoring of the pilot system will be used to optimize the operation of the pilot system and to design and implement the remaining components of the full scale system (multiple lines of injection wells).

The evaluations to be performed will consist of:

i) refinement of the TOD, including that for the principal dissolved constituents (i.e., VCM and methane);
ii) trending of VCM biodegradation;
iii) dissolved O_2 migration analyses; and
iv) nutrient and carbon source migration analyses.

9.0 SCHEDULE

The schedule for the design, construction, and start-up of the biosparge system is presented on Figure 9.1. The first step in this process is the installation of two additional monitoring wells in December 2002. The wells are to be located between wells MW-66 and MW-58/59 at the locations shown on Figure 7.2, to refine the southerly extent of the VCM subplume with elevated concentrations. The data from these wells will be used to assist in the design of the pilot system during the winter of 2002/2003. Construction of the pilot system is scheduled to be performed in the spring of 2003 with start-up in late spring/early summer of 2003. Thereafter, it is planned to operate and monitor the pilot system. The information obtained from the first year monitoring will be used to:

i) refine the operation of the pilot system; and

ii) design the remaining components of the full scale system.

The schedule may be impacted due to delays in securing property access or construction permits.

10.0 REFERENCES

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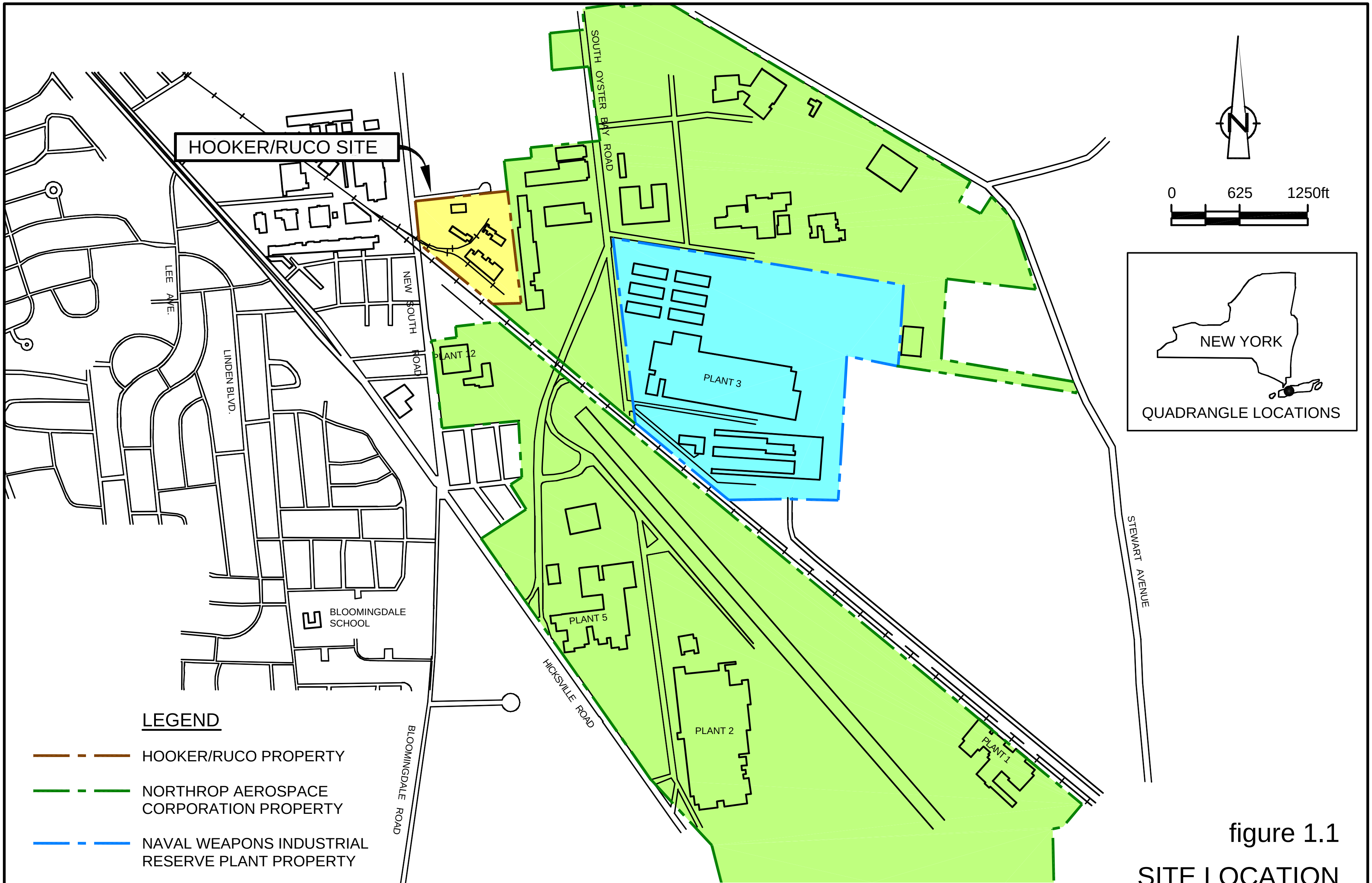


figure 1.1

SITE LOCATION

OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT

Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA001 NOV 07/2002

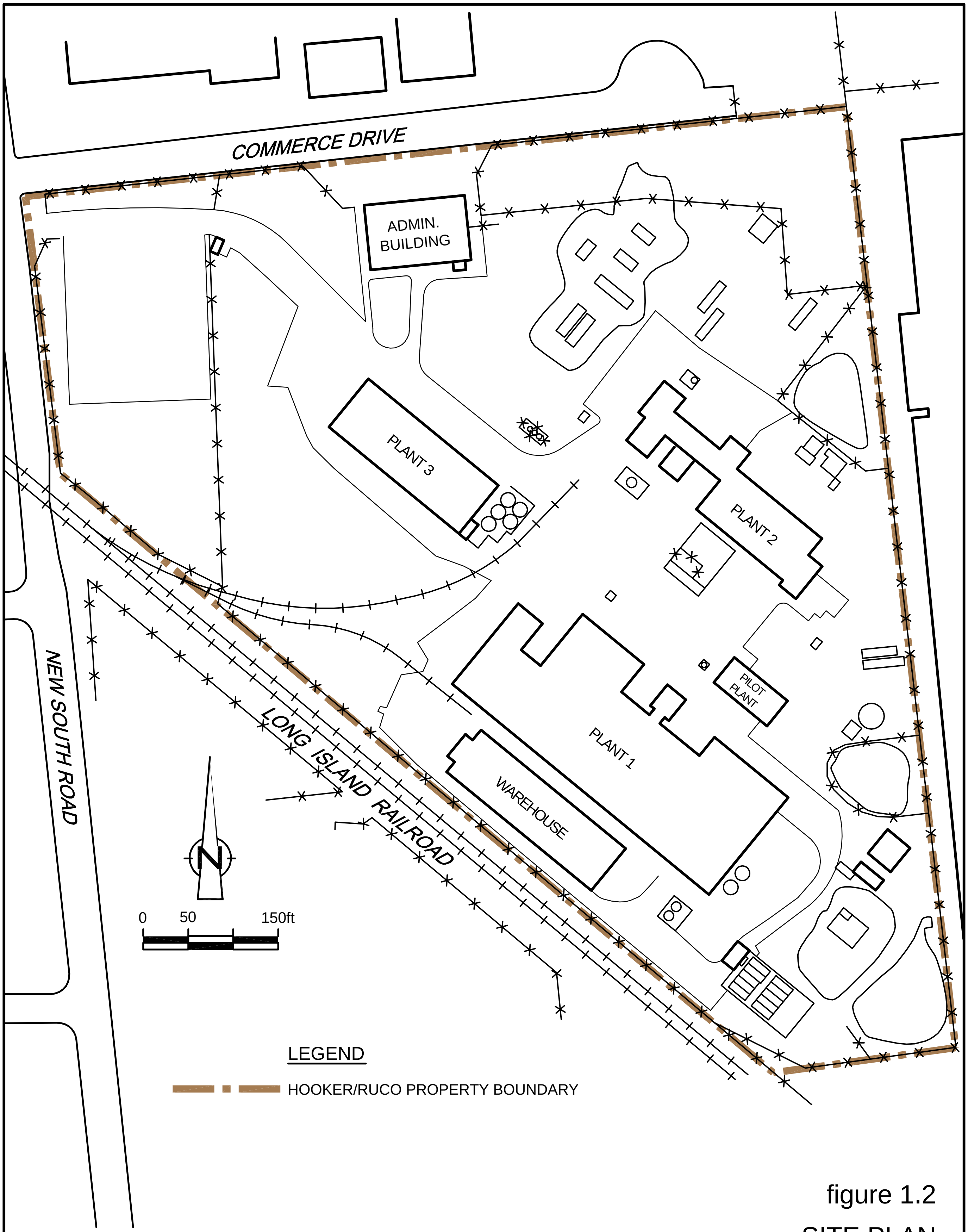


figure 1.2

SITE PLAN
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA002 NOV 07/2002

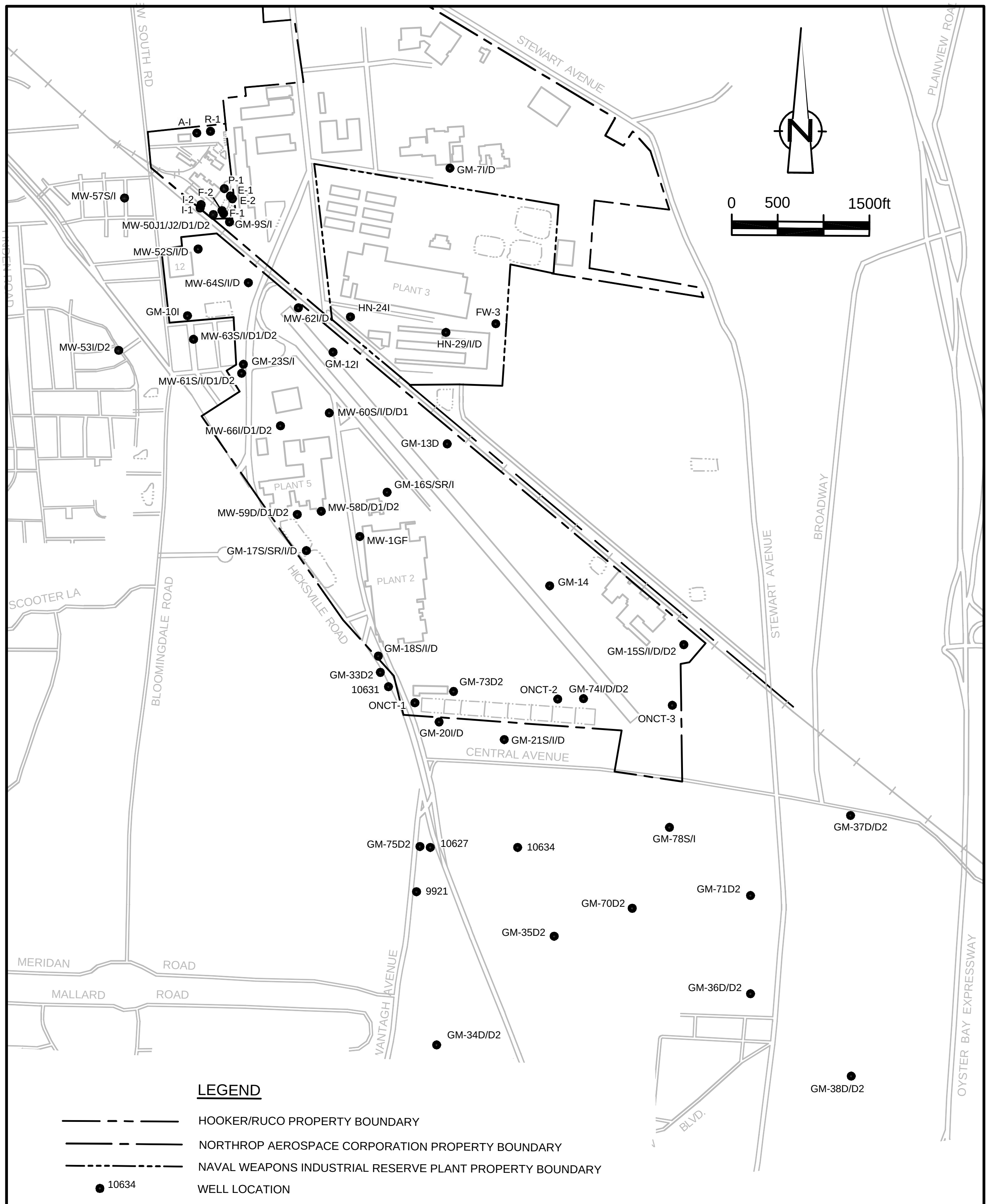


figure 2.1

WELLS WITH NATURAL ATTENUATION RESULTS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

CRA

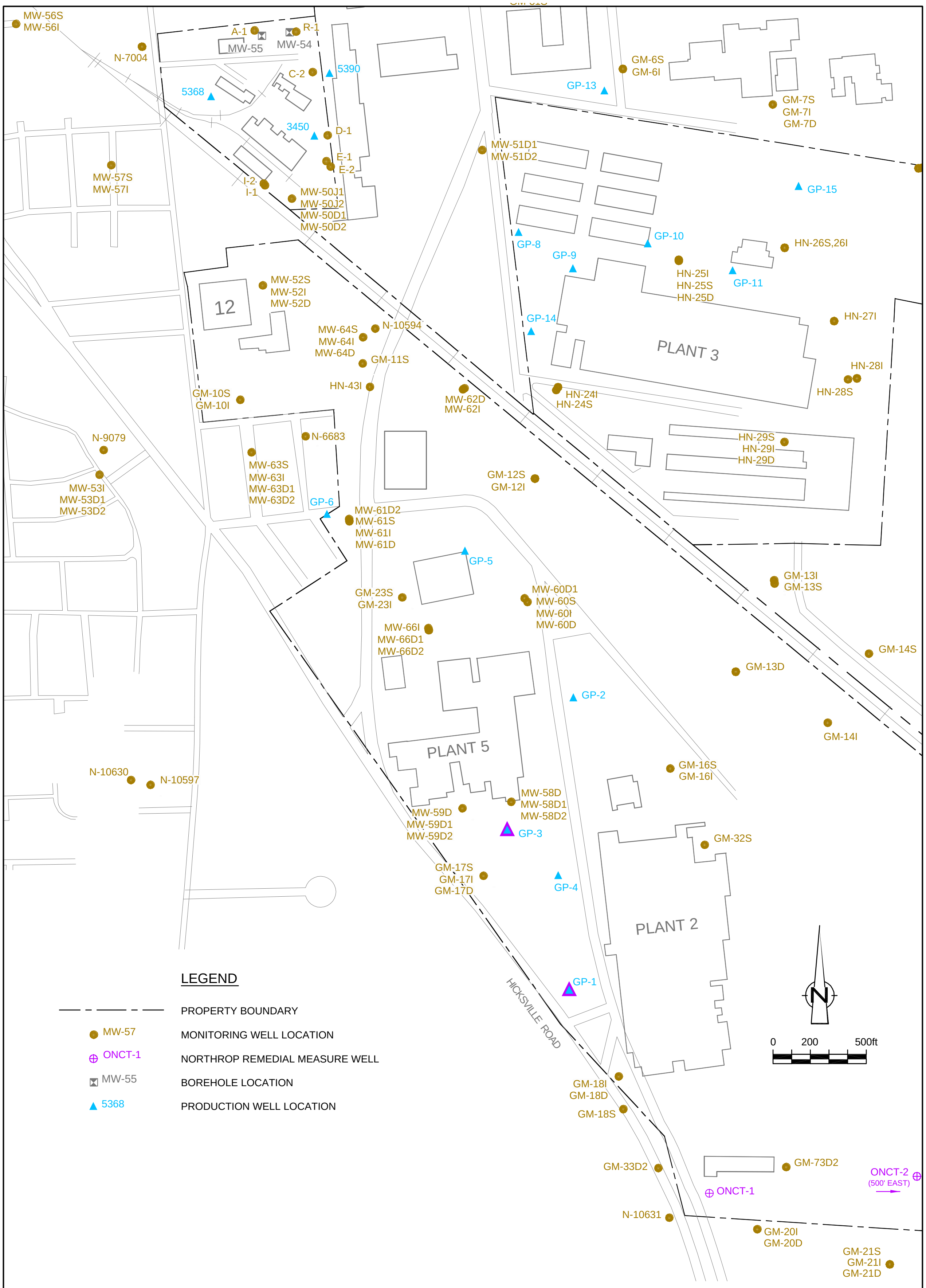
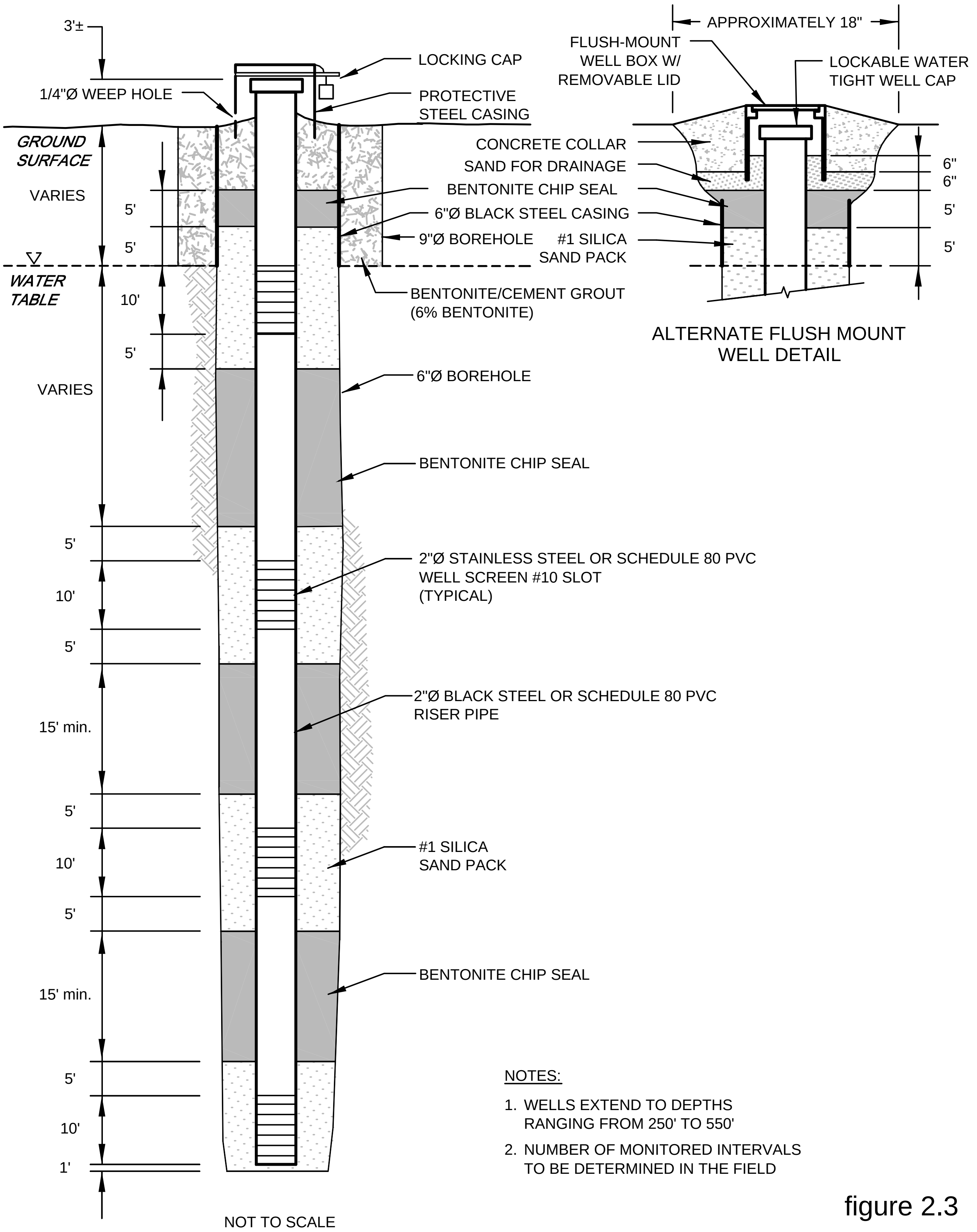


figure 2.2

BOREHOLE AND WELL LOCATIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

CRA

06883-00(034)GN-WA003 NOV 07/2002



NOTES:

1. WELLS EXTEND TO DEPTHS RANGING FROM 250' TO 550'
2. NUMBER OF MONITORED INTERVALS TO BE DETERMINED IN THE FIELD

figure 2.3

TYPICAL MONITORING WELL DETAILS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

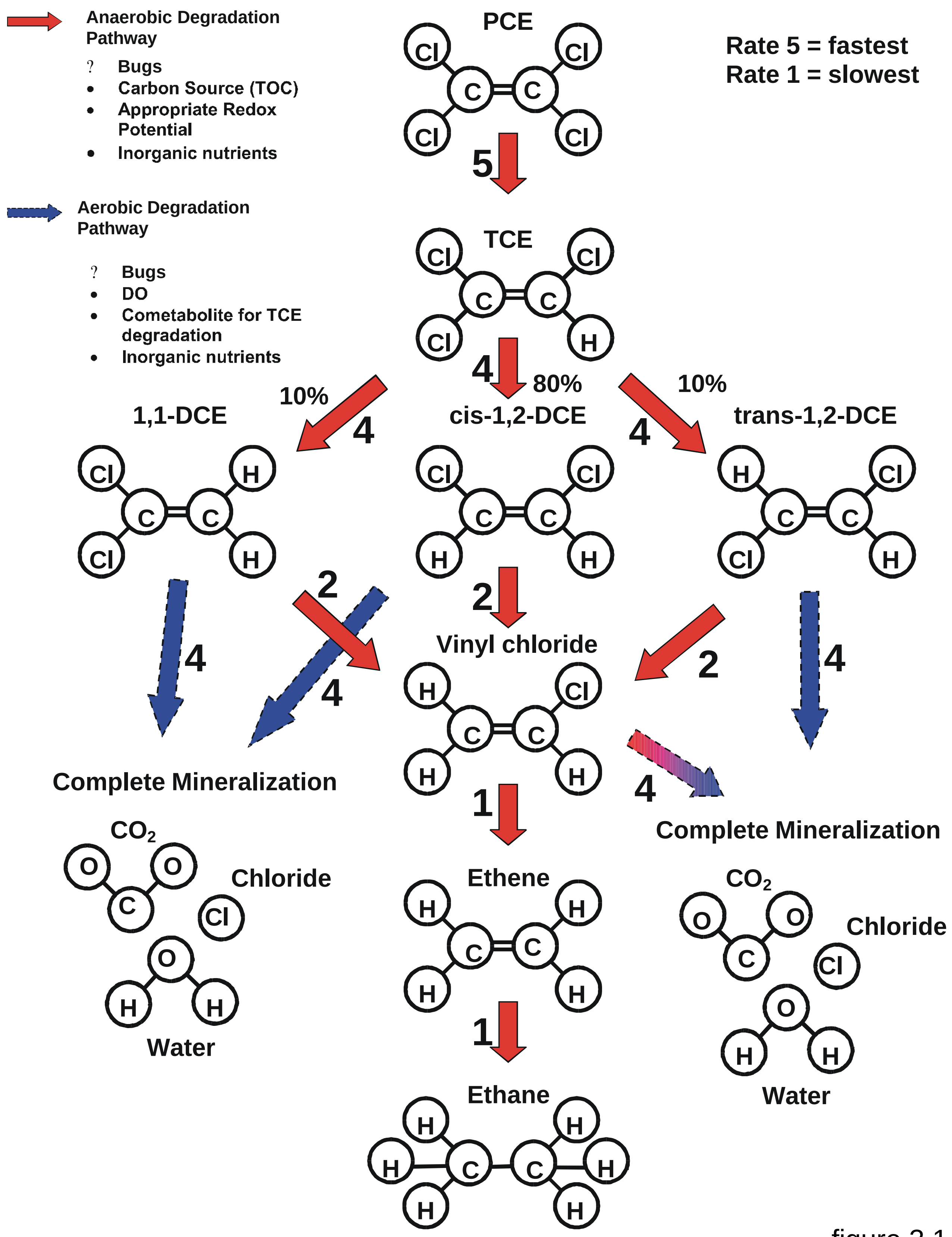


figure 3.1

DEGRADATION PATHWAYS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

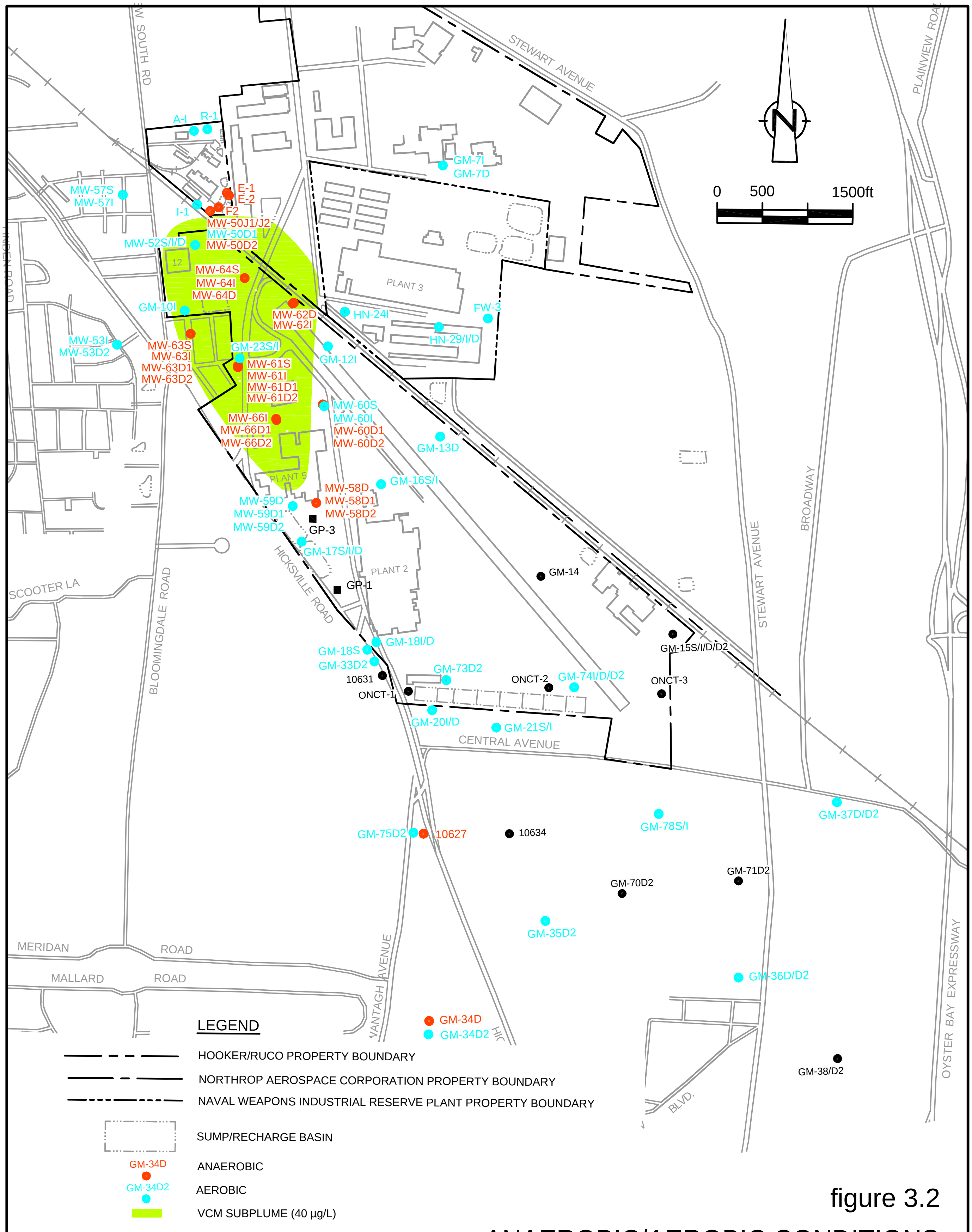
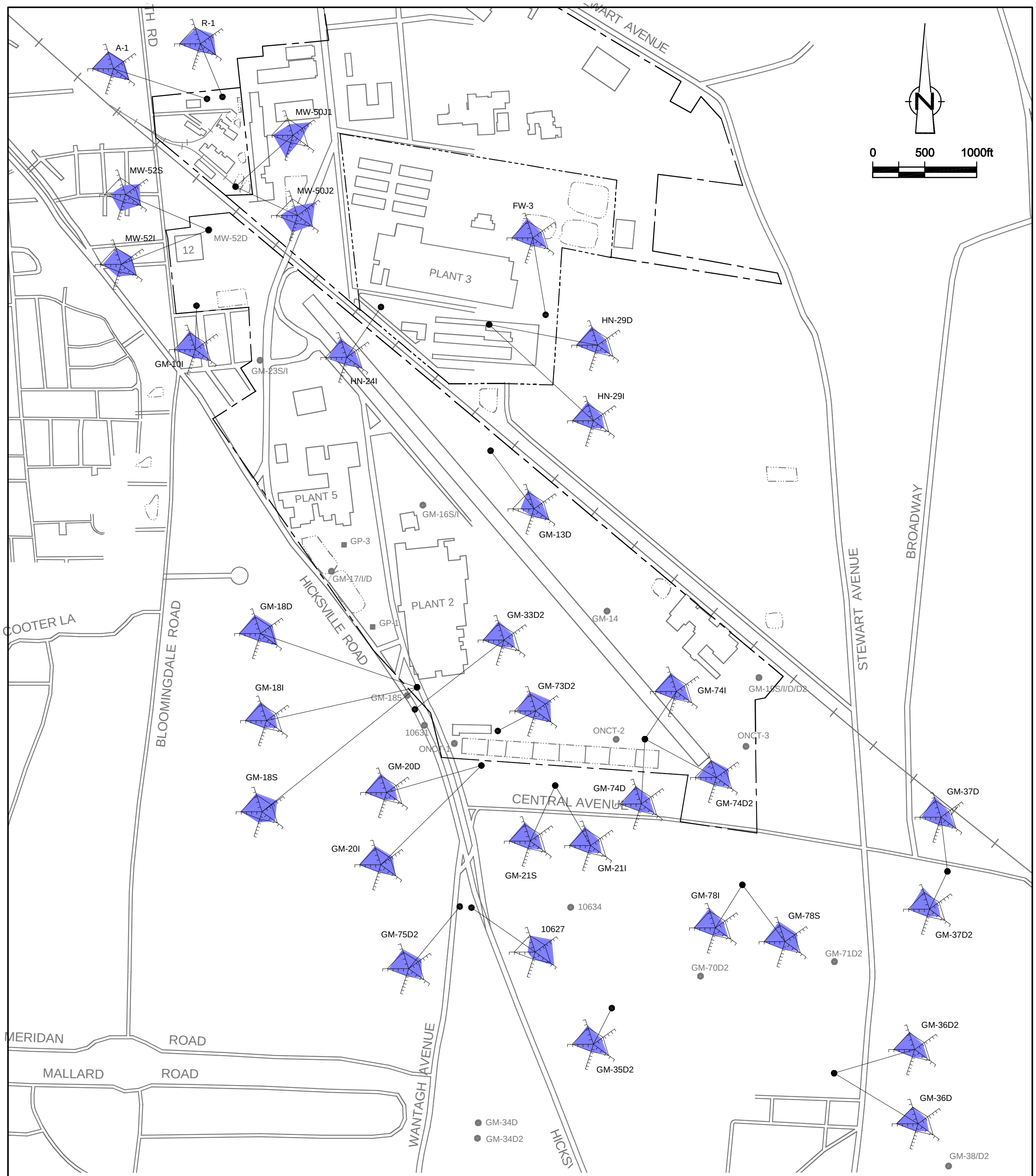
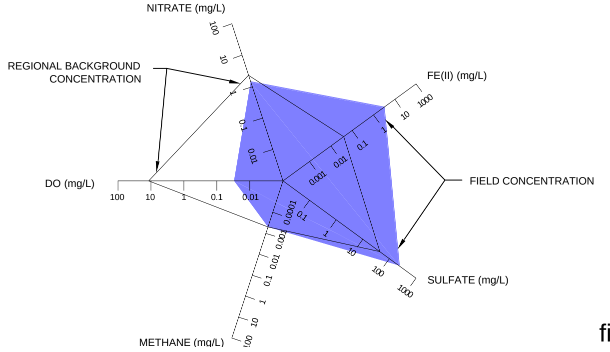


figure 3.2

ANAEROBIC/AEROBIC CONDITIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York





LEGEND

- HOOKER/RUCO PROPERTY BOUNDARY
- NORTHROP AEROSPACE CORPORATION PROPERTY BOUNDARY
- NAVAL WEAPONS INDUSTRIAL RESERVE PLANT PROPERTY BOUNDARY
- SUMP/RECHARGE BASIN
- ■ GP-16 NORTHROP PRODUCTION WELL LOCATION
- ● MW DATA NOT AVAILABLE FOR REDOX DIAGRAM
- ● MW MONITORING WELL LOCATION

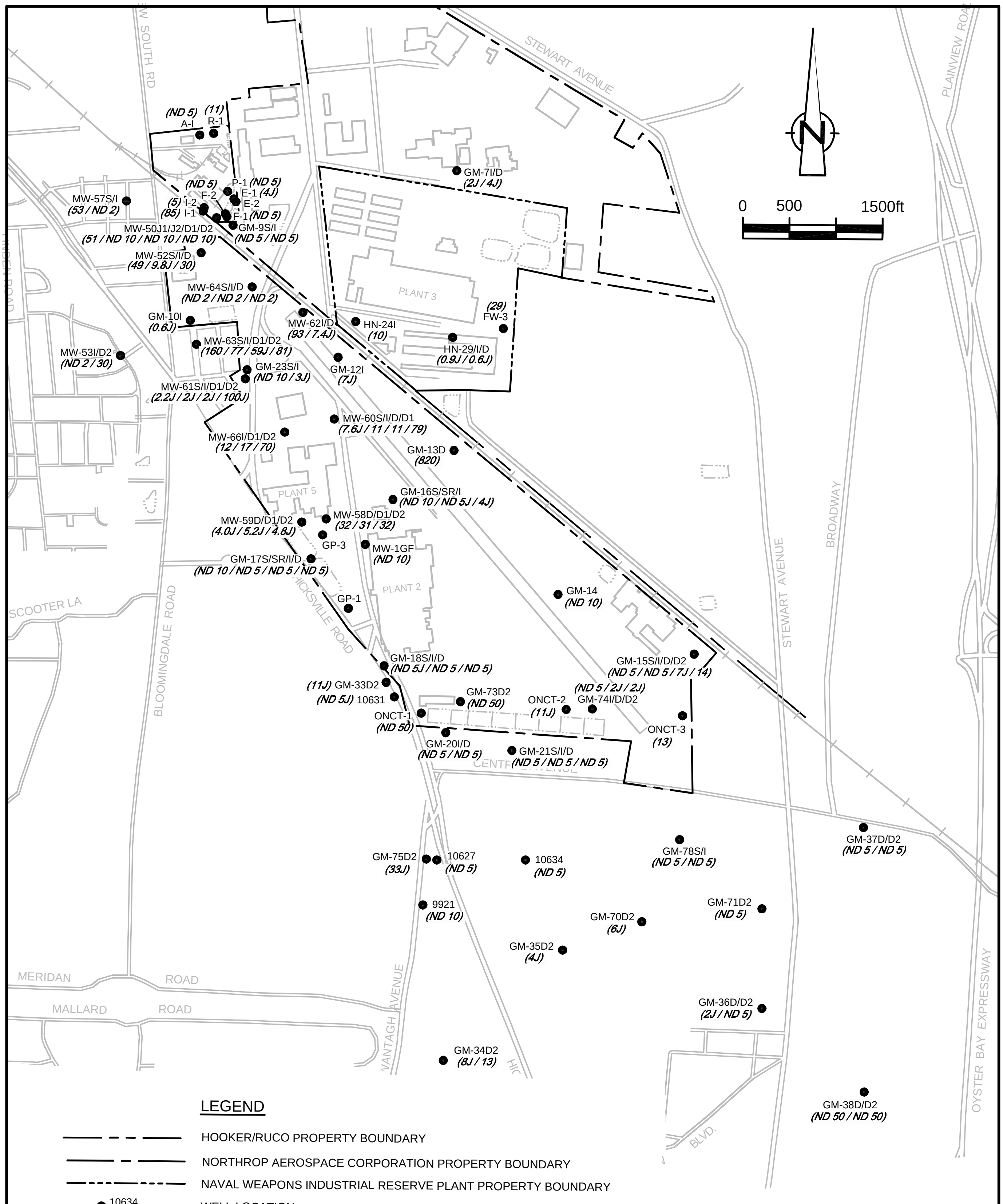
REGIONAL BACKGROUND CONCENTRATIONS

DISSOLVED OXYGEN (mg/L) = 11.82
NITRATE (mg/L) = 2.3
IRON (II) (mg/L) = 0.06
SULFATE (mg/L) = 43.1
METHANE (mg/L) = 0.0005

figure 3.3

REDOX INDICATOR RADIAL DIAGRAM
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hicksville, New York

06883-00(034)GN-WA032 NOV 07/2002



LEGEND

HOOKER/RUCO PROPERTY BOUNDARY
NORTHROP AEROSPACE CORPORATION PROPERTY BOUNDARY
NAVAL WEAPONS INDUSTRIAL RESERVE PLANT PROPERTY BOUNDARY
● 10634 WELL LOCATION
(85) PCE CONCENTRATION (µg/L)

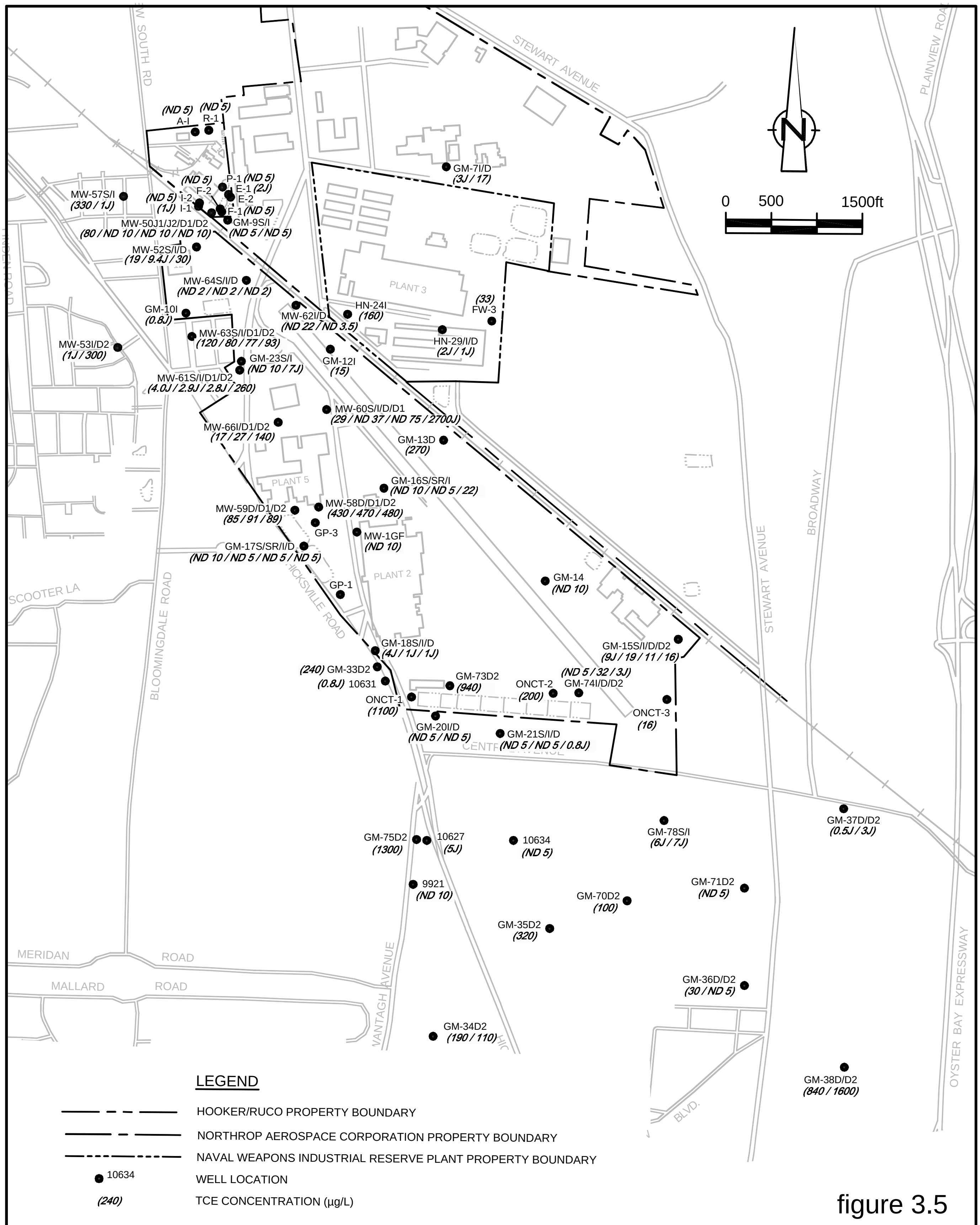
NOTE: MOST RECENT RESULTS SHOWN

figure 3.4

PCE PRESENCE IN BETHPAGE PLUMES
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

CRA

06883-00(034)GN-WA035 NOV 07/2002



NOTE: MOST RECENT RESULTS SHOWN

figure 3.5

TCE PRESENCE IN BETHPAGE PLUMES
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

CRA

06883-00(034)GN-WA036 NOV 07/2002

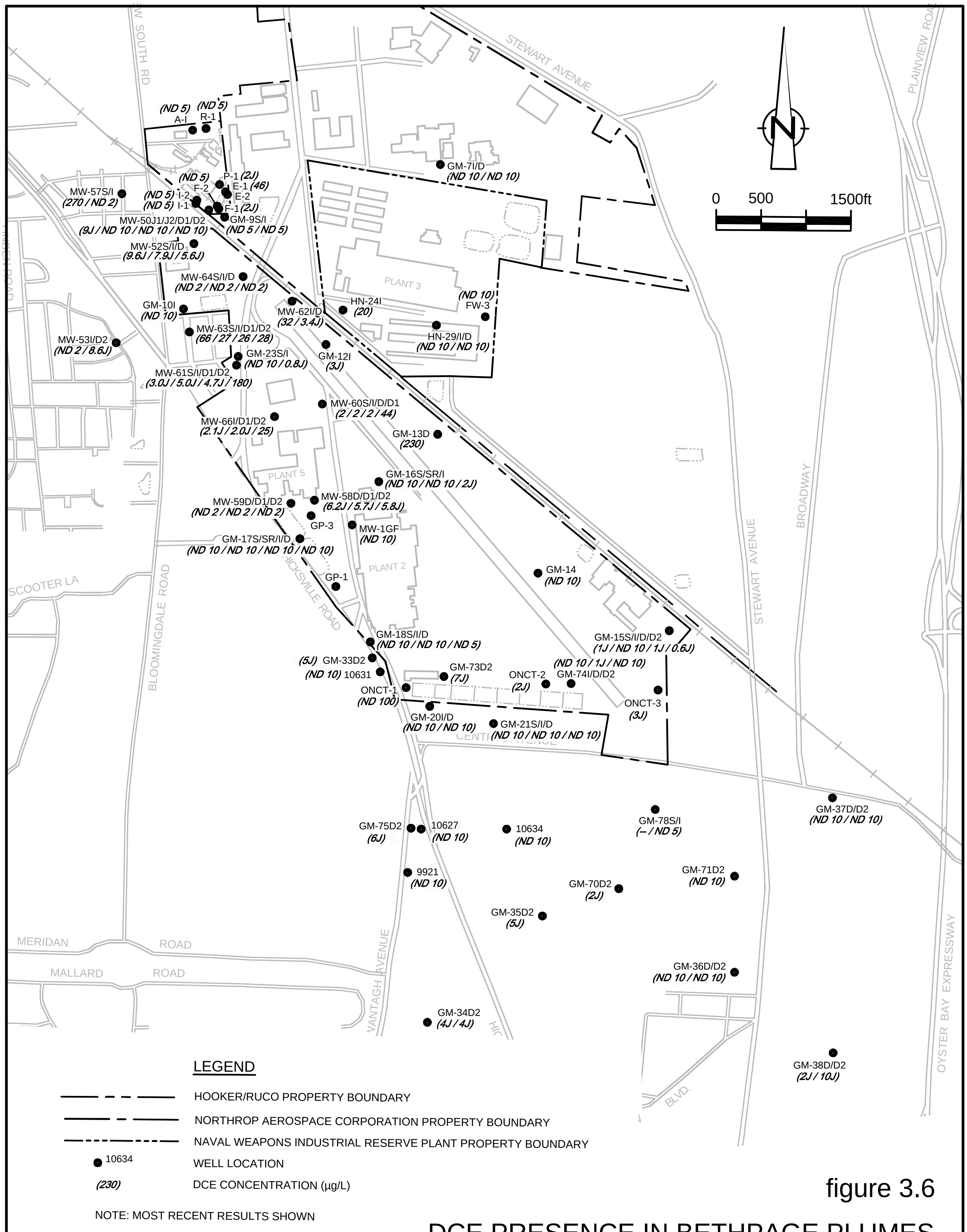
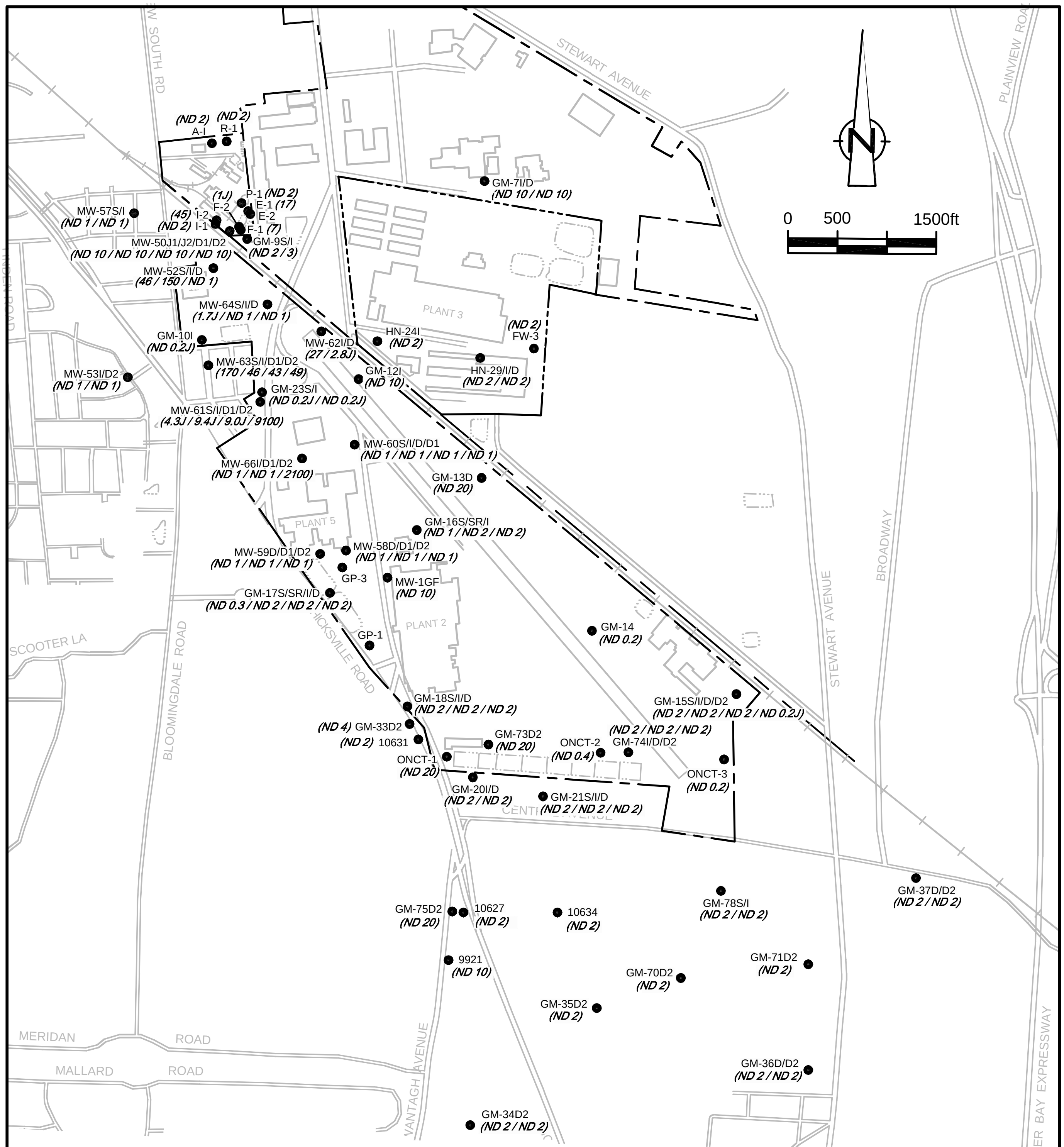


figure 3.6

DCE PRESENCE IN BETHPAGE PLUMES
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York



LEGEND

— — – — HOOKER/RUCO PROPERTY BOUNDARY

— – — NORTHROP AEROSPACE CORPORATION PROPERTY BOUNDARY

—·–·—·– NAVAL WEAPONS INDUSTRIAL RESERVE PLANT PROPERTY BOUNDARY

● 10634 WELL LOCATION

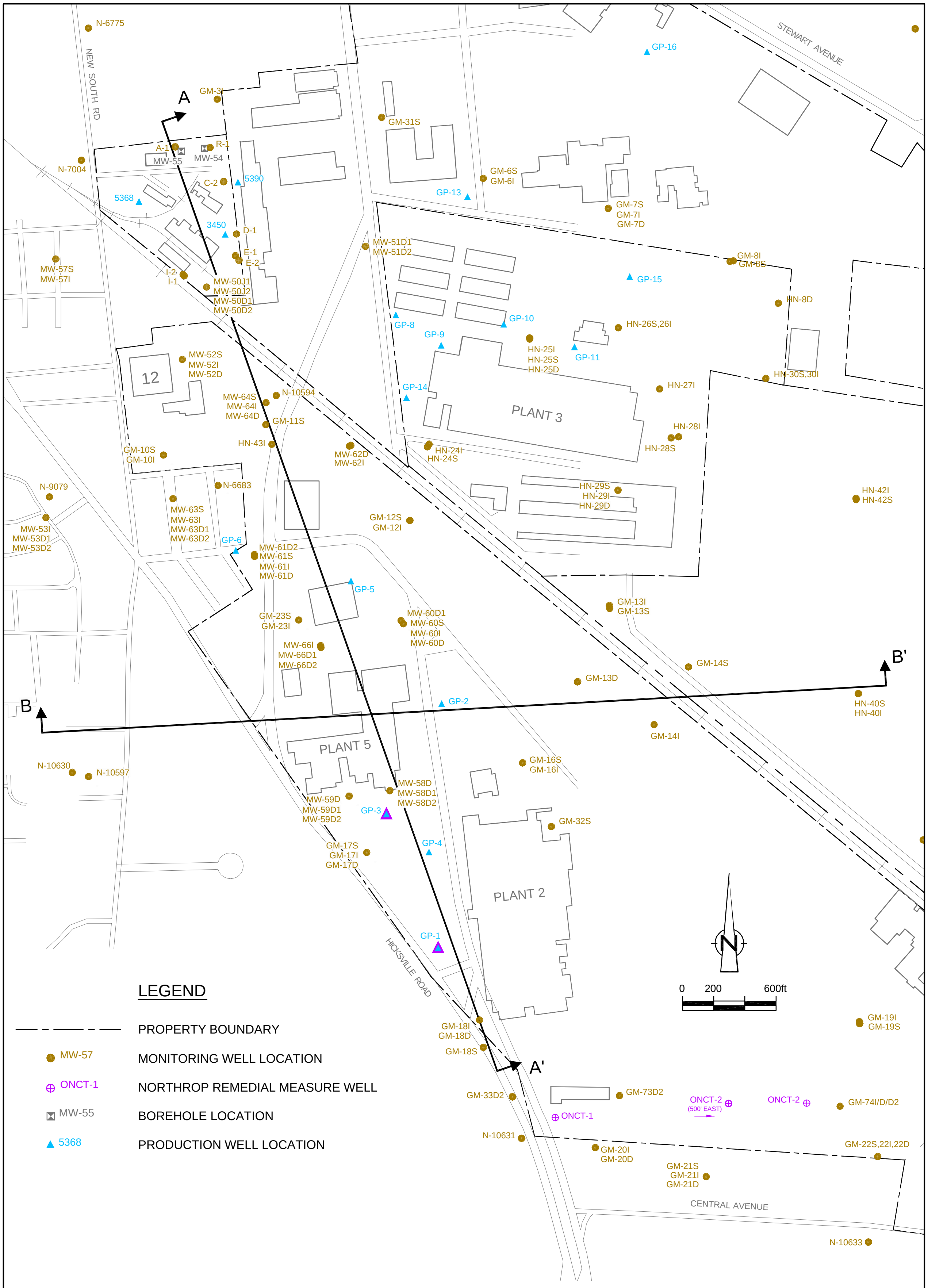
(27) VCM CONCENTRATION (µg/L)

NOTE: MOST RECENT RESULTS SHOWN

figure 3.7

VCM PRESENCE IN BETHPAGE PLUMES
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA038 NOV 07/2002



LEGEND

— - — -	PROPERTY BOUNDARY
● MW-57	MONITORING WELL LOCATION
⊕ ONCT-1	NORTHROP REMEDIAL MEASURE WELL
☒ MW-55	BOREHOLE LOCATION
▲ 5368	PRODUCTION WELL LOCATION

figure 4.1

GEOLOGIC CROSS-SECTION LOCATIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

CRA

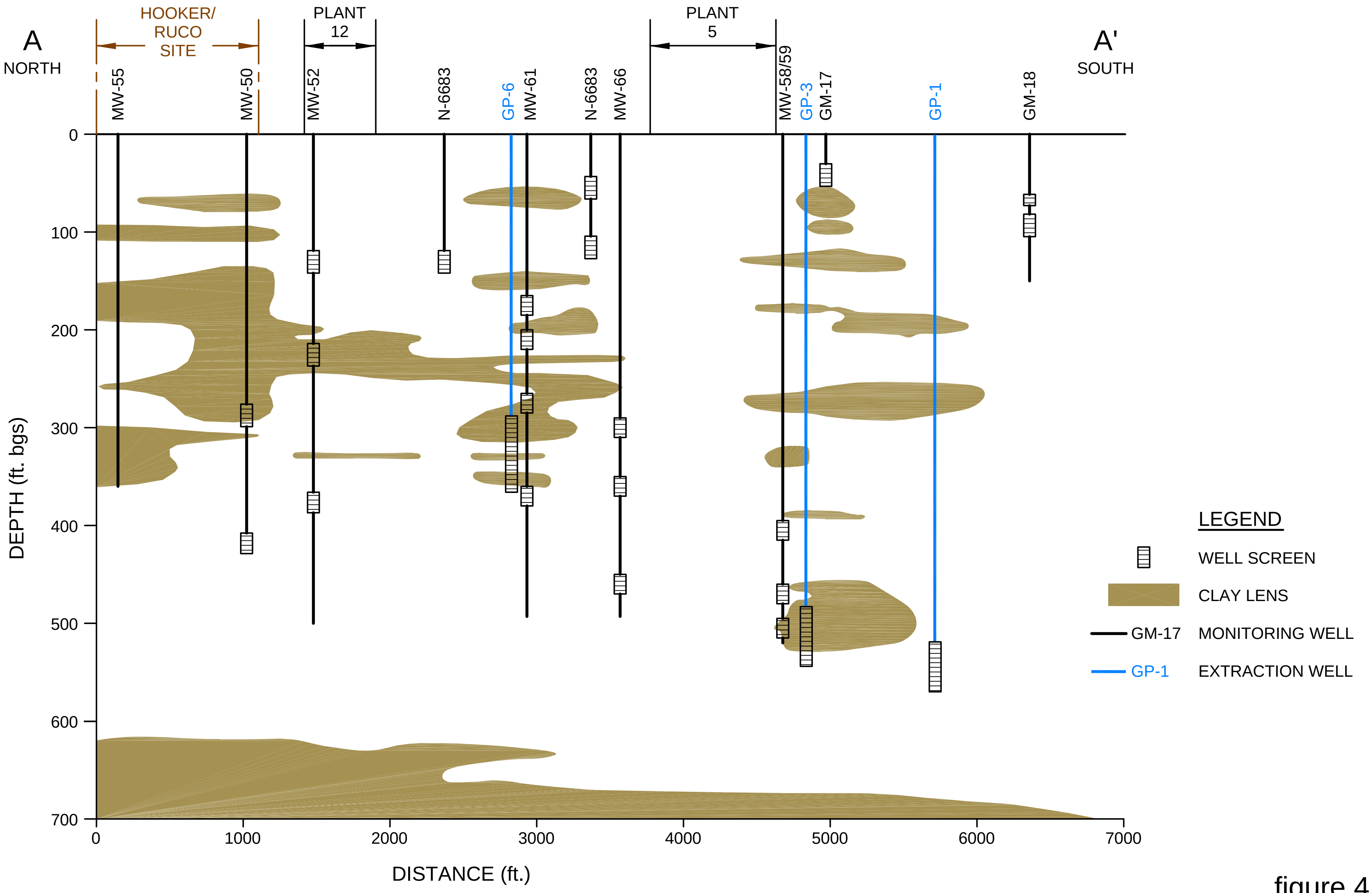


figure 4.2

NORTH-SOUTH GEOLOGIC CROSS-SECTION A-A'
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA026 NOV 07/2002

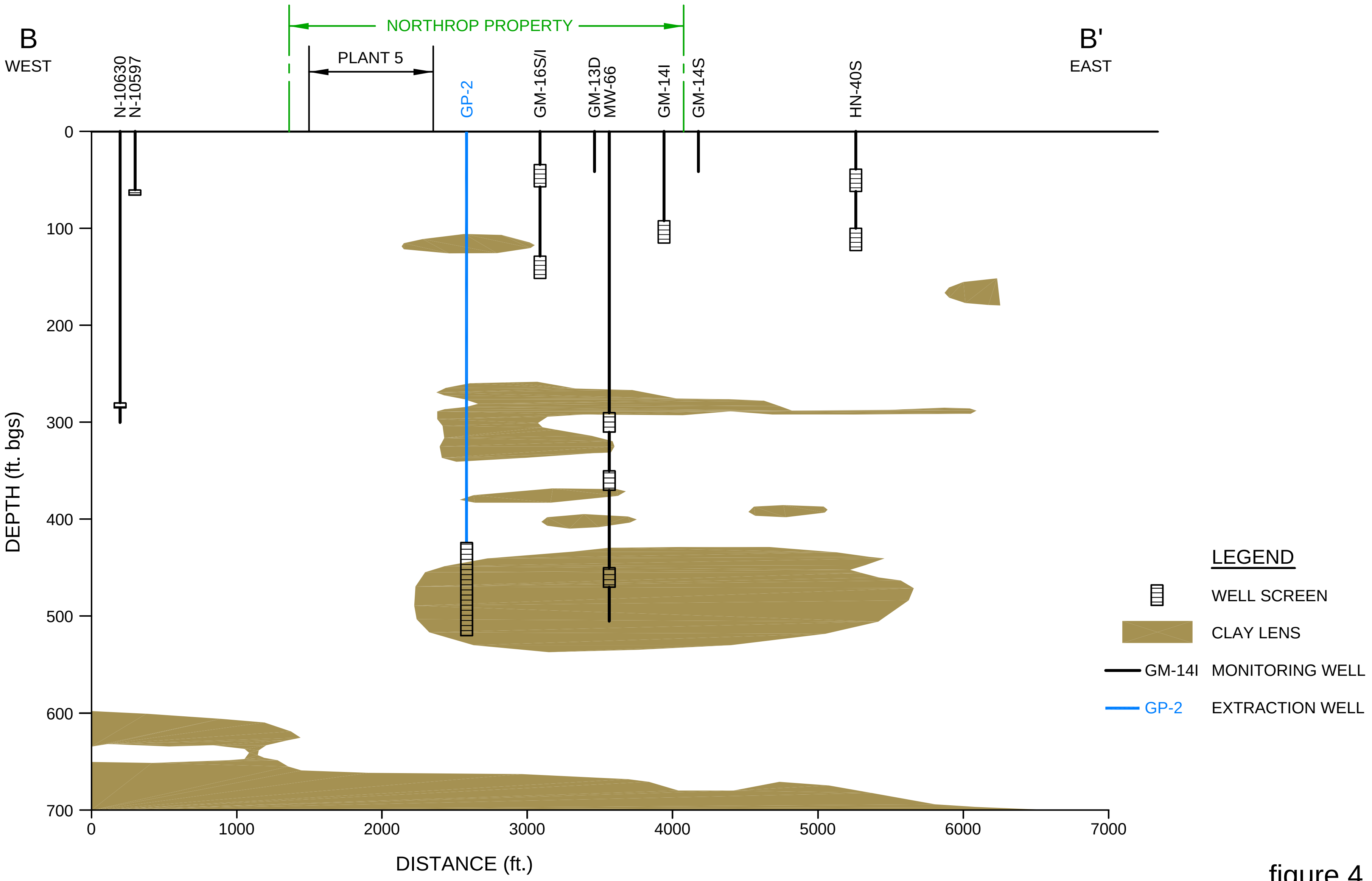


figure 4.3

WEST-EAST GEOLOGIC CROSS-SECTION B-B'
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

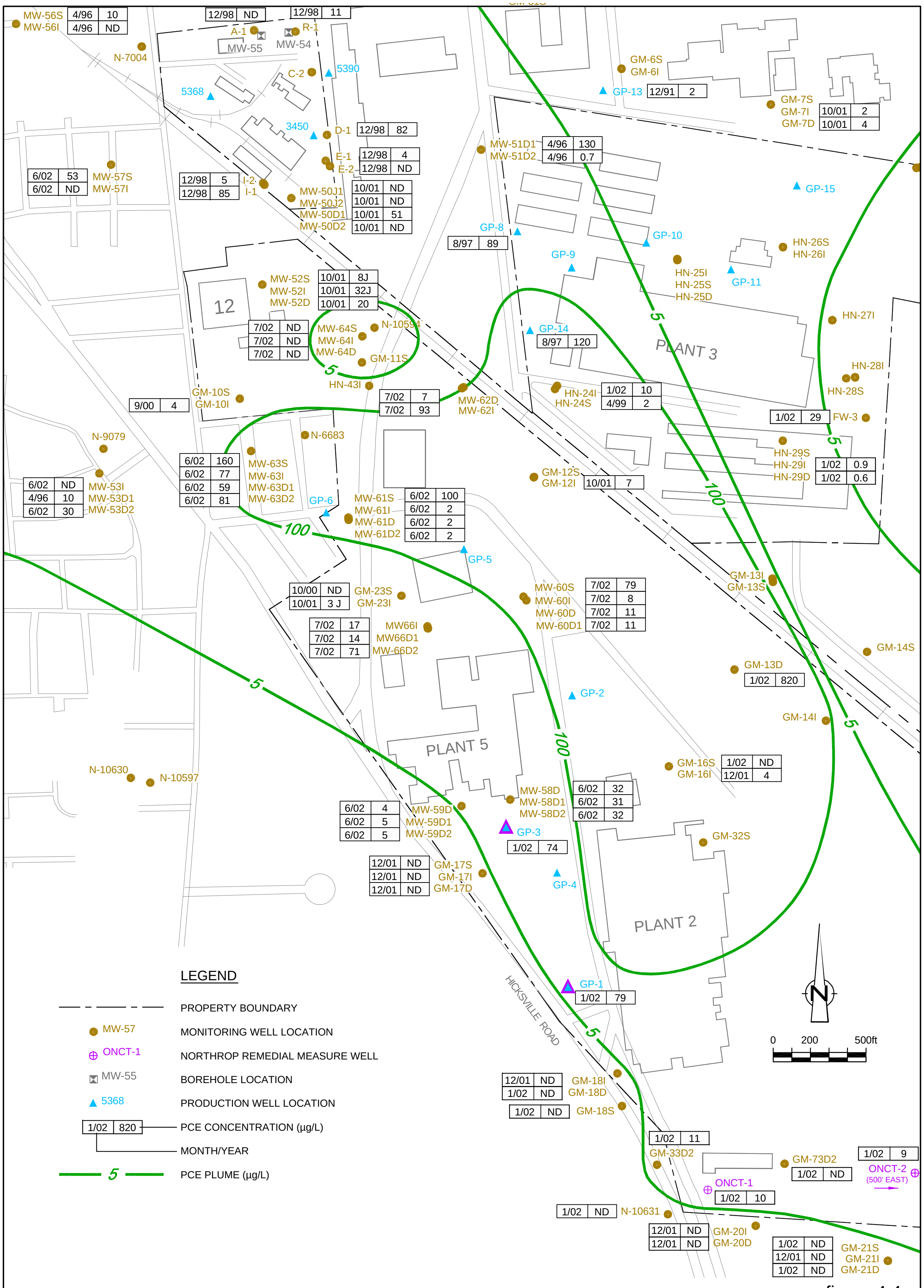


figure 4.4

PCE GROUNDWATER CONCENTRATIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA005 NOV 07/2002

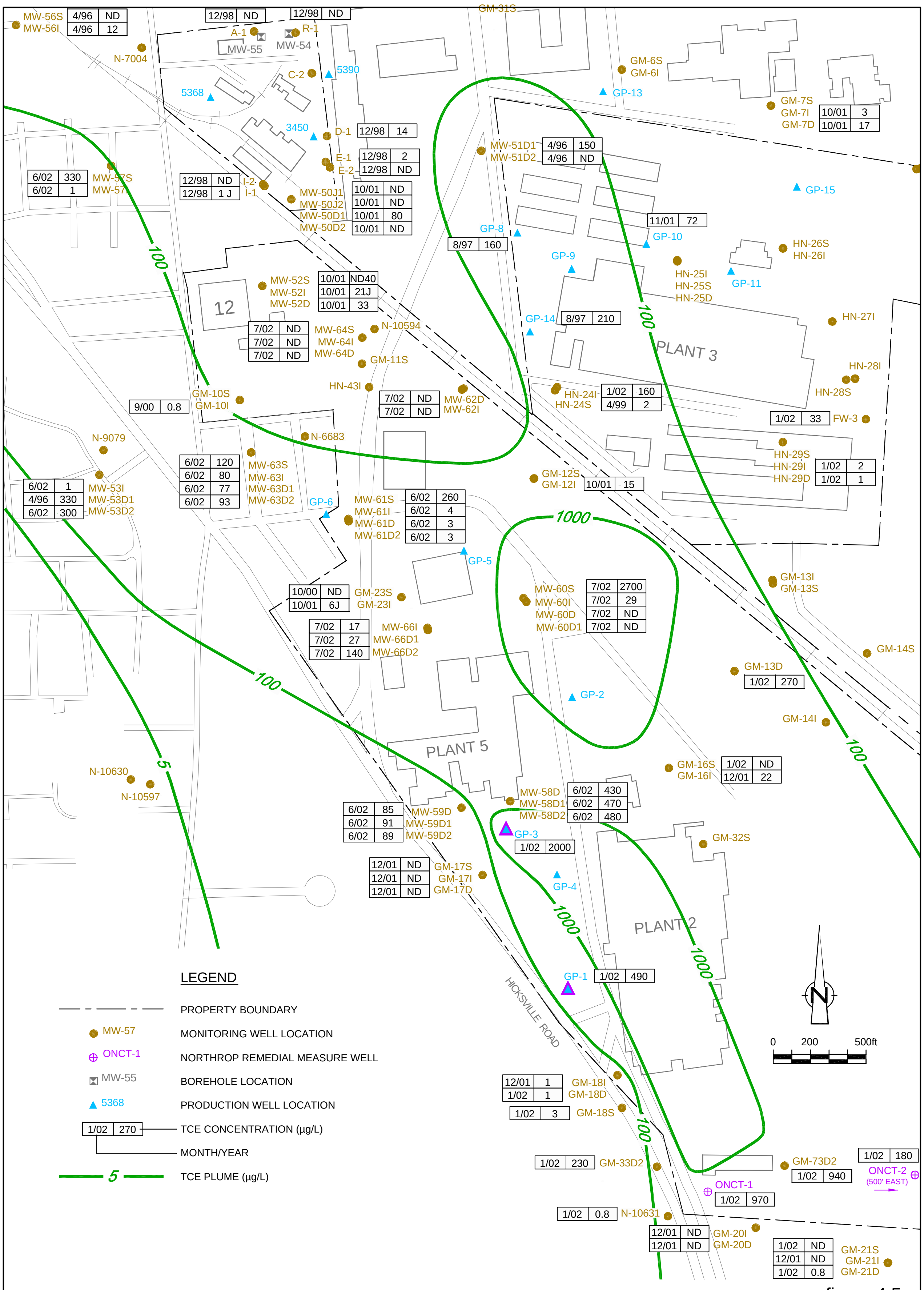


figure 4.5

TCE GROUNDWATER CONCENTRATIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

CRA

06883-00(034)GN-WA006 NOV 07/2002

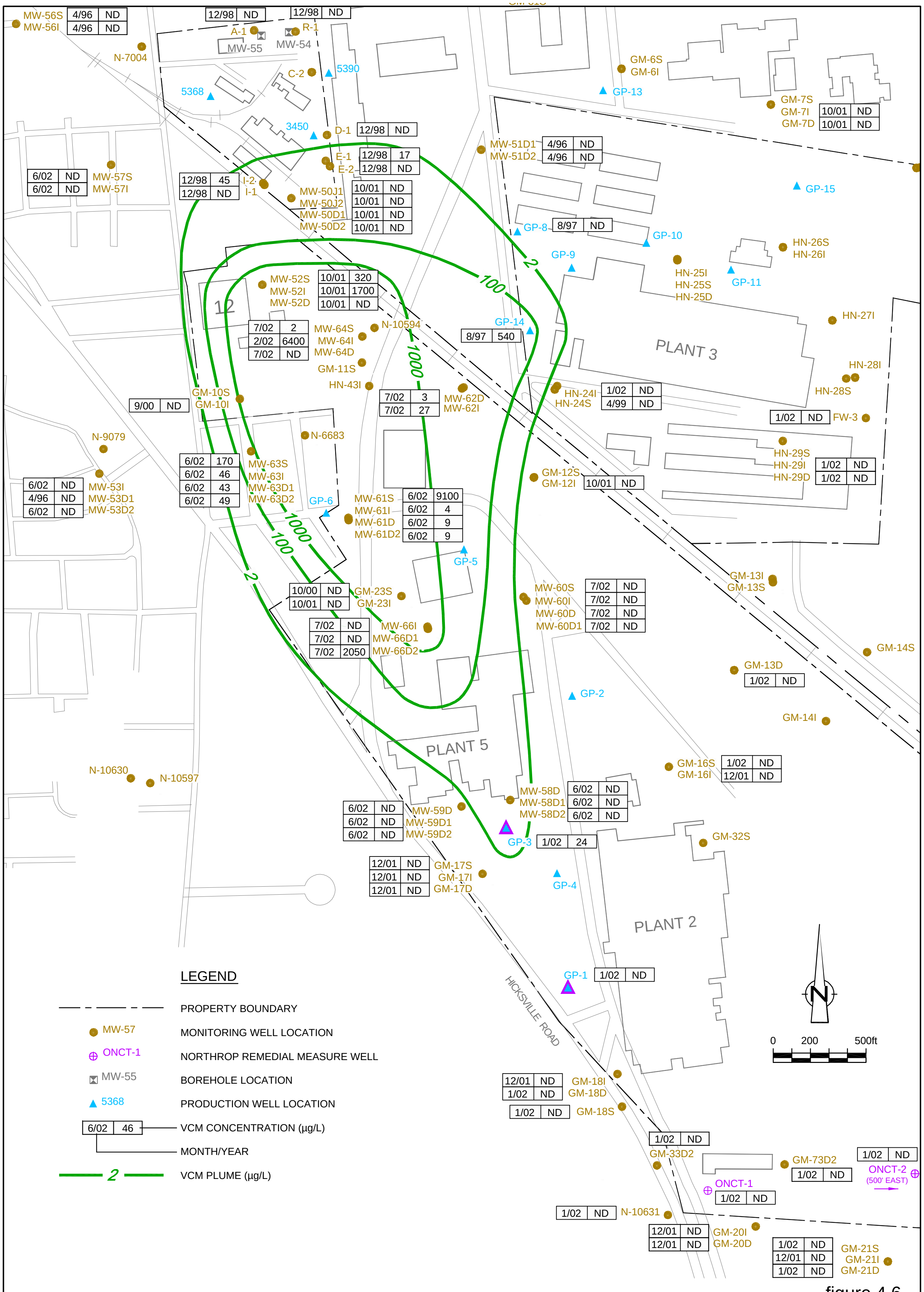


figure 4.6

VCM GROUNDWATER CONCENTRATIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA007 NOV 07/2002

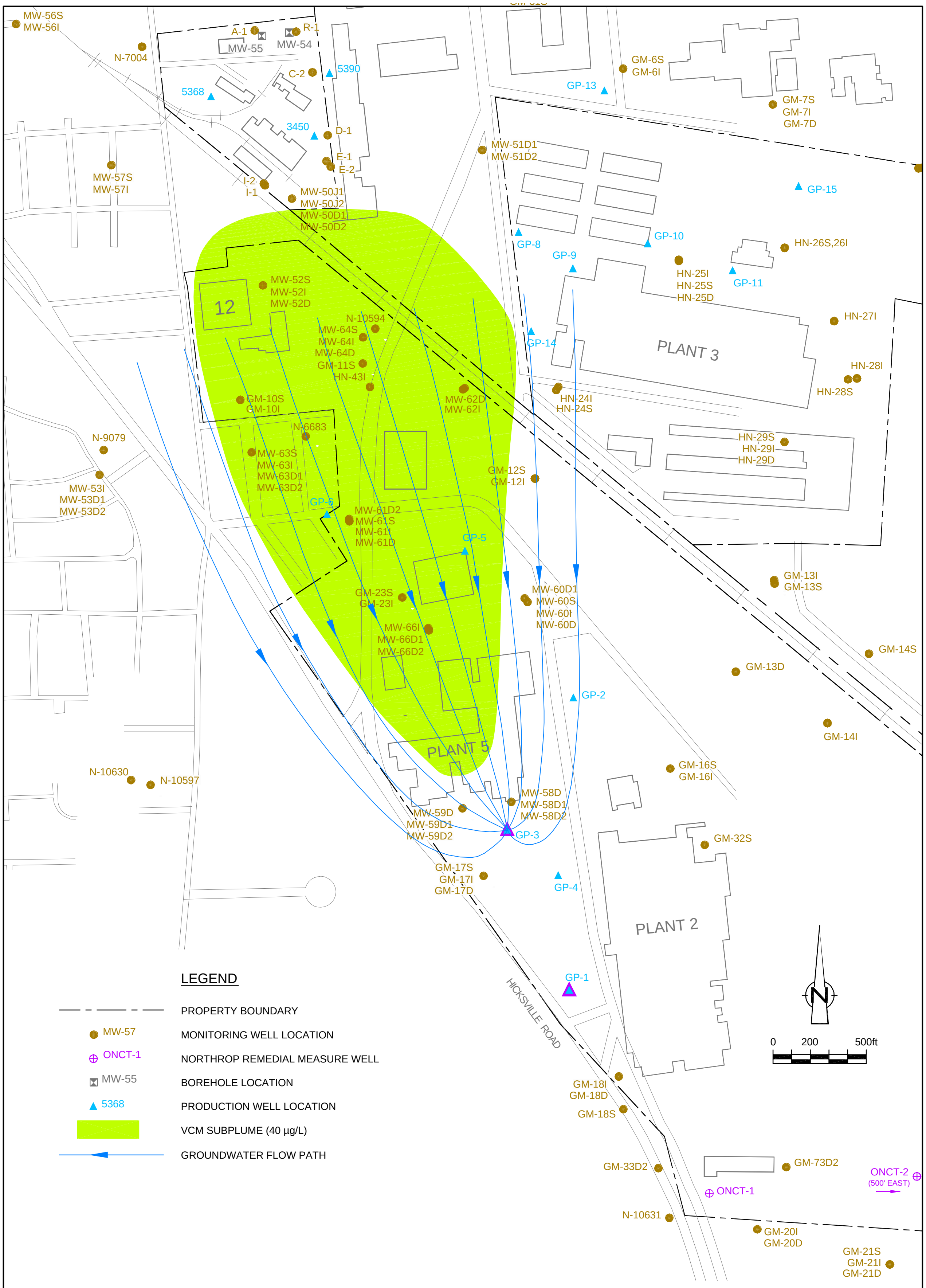


figure 4.7

SCHEMATIC OF GROUNDWATER FLOW PATHS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA009 NOV 07/2002

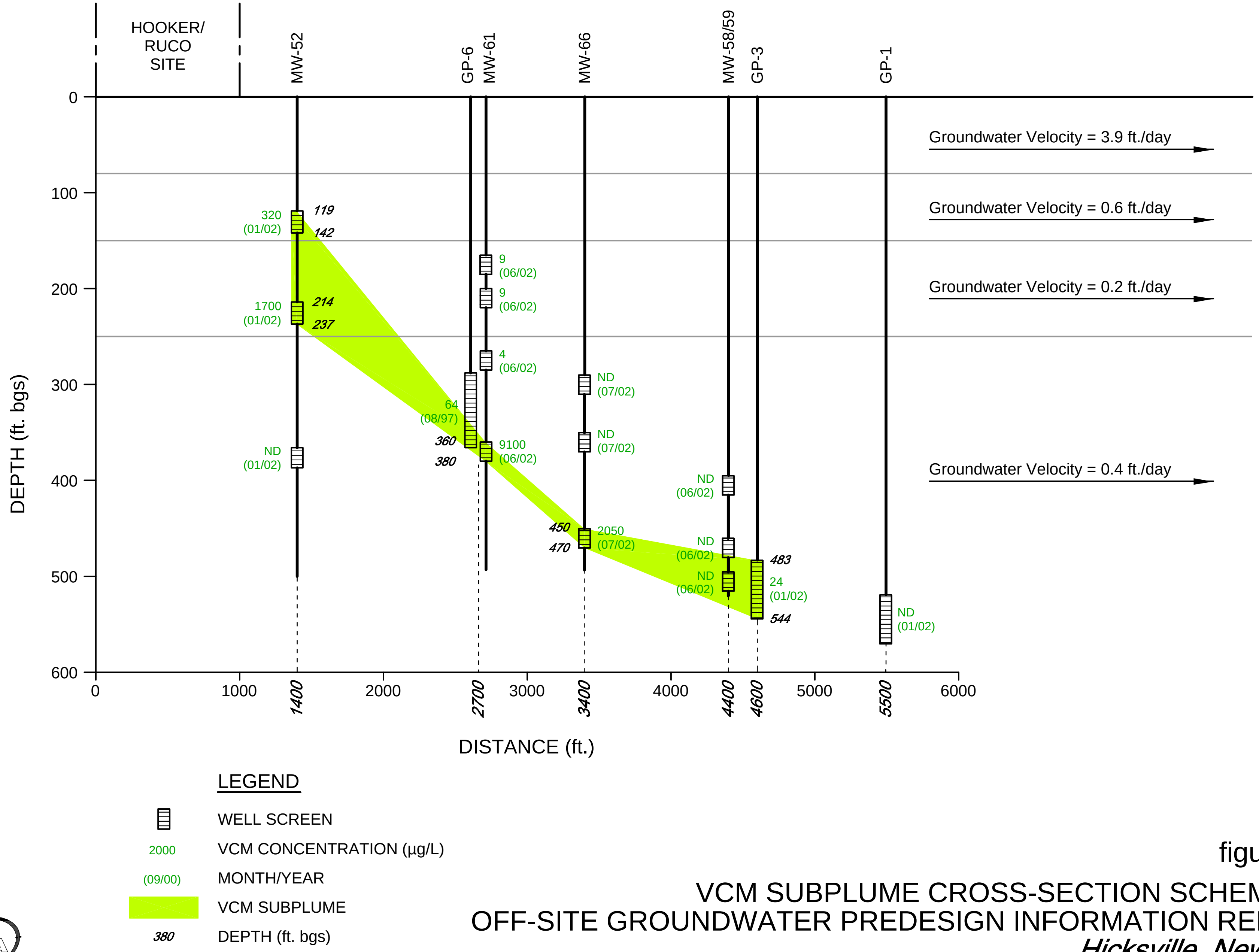
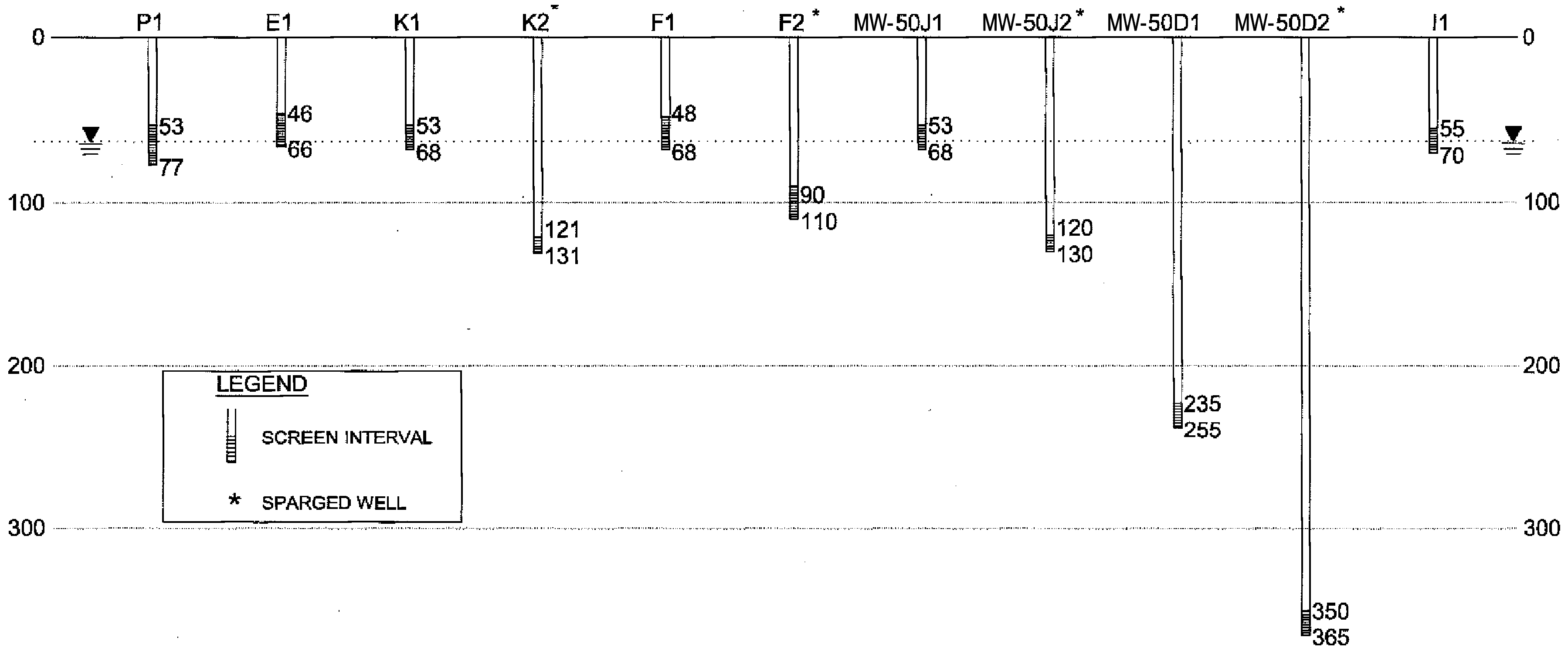


figure 4.8

VCM SUBPLUME CROSS-SECTION SCHEMATIC
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hicksville, New York

06883-00(034)GN-WA034 NOV 07/2002



Sparged Well	Test dates	End point flow & wellhead pressure (scfm / psi)	Comments
K2	7/10	102 @ 30 160 @ 31 197 @ 32	1 hour 1 hour 6 hours
F2	5/30 5/31 6/1	109 @ 14 156 @ 15 195 @ 15	4 hours 4 hours 4 hours
MW-50J2	5/9 5/10 5/13	111 @ 39 154 @ 39 220 @ 38	4 hours 4 hours 4 hours
MW-50D2	5/21	62 @155 159 @ 157 200 @ 159 230 @ 154	1 hour test 1 hour test 1 hour test 8 hours, post DAP injection
MW-50D1	5/21	0 @ 110	20 minutes

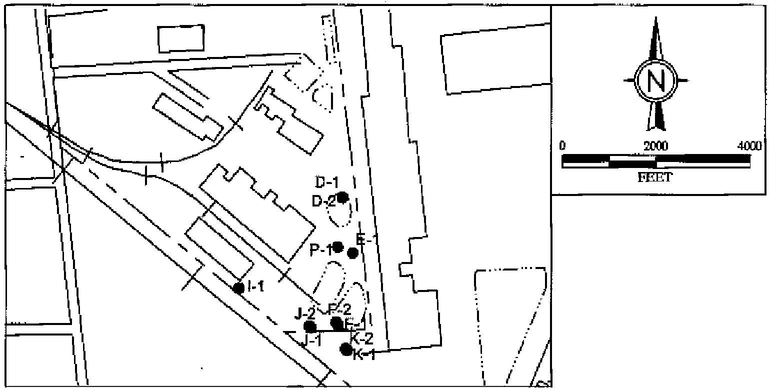
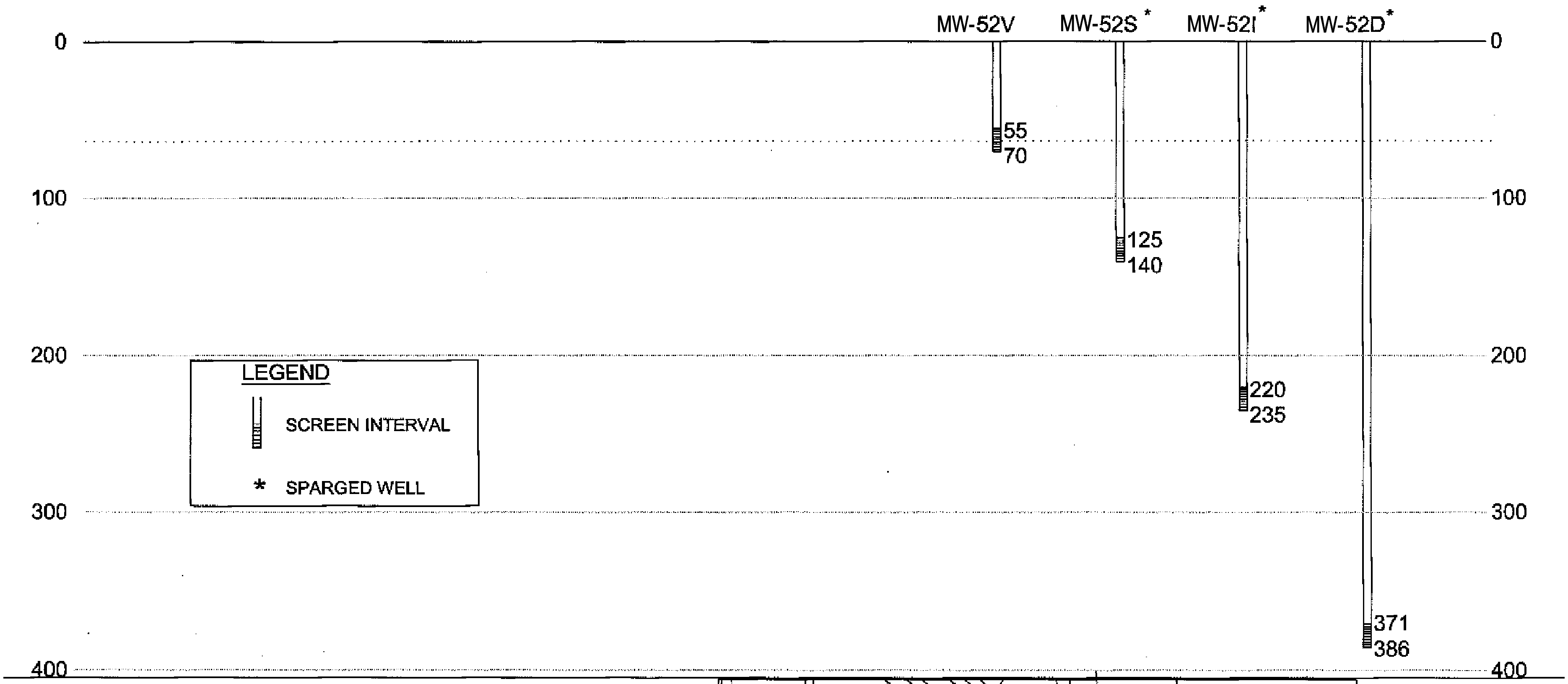


figure 5.1

HOOKER RUCO TEST WELLS

OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT

Hooker/Ruco Site, Hicksville, New York



Sparged Well	Test dates	End point flow & wellhead pressure (scfm / psi)	Comments
MW-52S	4/16 4/17 4/18	108 @ 34 159 @ 35 202 @ 36	4 hours 4.5 hours 4 hours
MW-52I	4/23 4/24 4/25	102 @ 78 152 @ 88 214 @ 96	4 hours 4.5 hours 4 hours
MW-52D	7/17	100 @ 135 150 @ 136 200 @ 138	Prelim. capacity test, 20 min. Prelim. capacity test Prelim. capacity test
	7/23 7/24 7/25	100 @ 138 150 @ 160 200 @ 180	4 hours with propane, N_2O 4 hours with propane, N_2O 4 hours with propane, N_2O
	8/8	115 @ 153 170 @ 154 310 @ 153	1 hour test, post sugar byproduct injection 1 hour 6 hours

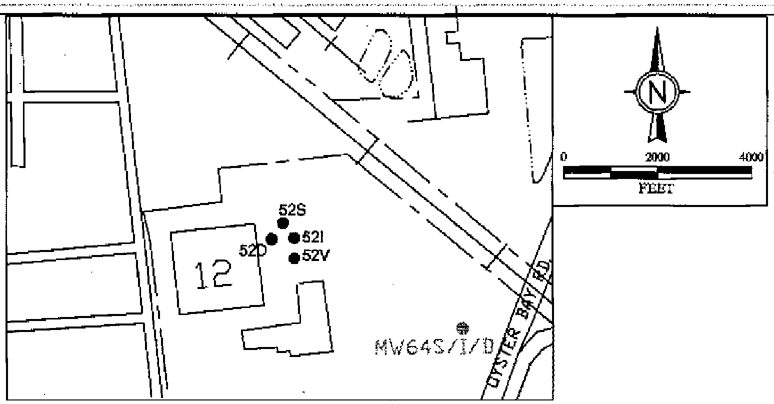


figure 5.2

NORTHROP PLANT 12 TEST WELLS

OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT

Hooker/Ruco Site, Hicksville, New York

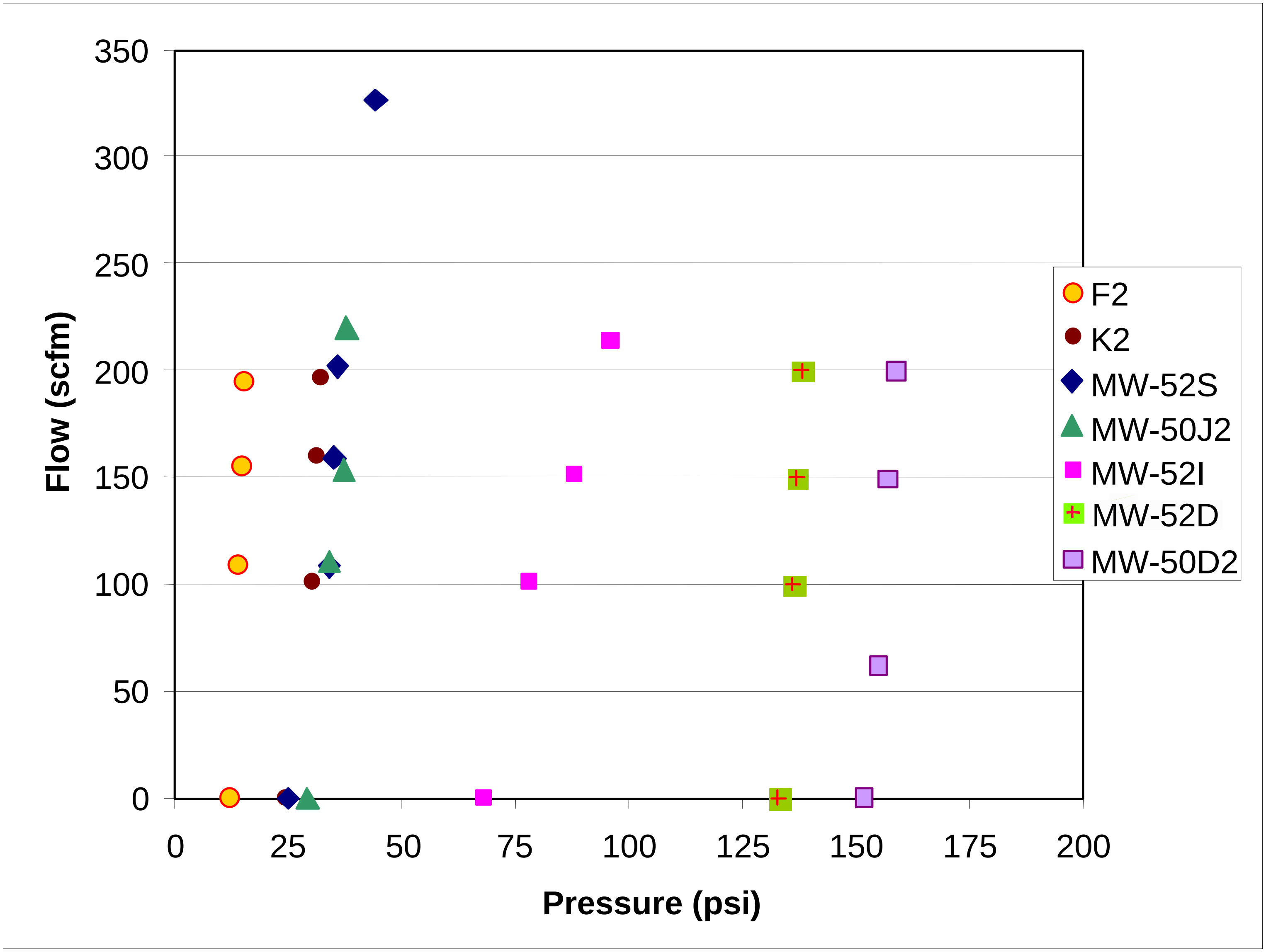


figure 5.3

AIR INJECTION CAPACITY OF ALL TESTED WELLS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

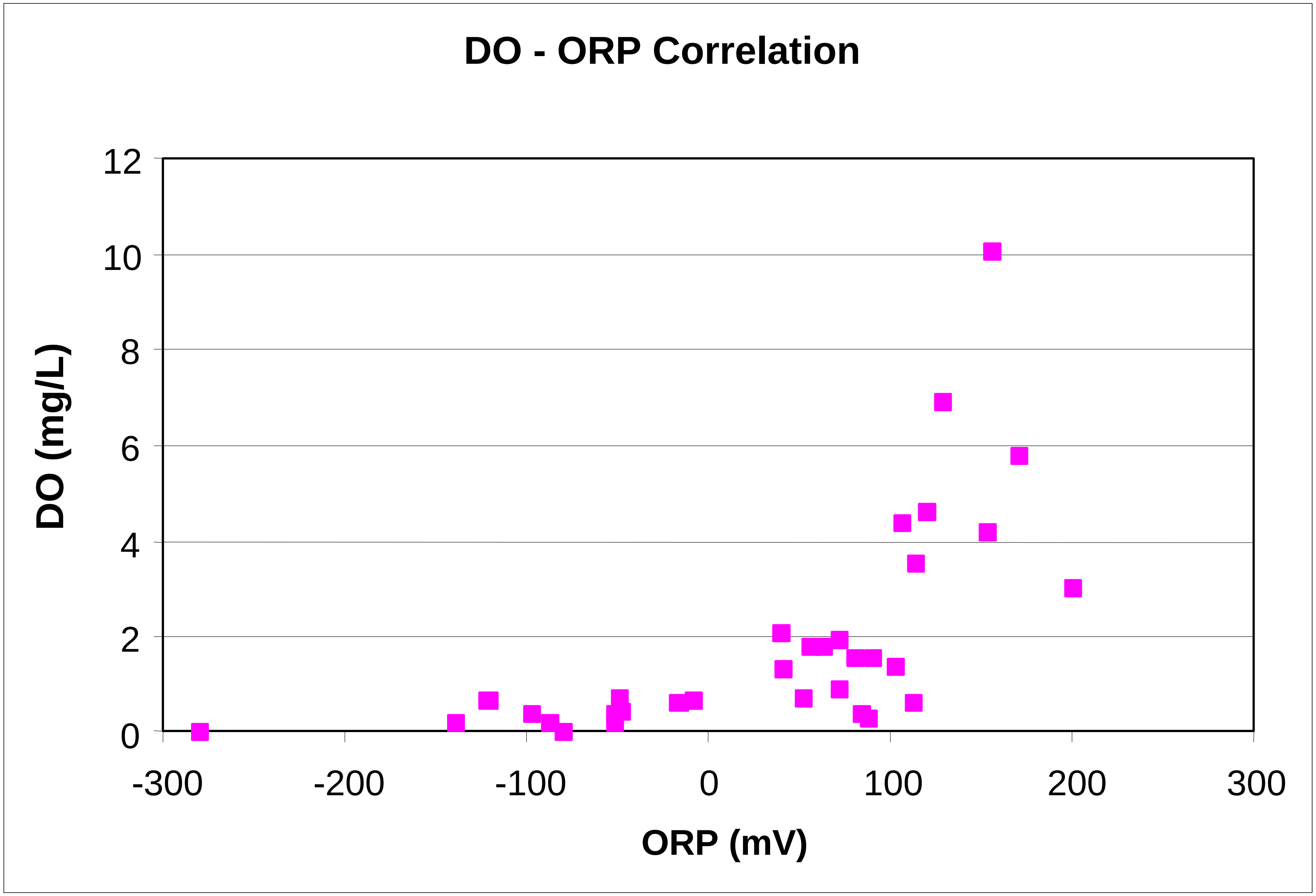


figure 5.4

CORRELATION OF ORP AND DO IN GROUNDWATER
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

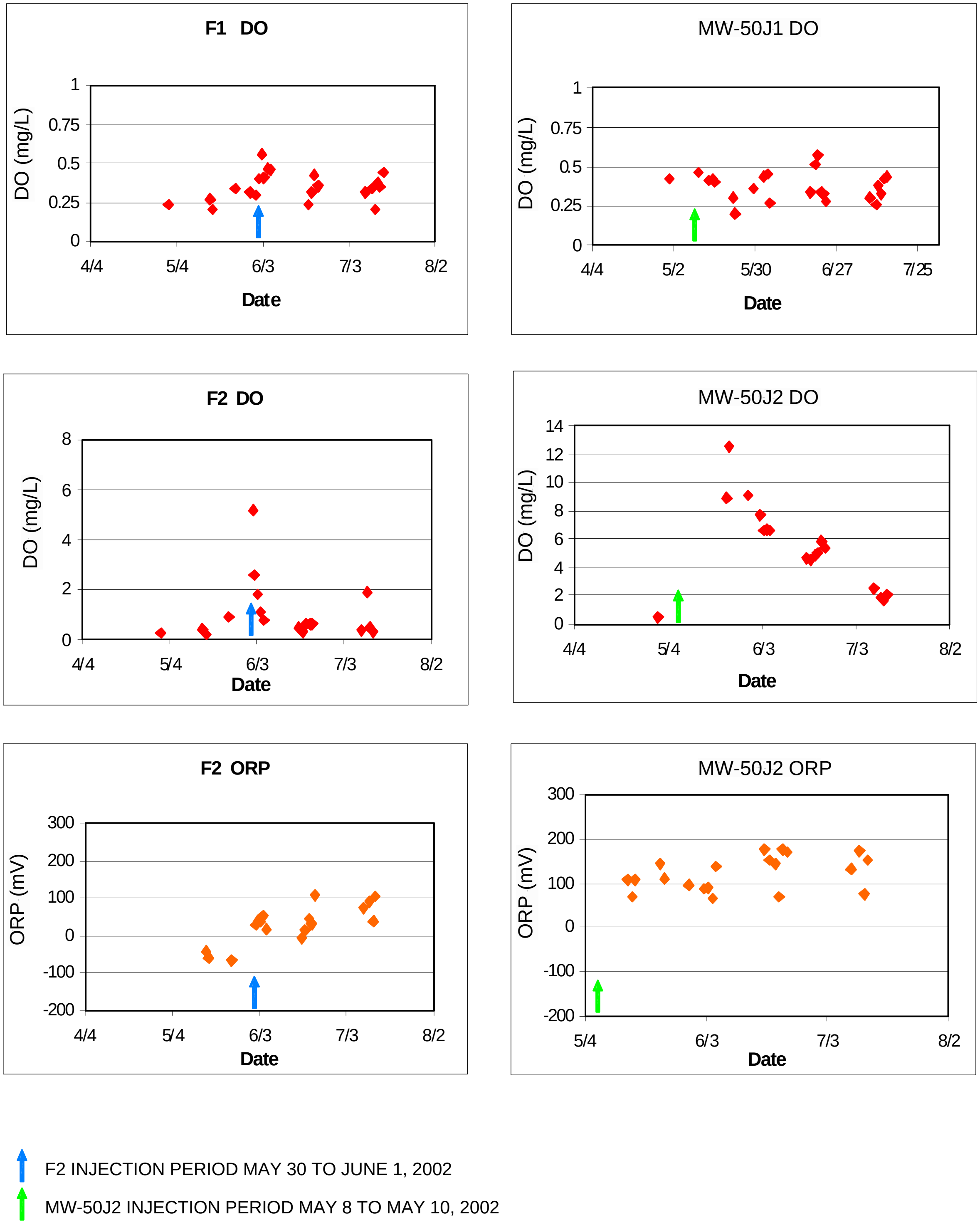


figure 5.5

DO RESPONSE TO SPARGING IN F2 AND MW-50J2
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, Ontario

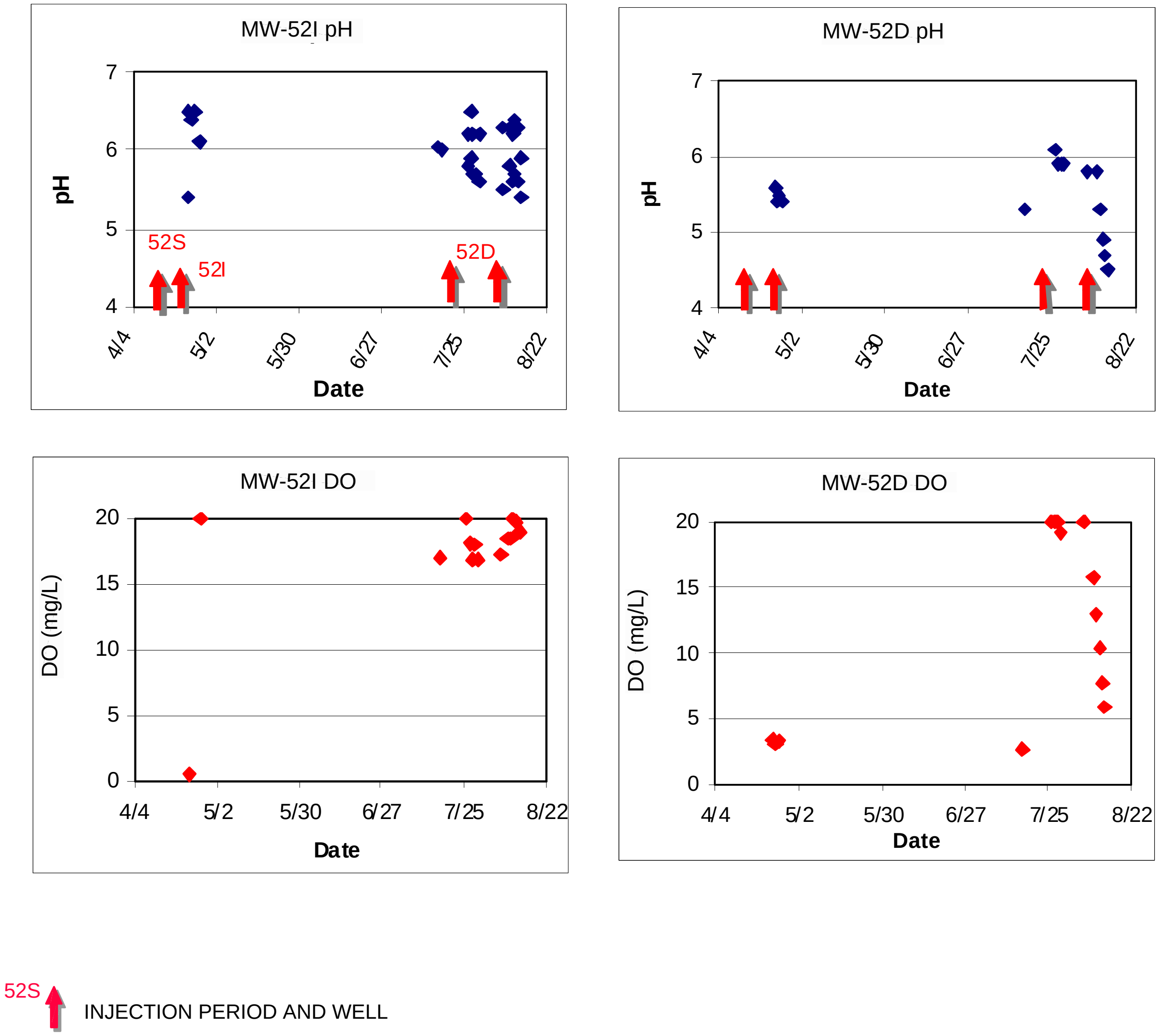


figure 5.6

COMPARISON OF DO AND pH RESPONSES
IN MW-52I AND MW-52D GROUNDWATER
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, Ontario

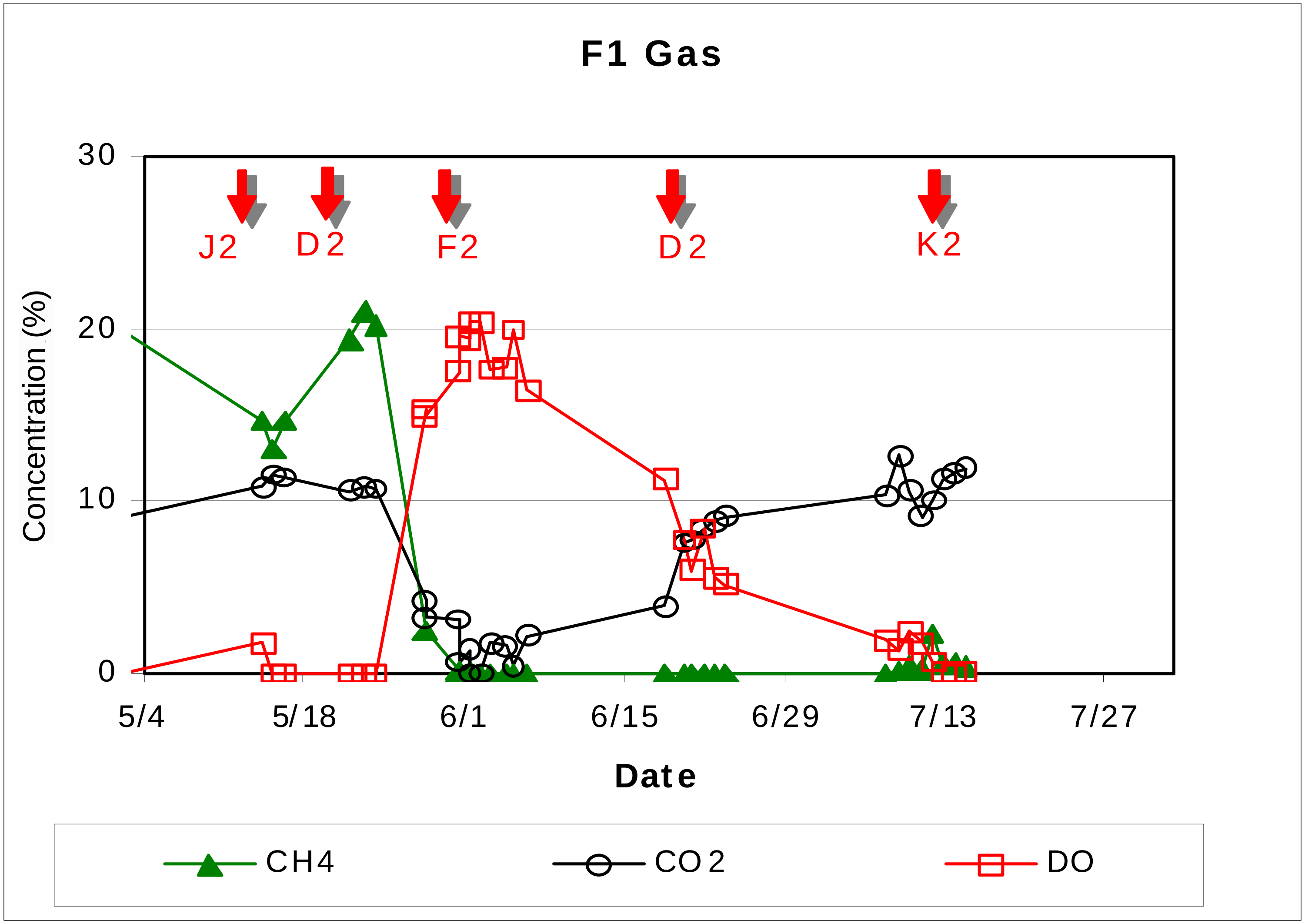


figure 5.7

MAJOR GASES IN F1 VADOSE ZONE
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

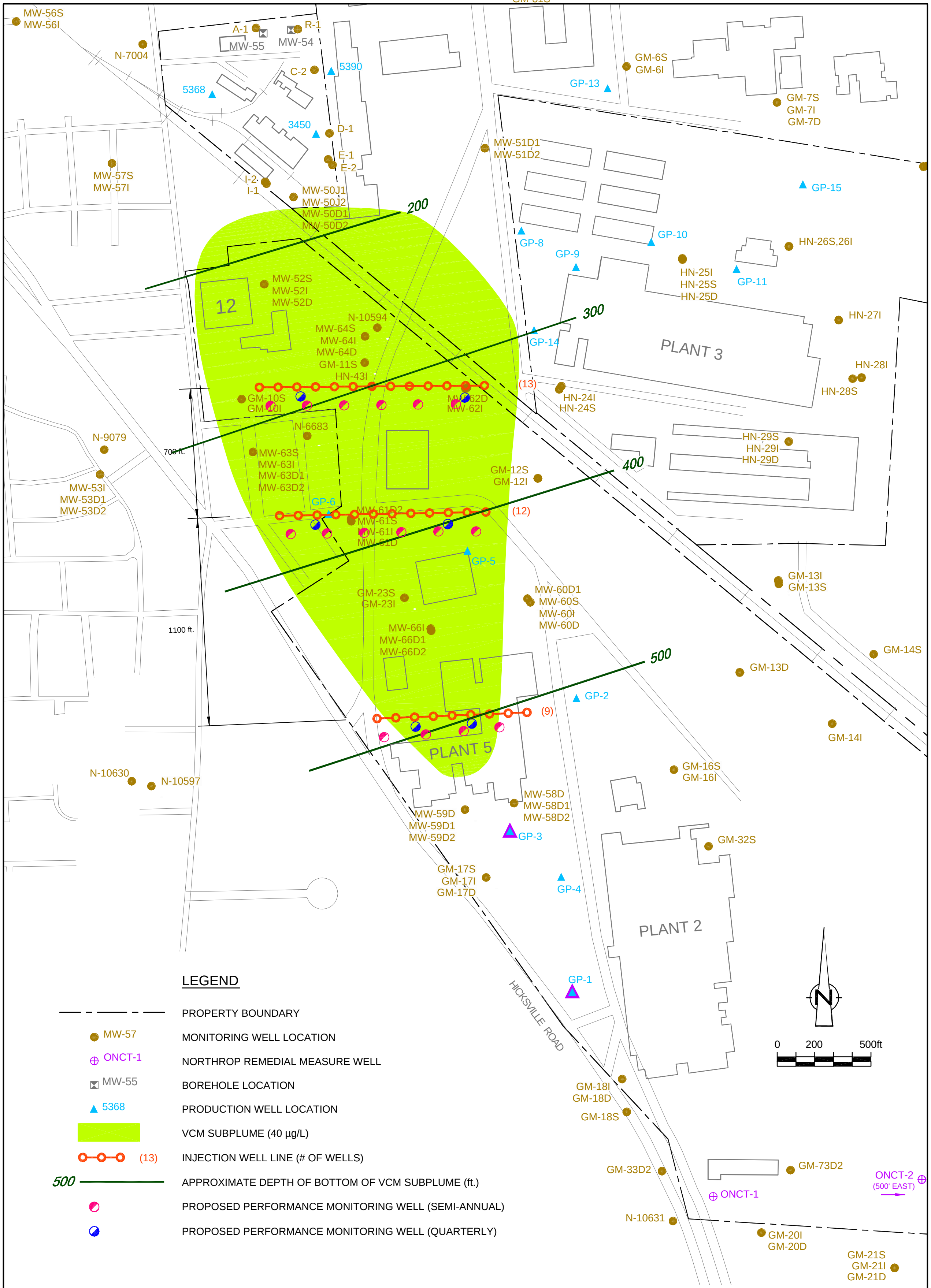


figure 7.1

PROPOSED BIOSPARGE INJECTION FENCE LOCATIONS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

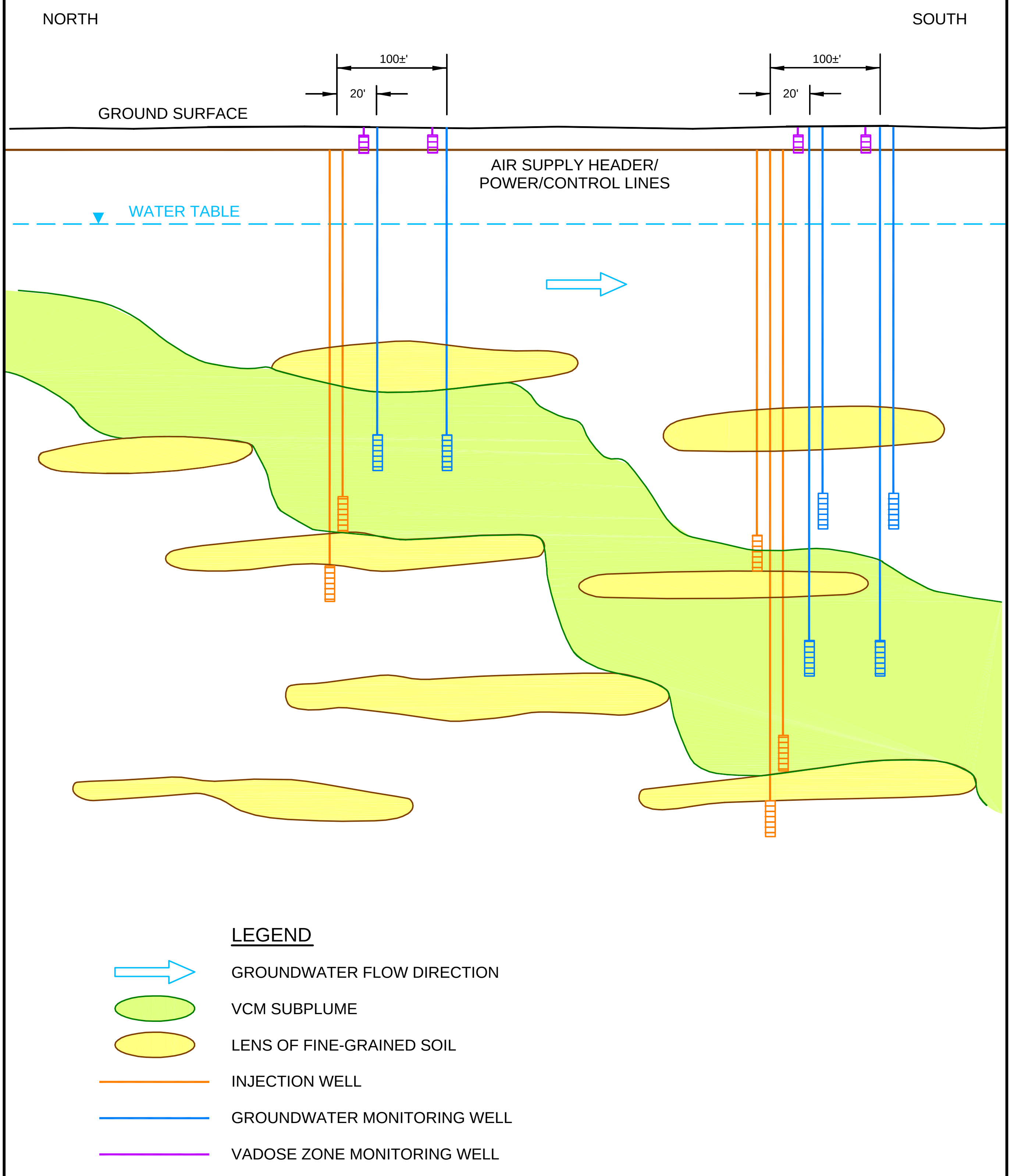


figure 7.2

PROPOSED VERTICAL DISTRIBUTION OF INJECTION WELLS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

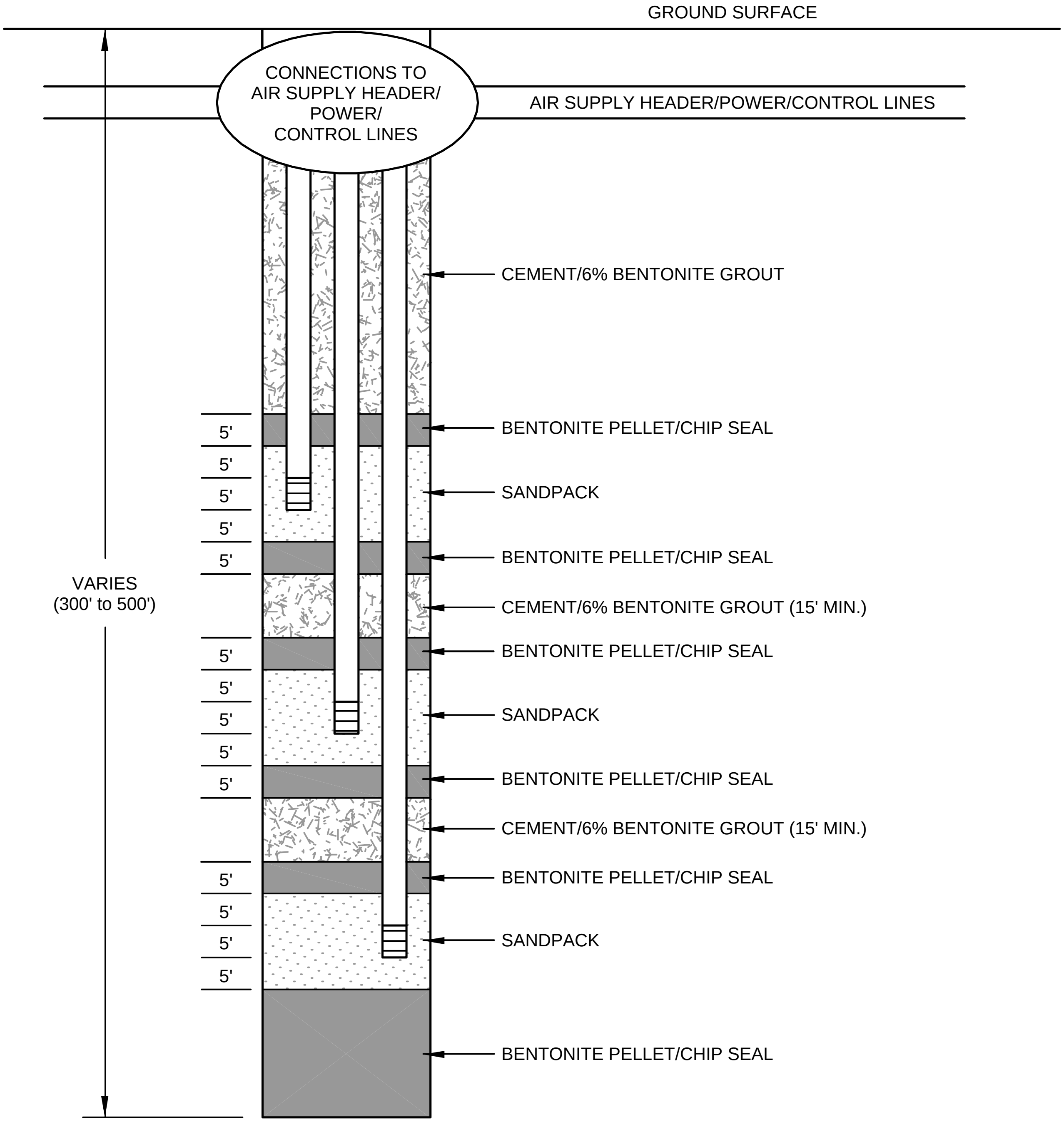


figure 7.3

TYPICAL INJECTION WELL DETAILS
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

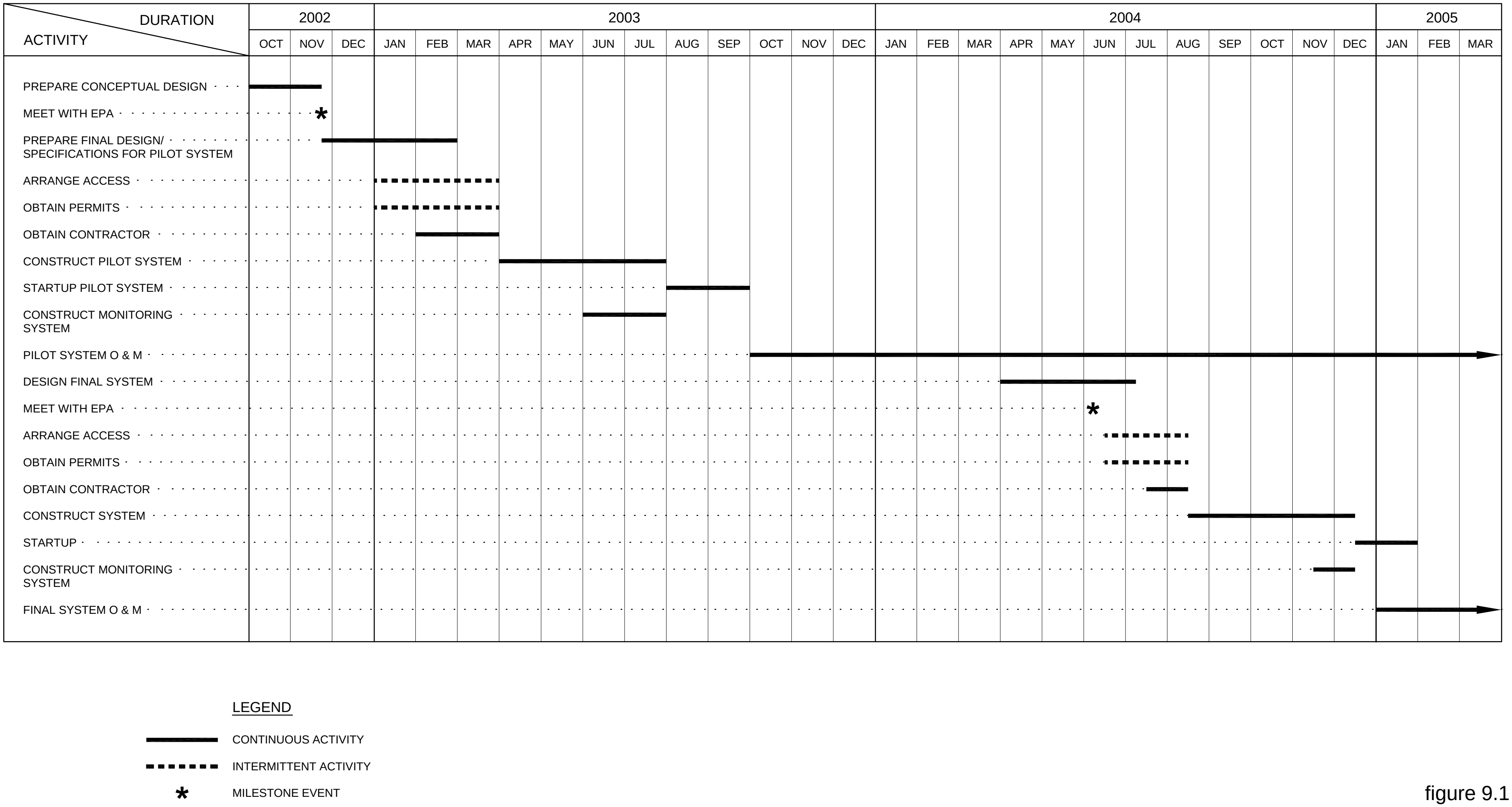


figure 9.1

DESIGN AND CONSTRUCTION SCHEDULE
OFF-SITE GROUNDWATER PREDESIGN INFORMATION REPORT
Hooker/Ruco Site, Hicksville, New York

06883-00(034)GN-WA010 NOV 07/2002

TABLE 2.1a

SUMMARY OF WELLS SAMPLED FOR NA PARAMETERS
TVOC PLUME, HICKSVILLE, NEW YORK
MAY 30 TO JUNE 7, 2001

WELL ID	PUMP USED	PACKER Y/N	DEDICATED Y/N
GM-18S	Redi-flo	N	N
GM-21I	Bladder	Y	Y
GM-21S	Redi-flo	N	N
HN-29D	Bladder	N	N
FW-3	Redi-flo	N	N
HN-24I	Redi-flo	N	N
HN-29I	Redi-flo	N	N
GM-37D2	Bladder	Y	Y
GM-37D	Bladder	Y	Y
GM-18D	Bladder	N	N
GM-18I	Bladder	Y	Y
GM-78S	Redi-flo	N	N
GM-78I	Redi-flo	N	N
GM-741	Redi-flo	N	N
GM-74D	Bladder	N	N
GM-74D2	Bladder	N	N
GM-73D2	Bladder	N	N
GM-20I	Bladder	Y	Y
GM-13D	Bladder	N	N
N-10627	Bladder	N	N
GM-75D2	Bladder	N	N
GM-33D2	Bladder	N	N
GM-20D	Bladder	Y	Y
GM-35D2	Bladder	Y	Y
GM-36D2	Bladder	Y	Y
GM-36D	Bladder	Y	Y

TABLE 2.1b

SUMMARY OF WELLS SAMPLED FOR NA PARAMETERS
TVOC PLUME, HICKSVILLE, NEW YORK
OCTOBER 2 TO 12, 2001

WELL ID	PUMP USED	PACKER Y/N	DEDICATED Y/N
GM17SR	Redi-flo	N	N
GM17I	Redi-flo	N	N
GM17D	Bladder	N	N
GM23I	Bladder	Y	Y
GM23S	Redi-flo	N	N
GM16I	Bladder	Y	Y
GM16SR	Redi-flo	N	N
MW52D	Bladder	N	N
MW52I	Bladder	N	N
MW52S	Bladder	N	N
GM7D	Bladder	N	N
GM7I	Bladder	N	N
GM12I	Bladder	N	N
9921	Bladder	N	N
MW50D1	Bladder	N	N
MW50D2	Bladder	N	N
MW50J1	Bladder	N	N
MW1GF	Bladder	N	N
MW50J2	Bladder	N	N

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe $^{+2}$ (mg/L)*
A-1 (2)	12/15/1998	NM	5	5.53	14.0	0.17	241	11.82	38.6	0.04
R-1 (2)	12/15/1998	NM	5.9	5.77	12.8	0.058	225	10.46	2.4	0.26
GM-10I (2)	12/18/1998	-0.02	2	11.09	13.8	0.71	1.9	5.16	2.0	NA
D-1	12/15/1998	0.06	5.6	5.71	12.9	0.166	189	2.09	25.6	
P-1	12/16/1998	0.04	5.6	6.44	13.2	0.218	-49	2.04	21.8	
E-1	12/16/1998	0.05	5.2	6.17	13.3	0.151	-20	1.76	0.9	
E-2	12/16/1998	0.06	4.2	6.68	12.0	0.175	-52	1.31	8.7	
I-1	12/20/1998	-0.04	10.9	6.51	15.7	0.289	238	0.95	5.5	
I-2	12/20/1998	-0.01	25	6.53	15.7	0.242	-88	1.94	38.5	
MW-50J1 (2)	12/17/1998	0.07	6.1	6.22	13.4	0.558	-38	5.94	7.7	5.20
MW-50J2 (2)	12/17/1998	0.02	9.1	6.70	13.0	0.295	-63	1.62	6.0	5.45
MW-50D1	12/17/1998	4.57	16.7	9.71	14.3	0.287	74	3.72	405	
MW-50D2	12/17/1998	1.19	5.5	11.59	13.5	0.767	-83	5.06	8.7	
F-1	12/19/1998	0.00	5.5	7.02	12.6	0.346	-14	0.7	0.9	
F-2	12/19/1998	0.00	4.7	7.34	13.1	0.392	-21	1.2	1.3	
K-1 (GM-9S)	12/16/1998	0.12	4.0	6.44	12.6	0.222	-22	1.5	6.8	
K-2 (GM-9I)	12/16/1998	0.15	4.4	6.81	13.2	0.269	-68	1.21	45	
MW-52I (2)	12/18/1998	0.00	6.3	5.41	13.0	0.153	133	2.82	5.7	0.05
MW-52S (2)	12/18/1998	0.04	20	6.05	13.1	0.208	80	0.71	55	0.47
MW-52D	12/18/1998	0.04	9.4	5.12	13.5	0.250	253	6.53	50	

Notes:

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
(1)	Negative indicates groundwater level during purging higher than initial water level.
(2)	Wells sampled for natural attenuation parameters.
NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe $^{+2}$ (mg/L)*
GM-17I (2)	Third Quarter 2000			6.5	20.2	110	200	6.4		
GM-17D (2)	Third Quarter 2000			6.0	18.8	85	240	8.8		
GM-34D (2)	Third Quarter 2000			8.8	18.5	155	-40	0.5		
GM-34D2 (2)	Third Quarter 2000			5.2	18.0	80	60	3.4		
HN-24I (2)	Third Quarter 2000			6.6	18.3	215	165	3.6		
GM-73D2 (2)	Third Quarter 2000			3.9	18.0	130	255	2.8		
MW-52S (2)	Third Quarter 2000			6.5	15.9	115	680	0.5		
MW-52I (2)	Third Quarter 2000			5.0	15.1	95	320	0.6		
MW-52D (2)	Third Quarter 2000			5.3	14.7	175	220	4.1		

Notes:

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
(1)	Negative indicates groundwater level during purging higher than initial water level.
(2)	Wells sampled for natural attenuation parameters.
NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe^{+2} (mg/L)*
GM-18S (2)	5/30/2001	0.18	4.5	4.7	17.5	90.3	124	8.28		1.1
GM-21I (2)	5/30/2001	0.10	1.3	6.0	13.5	114	185	10.05		0.0
GM-21S (2)	5/30/2001	0.10	4.3	4.8	20.0	72.4	151	11.19		0.0
HN-29D (2)	5/31/2001	0.00	1.8	7.2	18.8	110	138	11.05		0.0
FW-3 (2)	5/31/2001	0.03	5.8	4.0	17.7	155	256	7.61		0.0
HN-24I (2)	5/31/2001	0.19	2.1	3.4	15.6	181	283	4.08		0.0
HN-29I (2)	5/31/2001	1.72	1.5	7.9	18.8	278	104	10.18		0.0
GM-37D2 (2)	6/1/2001	0.07	1.1	4.0	14.7	160	443	4.66		0.0
GM-37D (2)	6/1/2001	0.02	1.0	4.0	14.7	151	451	6.21		0.0
GM-18D (2)	6/4/2001	0.00	2.4	4.5	19.2	90.3	263	9.64		0.1
GM-18I (2)	6/4/2001	0.10	1.1	4.4	16.5	73.7	336	10.72		0.0
GM-78S (2)	6/4/2001	0.02	1.3	4.5	19.2	217	288	9.67		0.1
GM-78I (2)	6/4/2001	0.02	1.6	4.6	17.7	320	288	10.43		0.0
GM-74I (2)	6/4/2001	0.21	1.8	4.7	15.1	67.3	265	12.74		0.0
GM-74D (2)	6/5/2001	0.07	1.6	4.1	16.2	59.3	340	5.76		0.0
GM-74D2 (2)	6/5/2001	0.00	2.9	4.2	15.5	34.2	300	4.15		0.1
GM-73D2 (2)	6/5/2001	0.00	3.4	4.4	17.4	96.1	247	4.89		0.8
GM-20I (2)	6/5/2001	0.01	0.60	8.8	11.3	215	82	12.05		0.1

<u>Notes:</u>

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
(1)	Negative indicates groundwater level during purging higher than initial water level.
(2)	Wells sampled for natural attenuation parameters.
NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe^{+2} (mg/L)*
GM-13D (2)	6/6/2001	0.01	2.0	4.6	15.5	186	311	0.34		0.0
N-10627 (2)	6/6/2001	0.10	2.6	6.6	18.3	76.7	-288	0.03		3.0
GM-75D2 (2)	6/6/2001	0.01	2.4	4.2	16.9	108	289	5.43		0.2
GM-33D2 (2)	6/6/2001	0.00	2.8	4.4	17.3	68.1	291	9.46		0.0
GM-20D (2)	6/6/2001	0.12	1.1	4.9	14.1	61.2	263	11.97		0.0
GM-35D2 (2)	6/7/2001	0.07	1.3	4.2	16.4	84.9	384	6.85		0.0
GM-36D2 (2)	6/7/2001	0.20	1.1	8.0	14.3	96.3	105	14.67		0.0
GM-36D (2)	6/7/2001	0.07	1.1	4.3	14.6	71.6	329	9.22		0.0

Notes:

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
(1)	Negative indicates groundwater level during purging higher than initial water level.
(2)	Wells sampled for natural attenuation parameters.
NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe^{+2} (mg/L)*
GM-17SR	10/2/2001	0.28	0.7	6.0	21.9	84.5	165	8.09	0.0	0.0
GM-17I	10/2/2001	0.14	1.0	5.8	22.6	87.7	193	6.42	1.3	0.0
GW-17D	10/2/2001	0.06	1.8	4.9	21.9	80.5	263	6.79	0.0	0.0
GM-23I	10/2/2001	0.00	1.1	4.8	17.8	121.7	297	1.09	0.0	0.0
GM-23S	10/2/2001	0.16	1.0	5.7	22.8	234.5	228	6.78	0.0	0.0
GM-16I	10/3/2001	0.00	0.4	6.7	19.3	326.4	191	1.11	41.3	0.0
GM-16SR	10/3/2001	0.00	0.8	5.2	21.4	91.2	251	8.18	0.0	0.0
MW-52D	10/3/2001	0.00	10.5	5.1	16.5	243.1	289	3.48	1000+	
MW-52I	10/3/2001	0.02	4.8	5.1	17.2	87.0	203	0.59	1.9	
MW-52S	10/3/2001	0.00	5.7	6.5	16.9	42.6	104	2.22	700	
GM-7D	10/10/2001	0.01	1.3	4.9	16.8	116.0	284	6.13	13.3	0.0
GM-7I	10/10/2001	0.01	1.2	4.8	16.9	252.6	314	6.66	0.0	0.0
GM-12I	10/10/2001	0.04	1.1	3.5	16.3	237.8	432	7.48	0.0	0.0
9921	10/10/2001	0.12	2.2	5.9	16.7	705.8	-36	0.76	143	0.6
MW-50D1	10/11/2001	6.56	5.6	8.3	21.9	269.3	52	1.59	1000+	
MW-50D2	10/11/2001	5.13	6.2	11.2	15.3	293.7	2	3.86	24.8	
MW-50J1	10/11/2001	0.19	3.9	5.5	15.0	330.8	-60	0.67	30.0	
MW-50J2	10/12/2001	0.19	4.3	6.0	16.9	184.2	-130	0.54	15.3	
MW-GF1	10/12/2001	0.02	1.2	4.9	17.2	67.7	233	8.39	519	0.0

Notes:

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
(1)	Negative indicates groundwater level during purging higher than initial water level.
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NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe^{+2} (mg/L)*
MW-52S	6/18/2002	0.11	9.7	6.57	17.1	158	130	6.90	49	
MW-52I	6/18/2002	0.02	5.6	6.61	24.4	122	156	10.04	30	
MW-52D	6/18/2002	0.00	9.7	5.69	15.8	208	200	3.01	41	
MW-57I	6/19/2002	0.60	4.8	10.94	17.7	308	40	2.08	14	
MW-57S	6/19/2002	-0.01	7.3	6.56	19.4	176	114	0.61	2.2	
MW-53I	6/20/2002	0.00	4.0	5.65	16.3	162	171	5.76	24	
MW-53D2	6/20/2002	-0.20	10.3	6.96	20.5	220	154	4.18	110	
MW-59D	6/21/2002	0.01	13.5	9.59	15.7	132	81	1.53	94	0
MW-59D1	6/21/2002	0.00	13.7	8.27	15.0	117	121	4.59	100	0
MW-59D2	6/21/2002	0.02	16.9	9.37	14.8	123	103	1.95	185	0
MW-58D	6/24/2002	0.11	14.5	6.21	20.4	112	42	1.32	45	3.0
MW-58D1	6/24/2002	0.06	30.6	6.48	20.5	127	-7	0.64	64	3.5
MW-58D2	6/24/2002	0.05	26.6	6.81	19.2	125	-121	0.65	50	2.0
MW-63S	6/25/2002	0.15	7.3	5.50	17.3	136	53	0.70	14	
MW-63I	6/26/2002	0.10	6.3	5.60	17.1	117	73	1.91	19	
MW-63D1	6/26/2002	0.07	8.3	5.76	17.4	129	57	1.79	117	
MW-63D2	6/26/2002	0.19	9.4	5.81	17.0	130	63	1.77	188	
MW-61S	6/26/2002	0.15	6.5	5.64	16.6	173	72	0.91	15	2.0
MW-61I	6/26/2002	0.10	7.3	5.56	16.9	213	85	0.36	40	
MW-61D1	6/26/2002	0.02	20.2	5.66	17.2	214	88	0.29	71	3.5
MW-61D2	6/27/2002	0.40	9.7	6.74	17.2	315	-51	0.18	40	
MW-62D	7/9/2002	4.41	3.1	9.75	22.0	312	-280	0	189	0.0

Notes:

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
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NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.2

SUMMARY OF PURGING FINAL STABILIZATION PARAMETER VALUES
NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Well	*Date Sampled*	*Drawdown from Initial Water Level (1) (feet)*	*Well Volumes Purged*	*pH (S.U.)*	*Temperature (°C)*	*Conductivity (µS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Turbidity (NTU)*	*Fe $^{+2}$ (mg/L)*
MW-62I	7/9/2002	0.09	5.1	5.46	16.5	62	91	1.53	0	2.0
MW-60D	7/9/2002	0.09	14.2	6.05	17.7	265	-49	0.69	338	5.0
MW-60I	7/9/2002	0.10	14.1	5.35	17.3	217	115	3.52	96	3.0
MW-60S	7/10/2002	0.15	6.2	5.54	16.0	236	107	4.39	43	2.6
MW-60D1	7/9/2002	0.01	8.1	6.78	17.0	249	-79	0	229	3.0
MW-64S	7/10/2002	0.06	7.1	6.91	16.3	200	-87	0.20	5.5	5.0
MW-64I	7/10/2002	0.00	5.1	6.78	16.2	209	-51	0.37	22	3.0
MW-64D	7/10/2002	0.13	4.5	6.78	16.1	206	-47	0.40	31	5.0
MW-66D2	7/10/2002	0.02	6.1	6.49	18.1	213	-16	0.61	25	5.5
MW-66I	7/11/2002	0.15	11.6	7.20	17.3	174	-97	0.36	>1000	2.5
MW-66D1	7/11/2002	0.15	6.9	7.50	17.8	192	-139	0.21	401	2.5

Notes:

NM	Not measured. Water level was below top of pump and water level measuring probe could not pass by top of pump.
(1)	Negative indicates groundwater level during purging higher than initial water level.
(2)	Wells sampled for natural attenuation parameters.
NA	Not available. The sample vial broke before a reading could be obtained.

TABLE 2.3

SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
ISOFLOW SAMPLE RESULTS
OU-3 BIOSPARGE SYSTEM - PHASE I
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

	Well Designation	*MW-81*			
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***
Chloroethane			15		
1,2-Dichloroethylene (total)		14	130	50	25
Tetrachloroethylene			130	98	56
Trichloroethylene			180	410E	280
Vinyl Chloride		150	2900E	650E	
Xylene (total)			5.7		

	Well Designation	*MW-82*				
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***	***500***
Acetone			5.9		13	5.3
Chloroethane				14		
1,1-Dichloroethylene				5.5	6.4	
1,2-Dichloroethylene (total)				28	140	
Tetrachloroethylene		5.5		160	230E	
Trichloroethylene				320E	810E	
Vinyl Chloride			19	1900E	47	

	Well Designation	*MW-83/IW-16*			
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***
Acetone			6.9	5.0	5.6
Bromoform		8.3			
Chloroform			5.3		
1,2-Dichloroethylene (total)				79	
Tetrachloroethylene				79	
Trichloroethylene				320	
Vinyl Chloride		27	140	2900	

TABLE 2.3

SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
ISOFLOW SAMPLE RESULTS
OU-3 BIOSPARGE SYSTEM - PHASE I
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

	Well Designation			*MW-84/IW-18*	
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***
Chloroethane		6.0			
1,1-Dichloroethane				7.0	
1,1-Dichloroethylene			6.6	12	10
1,2-Dichloroethylene (total)			35	24	180
1,1,1-Trichloroethane				5.9	
Tetrachloroethylene			190	87	260E
Trichloroethybene			930E	470E	1100E
Vinyl Chloride		59	1100E	55	

	Well Designation			*MW-87*	
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***
Acetone			5.4		
Chloroethane		8.2	5.9		
1,2-Dichloroethylene (total)		150	26	18	8.8
Methylene Chloride					5.1
Tetrachloroethylene		140	48	45	29
Trichloroethylene		750	180	230	86
Vinyl Chloride		670	270	99	

TABLE 2.3

SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
ISOFLOW SAMPLE RESULTS
OU-3 BIOSPARGE SYSTEM - PHASE I
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

	Well Designation	*MW-88*			
Compound (µg/L)	***Sample Depth (ft bgs)***	***310***	***350***	***400***	***450***
1,1--Dichloroethane				7.2	
1,1-Dichloroethylene				13	6.8
1,1,1-Trichloroethane				5.7	
1,2-Dichloroethylene (total)		24	67	120	130
Chloroethane			18	37	
Tetrachloroethylene		62	73	190	200E
Trichloroethylene		13	38	510E	910E
Vinyl Chloride		42	610E	1800E	5.3
Xylene (total)			10		

	Well Designation	*MW-90*			
Compound (µg/L)	***Sample Depth (ft bgs)***	***250***	***300***	***350***	***400***
1,2-Dichloroethylene (total)		16			99
Tetrachloroethylene		18		14	150
Trichloroethylene		16		13	1400
Vinyl Chloride		390E			

	Well Designation	*IW-17*			
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***
Chloroethane		14			
1,2-Dichloroethylene (total)		96	130		36
Tetrachloroethylene		90	140		80
Trichloroethylene		750	140	7.9	390E
Vinyl Chloride		540	9000	39	8.4

TABLE 2.3

SUMMARY OF DETECTED VOLATILE ORGANIC COMPOUNDS
ISOFLOW SAMPLE RESULTS
OU-3 BIOSPARGE SYSTEM - PHASE I
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

	Well Designation	***IW-19***			
Compound (µg/L)	***Sample Depth (ft bgs)***	***300***	***350***	***400***	***450***
Acetone		12			
Chloroethane			37		
1,2-Dichloroethylene (total)			34	150	20
1,1-Dichloroethylene				9.2	
Tetrachloroethylene			54	230E	50
Trichloroethylene			43	1200E	170
Vinyl Chloride			2000E	4300E	
Xylene (total)			8.9		

Note:

E - Value above quantitation range.

TABLE 2.4

WELL INSTALLATION DETAILS
OU-3 PREDIESGN ACTIVITIES
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Date Completed*	*Ground Surface (ft amsl)*	*Measuring Point Elevation (ft amsl)*	*Top of Sandpack*		*Top of Screen*		*Bottom of Screen*		*Bottom of Sandpack*		*Well Diameter (in)*	*Well Screen Slot Size*	*Well Material*
				(ft bgs)	*(ft amsl)*	*(ft bgs)*	*(ft amsl)*	*(ft bgs)*	*(ft amsl)*	*(ft bgs)*	*(ft amsl)*			
MW-58D	03/26/02	116.22	115.99	395	-278.78	400	-283.78	410	-293.78	415	-298.78	2	10	BI/SS
MW-58D1		116.22	115.99	460	-343.78	465	-348.78	475	-358.78	480	-363.78	2	10	BI/SS
MW-58D2		116.22	115.99	495	-378.78	500	-383.78	510	-393.78	515	-398.78	2	10	BI/SS
MW-59D	04/06/02	117.37	117.13	395	-277.63	400	-282.63	410	-292.63	415	-297.63	2	10	BI/SS
MW-59D1		117.37	117.13	460	-342.63	465	-347.63	475	-357.63	480	-362.63	2	10	BI/SS
MW-59D2		117.37	117.13	495	-377.63	500	-382.63	510	-392.63	515	-397.63	2	10	BI/SS
MW-60D1	03/05/02	119.02	118.70	325	-205.98	330	-210.98	340	-220.98	345	-225.98	2	10	BI/SS
MW-60S	03/08/02	118.96	118.93	175	-56.04	180	-61.04	190	-71.04	195	-76.04	2	10	BI/SS
MW-60I		118.96	118.93	225	-106.04	230	-111.04	240	-121.04	245	-126.04	2	10	BI/SS
MW-60D		118.96	118.93	275	-156.04	280	-161.04	290	-171.04	295	-176.04	2	10	BI/SS
MW-61S	02/22/02	121.19	120.91	165	-43.81	170	-48.81	180	-58.81	185	-63.81	2	10	BI/SS
MW-61I		121.19	120.91	200	-78.81	205	-83.81	215	-93.81	220	-98.81	2	10	BI/SS
MW-61D1		121.19	120.91	265	-143.81	270	-148.81	280	-158.81	285	-163.81	2	10	BI/SS
MW-61D2	03/12/02	121.15	121.05	360	-238.85	365	-243.85	375	-253.85	380	-258.85	2	10	BI/SS
MW-62D	04/20/02	128.03	127.82	325	-196.97	330	-201.97	340	-211.97	345	-216.97	2	10	BI/SS
MW-62I	05/14/02	128.27	128.15	255	-126.73	260	-131.73	270	-141.73	275	-146.73	2	10	Sch. 80 PVC
MW-63S	2/18/2002	118.67	118.45	175	-56.33	180	-61.33	190	-71.33	195	-76.33	2	10	Sch. 80 PVC
MW-63I		118.67	118.45	210	-91.33	215	-96.33	225	-106.33	230	-111.33	2	10	Sch. 80 PVC
MW-63D1		118.67	118.45	245	-126.33	250	-131.33	260	-141.33	265	-146.33	2	10	Sch. 80 PVC
MW-63D2		118.67	118.45	280	-161.33	285	-166.33	295	-176.33	300	-181.33	2	10	Sch. 80 PVC
MW-64S	02/09/02	125.66	125.59	175	-49.34	180	-54.34	190	-64.34	200	-74.34	2	10	Sch. 80 PVC
MW-64I		125.66	125.59	245	-119.34	250	-124.34	260	-134.34	265	-139.34	2	10	Sch. 80 PVC
MW-64D		125.66	125.59	285	-159.34	290	-164.34	300	-174.34	305	-179.34	2	10	Sch. 80 PVC
MW-66D2	06/08/02	118.60	118.15	450	-331.4	455	-336.4	465	-346.4	475	-356.4	2	10	BI/SS
MW-66I	06/19/02	118.27	118.20	290	-171.73	295	-176.73	305	-186.73	310	-191.73	2	10	BI/SS
MW-66D1		118.27	118.20	350	-231.73	355	-236.73	365	-246.73	320	-201.73	2	10	BI/SS

Notes:
BI - Black Steel Riser
SS - Stainless Steel Well Screen
PVC - Polyvinyl Chloride

TABLE 2.5

ANALYTICAL RESULTS SUMMARY
OU3 TASK II SAMPLING - DETECTED COMPOUNDS
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE
JUNE-JULY 2002

Sample Location:		*MW-52D*	*MW-52I*	*MW-52S*	*MW-53D2*	*MW-53I*	*MW-57I*
Sample ID:		*GW-61802-6883-LH-03*	*GW-61802-6883-LH-02*	*GW-61802-6883-LH-01*	*GW-62002-6883-LH-07*	*GW-62002-6883-LH-06*	*GW-61902-6883-LH-04*
Sample Date:		*6/18/2002*	*6/18/2002*	*6/18/2002*	*6/20/2002*	*6/20/2002*	*6/19/2002*
Sample Depth:							
Parameter	*Units*						
Volatiles							
1,1,1-Trichloroethane	ug/l				2		
1,1,2-Trichloroethane	ug/l						
1,1-Dichloroethane	ug/l	1 J					
1,1-Dichloroethene	ug/l				3.1 J		
1,2-Dichloroethene (total)	ug/l	5.6 J	7.9 J	9.6 J	8.6 J		
1,2-Dichloropropane	ug/L				11		
Acetone	ug/l		15				
Benzene	ug/L						
Carbon disulfide	ug/l						
Carbon tetrachloride	ug/l						
Chlorobenzene	ug/L						
Chloroethane	ug/l						
Chloroform (Trichloromethane)	ug/l						
Tetrachloroethene	ug/L	30	9.8 J	42	30		
Toluene	ug/l						
Trichloroethene	ug/L	30	9.4 J	19	300	1 J	1 J
Vinyl chloride	ug/l		150	46			
Xylene (total)	ug/l						

Notes:
J - Esimtated.

TABLE 2.5

ANALYTICAL RESULTS SUMMARY
OU3 TASK II SAMPLING - DETECTED COMPOUNDS
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE
JUNE-JULY 2002

Sample Location:		***MW-57S***	***MW-58***	***MW-58***	***MW-58***	***MW-59***	***MW-59***
Sample ID:		***GW-61902-6883-LH-05***	***GW-62402-6883-LH-11***	***GW-62402-6883-LH-12***	***GW-62402-6883-LH-13***	***GW-62102-6883-LH-08***	***GW-62102-6883-LH-09***
Sample Date:		***6/19/2002***	***6/24/2002***	***6/24/2002***	***6/24/2002***	***6/21/2002***	***6/21/2002***
Sample Depth:			***405 ft***	***470 ft***	***505 ft***	***405 ft***	***470 ft***
Parameter	***Units***						
Volatiles							
1,1,1-Trichloroethane	ug/l						
1,1,2-Trichloroethane	ug/l						
1,1-Dichloroethane	ug/l		1 J	2	1 J		
1,1-Dichloroethene	ug/l	1 J					
1,2-Dichloroethene (total)	ug/l	270	6.2 J	5.7 J	5.8 J		
1,2-Dichloropropane	ug/L						
Acetone	ug/l					6.5 J	
Benzene	ug/L						
Carbon disulfide	ug/l						
Carbon tetrachloride	ug/l						
Chlorobenzene	ug/L						
Chloroethane	ug/l						
Chloroform (Trichloromethane)	ug/l						
Tetrachloroethene	ug/L	53	32	31	32	4.0 J	5.2 J
Toluene	ug/l						
Trichloroethene	ug/L	330	430	470	480	85	91
Vinyl chloride	ug/l						
Xylene (total)	ug/l						

Notes:
J - Esimtated.

TABLE 2.5

ANALYTICAL RESULTS SUMMARY
OU3 TASK II SAMPLING - DETECTED COMPOUNDS
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE
JUNE-JULY 2002

Sample Location:		***MW-59***	***MW-60A***	***MW-60A***	***MW-60A***	***MW-60B***	***MW-61A***
Sample ID:		***GW-62102-6883-LH-10***	***GW-70902-6883-LH-26***	***GW-70902-6883-LH-27***	***GW-71002-6883-LH-28***	***GW-62602-6883-LH-29***	***GW-62602-6883-LH-19***
Sample Date:		***6/21/2002***	***7/9/2002***	***7/9/2002***	***7/10/2002***	***7/9/2002***	***6/26/2002***
Sample Depth:		***505 ft***	***285 ft***	***235 ft***	***190 ft***	***335 ft***	***175 ft***
Parameter	***Units***						
Volatiles							
1,1,1-Trichloroethane	ug/l		1 J	1 J	1 J	15	
1,1,2-Trichloroethane	ug/l					1 J	
1,1-Dichloroethane	ug/l		2.2 J	2.0 J	2.0 J	33	
1,1-Dichloroethene	ug/l		2	1 J	1 J	50	
1,2-Dichloroethene (total)	ug/l		2	2	2	44	3.0 J
1,2-Dichloropropane	ug/L						
Acetone	ug/l						
Benzene	ug/L						
Carbon disulfide	ug/l						
Carbon tetrachloride	ug/l					1 J	
Chlorobenzene	ug/L						
Chloroethane	ug/l						
Chloroform (Trichloromethane)	ug/l					1 J	
Tetrachloroethene	ug/L	4.8 J	11	11	7.6 J	79	2.2 J
Toluene	ug/l		3.1 J				
Trichloroethene	ug/L	89			29	2700 J	4.0 J
Vinyl chloride	ug/l						4.3 J
Xylene (total)	ug/l						

Notes:
J - Esimtated.

TABLE 2.5

ANALYTICAL RESULTS SUMMARY
OU3 TASK II SAMPLING - DETECTED COMPOUNDS
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE
JUNE-JULY 2002

Sample Location:		*MW-61A*	*MW-61A*	*MW-61A*	*MW-61B*	*MW-62A*	*MW-62B*
Sample ID:		*GW-62602-6883-LH-20*	*GW-62602-6883-LH-21*	*GW-62602-6883-LH-22*	*GW-62702-6883-LH-23*	*GW-70902-6883-LH-25*	*GW-62502-6883-LH-14*
Sample Date:		*6/26/2002*	*6/26/2002*	*6/26/2002*	*6/27/2002*	*7/9/2002*	*6/25/2002*
Sample Depth:		*175 ft*	*210 ft*	*275 ft*	*370 ft*	*270 ft*	
		Duplicate					
Parameter	*Units*						
Volatiles							
1,1,1-Trichloroethane	ug/l						
1,1,2-Trichloroethane	ug/l						
1,1-Dichloroethane	ug/l						
1,1-Dichloroethene	ug/l				4.6 J		8.0 J
1,2-Dichloroethene (total)	ug/l	3.2 J	5.0 J	4.7 J	180	32	10
1,2-Dichloropropane	ug/L						
Acetone	ug/l						
Benzene	ug/L				1.2 J		6.3 J
Carbon disulfide	ug/l						
Carbon tetrachloride	ug/l						
Chlorobenzene	ug/L					1 J	8.4 J
Chloroethane	ug/l					2.6 J	
Chloroform (Trichloromethane)	ug/l						
Tetrachloroethene	ug/L	2.3 J	2 J	2 J	100 J	93	21
Toluene	ug/l					2.9 J	9.1 J
Trichloroethene	ug/L	3.9 J	2.9 J	2.8 J	260		26
Vinyl chloride	ug/l	4.3 J	9.4 J	9.0 J	9100	27	15
Xylene (total)	ug/l				2		

Notes:
J - Esimtated.

TABLE 2.5

ANALYTICAL RESULTS SUMMARY
OU3 TASK II SAMPLING - DETECTED COMPOUNDS
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE
JUNE-JULY 2002

Sample Location:		*MW-62B*	*MW-63*	*MW-63*	*MW-63*	*MW-63*	*MW-64*
Sample ID:		*GW-70902-6883-LH-24*	*GW-62502-6883-LH-15*	*GW-62502-6883-LH-16*	*GW-62602-6883-LH-17*	*GW-62602-6883-LH-18*	*GW-71002-6883-LH-30*
Sample Date:		*7/9/2002*	*6/25/2002*	*6/25/2002*	*6/26/2002*	*6/26/2002*	*7/10/2002*
Sample Depth:		*335 ft*	*185 ft*	*220 ft*	*255 ft*	*290 ft*	*185 ft*
Parameter	*Units*						
Volatiles							
1,1,1-Trichloroethane	ug/l						
1,1,2-Trichloroethane	ug/l						
1,1-Dichloroethane	ug/l						
1,1-Dichloroethene	ug/l		1 J				
1,2-Dichloroethene (total)	ug/l	3.4 J	66	27	26	28	
1,2-Dichloropropane	ug/L						
Acetone	ug/l	16					
Benzene	ug/L						
Carbon disulfide	ug/l	3.3 J					2
Carbon tetrachloride	ug/l						
Chlorobenzene	ug/L						
Chloroethane	ug/l	1 J					
Chloroform (Trichloromethane)	ug/l						
Tetrachloroethene	ug/L	7.4 J	160	77	59 J	81	
Toluene	ug/l	1 J					
Trichloroethene	ug/L		120	80	77	93	
Vinyl chloride	ug/l	2.8 J	170	46	43	49	1.7 J
Xylene (total)	ug/l						

Notes:
J - Esimtated.

TABLE 2.5

ANALYTICAL RESULTS SUMMARY
OU3 TASK II SAMPLING - DETECTED COMPOUNDS
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE
JUNE-JULY 2002

Sample Location:		*MW-64*	*MW-64*	*MW-66A*	*MW-66A*	*MW-66B*	*MW-66B*
Sample ID:		*GW-71002-6883-LH-31*	*GW-71002-6883-LH-32*	*GW-71102-6883-LH-35*	*GW-71102-6883-LH-36*	*GW-71002-6883-LH-33*	*GW-71002-6883-LH-34*
Sample Date:		*7/10/2002*	*7/10/2002*	*7/11/2002*	*7/11/2002*	*7/10/2002*	*7/10/2002*
Sample Depth:		*255 ft*	*295 ft*	*300 ft*	*360 ft*	*460 ft*	*460 ft*
							Duplicate
Parameter	*Units*						
Volatiles							
1,1,1-Trichloroethane	ug/l					5.3 J	5.3 J
1,1,2-Trichloroethane	ug/l						
1,1-Dichloroethane	ug/l					6.0 J	6.0 J
1,1-Dichloroethene	ug/l			1 J	1 J	7.8 J	7.6 J
1,2-Dichloroethene (total)	ug/l			2.1 J	2.0 J	25	25
1,2-Dichloropropane	ug/L						
Acetone	ug/l						
Benzene	ug/L					1.3 J	1.3 J
Carbon disulfide	ug/l	5.4 J	2				
Carbon tetrachloride	ug/l						
Chlorobenzene	ug/L						
Chloroethane	ug/l					31	32
Chloroform (Trichloromethane)	ug/l						
Tetrachloroethene	ug/L			12	14	70	72
Toluene	ug/l						
Trichloroethene	ug/L			17	27	140	140
Vinyl chloride	ug/l					2100	2000
Xylene (total)	ug/l					2	2

Notes:
J - Esimtated.

TABLE 3.1

TYPICAL NATURAL ATTENUATION PARAMETERS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Parameter	*Units*	*Possible Anaerobic Conditions*	*Possible Aerobic Conditions*
Ammonia	mg/L	NA	NA
Chloride	mg/L	> 2 times background	background
Conductivity	mS/cm	NA	NA
Dissolved Hydrogen (DH)	nM	> 1	< 1
Dissolved Oxygen (DO)	mg/L	< 1	> 2
Ethane	mg/L	> 0.1	< 0.1
Ethene	mg/L	> 0.01	< 0.01
Iron (II) (Dissolved)	mg/L	> 1	< 1
Methane	mg/L	> 0.5	< 0.5
Nitrate	mg/L	< 1	> 1
Nitrite	mg/L	NA	NA
pH	S.U.	NA	NA
Phosphorus	mg/L	NA	NA
Redox Potential	mV	< 0	> 100
Sulfate	mg/L	< 20	> 20
Sulfide	mg/L	> 1	< 1
Temperature	°C	> 10	> 10
Total Alkalinity (as $CaCO_3$)	mg/L	NA	NA
Total Organic Carbon (TOC)	mg/L	> 20	< 20
Turbidity	NTU	NA	NA

Notes:

NA	Not applicable for determining if conditions are anaerobic or aerobic, but is typically included as a parameter that is analyzed to determine if biological activity is occurring.

TABLE 3.2

ANALYTICAL RESULTS SUMMARY - UPGRADIENT WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	*R-1*	*A-1*	*GM-7I*	*GM-7D*
	Collection Date:	*12/14/98*	*12/14/98*	*10/10/01*	*10/10/01*
Parameters					
	Units				
TCL Volatiles					
Tetrachloroethene	µg/L	11	ND 5	2J	4J
Trichloroethene	µg/L	ND 5	ND 5	3J	17
1,1-Dichloroethene	µg/L	ND 10	ND 10	ND 10	ND 10
cis-1,2-Dichloroethene	µg/L				
trans-1,2-Dichloroethene	µg/L				
1,2-Dichloroethene	µg/L	ND 5	ND 5	ND 10	ND 10
Vinyl chloride	µg/L	ND 2	ND 2	ND 10	ND 10
Natural Attenuation Parameters					
Total Organic Carbon (TOC)	mg/L	-	-	1.3	1.0
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	12.4	9.6
Chloride	mg/L	-	-	53.0	25.4
Dissolved Oxygen (DO)	mg/L	10.46	11.82	6.66	6.13
Oxidation Reduction Potential (ORP)	mV	+225	+241	+314	+284
Nitrate (As N)	mg/L	1.1	2.3	5.85	6.33
Nitrite (As N)	mg/L	ND 0.05J	ND 0.05	ND 0.10	ND 0.10
Ammonia (As N)	mg/L	0.14	ND 0.05	ND 0.10	ND 0.10
Phosphorus	mg/L	-	-	ND 0.05	ND 0.05
Manganese (dissolved-lab)	mg/L	0.003	0.020	0.0045J	0.0018J
Iron (dissolved-lab)	mg/L	ND 0.0166	ND 0.0166	-	-
Iron (dissolved-field)	mg/L	0.26	0.04	-	-
Sulfate	mg/L	27.9	43.1	20.5	6.2
Sulfide	mg/L	ND 0.5	ND 0.5	ND 0.5	ND 0.5
Methane	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethane	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethene	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001
pH	S.U.	5.77	5.53	4.8	4.9
Temperature	°C	12.8	14.0	16.9	16.8
Conductivity	mS/cm	0.058	0.17	252.6	116.0
Aerobic/Anaerobic Conditions	-	Aerobic	Aerobic	Aerobic	Aerobic

Notes:

-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.3

ANALYTICAL RESULTS SUMMARY - VCM SUBPLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Parameters	*Location ID:*	*MW-50D1*	*MW-50D2*	*MW50J1*	*MW50J2*	*MW52S*	*MW52I*	*MW52D*	*GM-10I*	*E-1*	*F-1*
	Collection Date:	*10/11/01*	*10/11/01*	*10/11/01*	*10/12/01*	*06/18/02*	*06/18/02*	*06/18/02*	*09/26/00*	*05/02/02*	*05/02/02*
	Units										
TCL Volatiles*											
Tetrachloroethene	μg/L	51	ND 10	ND 10	ND 10	**42**	**9.8J**	**30**	0.6J	4J	ND 5
Trichloroethene	μg/L	80	ND 10	ND 10	ND 10	**19**	**9.4J**	**30**	0.8J	2J	ND 5
1,1-Dichloroethene	μg/L	1J	ND 10	ND 10	ND 10	**ND 2**	**ND 2**	**ND 2**	ND 10	ND 10	ND 10
cis-1,2-Dichloroethene	μg/L					**8.77**	**7.18**	**5.09**			
trans-1,2-Dichloroethene	μg/L					**0.83**	**0.72**	**0.51**			
1,2-Dichloroethene	μg/L	9J	ND 10	ND 10	ND 10	**9.6J**	**7.9J**	**5.6J**	ND 10	46	2J
Vinyl chloride	μg/L	ND 10	ND 10	ND 10	ND 10	**46**	**150**	ND **1**	ND 0.2J	17	7
Natural Attenuation Parameters											
Total Organic Carbon (TOC)	mg/L	-	-	13.9	ND 1.5	ND 1.4	ND 1.1	-	ND 1.1	ND 2.1	ND 2.8
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	-	-	-	-
Chloride	mg/L	19.8	8.2	8.7	10.4	4.75	19.7	23.2	-	-	-
Dissolved Oxygen (DO)	mg/L	2.98	3.86	0.36	0.49	**6.90 (1)**	**10.04 (2)**	**3.01**	5.16	0.27	0.31
Oxidation Reduction Potential (ORP)	mV	+130	+2	-68	-79	**+130 (1)**	**+156 (2)**	**+200**	1.9	-83	-93
Nitrate (As N)	mg/L	-	-	ND 0.24	ND 0.11	ND 0.10	1.2	-	4.9	-	-
Nitrite (As N)	mg/L	-	-	0.12	ND 0.05	ND 0.05	ND 0.05	-	ND 0.05	-	-
Ammonia (As N)	mg/L	-	-	2.1	1.3	0.48	ND 0.12	-	0.49	-	-
Phosphorus	mg/L	-	-	-	-	-	-	-	-	-	-
Manganese (dissolved-lab)	mg/L	-	-	0.407	0.316	0.374	0.008	-	0.172	-	-
Iron (dissolved-lab)	mg/L	-	-	106	30.7	0.452	ND 0.0166	-	ND 0.0166	-	-
Iron (dissolved-field)	mg/L	-	-	5.2	5.45	0.47	0.05	-	NA	-	-
Sulfate	mg/L	-	-	ND 1.0	17.3	24.3	24.3	-	14.2	-	-
Sulfide	mg/L	-	-	ND 0.5	ND 0.5	ND 0.5	ND 0.5	-	ND 0.5	-	-
Methane	mg/L	-	-	13	0.430J	0.42	0.016	-	ND 0.0019	-	-
Ethane	mg/L	-	-	0.51	0.0039	0.0038	ND 0.0005	-	ND 0.0005	-	-
Ethene	mg/L	-	-	0.0017	0.055J	0.81	0.65	-	0.0016	-	-
pH	S.U.	8.3	11.2	5.5	6.0	**6.57**	**6.61**	**5.69**	11.09	6.17	-
Temperature	°C	21.9	15.3	15.0	16.9	16.9	17.2	16.5	13.8	13.3	-
Conductivity	**μS/cm**	223.5	293.7	326.3	175.7	**158**	**122**	**208**	0.71	64.6	194.4
Total Microbial Population	CFUs/mL	1.3×10^4	1.6×10^4	1.2×10^3	1.2×10^3	-	-	-	-	-	7.0×10^4
Aerobic/Anaerobic Conditions	-	Aerobic	Borderline	Anaerobic	Anaerobic	Aerobic	Aerobic	Aerobic	Aerobic	Anaerobic	Anaerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.
(1)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.5 mg/L and ORP = +680 mV which is aerobic.
(2)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.6 mg/L and ORP = +320 mV which is aerobic.

TABLE 3.3

ANALYTICAL RESULTS SUMMARY - VCM SUBPLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	*F-2*	*I-1*	*I-2*	*GM-9S*	*GM-9I*	*P-1*	*GM-23S*	*GM-23I*	*MW-61S*	*MW-61S*	*MW-61I*
	Collection Date:	*05/02/02*	*05/02/02*	*05/02/02*	*05/02/02*	*05/02/02*	*05/02/02*	*10/02/01*	*10/02/01*	*06/26/02*	*06/26/02*	*06/26/02*
Parameters											*Duplicate*	
	Units											
*TCL Volatiles**												
Tetrachloroethene	µg/L	ND 5	85	5	ND 5	ND 5	ND 5	ND 10	3J	2.2J	2.3J	2J
Trichloroethene	µg/L	ND 5	1J	ND 5	ND 5	ND 5	ND 5	ND 10	7J	4.0J	3.9J	2.9J
1,1-Dichloroethene	µg/L	ND 10	ND 10	ND 10	ND 10	ND 10	ND 10	ND 10	ND 10	ND 2	ND 2	ND 2
cis-1,2-Dichloroethene	µg/L									2.87	3.11	4.87
trans-1,2-Dichloroethene	µg/L									0.13	0.09	0.13
1,2-Dichloroethene	µg/L	ND 5	ND 5	ND 5	ND 5	ND 5	2J	ND 10	0.8J	3.0J	3.2J	5.0J
Vinyl chloride	µg/L	1J	ND 2	45	ND 2	3	ND 2	ND 0.2J	ND 0.2J	4.3J	4.3J	9.4J
Natural Attenuation Parameters												
Total Organic Carbon (TOC)	mg/L	ND 4.8	ND 1.8	ND 1.0	ND 2.0	ND 3.1	-	1.5	1.0	3.0	3.5	4.3
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	-	27.3	2.4	30.4	32.8	40.5
Chloride	mg/L	-	-	-	-	-	-	21.1	26.4	41.6	43.1	52.2
Dissolved Oxygen (DO)	mg/L	0.27	0.21	-	0.25	0.49	0.25	6.78	1.09	0.91	-	0.36
Oxidation Reduction Potential (ORP)	mV	-72	+126	-	-45	-83	-86	+228	+297	+72	-	+85
Nitrate (As N)	mg/L	-	-	-	-	-	-	10.5	5.09	0.89	0.75	0.18
Nitrite (As N)	mg/L	-	-	-	-	-	-	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10
Ammonia (As N)	mg/L	-	-	-	-	-	-	ND 0.10	0.51	1.82	1.77	1.69
Phosphorus	mg/L	-	-	-	-	-	-	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05
Manganese (dissolved-lab)	mg/L	-	-	-	-	-	-	ND 0.0021	0.072	0.206	0.212	0.259
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-	5.98	6.30	7.91
Iron (dissolved-field)	mg/L	-	-	-	-	-	-	-	-	2.0	-	-
Sulfate	mg/L	-	-	-	-	-	-	21.3	7.2	14.6	14.8	19.4
Sulfide	mg/L	-	-	-	-	-	-	ND 0.5	ND 0.5	ND 0.50	ND 0.50	ND 0.50
Methane	mg/L	-	-	-	-	-	-	ND 0.001	ND 0.001	19.0	16.0	20.0
Ethane	mg/L	-	-	-	-	-	-	ND 0.001	ND 0.001	ND 2.60	ND 5.10	ND 5.10
Ethene	mg/L	-	-	-	-	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	0.001
pH	S.U.	-	-	-	-	-	-	5.7	4.8	5.64	-	5.56
Temperature	°C	-	-	-	-	-	-	22.8	17.8	-	-	-
Conductivity	µS/cm	255.3	102	-	156.9	133.3	170.7	234.5	121.7	173	-	213
Total Microbial Population	CFUs/mL	2.0 x $10^{[illegible]}$	-	-	-	-	-	-	-	-	-	-
Aerobic/Anaerobic Conditions	-	Anaerobic	Aerobic	-	Anaerobic	Anaerobic	Anaerobic	Aerobic	Aerobic	Borderline	-	Borderline

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.
(1)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.5 mg/L and ORP = +680 mV which is aerobic.
(2)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.6 mg/L and ORP = +320 mV which is aerobic.

TABLE 3.3

ANALYTICAL RESULTS SUMMARY - VCM SUBPLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Parameters	***Location ID:*** ***Collection Date:*** ***Units***	*MW-61D1* *06/26/02*	*MW-61D2* *06/27/02*	*MW-62I* *07/09/02*	*MW-62D* *07/09/02*	*MW-63S* *06/24/02*	*MW-63I* *06/24/02*	*MW-63D1* *06/24/02*	*MW-63D2* *06/24/02*	*MW-64S* *07/10/02*	*MW-64I* *07/10/02*
TCL Volatiles*											
Tetrachloroethene	µg/L	2J	100J	93	7.4J	160	77	59J	81	ND 2	ND 2
Trichloroethene	µg/L	2.8J	260	ND 22	ND 3.5	120	80	77	93	ND 2	ND 2
1,1-Dichloroethene	µg/L	ND 2	4.6J	ND 2	ND 2	1J	ND 2	ND 2	ND 2	ND 2	ND 2
cis-1,2-Dichloroethene	µg/L	4.60	12	28	2.99	60	25	25	26	-	-
trans-1,2-Dichloroethene	µg/L	0.10	93	4.3	0.41	6.1	2.3	0.94	2.4	-	-
1,2-Dichloroethene	µg/L	4.7J	180	32	3.4J	66	27	26	28	ND 2	ND 2
Vinyl chloride	µg/L	9.0J	9100	27	2.8J	170	46	43	49	1.7J	ND 1
Natural Attenuation Parameters											
Total Organic Carbon (TOC)	mg/L	4.6	1.6	1.1	8.7	1.7	1.3	ND 1.4	ND 1.4	1.1	1.1
Total Alkalinity (as $CaCO_3$)	mg/L	42.6	46.5	11.5	182	35.8	25.2	17.2	21.2	16.2	16.2
Chloride	mg/L	51.3	38.7	19.3	19.9	24.9	24.0	24.2	26.2	49.9	49.9
Dissolved Oxygen (DO)	mg/L	0.29	0.18	1.53	0	0.70	1.91	1.79	1.77	0.20	0.37
Oxidation Reduction Potential (ORP)	mV	+88	-51	+91	-280	+53	+73	+57	+63	-87	-51
Nitrate (As N)	mg/L	0.30	1.57	ND 0.10	ND 0.10	1.99	2.25	2.15	2.17	ND 0.10	ND 0.10
Nitrite (As N)	mg/L	ND 0.10	ND 0.10	ND 0.10	ND 0.10	0.21	0.13	0.12	0.10	ND 0.10	ND 0.10
Ammonia (As N)	mg/L	1.55	0.65	0.15	1.14	0.55	0.26	0.30	0.29	0.56	0.54
Phosphorus	mg/L	ND 0.05	ND 0.05	ND 0.05	0.18	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05
Manganese (dissolved-lab)	mg/L	0.240	0.201	0.071	0.007	0.280	0.231	0.185	0.195	0.943	0.891
Iron (dissolved-lab)	mg/L	6.62	15.7	1.69	0.035	16.0	9.19	7.61	7.88	15.2	15.6
Iron (dissolved-field)	mg/L	3.5	-	2.0	0.0	-	-	-	-	5.0	3.0
Sulfate	mg/L	20.4	5.8	10	182	24.2	20.5	19.9	19.9	8.4	8.8
Sulfide	mg/L	ND 0.50	ND 0.50	ND 0.50	0.8	ND 0.50	ND 0.50	ND 0.50	ND 0.50	ND 0.50	ND 0.50
Methane	mg/L	30.0	0.86	3.60	5.60	1.20	0.66	0.38	2.20	0.056	0.049
Ethane	mg/L	ND 5.10	ND 0.26	ND 2.00	0.200J	5.4	1.8	2.5	2.4	ND 0.001	ND 0.001
Ethene	mg/L	0.0012	1.50	0.007	ND 1.00	0.0022	ND 0.001	0.0012	0.0011	ND 0.001	ND 0.001
pH	S.U.	5.66	6.74	5.46	9.75	5.50	5.60	5.76	5.81	6.91	6.78
Temperature	°C	-	-	-	-	-	-	-	-	-	-
Conductivity	µS/cm	214	315	62	312	136	117	129	130	200	209
Total Microbial Population	CFUs/mL	-	-			-	-	-	-	-	-
Aerobic/Anaerobic Conditions	-	Borderline	Anaerobic	Borderline	Anaerobic	Borderline	Borderline	Borderline	Borderline	Anaerobic	Anaerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.
(1)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.5 mg/L and ORP = +680 mV which is aerobic.
(2)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.6 mg/L and ORP = +320 mV which is aerobic.

TABLE 3.3

ANALYTICAL RESULTS SUMMARY - VCM SUBPLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	*MW-64D*	*MW-66I*	*MW-66D1*	*MW-66D2*
	Collection Date:	*07/10/02*	*07/11/02*	*07/11/02*	*07/10/02*
Parameters					
	Units				
TCL Volatiles*					
Tetrachloroethene	µg/L	ND 2	12	17	70
Trichloroethene	µg/L	ND 2	17	27	140
1,1-Dichloroethene	µg/L	ND 2	1J	1J	7.8J
cis-1,2-Dichloroethene	µg/L	-	2.0		24
trans-1,2-Dichloroethene	µg/L	-	0.11		0.92
1,2-Dichloroethene	µg/L	ND 2	2.1J	2.0J	25
Vinyl chloride	µg/L	ND 1	ND 1	ND 1	2100
Natural Attenuation Parameters					
Total Organic Carbon (TOC)	mg/L	1.1	1.3	1.2	1.9
Total Alkalinity (as $CaCO_3$)	mg/L	16.4	37.8	42.4	48.4
Chloride	mg/L	49.8	23.6	24.3	29.6
Dissolved Oxygen (DO)	mg/L	0.40	0.36	0.21	0.61
Oxidation Reduction Potential (ORP)	mV	-47	-97	-139	-16
Nitrate (As N)	mg/L	ND 0.10	3.66	3.50	3.38
Nitrite (As N)	mg/L	ND 0.10	0.25	0.32	0.14
Ammonia (As N)	mg/L	0.55	1.67	0.78	0.15
Phosphorus	mg/L	ND 0.05	0.21	0.14	ND 0.05
Manganese (dissolved-lab)	mg/L	0.911	0.151	0.205	0.115
Iron (dissolved-lab)	mg/L	15.8	2.81	4.60	19.0
Iron (dissolved-field)	mg/L	5.0	2.5	2.5	5.5
Sulfate	mg/L	9.6	15.5	7.7	5.7
Sulfide	mg/L	ND 0.50	ND 0.50	ND 0.50	ND 0.50
Methane	mg/L	0.042J	2.8	3.0	14.0
Ethane	mg/L	ND 0.001	ND 2.6	ND 2.6	ND 2.6
Ethene	mg/L	ND 0.001	0.001	ND 0.001	0.5J
pH	S.U.	6.78	7.20	7.50	6.49
Temperature	°C	-	-	-	-
Conductivity	µS/cm	206	174	192	213
Total Microbial Population	CFUs/mL	-	-	-	-
Aerobic/Anaerobic Conditions	-	Anaerobic	Anaerobic	Anaerobic	Anaerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.
(1)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.5 mg/L and ORP = +680 mV which is aerobic.
(2)	Values were obtained after air injection testing. Third Quarter 2000 values were DO = 0.6 mg/L and ORP = +320 mV which is aerobic.

TABLE 3.4

ANALYTICAL RESULTS SUMMARY - PCE/TCE PLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	***GM-12I***	***GM-13D***	***GM-16S***	***GM-16SR***	***GM-16I***	***GM-17S***	***GM-17SR***	***GM-17I***	***GM-17D***	***GM-18S***	***GM-18I***	***GM-18D***
	Collection Date:	***10/10/01***	***01/10/02***	***03/13/00***	***01/02/02***	***12/19/01***	***07/06/00***	***12/07/01***	***12/27/01***	***12/27/01***	***01/02/02***	***12/13/01***	***01/10/02***
Parameters													
	Units												
TCL Volatiles*													
Tetrachloroethene	µg/L	7J	820	ND 10	ND 5J	4J	ND 10	ND 5	ND 5	ND 5	ND 5J	ND 5	ND 5
Trichloroethene	µg/L	15	270	ND 10	ND 5	22	ND 10	ND 5	ND 5	ND 5	4J	1J	1J
1,1-Dichloroethene	µg/L	ND 10	100J	ND 10	ND 5	1J	ND 10	ND 5	ND 5	ND 5	ND 5	ND 5	ND 5
cis-1,2-Dichloroethene	µg/L		210		ND 5	2J		ND 5	ND 5	ND 5	0.5J	ND 5	ND 5
trans-1,2-Dichloroethene	µg/L		ND 50							ND 5			ND 5
1,2-Dichloroethene	µg/L	3J	230	ND 10	ND 10	2J	ND 10	ND 10	ND 10	ND 10	ND 10	ND 10	ND 5
Vinyl chloride	µg/L	ND 10	ND 20	ND 1	ND 2	ND 2	ND 0.3	ND 2	ND 2	ND 2	ND 2	ND 2	ND 2
Natural Attenuation Parameters													
Total Organic Carbon (TOC)	mg/L	1.2	1.1	-	1.4	1.4	-	ND 1.0	1.2	ND 1.0	ND 1.0	ND 1.0	ND 1.0
Total Alkalinity (as $CaCO_3$)	mg/L	ND 1.0	16.2	-	2.7	47.7	-	2.4	2.6	ND 1.0	10.9	1.4	2.2
Chloride	mg/L	53.2	23.1	-	10.9	54.4	-	16.9	16.3	17.9	13.2	13	22.5
Dissolved Oxygen (DO)	mg/L	7.48	0.34	-	8.18	1.11	-	8.09	6.42	6.79	8.28	10.72	9.64
Oxidation Reduction Potential (ORP)	mV	+432	+311	-	+251	+191	-	+165	+193	+263	+124	+336	+263
Nitrate (As N)	mg/L	4.44	5.01	-	1.89	3.77	-	5.39	5.44	5.04	4.27	4.7	4.34
Nitrite (As N)	mg/L	ND 0.10	0.35	-	ND 0.10	ND 0.10	-	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10
Ammonia (As N)	mg/L	ND 0.10	1.21	-	ND 0.10	ND 0.10	-	ND 0.10	ND 0.10	ND 0.10	0.12	0.16	0.21
Phosphorus	mg/L	ND 0.05	ND 0.05	-	ND 0.05	ND 0.05	-	ND 0.05	ND 0.05	ND 0.05	0.13	ND 0.05	ND 0.05
Manganese (dissolved-lab)	mg/L	0.0488	0.009	-	ND 0.0044	0.119	-	ND 0.0012	ND 0.0059	ND 0.0044	0.038	0.0014	0.0093
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-
Iron (dissolved-field)	mg/L	0.0	0.0	-	0.0	0.0	-	0.0	0.0	0.0	1.1	0.0	0.1
Sulfate	mg/L	34.4	30.5	-	29.5	34.9	-	5.5	5.6	ND 5.0	8.2	ND 5.0	73.5
Sulfide	mg/L	ND 0.5	ND 0.5	-	ND 0.5	ND 0.5	-	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5
Methane	mg/L	ND 0.001	ND 0.001	-	ND 0.001	ND 0.001	-	ND 0.001	ND 0.001	ND 0.001	0.007	ND 0.001	ND 0.001
Ethane	mg/L	ND 0.001	ND 0.001	-	ND 0.001	ND 0.001	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethene	mg/L	ND 0.001	ND 0.001	-	ND 0.001	ND 0.001	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
pH	S.U.	3.5	4.6	-	5.2	6.7	-	6.0	5.8	4.9	4.7	4.4	4.5
Temperature	°C	16.3	15.5	-	21.4	19.3	-	21.9	22.6	21.9	17.5	16.5	19.2
Conductivity	**µS/cm**	237.8	186	-	91.2	326.4	-	84.5	87.7	80.5	90.3	73.7	90.3
Aerobic/Anaerobic Conditions	-	Aerobic	Aerobic	-	Aerobic	Aerobic	-	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.4

ANALYTICAL RESULTS SUMMARY - PCE/TCE PLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Parameters	*Location ID:*	*HN24I*	*HN29I*	*HN29D*	*FW-3*	*MW-1GF*	*MW-1GF*	*10631*	*ONCT-1*	*MW-58D*	*MW-58D1*	*MW-58D2*	*MW-59D*	*MW-59D1*
	Collection Date:	*01/03/02*	*01/03/02*	*01/03/02*	*01/03/02*	*10/12/01*	*10/12/01*	*01/01/02*	*01/23/02*	*06/24/02*	*06/24/02*	*06/24/02*	*06/21/02*	*06/21/02*
							Duplicate							
	Units													
*TCL Volatiles**														
Tetrachloroethene	µg/L	10	0.9J	0.6J	29	ND 10	ND 10	ND 5J	ND 50	32	31	32	4.0J	5.2J
Trichloroethene	µg/L	160	2J	1J	33	ND 10	ND 10	0.8J	1100	430	470	480	85	91
1,1-Dichloroethene	µg/L	14	ND 5	ND 10	ND 5	ND 10	ND 10	ND 5	ND 50	ND 2	ND 2	ND 2	ND 2	ND 2
cis-1,2-Dichloroethene	µg/L	17	ND 5		0.7J					5.68	5.23	5.26	-	-
trans-1,2-Dichloroethene	µg/L	0.5J	ND 5							0.52	0.47	0.54	-	-
1,2-Dichloroethene	µg/L	20	ND 10	ND 10	ND 10	ND 10	ND 10	ND 10	ND 100	6.2J	5.7J	5.8J	ND 2	ND 2
Vinyl chloride	µg/L	ND 2	ND 2	ND 2	ND 2	ND 10	ND 10	ND 2	ND 20	ND 1	ND 1	ND 1	ND 1	ND 1
Natural Attenuation Parameters														
Total Organic Carbon (TOC)	mg/L	ND 1.0	ND 1.0	ND 1.0	ND 1.0	ND 1.0	1.4	-	-	1.1	1.1	1.1	1.0	1.0
Total Alkalinity (as $CaCO_3$)	mg/L	31.8	62.1	24.1	25.4	1.2	1.5	-	-	10.6	13.6	10.9	17.6	12.4
Chloride	mg/L	22.0	14.4	11.9	17.6	17.6	17.7	-	-	18.4	20.8	20.8	12.7	12.3
Dissolved Oxygen (DO)	mg/L	4.08	10.18	11.05	7.61	8.39	-	-	-	1.32	0.64	0.65	1.53	4.59
Oxidation Reduction Potential (ORP)	mV	+283	+104	+138	+256	+233	-	-	-	+42	-7	-121	+81	+121
Nitrate (As N)	mg/L	5.95	5.83	4.57	7.16	4.78	4.89	-	-	4.06	3.71	3.83	4.10	4.62
Nitrite (As N)	mg/L	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10	-	-	0.19	0.30	0.26	0.12J	ND 0.10J
Ammonia (As N)	mg/L	ND 0.10	ND 0.10	ND 0.10	0.14	ND 0.10	ND 0.10	-	-	0.21	0.32	0.33	0.37	0.16
Phosphorus	mg/L	ND 0.05	ND 0.05	0.08	ND 0.05	ND 0.05	0.09	-	-	ND 0.05	ND 0.05	0.37	ND 0.05	ND 0.05
Manganese (dissolved-lab)	mg/L	0.0054	0.0014	ND 0.0011	ND 0.0011	0.0042	0.0038	-	-	0.104	0.178	0.160	0.005	0.065
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-	3.08	6.44	5.91	0.018	0.016
Iron (dissolved-field)	mg/L	0.0	0.0	0.0	0.0	0.0	-	-	-	3.0	3.5	2.0	0.0	0.0
Sulfate	mg/L	19.8	ND 5.0	6.4	10.2	7.5	9.7	-	-	ND 5.0	ND 5.0	ND 5.0	9.7	12.6
Sulfide	mg/L	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	-	-	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5
Methane	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethane	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethene	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
pH	S.U.	3.4	7.9	7.2	4.0	4.9	-	-	-	6.21	6.48	6.81	9.59	8.27
Temperature	°C	15.6	18.8	18.8	17.7	17.2	-	-	-	-	-	-	-	-
Conductivity	µS/cm	181	278	110	155	67.7	-	-	-	112	127	125	132	117
Aerobic/Anaerobic Conditions	-	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	-	-	-	Borderline	Anaerobic	Anaerobic	Aerobic	Aerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.4

ANALYTICAL RESULTS SUMMARY - PCE/TCE PLUME WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Parameters	***Location ID:***	*MW-59D2*	*MW-60S*	*MW-60I*	*MW-60D*	*MW-60D1*
	Collection Date:	*06/21/02*	*07/10/02*	*07/09/02*	*07/09/02*	*07/09/02*
	Units					
TCL Volatiles*						
Tetrachloroethene	μg/L	4.8J	7.6J	11	11	79
Trichloroethene	μg/L	89	29	ND 37	ND 75	2700J
1,1-Dichloroethene	μg/L	ND 2	1J	1J	2	50
cis-1,2-Dichloroethene	μg/L	-				
trans-1,2-Dichloroethene	μg/L	-				
1,2-Dichloroethene	μg/L	ND 2	2	2	2	44
Vinyl chloride	μg/L	ND 1	ND 1	ND 1	ND 1	ND 1
Natural Attenuation Parameters						
Total Organic Carbon (TOC)	mg/L	1.1	1.2	1.2	1.2	1.3
Total Alkalinity (as $CaCO_3$)	mg/L	16.2	11.6	21.8	43.2	36.6
Chloride	mg/L	13.0	43.5	45.3	46.9	27.6
Dissolved Oxygen (DO)	mg/L	1.37	4.39	3.52	0.69	0
Oxidation Reduction Potential (ORP)	mV	+103	+107	+115	-49	-79
Nitrate (As N)	mg/L	4.48	5.21	5.27	3.77	10.6
Nitrite (As N)	mg/L	ND 0.10J	ND 0.1	ND 0.1	0.18	ND 0.1
Ammonia (As N)	mg/L	0.23	0.20	0.23	1.19	0.70
Phosphorus	mg/L	0.18	ND 0.05	ND 0.05	ND 0.05	ND 0.05
Manganese (dissolved-lab)	mg/L	0.015	0.057	0.092	0.175	0.269
Iron (dissolved-lab)	mg/L	0.014	2.5	6.45	18.1	10.2
Iron (dissolved-field)	mg/L	0.0	2.6	3.0	5.0	3.0
Sulfate	mg/L	19.5	24.8	24.7	23.5	18.0
Sulfide	mg/L	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5
Methane	mg/L	ND 0.001	ND 0.001	ND 0.001	ND 0.001	0.003
Ethane	mg/L	ND 0.001	ND 0.001	ND 0.001	0.002	0.01
Ethene	mg/L	ND 0.001	ND 0.001	ND 0.001	0.002	ND 0.001
pH	S.U.	9.37	5.54	5.35	6.05	6.78
Temperature	°C	-	-	-	-	-
Conductivity	μS/cm	127	236	217	265	249
Aerobic/Anaerobic Conditions	-	Aerobic	Aerobic	Aerobic	Anaerobic	Anaerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.5

ANALYTICAL RESULTS SUMMARY - BOUNDARY WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	*GM-14*	*GM-15S*	*GM-15I*	*GM-15D*	*GM-15D2*	*GM-20I*	*GM-20D*	*GM-21S*	*GM-21I*	*GM-21D*	*GM-33D2*	*GM-73D2*	*GM-74I*
	Collection Date:	*10/02/00*	*12/19/01*	*12/18/01*	*12/19/01*	*12/19/01*	*12/12/01*	*12/13/01*	*01/03/02*	*12/12/01*	*01/10/02*	*01/15/02*	*01/04/02*	*01/04/02*
Parameters	*Units*													
*TCL Volatiles**														
Tetrachloroethene	µg/L	ND 10	ND 5	ND 5	7J	14	ND 5	ND 5	ND 5	ND 5	ND 5	11J	ND 50	ND 5
Trichloroethene	µg/L	ND 10	9J	19	11	16	ND 5	ND 5	ND 5	ND 5	0.8J	240	940	ND 5
1,1-Dichloroethene	µg/L	ND 10	ND 5	ND 5	5J	0.9J	ND 5	ND 5	ND 5	ND 5	ND 5	ND 10	ND 50	ND 5
cis-1,2-Dichloroethene	µg/L			2J	0.6J		ND 5	ND 5	ND 5	ND 5	ND 5			ND 5
trans-1,2-Dichloroethene	µg/L													
1,2-Dichloroethene	µg/L	ND 10	1J	ND 10	1J	0.6J	ND 10	ND 10	ND 10	ND 10	ND 10	5J	7J	ND 10
Vinyl chloride	µg/L	ND 0.2	ND 2	ND 2	ND 2	ND 0.2J	ND 2	ND 2	ND 2	ND 2	ND 2	ND 4	ND 20	ND 2
Natural Attenuation Parameters														
Total Organic Carbon (TOC)	mg/L	-	-	-	-	-	ND 1.0	ND 1.0	ND 1.0	ND 1.0	ND 1.0	ND 1.0	ND 1.0	ND 1.0
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	-	-	-	54.8	2.7	4.0	17.5	17.5	2.2	4.4	1.9
Chloride	mg/L	-	-	-	-	-	12.8	10	11.4	15.5	15.5	12.5	14.7	10.8
Dissolved Oxygen (DO)	mg/L	-	-	-	-	-	12.05	11.97	11.119	10.05	10.05	9.46	4.89	12.74
Oxidation Reduction Potential (ORP)	mV	-	-	-	-	-	+82	+263	+151	+185	+185	+291	+247	+265
Nitrate (As N)	mg/L	-	-	-	-	-	4.4	4.64	4.6	4.52	4.52	4.37	5.85	4.57
Nitrite (As N)	mg/L	-	-	-	-	-	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10	ND 0.10
Ammonia (As N)	mg/L	-	-	-	-	-	0.29	0.32	0.13	ND 0.10	ND 0.10	ND 0.10	0.29	1.29
Phosphorus	mg/L	-	-	-	-	-	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05	0.09
Manganese (dissolved-lab)	mg/L	-	-	-	-	-	ND 0.0011	0.0026	0.0065	ND 0.0011	ND 0.0011	0.0014	0.012	0.0149
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-	-	-	-	-	-
Iron (dissolved-field)	mg/L	-	-	-	-	-	0.1	0.0	0.0	0.0	0.0	0.0	0.8	0.0
Sulfate	mg/L	-	-	-	-	-	19.5	ND 5.0	5.0	ND 5.0	ND 5.0	ND 5.0	28.8	8.6
Sulfide	mg/L	-	-	-	-	-	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5
Methane	mg/L	-	-	-	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethane	mg/L	-	-	-	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
Ethene	mg/L	-	-	-	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001
pH	S.U.	-	-	-	-	-	8.8	4.9	4.8	6.0	6.0	4.4	4.4	4.7
Temperature	°C	-	-	-	-	-	11.3	14.1	20.0	13.5	13.5	17.3	17.4	15.1
Conductivity	µS/cm	-	-	-	-	-	215	61.2	72.4	114	114	68.1	96.1	67.3
Aerobic/Anaerobic Conditions	-	-	-	-	-	-	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.5

ANALYTICAL RESULTS SUMMARY - BOUNDARY WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	*GM-74D*	*GM-74D2*	*ONCT-2*	*ONCT-3*	*MW-53I*	*MW-53D2*	*MW-57S*	*MW-57I*
	Collection Date:	*01/04/02*	*01/04/02*	*10/16/00*	*10/16/00*	*06/20/02*	*06/20/02*	*06/19/02*	*06/19/02*
Parameters	*Units*								
*TCL Volatiles**									
Tetrachloroethene	µg/L	2J	2J	11J	13	**ND 2**	**30**	**53**	**ND 2**
Trichloroethene	µg/L	32	3J	200	16	**1J**	**300**	**330**	**1J**
1,1-Dichloroethene	µg/L	ND 10	0.6J	3J	1J	**ND 2**	**3.1J**	**1J**	**ND 2**
cis-1,2-Dichloroethene	µg/L					**-**	**7.89**	**246**	**-**
trans-1,2-Dichloroethene	µg/L					**-**	**0.71**	**24**	**-**
1,2-Dichloroethene	µg/L	1J	ND 10	2J	1J	**ND 2**	**8.6J**	**270**	**ND 2**
Vinyl chloride	µg/L	ND 2	ND 2	ND 0.4	ND 0.2	**ND 1**	**ND 1**	**ND 1**	**ND 1**
Natural Attenuation Parameters									
Total Organic Carbon (TOC)	mg/L	ND 1.0	ND 1.0	-	-	-	-	-	-
Total Alkalinity (as $CaCO_3$)	mg/L	1.2	1.7	-	-	-	-	-	-
Chloride	mg/L	10.3	4.6	-	-	-	-	-	-
Dissolved Oxygen (DO)	mg/L	5.76	4.15	-	-	**5.76**	**4.18**	**0.61**	**2.08**
Oxidation Reduction Potential (ORP)	mV	+340	+300	-	-	**+171**	**+154**	**+114**	**+40**
Nitrate (As N)	mg/L	3.24	2.28	-	-	-	-	-	-
Nitrite (As N)	mg/L	ND 0.10	ND 0.10	-	-	-	-	-	-
Ammonia (As N)	mg/L	0.23	0.23	-	-	-	-	-	-
Phosphorus	mg/L	ND 0.05	ND 0.05	-	-	-	-	-	-
Manganese (dissolved-lab)	mg/L	0.0051	0.0030	-	-	-	-	-	-
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-
Iron (dissolved-field)	mg/L	0.0	0.1	-	-	-	-	-	-
Sulfate	mg/L	7.8	11	-	-	-	-	-	-
Sulfide	mg/L	ND 0.5	ND 0.5	-	-	-	-	-	-
Methane	mg/L	ND 0.001	ND 0.001	-	-	-	-	-	-
Ethane	mg/L	ND 0.001	ND 0.001	-	-	-	-	-	-
Ethene	mg/L	ND 0.001	ND 0.001	-	-	-	-	-	-
pH	S.U.	4.1	4.2	-	-	**5.65**	**6.96**	**6.56**	**10.94**
Temperature	°C	16.2	15.5	-	-	-	-	-	-
Conductivity	µS/cm	59.3	34.2	-	-	**162**	**220**	**176**	**308**
Aerobic/Anaerobic Conditions	-	Aerobic	Aerobic	-	-	**Aerobic**	**Aerobic**	**Borderline**	**Aerobic**

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.6

ANALYTICAL RESULTS SUMMARY - DOWNGRADIENT WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Parameters	*Location ID:* *Collection Date:* ***Units***	***GM-34D*** ***01/08/02***	***GM-34D2*** ***01/08/02***	***GM-35D2*** ***01/15/02***	***GM-36D*** ***12/18/01***	***GM-36D2*** ***12/18/01***	***GM-37D*** ***06/01/01***	***GM-37D2*** ***01/14/02***	***GM-38D*** ***12/14/01***	***GM-38D2*** ***12/14/01***
TCL Volatiles*										
Tetrachloroethene	µg/L	8J	13	4J	2J	ND 5	ND 5	ND 5	ND 50	ND 50
Trichloroethene	µg/L	190	110	320	30	ND 5	0.5J	3J	840	1600
1,1-Dichloroethene	µg/L	5J	5J	2J	ND 5	ND 5	3J	ND 5	6J	ND 50
cis-1,2-Dichloroethene	µg/L	5J			ND 5		ND 5			
trans-1,2-Dichloroethene	µg/L									
1,2-Dichloroethene	µg/L	4J	4J	5J	ND 10	ND 10	ND 10	ND 10	2J	10J
Vinyl chloride	µg/L	ND 2	ND 2	ND 2	ND 2	ND 2	ND 2	ND 2	ND 20	ND 20
Natural Attenuation Parameters										
Total Organic Carbon (TOC)	mg/L	-	-	ND 1.0	ND 1.0	ND 1.0	ND 1.0	ND 1.0	-	-
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	2.0	2.4	37.4	1.0	1.8	-	-
Chloride	mg/L	-	-	8.0	13.0	4.9	15.6	20.4	-	-
Dissolved Oxygen (DO)	mg/L	0.5	3.4	6.85	14.67	9.22	4.66	6.21	-	-
Oxidation Reduction Potential (ORP)	mV	-40	+60	+384	+105	+329	+443	+451	-	-
Nitrate (As N)	mg/L	-	-	4.64	1.99	2.69	9.65	15	-	-
Nitrite (As N)	mg/L	-	-	ND 0.10	ND 0.10	0.15	ND 0.10	ND 0.10	-	-
Ammonia (As N)	mg/L	-	-	0.93	ND 0.10	0.29	ND 0.10	0.24	-	-
Phosphorus	mg/L	-	-	ND 0.05	ND 0.05	ND 0.05	ND 0.05	ND 0.05	-	-
Manganese (dissolved-lab)	mg/L	-	-	0.0033	0.0024	0.0013	0.0075	0.0075	-	-
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-	-
Iron (dissolved-field)	mg/L	-	-	0.0	0.0	0.0	0.0	0.0	-	-
Sulfate	mg/L	-	-	13.8	ND 5.0	6.4	14.9	ND 5.0	-	-
Sulfide	mg/L	-	-	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	-	-
Methane	mg/L	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-	-
Ethane	mg/L	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-	-
Ethene	mg/L	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-	-
pH	S.U.	8.8	5.2	4.2	8.0	4.3	4.0	4.0	-	-
Temperature	°C	18.5	18.0	16.4	14.3	14.6	14.7	14.7	-	-
Conductivity	mS/cm	155	80	84.9	96.3	71.6	160	151	-	-
Aerobic/Anaerobic Conditions	-	Anaerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	Aerobic	-	-

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.6

ANALYTICAL RESULTS SUMMARY - DOWNGRADIENT WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

	Location ID:	***GM-70D2***	***GM-71D2***	***GM-75D2***	***GM-78S***	***GM-78I***	***N10627***	***N-09921***	***10634***
	Collection Date:	***12/17/01***	***12/17/01***	***12/26/01***	***01/08/02***	***01/09/02***	***12/26/01***	***10/10/01***	***12/26/01***
Parameters									
	Units								
TCL Volatiles*									
Tetrachloroethene	µg/L	6J	ND 5	33J	ND 5	ND 5	ND 5	ND 10	ND 5
Trichloroethene	µg/L	100	ND 5	1300	6J	7J	5J	ND 10	ND 5
1,1-Dichloroethene	µg/L	0.5J	ND 5	56J	ND 5	ND 5	ND 5	ND 10	ND 5
cis-1,2-Dichloroethene	µg/L				1J	ND 5	0.5J		
trans-1,2-Dichloroethene	µg/L								
1,2-Dichloroethene	µg/L	2J	ND 10	6J	-	ND 5	ND 10	ND 10	ND 10
Vinyl chloride	µg/L	ND 2	ND 2	ND 20	ND 2	ND 2	ND 2	ND 10	ND 2
Natural Attenuation Parameters									
Total Organic Carbon (TOC)	mg/L	-	-	ND 1.0	ND 1.0	ND 1.0	8.5	1.8	-
Total Alkalinity (as $CaCO_3$)	mg/L	-	-	1.1	6.3	6.6	57.7	45.4	-
Chloride	mg/L	-	-	14.0	54.5	90.6	11.0	158	-
Dissolved Oxygen (DO)	mg/L	-	-	5.43	9.67	10.43	0.03	0.76	-
Oxidation Reduction Potential (ORP)	mV	-	-	+289	+288	+288	-288	-36	-
Nitrate (As N)	mg/L	-	-	5.99	7.82	6.77	1.38	3.14	-
Nitrite (As N)	mg/L	-	-	ND 0.10	ND 0.10	ND 0.10	0.16	ND 0.10	-
Ammonia (As N)	mg/L	-	-	0.14	0.45	0.12	1.45	0.18	-
Phosphorus	mg/L	-	-	ND 0.05	ND 0.05	ND 0.05	0.4	ND 0.5	-
Manganese (dissolved-lab)	mg/L	-	-	0.0031	0.0101	0.0029	148?	0.814	-
Iron (dissolved-lab)	mg/L	-	-	-	-	-	-	-	-
Iron (dissolved-field)	mg/L	-	-	0.2	0.1	0.0	3.0	0.6	-
Sulfate	mg/L	-	-	10.2	10.2	6.5	225	43.5	-
Sulfide	mg/L	-	-	ND 0.5	ND 0.5	ND 0.5	ND 0.5	ND 0.5	-
Methane	mg/L	-	-	ND 0.001	ND 0.001	ND 0.001	2800D	1100D	-
Ethane	mg/L	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-
Ethene	mg/L	-	-	ND 0.001	ND 0.001	ND 0.001	ND 0.001	ND 0.001	-
pH	S.U.	-	-	4.2	4.5	4.6	6.6	5.9	-
Temperature	°C	-	-	16.9	19.2	17.7	18.3	16.7	-
Conductivity	mS/cm	-	-	108	217	320	76.7	705.8	-
Aerobic/Anaerobic Conditions	-	-	-	Aerobic	Aerobic	Aerobic	Anaerobic	Anaerobic	-

Notes:

*	Data shown are from most recent sampling event, which may be earlier than collection date shown in header.
-	Not measured or not applicable.
J	Estimated.
NDx	Not detected at or above x.
TCL	Target Compound List.

TABLE 3.7

SUMMARY OF PCE, TCE, 1,2-DCE AND VCM PRESENCE IN WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

Upgradient Wells

Well	*PCE*	*TCE*	*1,2-DCE*	*VCM*
A-1				
R-1	Y			
GM-7I	Y	Y		
GM-7D	Y	Y		

VCM Subplume Wells

Well	*PCE*	*TCE*	*1,2-DCE*	*VCM*
MW-50J1				
MW-50J2				
MW-50D1	Y	Y	Y	
MW-50D2				
MW-52S	Y	Y	Y	Y
MW-52I	Y	Y	Y	Y
MW-52D	Y	Y	Y	
GM-10I	Y	Y		
E-1	Y	Y	Y	Y
F-1			Y	Y
I-1	Y	Y		
I-2	Y			Y
F2				Y
GM-9S				
GM-9I				Y
P-1			Y	
GM23S				
GM-23I	Y	Y	Y	
MW-61S	Y	Y	Y	Y
MW-61I	Y	Y	Y	Y
MW-61D1	Y	Y	Y	Y
MW-61D2	Y	Y	Y	Y
MW-62I	Y		Y	Y
MW-62D	Y		Y	Y
MW-63S	Y	Y	Y	Y
MW-63I	Y	Y	Y	Y
MW-63D1	Y	Y	Y	Y
MW-63D2	Y	Y	Y	Y
MW-64S				Y

TABLE 3.7

SUMMARY OF PCE, TCE, 1,2-DCE AND VCM PRESENCE IN WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

VCM Subplume Wells

MW-64I				
MW-64D				
MW-66I	Y	Y	Y	
MW-66D1	Y	Y	Y	
MD-66D2	Y	Y	Y	Y

PCE/TCE Plume Wells

Well	*PCE*	*TCE*	*1,2-DCE*	*VCM*
GM-12I	Y	Y	Y	
GM-13D	Y	Y	Y	
GM-16S				
GM-16I	Y	Y	Y	
GM-17S				
GM-17I				
GM-17D				
GM-18S		Y	Y	
GM-18I		Y		
GM-18D		Y		
HN-24I	Y	Y	Y	Y
HN-29I	Y	Y		
HN-29D	Y	Y		
FW-3	Y	Y	Y	
N10631		Y		
ONCT-1		Y		
MW-1GF				
MW-58D	Y	Y	Y	
MW-58D1	Y	Y	Y	
MW-58D2	Y	Y	Y	
MW-59D	Y	Y		
MW-59D1	Y	Y		
MW-59D2	Y	Y		
MW-60S	Y	Y	Y	
MW-60I	Y		Y	
MW-60D	Y		Y	
MW-60D1	Y	Y	Y	

TABLE 3.7

SUMMARY OF PCE, TCE, 1,2-DCE AND VCM PRESENCE IN WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

PCE/TCE Plume Boundary Wells

Well	*PCE*	*TCE*	*1,2-DCE*	*VCM*
GM-14				
GM-15S		Y		
GM-15I		Y		
GM-15D	Y	Y		
GM-15D2	Y	Y		
GM-20I				
GM-20D				
GM-21S				
GM-21I				
GM-21D		Y		
GM-33D2	Y	Y	Y	
GM-73D2		Y	Y	
GM-74I				
GM-74D	Y	Y	Y	
GM-74D2	Y	Y		
ONCT-2	Y	Y		
ONCT-3	Y	Y		
MW-53I		Y		
MW-53D2	Y	Y	Y	
MW-57S	Y	Y	Y	
MW-57I		Y		

PCE/TCE Plume Downgradient Wells

Well	*PCE*	*TCE*	*1,2-DCE*	*VCM*
GM-34D	Y	Y		
GM-34D2	Y	Y		
GM-35D2	Y	Y		
GM-36D	Y	Y		
GM-36D2		Y		
GM-37D		Y		
GM-37D2		Y		
GM-38D		Y		
GM-38D2		Y		
GM-70D2	Y	Y		
GM-71D2				
GM-75D2	Y	Y	Y	

TABLE 3.7

SUMMARY OF PCE, TCE, 1,2-DCE AND VCM PRESENCE IN WELLS
HOOKER/RUCO SITE
HICKSVILLE, NEW YORK

PCE/TCE Plume Downgradient Wells

GM-78S	Y	Y
GM-78I	Y	
N10627	Y	Y
N09921		
N10634		

TABLE 4.1

ESTIMATED GROUNDWATER FLOW VELOCITIES
VCM SUBPLUME REMEDY
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

	Upgradient		*Downgradient*						*Effective Porosity* (5)		*Estimate Horizontal Groundwater Flow Velocity (ft/d)* (6)	
Aquifer Depth Interval	*Monitoring Well*	*Measured Groundwater Elevation* (1) *(ft AMSL)*	*Monitoring Well*	*Measured Groundwater Elevation* (1) *(ft AMSL)*	*Monitoring Well Separation Distance (ft)*	*Estimated Horizontal Hydraulic Gradient* (2) *(ft/ft)*	*Hydraulic Conductivity in Calibrated Groundwater Flow Model for Sand* (3) *(ft/d)*	*Estimated Hydraulic Conductivity for Clay Lenses* (4) *(ft/d)*	*Sand*	*Clay Lenses*	*Sand*	*Clay Lenses*
Shallow (<80 ft BGS)	S-1	69.97	N-10954	64.4	1,799	0.003	250	0.0283	0.20	0.25	3.9	0.000
Intermediate (80 - 150 ft BGS)	S-2	65.44	K-2	64.32	1,221	0.001	120	0.0283	0.20	0.25	0.6	0.000
Deep (150 - 250 ft BGS)	MW-57I	66.32	HN-43I	63.74	1,826	0.001	30	0.0283	0.20	0.25	0.2	0.000
Very Deep (>250 ft BGS)	MW-56I	66.74	MW-50D2	62.22	1,575	0.003	30	0.0283	0.20	0.25	0.4	0.000

Notes:

ft BGS	Feet below ground surface.
ft AMSL	Feet above mean sean level.
ft/ft	Feet per foot.
ft/d	Feet per day.
(1)	Groundwater elevation measured October 2, 1995.
(2)	Hydraulic gradient calculated from the upgradient groundwater elevation minus the downgradient groundwater elevation divided by the monitoring well separation distance.
(3)	Hydraulic conductivity value applied at corresponding depth interval in the Geraghty and Miller calibrated groundwater flow model predominantly representative of sand lenses.
(4)	Estimated hydraulic conductivity for clay lenses based on a glacial clay till hydraulic conductivity value of 1e-5 cm/s reported by Freeze and Cherry (1979).
(5)	Effective porosity values determined from total porosity values of 0.3 and 0.35 for the sand and clay lenses, respectivey (after Zheng and Bennett, 2002), and reducing these total porosity values by 0.1 each to reflect the portion of the porosity typically considered representative of isolated pore space through which active groundwater flow does not occur.
(6)	Groundwater flow velocity calculated from the hydraulic gradient multiplied by hydraulic conductivity and divided by effective porosity.

TABLE 5.1

DATA COLLECTION AND OBJECTIVES
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

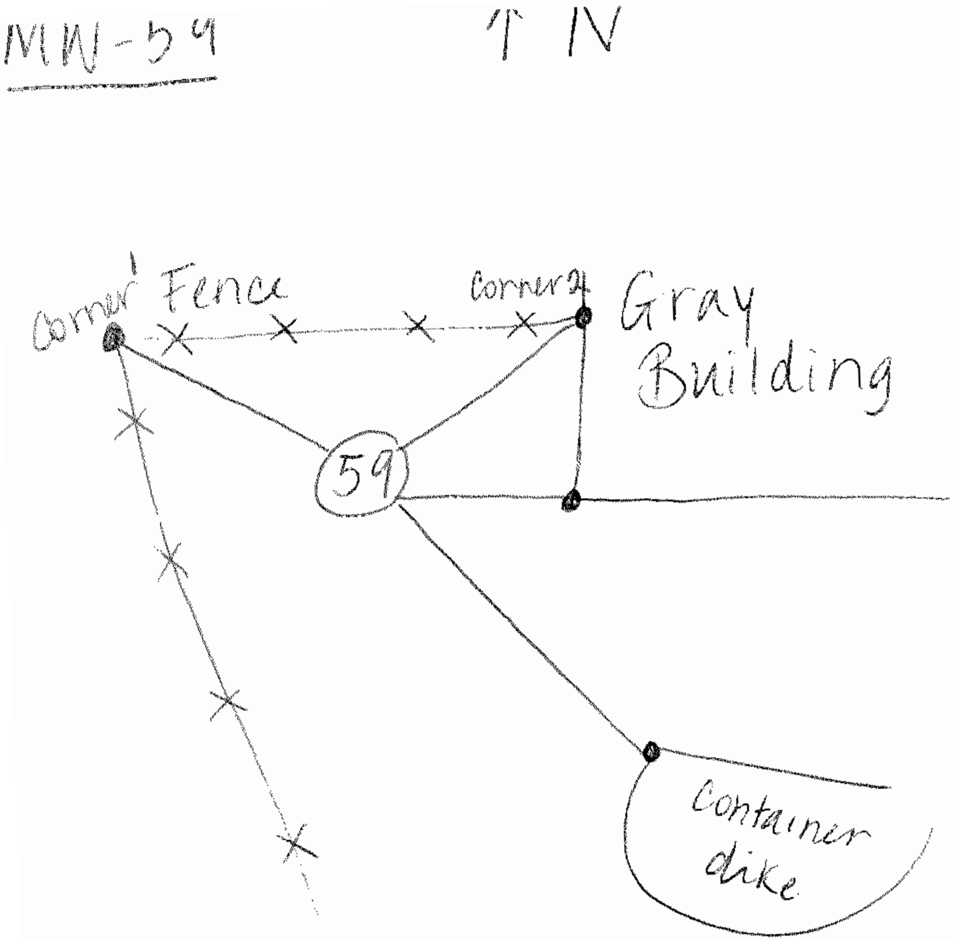
Data	*How collected*	*Purpose*
Air injection capacity (flow at varying pressure)	Wellhead pressure and CI trailer flowmeters	Deliverable rate of air sizes compressors, piping
Groundwater field parameters: DO pH redox potential (ORP) conductivity (SC) temperature (T) turbidity (TU)	Micropurge by nitrogen-driven bladder pump, with flow-through cell; meters calibrated daily	Monitored impacts in sparged well and adjacent wells DO => short term aeration pH can show respiration ORP => anaerobic O_2 demand SC, T and TU stability generally show adequate purging prior to meter reading, sampling
Groundwater lab analytes: VOC C1 – C4 gases Helium (He) microbial assay electron acceptors: nitrate, iron, sulfate nutrients N & P	Samples collected after micropurging, sent to labs	Monitor microbial activity, distance to which impacts observable VOC and C1-thru C4 gases => short term microbial response to aeration He => gas reach from injected well Microbial counts => growth response to air NO_3, Fe, SO_4 => natural attenuation capacity / activity N, P => microbial mineral needs
Water table well pressure	Pressure gauge prior to purge and sample	Indicates air flow reaching vadose zone, and flow pattern in vadose zone
Water table well gases Oxygen (O_2) Carbon dioxide (CO_2) Methane (CH_4) Helium (He)	Vacuum pump purge through sealing well cap, and gas meter readings in field; meter calibrated daily	Impacts of injected gas rising above water table Gas concentrations => vadose zone air flow Depletion of O_2 and rise of CO_2 after sparging => aerobic respiration CH4 => vadose zone microbe activity He => injected air reaching obs. point

Note: DO refers to dissolved oxygen in water; oxygen refers to vadose zone gas

APPENDIX A

STRATIGRAPHIC AND INSTRUMENTATION LOGS

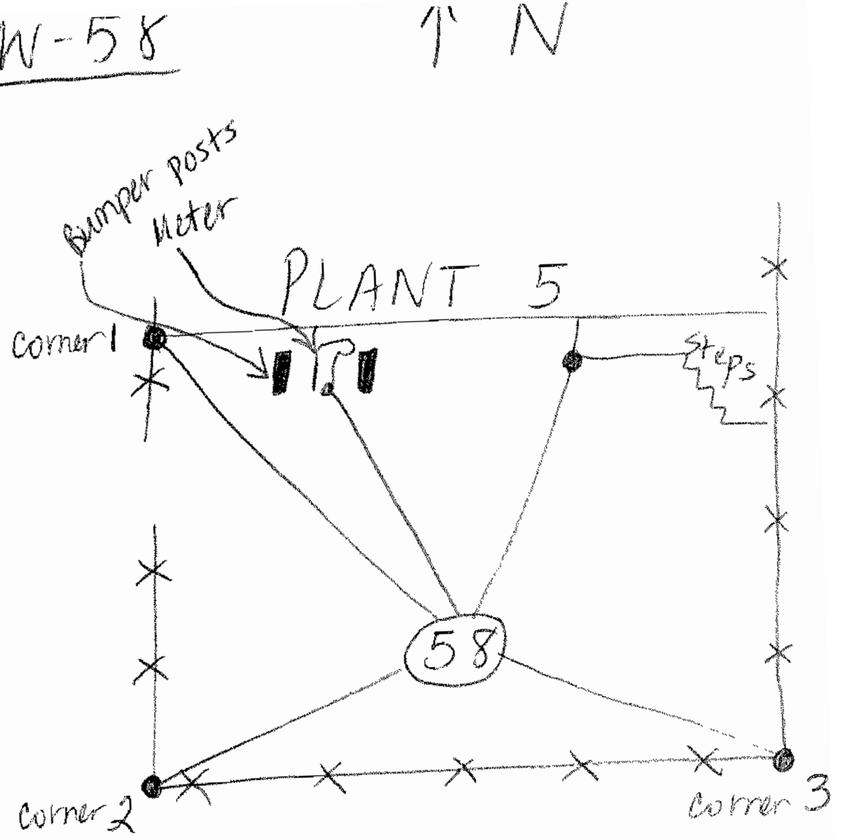
MW-59



MW-59

to Container dike = 71.5'
to gray building = 44.1
to Corner # 2 = 47.0'
to corner #1 = 36.0'

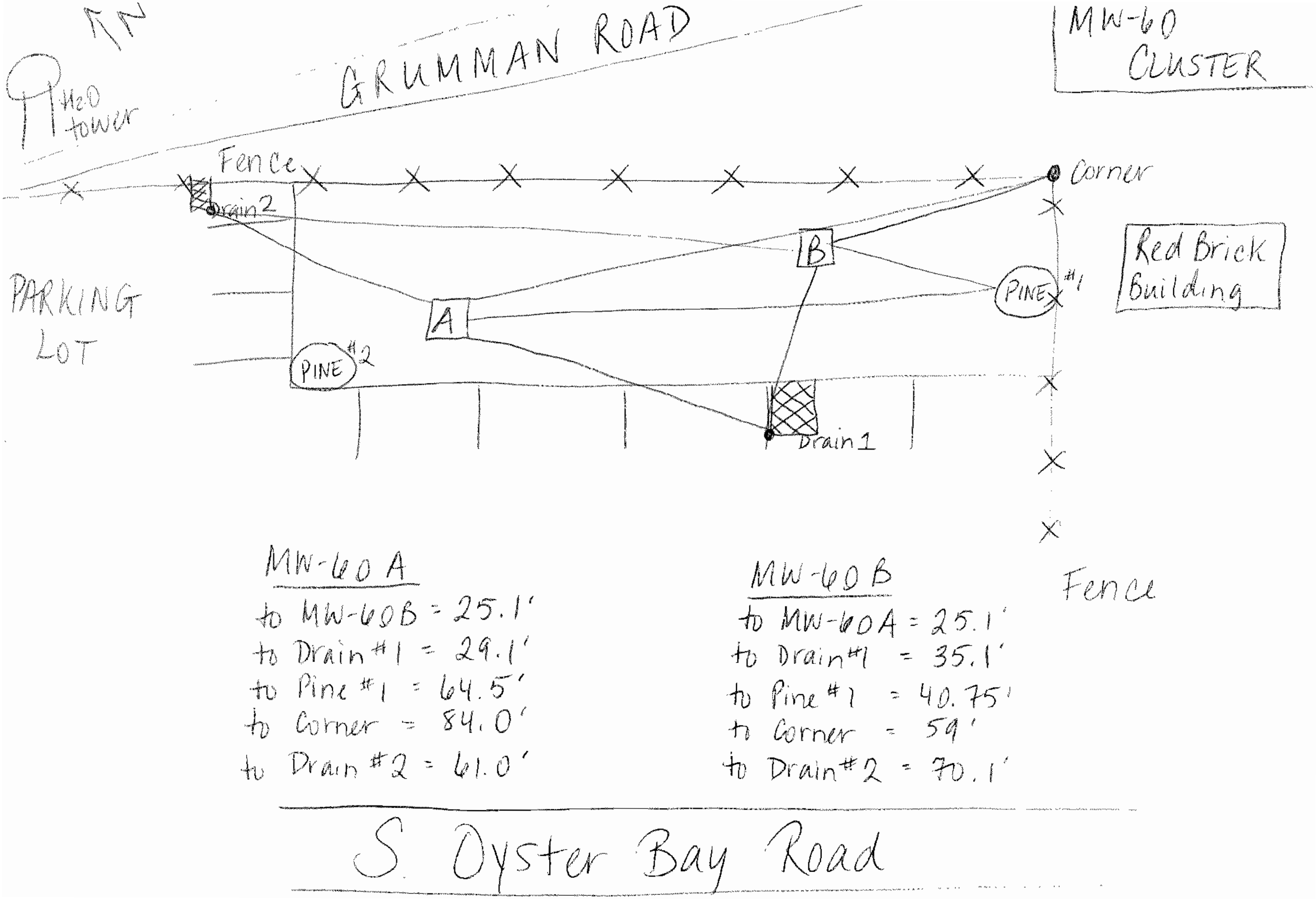
MW-58



MW-58

to meter = 27.8'
to Steps = 26.1'
to Corner #3 = 34.0'
to Corner #2 = 42.3'
to Corner #1 = 50.1'

MW-60
CLUSTER



MW-60 A
to MW-60B = 25.1'
to Drain #1 = 29.1'
to Pine #1 = 64.5'
to Corner = 84.0'
to Drain #2 = 61.0'

MW-60 B
to MW-60A = 25.1'
to Drain#1 = 35.1'
to Pine #1 = 40.75'
to Corner = 59'
to Drain#2 = 70.1'

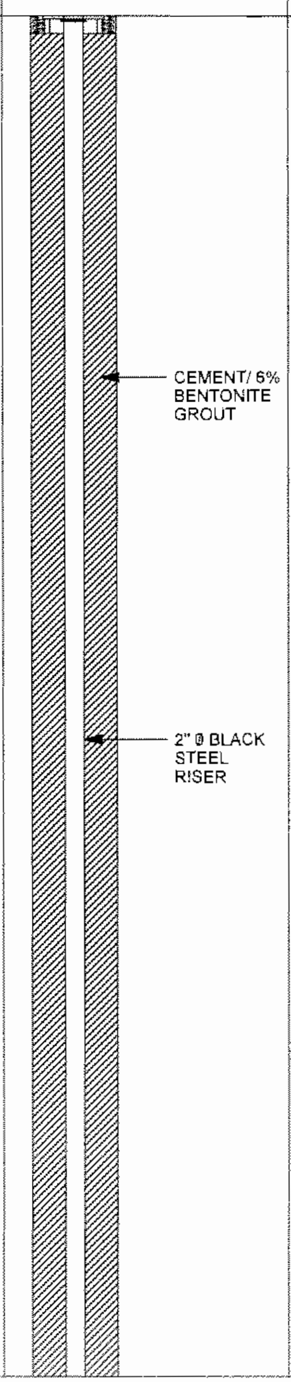
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE	116.22
	TOP OF RISER	115.99
	SAND, with rock and gravel, orange/tan, moist	
5		
10		
15		
20		
25		
30		
35		
40		
45		
50		
55	- wet at 54.5ft BGS	
	SANDY CLAY, stiff, no rock or gravel, orange/tan, saturated	58.22
60	- little clay at 60.0ft BGS	
	SAND, little clay, tan/brown, moist	53.22
	CLAY, stiff, gray, with tan/brown sand	52.22
65	SAND, coarse to fine grained, pink/orange	51.22
70		

MONITOR INSTALLATION



SAMPLE

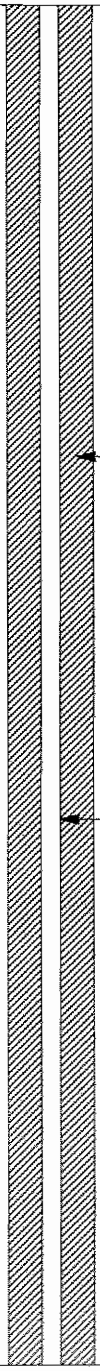
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1	⊠			0
2	⊠			0
3	⊠			0
4	⊠			0
5	⊠			0
6	⊠			0
7	⊠			0
8	⊠			0
9	⊠			0
10	⊠			0
11	⊠			0
12	⊠			0
13	⊠			0
14	⊠			0
15	⊠			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
				16				0
80								
				17				0
85								
	- little brown clay at 87.0ft BGS			18				0
90	SAND, with gray stiff clay, brown/orange, wet	26.22						
				19				0
95								
				20				0
100	SAND, coarse to fine grained, tan/gray, wet	16.22	CEMENT/ 6% BENTONITE GROUT					
				21				0
105								
				22				0
110	SAND, with some light gray clay inclusions, brown/orange	6.22						
				23				0
115	CLAY, very stiff, brown/light gray	1.22						
				24				0
120	SANDY CLAY, tan/orange, wet	-3.78	2" Ø BLACK STEEL RISER					
				25				0
125	SANDY CLAY, stiff, brown/tan, wet	-8.78						
	- little clay at 128.0ft BGS			26				0
130	SAND, gray, moist	-13.78						
				27				0
	- very stiff, light gray/pink clay at 134.5ft BGS							
135	SAND, orange/brown, wet	-18.78						
				28				0
140	SAND, brown/gray/orange	-23.78						
				29				0
	- some light gray clay inclusions at 144.5ft BGS							
145	SAND, orange/brown	-28.78						
				30				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
				31				0
155	SANDY CLAY, brown/orange, light gray inclusions	-38.78						
				32				0
160	SAND, brown/orange	-43.78						
				33				0
165	SANDY CLAY, stiff, tan/orange/gray, wet	-48.78						
				34				0
170								
				35				0
175	SAND, tan/orange/gray	-58.78	2" Ø BLACK STEEL RISER					
				36				0
180								
				37				0
185								
				38				0
190								
				39				0
195	- Groundwater sample collected at 195.0ft BGS		CEMENT/ 6% BENTONITE GROUT					
				40				0.3
200								
				41				2.1
205								
				42				0.5
210								
	- light gray clay inclusions at 213.0ft BGS			43				0.4
215								
				44				0
220								
				45				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	SAND, with stiff light gray clay, brown	-108.78						
				46	☒			0
230								
				47	☒			0.1
235								
				48	☒			0
240	- some light gray stiff clay inclusions at 240.0ft BGS							
				49	☒			0
245	SAND, brown/orange, wet. Groundwater sample collected at 245ft BGS	-128.78						
				50	☒			4.6
250								
				51	☒			0
255			CEMENT/ 6% BENTONITE GROUT					
				52	☒			2.4
260	CLAY, very stiff, dark gray	-143.78						
				53	☒			0
265								
				54	☒			0
270								
				55	☒			0
275	SAND, tan/brown/orange	-158.78	2" Ø BLACK STEEL RISER					
				56	☒			0
280								
				57	☒			0
285	SANDY CLAY, stiff, light gray/tan	-168.78						
				58	☒			0
290								
				59	☒			0
295	SAND, tan/light gray, moist	-178.78						
				60	☒			0
	- some light gray clay inclusions at 299.0ft BGS							

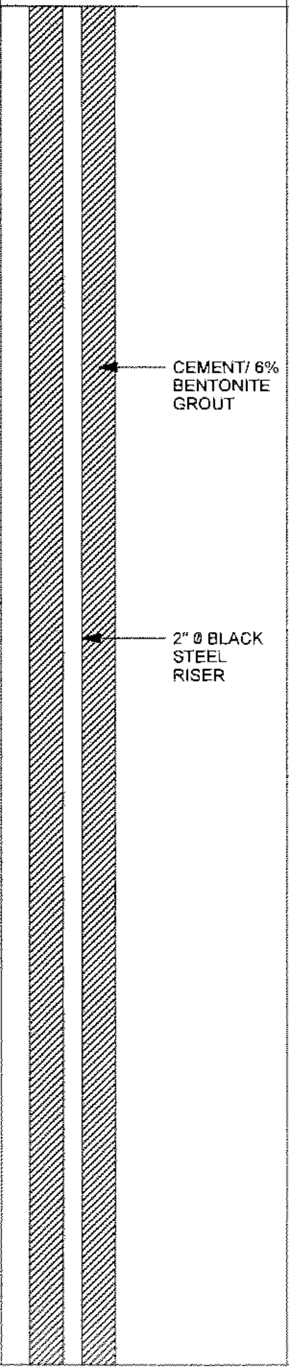
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
				61				0
305								
				62				0
310	SANDY CLAY, firm, brown/orange, wet	-194.78						
				63				0
315	- Groundwater sample collected at 315.0ft BGS							
				64				0.2
320								
				65				0
325								
				66				0
330								
				67				0
335								
				68				0
340	SAND, gray/orange/brown	-223.78						
	- stiff light gray clay, dry at 343.0ft BGS			69				0
345	SAND, some clay, tan/gray/orange, wet	-228.78						
				70				0
350								
				71				0
355								
				72				0
360								
				73				0
365	SAND, light gray. Groundwater sample collected at 365ft BGS	-248.78						
				74				0
370								
	SANDY CLAY, firm, light gray, wet	-256.78		75				0



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

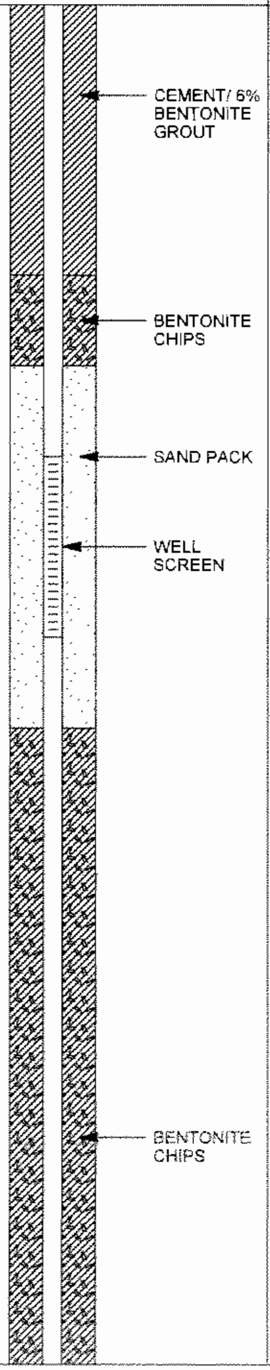
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	CLAY, sand, firm, brown/gray	-258.78					
			76				0
380							
			77				0.1
385							
			78				0.2
390	SAND, little clay, hard, orange, wet	-273.78					
395	- dark gray at 395.0ft BGS						
			79				3.0
400							
			80				4.5
405							
			81				6.1
410							
			82				7.8
	CLAY, stiff, very hard, dark gray	-297.78					
415	SANDY CLAY, coarse sand, very hard, orange/gray. Groundwater sample collected at 415ft BGS - little clay, more sand at 418.0ft BGS	-298.78					
			83				6.7
420	CLAY, stiff, dark gray, moist - less clay at 423.0ft BGS	-303.78					
			84				0
425	SAND, coarse, tan/gray	-308.78					
			85				0.1
430							
			86				1.2
435							
			87				0.4
440							
			88				1.8
445	CLAY, with some sand, firm, dark gray, moist	-328.78					
			89				0

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

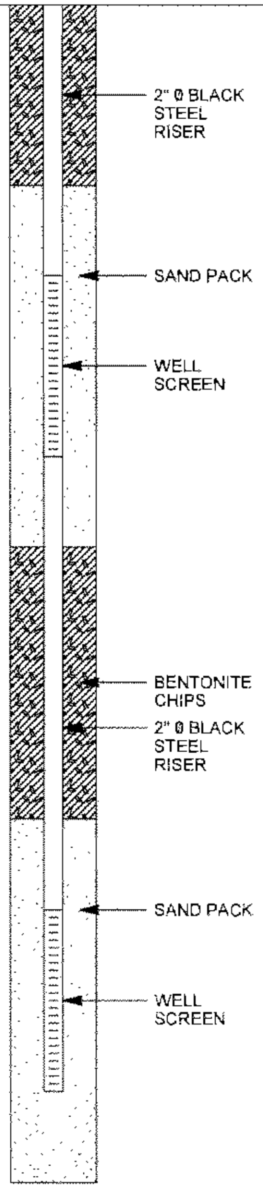
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	- sandier, wet at 450.0ft BGS						
	- brittle, dry clay, very little sand at 453.0ft BGS		90				0
455	- very stiff, moist at 455.0ft BGS						
			91				0.1
460							
	SAND, coarse with light gray clay inclusions, firm	-346.28	92				20.2
465	SANDY CLAY, stiff, light gray, wet. Groundwater sample collected at 465ft BGS	-348.78					
			93				139
470							
			94				121
475							
			95				136
480							
			96				4.6
485							
			97				0
490							
			98				95.8
495							
500							
505							
510	- Groundwater sample collected at 510.0ft BGS						
515	END OF BOREHOLE @ 515.0ft BGS	-398.78					
520							

MONITOR INSTALLATION



WELL DETAILS
Screened interval:
-283.78 to -293.78ft AMSL
400.00 to 410.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-58 D/D1/D2
DATE COMPLETED: March 26, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
530			Material: S.S. Sand Pack: -278.78 to -298.78ft AMSL 395.00 to 415.00ft BGS Material: SILICA SAND ---------- Screened interval: -348.78 to -358.78ft AMSL 465.00 to 475.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -343.78 to -363.78ft AMSL 460.00 to 480.00ft BGS Material: SILICA SAND ---------- Screened interval: -383.78 to -393.78ft AMSL 500.00 to 510.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -378.78 to -398.78ft AMSL 495.00 to 515.00ft BGS Material: SILICA SAND					
535								
540								
545								
550								
555								
560								
565								
570								
575								
580								
585								
590								
595								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

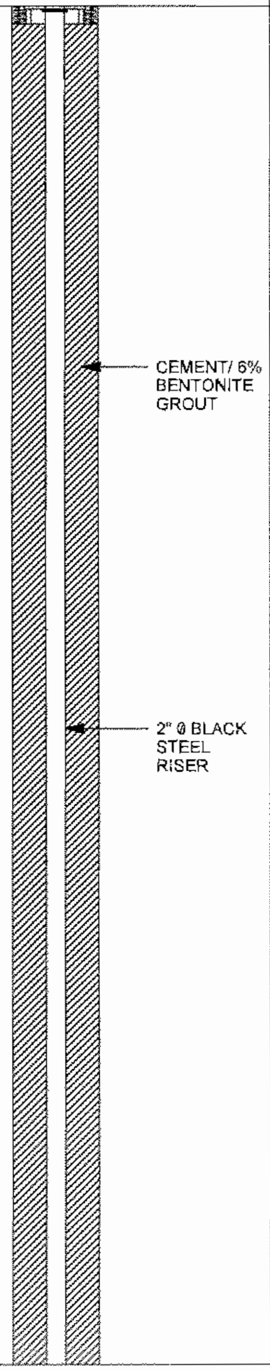
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-59 D/D1/D2
DATE COMPLETED: April 6, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE TOP OF RISER	117.37 117.13
	SAND, with rocks and gravel, brown/orange, dry	
50	SAND, tan/orange, dry	67.37
55	SAND, with rock/gravel, brown, dry	62.37
65	- wet at 65.0ft BGS	

MONITOR INSTALLATION



SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1				0
2				0
3				0
4				0
5				0
6				0
7				0
8				0
9				0
10				0
11				0
12				0
13				0
14				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

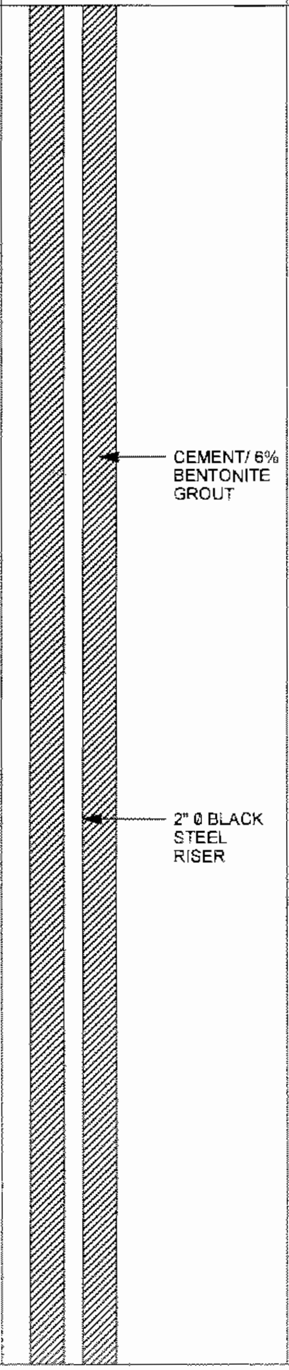
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-59 D/D1/D2
DATE COMPLETED: April 6, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	SANDY CLAY, firm, tan/gray, moist	42.37					
			15	☒			0
80	SAND, tan/orange	38.37					
			16	☒			0
85	- rock/gravel at 84.0ft BGS - coarse grained, pink/orange/brown at 85.0ft BGS						
			17	☒			0
90							
			18	☒			0
95							
			19	☒			0
100							
			20	☒			0
105							
			21	☒			0
110							
	SANDY CLAY, brown/tan, wet to saturated	5.37	22	☒			0
115	- very little clay at 115.0ft BGS						
			23	☒			0
120							
			24	☒			0
125	- firm, wet at 125.0ft BGS						
			25	☒			0
130	SAND, tan/orange/gray	-12.63					
			26	☒			0
135	- coarse sand, brown at 135.0ft BGS						
			27	☒			0
140							
			28	☒			0.1
145							
			29	☒			0

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-59 D/D1/D2
DATE COMPLETED: April 6, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- light gray firm clay inclusions at 153.0ft BGS			30	X			0
155				31	X			0
160				32	X			0
165				33	X			0
170	SANDY CLAY, light gray, wet	-53.63		34	X			0
175			2" Ø BLACK STEEL RISER	35	X			0
180				36	X			0
185				37	X			0
190	SAND, brown/orange - with stiff light gray clay inclusions at 191.0ft BGS	-72.63		38	X			0.1
195			CEMENT/ 6% BENTONITE GROUT	39	X			0.1
200				40	X			0.1
205				41	X			0
210				42	X			0
215				43	X			0
220	- brown clay fragments at 224.0ft BGS			44	X			0.1

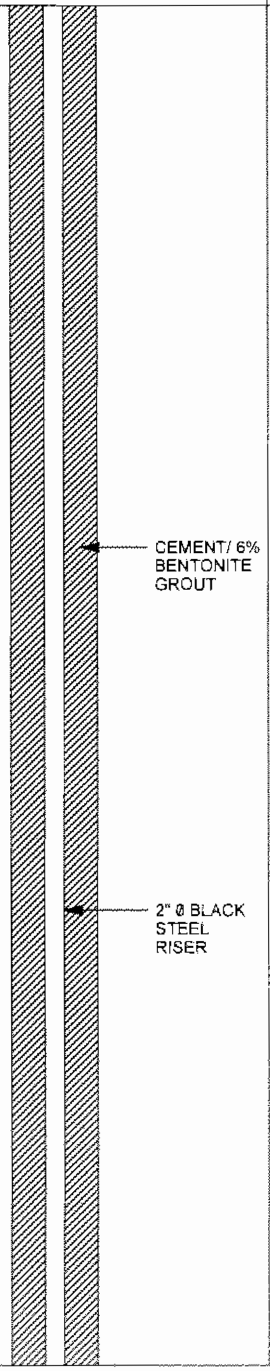
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-59 D/D1/D2
PROJECT NUMBER: 6883	DATE COMPLETED: April 6, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	- dark brown/orange, pieces of hard brown sand at 225.0ft BGS	
230	- black layering at 230.0ft BGS	
235		
240		
245		
250	- black layering at 250.0ft BGS	
255	CLAY, very stiff, dark gray, dry	-137.63
260		
265		
270		
275	SAND, brown/orange, saturated	-157.63
280		
285	- some light gray clay inclusions at 285.0ft BGS	
290		
295		

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
45				1.0
46				0.4
47				0
48				0
49				0
50				0
51				0
52				0
53				NM
54				NM
55				0
56				0.3
57				1.6
58				1.0
59				0.2

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

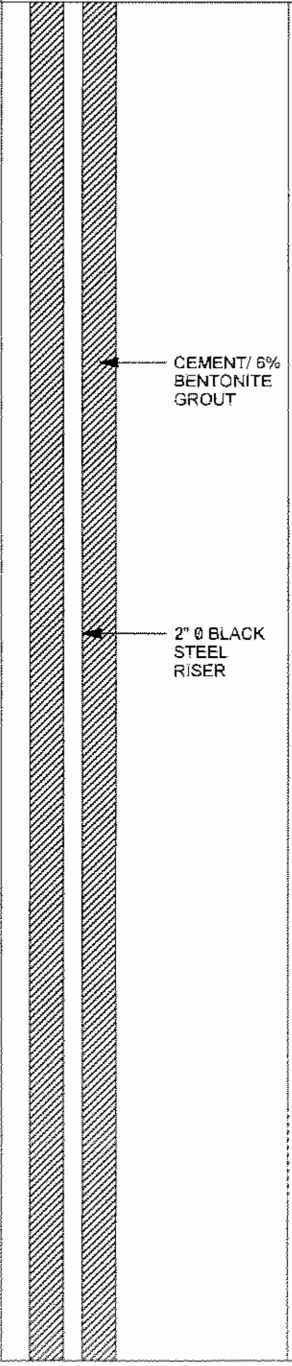
Page 5 of 8

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-59 D/D1/D2
DATE COMPLETED: April 6, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
305	- Groundwater sample collected at 305.0ft BGS	
	- black layering at 307.0ft BGS	
310	CLAY, very stiff, light gray/brown	-192.63
	SAND, medium to coarse, bright orange/brown, wet	-194.63
315		
320		
325		
330		
335	SAND, dark gray/black, dry	-217.63
340		
	SANDY CLAY, firm, brown/orange, wet	-224.63
	SAND, little clay, light gray/tan, moist	-225.63
345		
	- hard sand, light gray at 348.0ft BGS	
350	SANDY CLAY, stiff, light gray/orange, moist	-232.63
355	SAND, little clay, firm, tan/light gray. Groundwater sample collected at 355ft BGS	-237.63
	- some black layering at 359.0ft BGS	
360		
	- more clay at 364.0ft BGS	
365		
370		

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
60				0.7
61				1.6
62				0.7
63				2.0
64				1.2
65				1.3
66				1.0
67				0.6
68				1.2
69				0.7
70				1.3
71				0.5
72				3.0
73				3.5
74				3.6

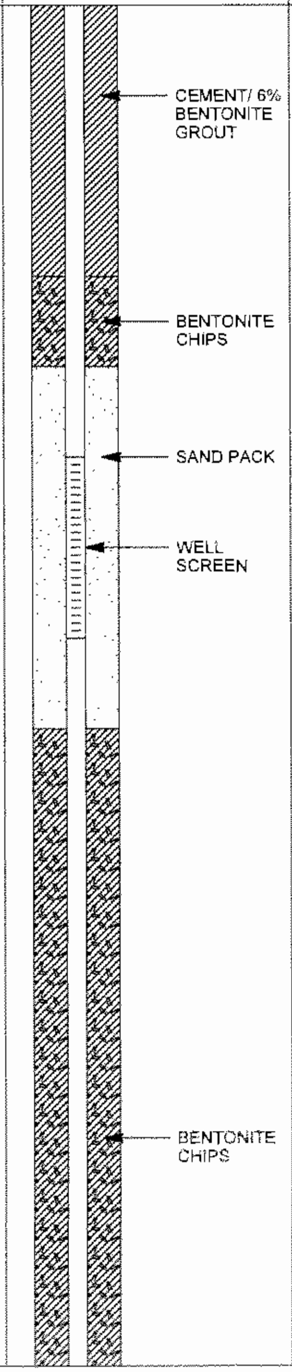
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-59 D/D1/D2
PROJECT NUMBER: 6883	DATE COMPLETED: April 6, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	- some clay at 379.0ft BGS	
380		
	CLAY, stiff brown, some orange sand, moist	-264.13
385	SAND, tan, little clay	-266.63
390		
395		
	- black layering, some clay at 399.0ft BGS	
400		
405	- light gray/tan, some clay. Groundwater sample collected at 405.0ft BGS	
410		
415		
420		
425		
	- dark gray/black layering at 429.0ft BGS	
430	- stiff light gray clay inclusions at 430.5ft BGS	
435		
	CLAY, some sand, stiff, light brown, moist	-318.63
	- wet, less stiff at 437.0ft BGS	
440	- very stiff, wet at 440.0ft BGS	
445		
	SAND, tan/orange	-327.63
	- light brown firm clay inclusions at 447.0ft BGS	

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
75	☒			1.5
76	☒			2.8
77	☒			0.5
78	☒			0.8
79	☒			1.4
80	☒			3.5
81	☒			0.7
82	☒			1.9
83	☒			1.9
84	☒			1.6
85	☒			0.2
86	☒			57.2
87	☒			6.3
88	☒			2.6

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

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PROJECT NUMBER: 6883
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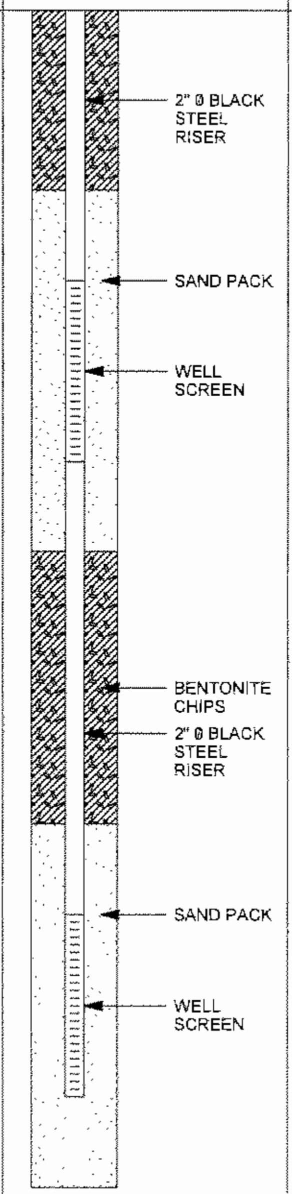
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-59 D/D1/D2
DATE COMPLETED: April 6, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	SAND, some clay, light gray	-332.63
455	SAND/clay mix, firm, tan/brown, moist, rust colored spotting. Groundwater sample collected at 455ft BGS	-337.63
460	SAND, firm, tan/light gray	-342.63
	CLAY, very stiff dark brown	-345.63
465	SAND/clay mix, light gray/orange, saturated	-347.63
470	SAND, some clay, firm, light gray, moist	-352.63
475		
480		
	- very little clay at 483.0ft BGS	
485		
490		
495	- sand, with some clay, tan/orange, wet at 495.0ft BGS	
	CLAY, tan/brown, very stiff	-380.63
500	SAND, little clay, hard, gray/tan/orange	-383.13
505		
	- light gray clay inclusions at 508.0ft BGS	
510		
515	- Groundwater sample collected at 515.0ft BGS	-397.63
	END OF BOREHOLE @ 515.0ft BGS	
520		

MONITOR INSTALLATION



WELL DETAILS
Screened interval:
-282.63 to -292.63ft AMSL
400.00 to 410.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10

SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
89	☒			2.1
90	☒			3.3
91	☒			1.8
92	☒			4.5
93	☒			2.4
94	☒			0.8
95	☒			0.1
96	☒			22.0
97	☒			8.2
98	☒			0.4
99	☒			5.6
100	☒			4.9
101	☒			27

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-59 D/D1/D2
DATE COMPLETED: April 6, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
530 535 540 545 550 555 560 565 570 575 580 585 590 595			Material: S.S. Sand Pack: -277.63 to -297.63ft AMSL 395.00 to 415.00ft BGS Material: SILICA SAND ——— Screened interval: -347.63 to -357.63ft AMSL 465.00 to 475.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -342.63 to -362.63ft AMSL 460.00 to 480.00ft BGS Material: SILICA SAND ——— Screened interval: -382.63 to -392.63ft AMSL 500.00 to 510.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -377.63 to -397.63ft AMSL 495.00 to 515.00ft BGS Material: SILICA SAND					

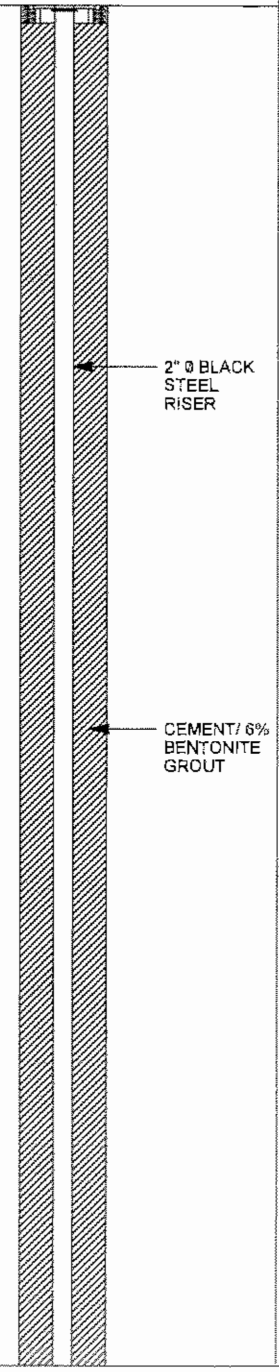
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY
HOLE DESIGNATION: MW-60 D1
DATE COMPLETED: March 5, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE	119.02
	TOP OF RISER	118.70
	SAND, gray/orange, dry	
5		
10		
15		
20		
25		
30		
35		
40		
45		
50		
55		
	- light gray clay inclusions at 57.0ft BGS	
60		
65	SAND, tan/orange/brown, moist	54.02
70		
	- wet at 74.0ft BGS	

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1				0
2				0
3				0
4				0
5				0
6				0
7				0
8				0
9				0
10				0
11				0
12				0
13				0
14				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

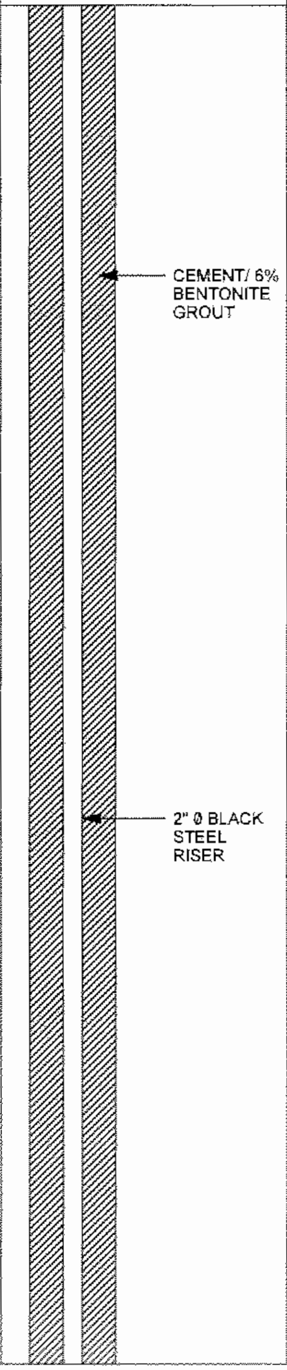
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-60 D1
DATE COMPLETED: March 5, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
80		
	CLAY, very stiff, light gray	37.02
85	SAND, light gray, moist to wet	34.02
90		
95		
100		
105		
110		
115	SANDY CLAY, light gray, wet	4.02
120		
125	CLAY, light gray/tan, wet	-5.98
130		
135	SAND, light gray/dark gray/black, wet - dark gray/black clay fragments at 136.0ft BGS	-15.98
140		
145	SAND, some light gray clay inclusions, brown/orange, moist. Groundwater sample collected at 145.0ft BGS - no clay at 147.0ft BGS	-25.98

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
15				0
16				0
17				0
18				0
19				0
20				0
21				0
22				0
23				0
24				0
25				0
26				0
27				0
28				0
29				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

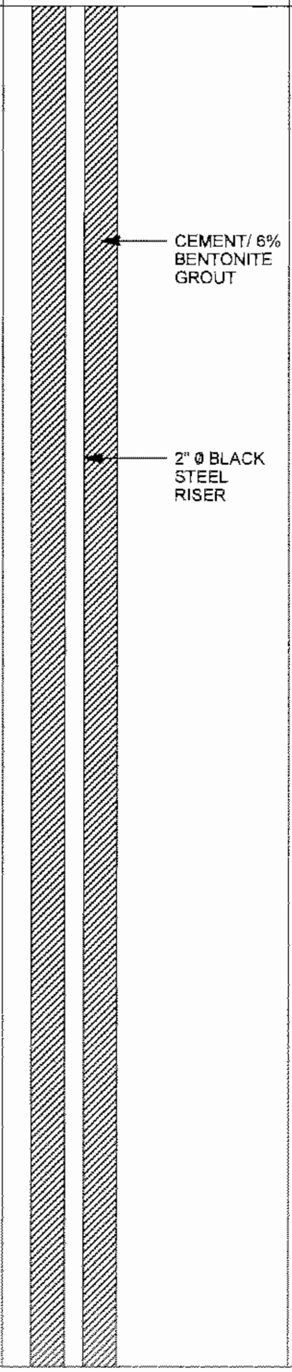
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-60 D1
DATE COMPLETED: March 5, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
155		
	- light gray clay, stiff, moist at 157.0ft BGS	
160	- light gray, wet at 160.0ft BGS	
165	SANDY CLAY, firm, tan/light gray, wet	-45.98
170		
175		
180	SAND, orange/tan/brown, wet	-59.98
185	- tan/light gray. Groundwater sample collected at 185.0ft BGS	
190		
195		
200	SANDY CLAY, stiff, orange	-79.98
205	- light gray clay inclusions, wet at 204.0ft BGS	
210	- clay inclusions at 210.0ft BGS	
215		
220	SAND, orange, wet - clay, stiff at 221.0ft BGS - clay, stiff at 223.0ft BGS	-100.98

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
30				0
31				0
32				0
33				0
34				0
35				0
36				0
37				0
38				0
39				0
40				NM
41				0
42				0
43				0
44				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

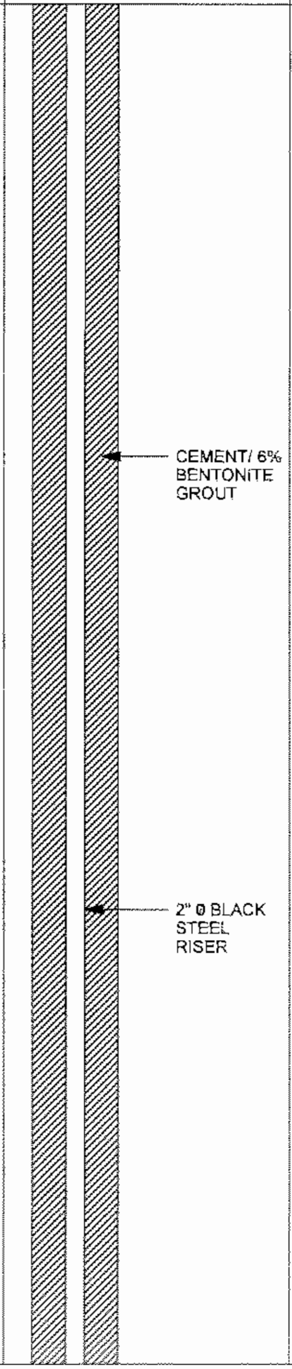
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-60 D1
DATE COMPLETED: March 5, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	- black at 228.0ft BGS	
230	- sand, wet at 230.5ft BGS SANDY CLAY	-110.98
235	SAND, firm, orange/brown, moist. Groundwater sample collected at 235ft BGS	-115.98
240		
245		
250	CLAY, very stiff, tan/orange	-131.98
255	- dark gray/black, very stiff at 256.0ft BGS	
260		
265	SANDY CLAY, firm, light gray/tan, wet	-145.98
270		
275		
280	SAND, orange/brown	-160.98
285	- stiff, tan/brown, moist. Groundwater sample collected at 285.0ft BGS	
290		
295	CLAY, some sand, stiff, tan/brown, moist	-175.98

MONITOR INSTALLATION



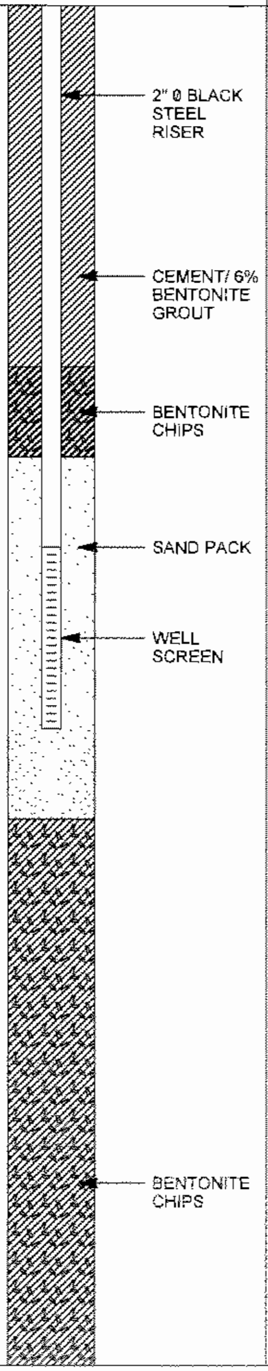
SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
45				0
46				0
47				0
48				0
49				0
50				0
51				0
52				0
53				0
54				0
55				0
56				0
57				0
58				0
59				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-60 D1
DATE COMPLETED: March 5, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	- dark brown, very stiff at 302.0ft BGS		60				0
305							
	- sandy clay, orange/tan, moist at 307.0ft BGS		61				0
310	- stiff, tan/gray, moist at 310.0ft BGS						
			62				10.2
315	SAND, orange/gray, wet	-194.98					
			63				0
320							
			64				0
325	- firm, gray/tan/pink at 325.0ft BGS						
			65				0
330							
			66				0
335	- pink/brown, moist. Groundwater sample collected at 335.0ft BGS						
			67				0
340							
			68				0
345	SANDY CLAY, firm to stiff, pink/brown, wet	-225.98					
			69				0
350							
			70				0
355	- pink/gray at 355.0ft BGS END OF BOREHOLE @ 355.0ft BGS						
			71				0
360	SAND, light gray/pink, little clay	-241.98					
			72				0
365	- pink/orange at 365.0ft BGS						
			73				0
370	CLAY, tan/pink/orange	-250.98					
	- firm, wet at 371.0ft BGS SAND, tan/gray	-252.98	74				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-60 D1
PROJECT NUMBER: 6883	DATE COMPLETED: March 5, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
			▨	75	☒			0
380	- stiff orange/brown clay at 381.0ft BGS		▨	76	☒			0
385	- Groundwater sample collected at 385.0ft BGS	-265.98						
390								
395								
400								
405								
410								
415								
420								
425								
430								
435								
440								
445								

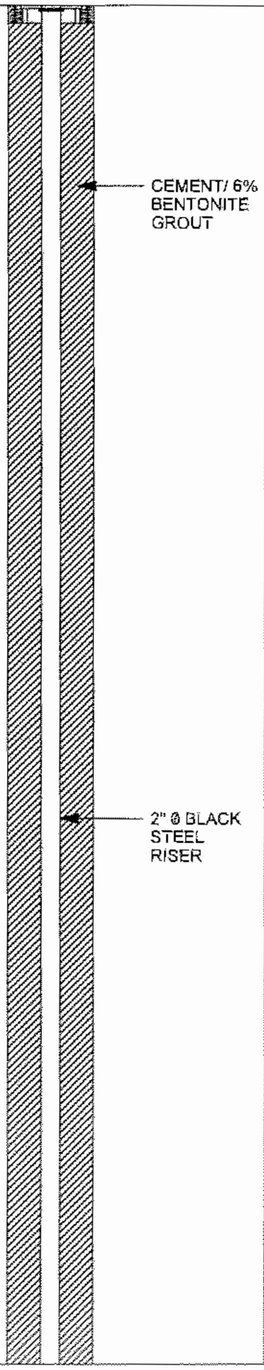
WELL DETAILS
Screened interval:
-210.98 to -220.96ft AMSL
330.00 to 340.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10
Material: S.S.
Sand Pack:
-205.98 to -225.98ft AMSL
325.00 to 345.00ft BGS
Material: SILICA SAND

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

Page 1 of 5

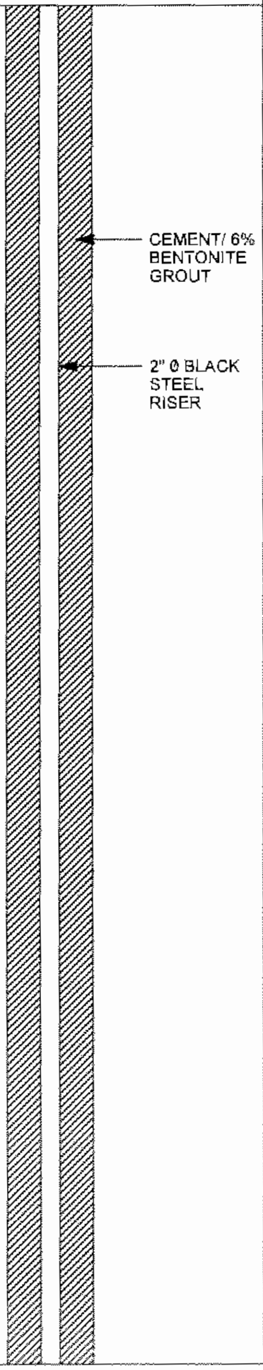
PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-60 S/I/D
PROJECT NUMBER: 6883	DATE COMPLETED: March 8, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	GROUND SURFACE TOP OF RISER	118.96 118.93						
	SAND, gray/orange, dry							
5				1	☒			0
10			CEMENT/ 6% BENTONITE GROUT	2	☒			0
15				3	☒			0
20				4	☒			0
25				5	☒			0
30				6	☒			0
35				7	☒			0
40				8	☒			0
45			2" Ø BLACK STEEL RISER	9	☒			0
50				10	☒			0
55	- light gray clay inclusions at 57.0ft BGS			11	☒			0
60				12	☒			0
65	SAND, tan/orange/brown, moist	53.96		13	☒			0
70	- wet at 74.0ft BGS			14	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY
HOLE DESIGNATION: MW-60 S/I/D
DATE COMPLETED: March 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
				15				0
80	CLAY, very stiff, light gray	36.96		16				0
85	SAND, light gray, moist to wet	33.96		17				0
90				18				0
95				19				0
100				20				0
105				21				0
110				22				0
115	SANDY CLAY, light gray, wet	3.96		23				0
120				24				0
125	CLAY, light gray/tan, wet	-6.04		25				0
130				26				0
135	SAND, light gray/dark gray/black, wet - dark gray/black clay fragments at 136.0ft BGS	-16.04		27				0
140				28				0
145	SAND, some light gray clay inclusions, brown/orange, moist. Groundwater sample collected at 145.0ft BGS - no clay at 147.0ft BGS	-26.04		29				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

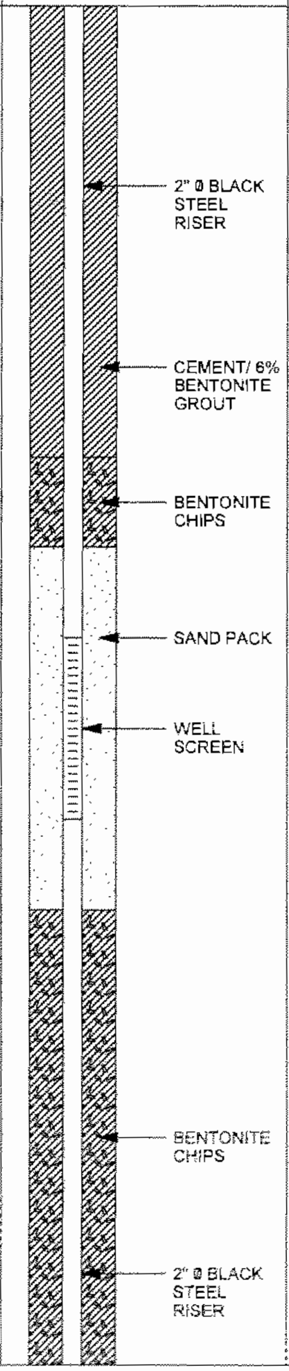
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-60 S/I/D
DATE COMPLETED: March 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
			30				0
155	- light gray clay, stiff, moist at 157.0ft BGS		31				0
160	- light gray, wet at 160.0ft BGS		32				0
165	SANDY CLAY, firm, tan/light gray, wet	-46.04	33				0
170			34				0
175			35				0
180	SAND, orange/tan/brown, wet	-60.04	36				0
185	- tan/light gray. Groundwater sample collected at 185.0ft BGS		37				0
190			38				0
195			39				0
200	SANDY CLAY, stiff, orange	-80.04	40				NM
205	- light gray clay inclusions, wet at 204.0ft BGS		41				0
210	- clay inclusions at 210.0ft BGS		42				0
215			43				0
220	SAND, orange, wet - clay, stiff at 221.0ft BGS - clay, stiff at 223.0ft BGS	-101.04	44				0

MONITOR INSTALLATION



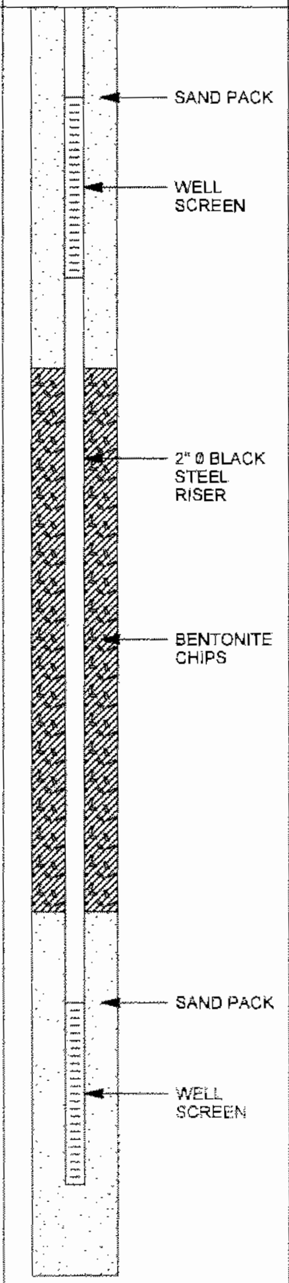
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY
HOLE DESIGNATION: MW-60 S/I/D
DATE COMPLETED: March 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- black at 228.0ft BGS		45				0
230	- sand, wet at 230.5ft BGS	-111.04					
	SANDY CLAY		46				0
235	SAND, firm, orange/brown, moist. Groundwater sample collected at 235ft BGS	-116.04	47				0
240			48				0
245			49				0
250	CLAY, very stiff, tan/orange	-132.04	50				0
255	- dark gray/black, very stiff at 256.0ft BGS		51				0
260			52				0
265	SANDY CLAY, firm, light gray/tan, wet	-146.04	53				0
270			54				0
275			55				0
280	SAND, orange/brown	-161.04	56				0
285	- stiff, tan/brown, moist. Groundwater sample collected at 285.0ft BGS		57				0
290			58				0
295	END OF BOREHOLE @ 295.0ft BGS	-176.04					

MONITOR INSTALLATION



WELL DETAILS
Screened interval:
-66.04 to -76.04ft AMSL

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

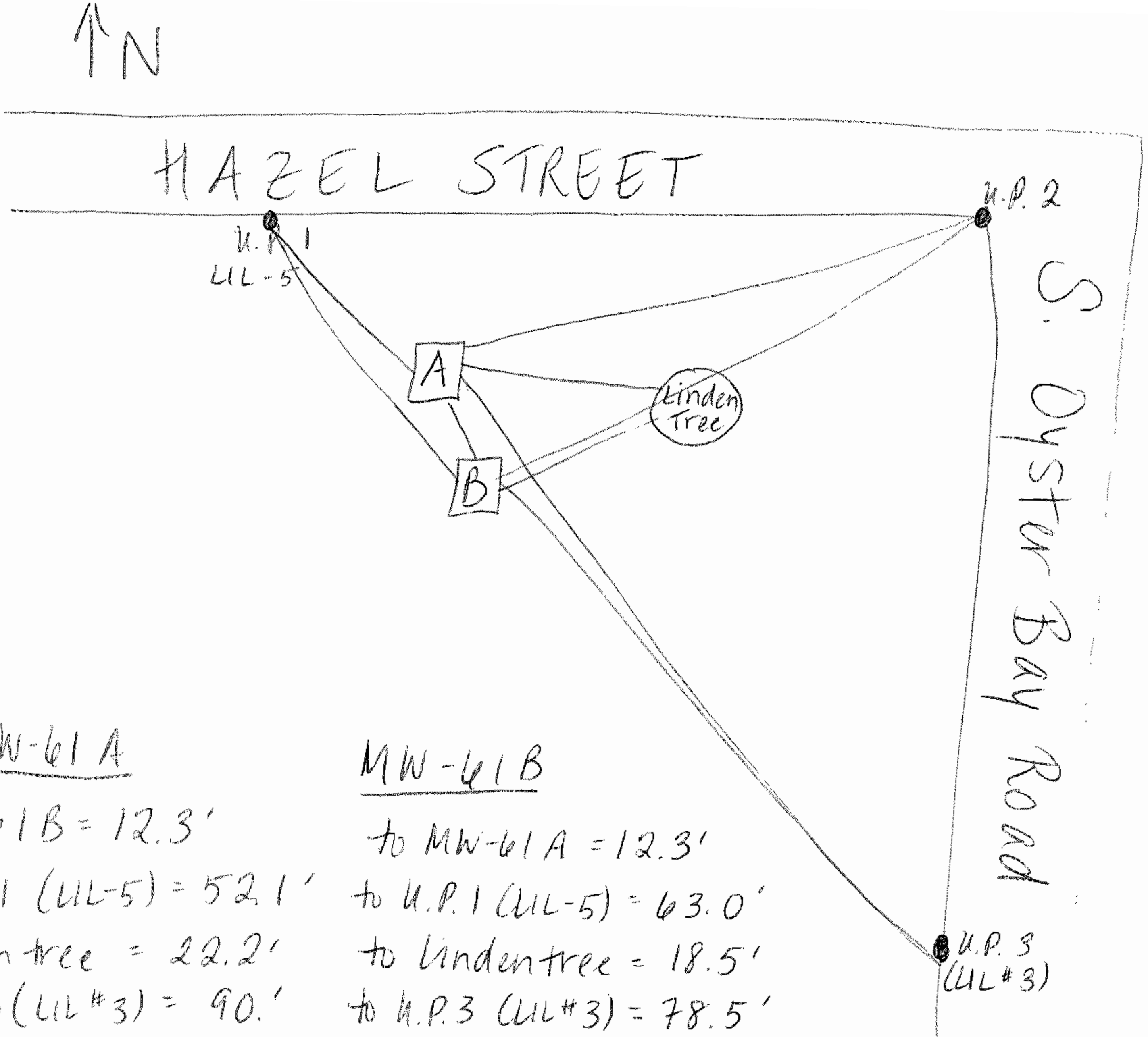
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
HOLE DESIGNATION: MW-60 S/I/D
PROJECT NUMBER: 6883
DATE COMPLETED: March 8, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
305 310 315 320 325 330 335 340 345 350 355 360 365 370			185.00 to 195.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -61.04 to -81.04ft AMSL 180.00 to 200.00ft BGS Material: SILICA SAND --------- Screened interval: -111.04 to -121.04ft AMSL 230.00 to 240.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -106.04 to -126.04ft AMSL 225.00 to 245.00ft BGS Material: SILICA SAND --------- Screened interval: -161.04 to -171.04ft AMSL 280.00 to 290.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -156.04 to -176.04ft AMSL 275.00 to 295.00ft BGS Material: SILICA SAND					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

MW-61
CLUSTER



MW-61 A

to MW-61B = 12.3'
to U.P. 1 (LIL-5) = 52.1'
to Linden tree = 22.2'
to U.P. 3 (LIL#3) = 90.'
to U.P. 2 = 54'

MW-61 B

to MW-61 A = 12.3'
to U.P. 1 (LIL-5) = 63.0'
to Linden tree = 18.5'
to U.P. 3 (LIL#3) = 78.5'
to U.P. 2 = 63'

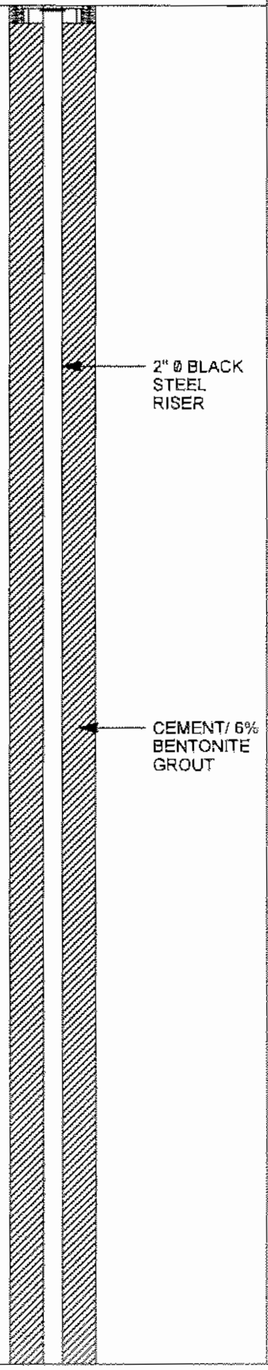
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61 S/I/D1
DATE COMPLETED: February 22, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE	121.19
	TOP OF RISER	120.91
	SOIL, brown, some vegetation	
5	SAND/soil, rock, brown/orange	116.69
25	- some clay inclusions, tan/black at 25.0ft BGS	
	CLAY, stiff, moist	95.19
	- very stiff clay at 29.0ft BGS	
	SAND, tan/black	87.99
45	- stiff clay at 45.0ft BGS	
	- black, gray clay inclusions, moist at 52.0ft BGS	
	- no clay at 54.0ft BGS	
55	SANDY CLAY, tan/orange, wet	66.19
	- sand, wet at 56.0ft BGS	
60	CLAY, dark gray, moist	61.19
	SAND, stiff, gray/tan, clay inclusions, light gray	53.19

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1	⊠			0
2	⊠			0
3	⊠			0
4	⊠			0
5	⊠			0
6	⊠			0
7	⊠			0
8	⊠			0
9	⊠			0
10	⊠			0
11	⊠			0
12	⊠			0
13	⊠			0
14	⊠			0
15	⊠			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

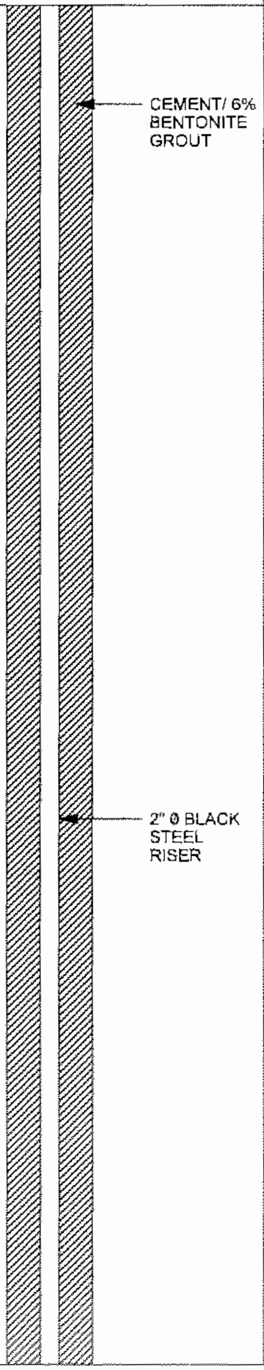
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61 S/I/D1
DATE COMPLETED: February 22, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- gray/orange layering, moist at 75.0ft BGS		16				0
80	- tan/orange, moist at 80.0ft BGS		17				0
85	- wet at 85.0ft BGS		18				0
90			19				0
95			20				0
100			21				0
105			22				0
110			23				0
115	- light gray clay inclusions at 114.0ft BGS - light gray clay inclusions at 115.5ft BGS		24				0
120	- some gray clay at 120.5ft BGS		25				0
125			26				0
130	- Groundwater sample collected at 130.0ft BGS		27				0
135	CLAY, red/brown, moist - dark gray clay, very stiff, dry at 136.0ft BGS	-13.31	28				0
140			29				0
145	- wet at 145.0ft BGS		30				0

MONITOR INSTALLATION



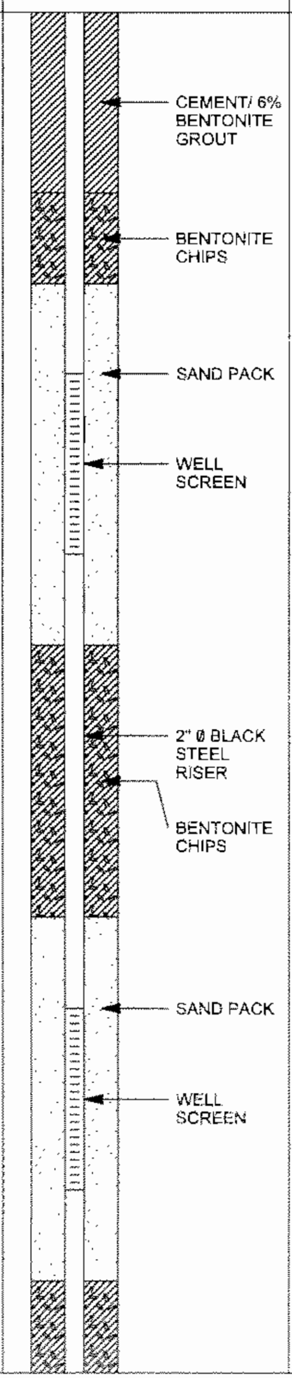
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY
HOLE DESIGNATION: MW-61 S/I/D1
DATE COMPLETED: February 22, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	- dry to moist at 151.0ft BGS	
155		
160	SAND, brown/orange, saturated - light gray clay inclusions at 161.5ft BGS	-38.81
165		
170		
	- stiff clay at 173.0ft BGS	
175		
	- stiff clay inclusions at 177.0ft BGS	
180	SAND, with clay inclusions, gray/tan	-58.81
	- no clay at 183.5ft BGS	
185	- Groundwater sample collected at 185.0ft BGS	
190		
	- dark gray/black with some clay inclusions at 191.0ft BGS	
	CLAY, stiff, light gray/bright orange	-70.31
195	SAND, some clay, light gray/tan orange	-73.81
200	CLAY, stiff, gray, with tan/orange sand	-78.81
	SAND, orange/brown, wet	-79.81
205		
210	- clay inclusions at 210.0ft BGS	
215	- tan/orange at 215.0ft BGS	
	- stiff sandy clay, tan/orange at 219.0ft BGS	
220	- stiff clay inclusions at 220.0ft BGS	

MONITOR INSTALLATION



SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
31	☒			0
32	☒			0
33	☒			0
34	☒			0
35	☒			0
36	☒			0
37	☒			0
38	☒			0
39	☒			0
40	☒			0
41	☒			0
42	☒			0
43	☒			0
44	☒			0
45	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

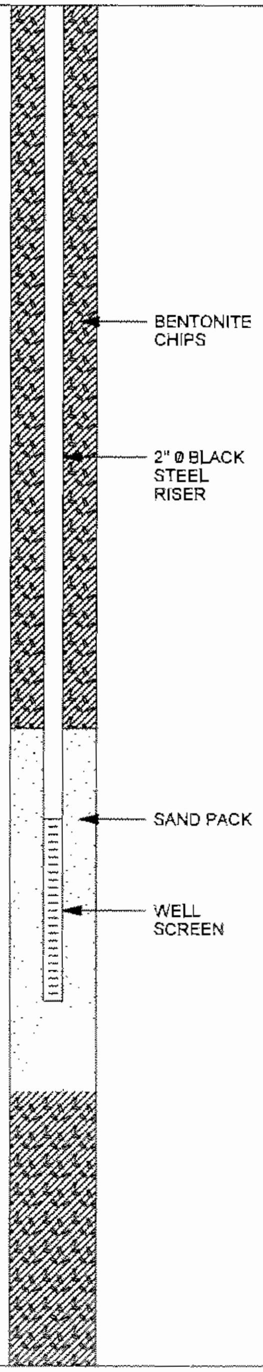
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61 S/I/D1
DATE COMPLETED: February 22, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	CLAY, stiff, tan/orange sand, wet	-103.81
230		
235	SAND, brown/tan, reddish, wet - clay, stiff at 236.0ft BGS	-113.81
240	CLAY, stiff, dark gray - wet at 243.0ft BGS	-118.81
245		
250	SAND, tan/orange, wet	-128.81
255	- Groundwater sample collected at 255.0ft BGS	
260		
265		
270		
	SANDY CLAY, gray/orange, stiff	-150.81
275		
	SAND, light gray clay inclusions, some red	-156.81
280		
285	CLAY, very stiff, gray	-163.81
290		
295		

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
46				0
47				0
48				0
49				0.4
50				0
51				20.1
52				12.1
53				13.2
54				24.4
55				10.3
56				6.0
57				0.8
58				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61 S/I/D1
DATE COMPLETED: February 22, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
305	SANDY CLAY, pink/red gray, moist. Groundwater sample collected at 305.0ft BGS	-183.81		59	☒			0
310				60	☒			0
315	SAND, gray/tan, dry to moist	-193.81		61	☒			0
320	- tan/orange, moist at 320.0ft BGS - some light gray clay inclusions at 321.5ft BGS		BENTONITE CHIPS	62	☒			0
325	SANDY CLAY, tan/gray, saturated	-203.81		63	☒			0
330	- some clay inclusions, wet at 331.0ft BGS			64	☒			0
	CLAY, very stiff, tan/gray	-211.81						
335	SAND, orange/brown/tan	-213.81		65	☒			0
340				66	☒			0
345	SANDY CLAY, firm, tan/orange - very stiff dark gray clay at 346.0ft BGS	-223.81		67	☒			0
350				68	☒			0
	SAND, gray/tan - Groundwater sample collected at 355.0ft BGS	-231.81						
355	END OF BOREHOLE @ 355.0ft BGS	-233.81						
360								
365								
370								

WELL DETAILS
Screened interval:
-48.81 to -58.81ft AMSL
170.00 to 180.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10
Material: S.S.
Sand Pack:
-43.81 to -63.81ft AMSL
165.00 to 185.00ft BGS
Material: SILICA SAND

Screened interval:
-83.81 to -93.81ft AMSL

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61 S/I/D1
DATE COMPLETED: February 22, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
380 385 390 395 400 405 410 415 420 425 430 435 440 445			205.00 to 215.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -78.81 to -98.81ft AMSL 200.00 to 220.00ft BGS Material: SILICA SAND ——— Screened interval: -148.81 to -158.81ft AMSL 270.00 to 280.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -143.81 to -163.81ft AMSL 265.00 to 285.00ft BGS Material: SILICA SAND					

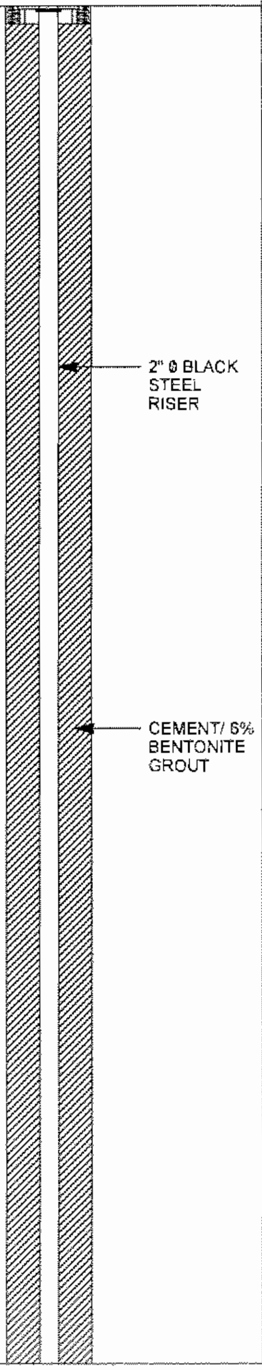
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-61D2
PROJECT NUMBER: 6883	DATE COMPLETED: March 12, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE TOP OF RISER	121.15 121.05
	SOIL, brown, some vegetation	
5	SAND/soil, rock, brown/orange	116.65
10		
15		
20		
25	- some clay inclusions, tan/black at 25.0ft BGS	
	CLAY, stiff, moist	95.15
30	- very stiff clay at 29.0ft BGS	
	SAND, tan/black	87.95
35		
40		
45	- stiff clay at 45.0ft BGS	
50	- black, gray clay inclusions, moist at 52.0ft BGS	
	- no clay at 54.0ft BGS	
55	SANDY CLAY, tan/orange, wet - sand, wet at 56.0ft BGS	66.15
60	CLAY, dark gray, moist	61.15
65		
	SAND, stiff, gray/tan, clay inclusions, light gray	53.15
70		

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1				0
2				0
3				0
4				0
5				0
6				0
7				0
8				0
9				0
10				0
11				0
12				0
13				0
14				0
15				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

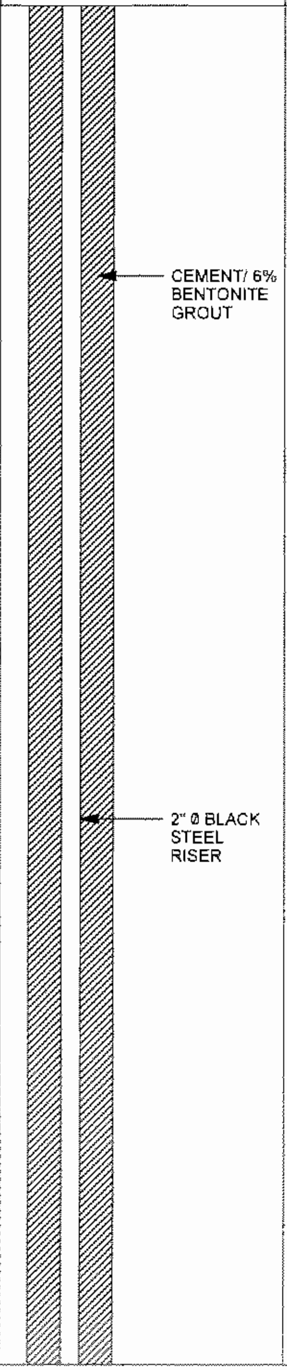
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61D2
DATE COMPLETED: March 12, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- gray/orange layering, moist at 75.0ft BGS		16	☒			0
80	- tan/orange, moist at 80.0ft BGS		17	☒			0
85	- wet at 85.0ft BGS		18	☒			0
90			19	☒			0
95			20	☒			0
100			21	☒			0
105			22	☒			0
110			23	☒			0
115	- light gray clay inclusions at 114.0ft BGS - light gray clay inclusions at 115.5ft BGS		24	☒			0
120	- some gray clay at 120.5ft BGS		25	☒			0
125			26	☒			0
130	- Groundwater sample collected at 130.0ft BGS		27	☒			0
135	CLAY, red/brown, moist - dark gray clay, very stiff, dry at 136.0ft BGS	-13.35	28	☒			0
140			29	☒			0
145	- wet at 145.0ft BGS		30	☒			0

MONITOR INSTALLATION

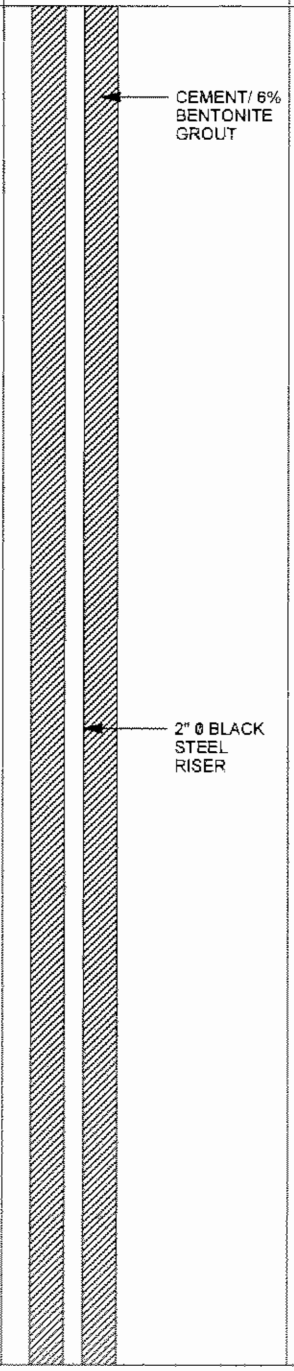


NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY
HOLE DESIGNATION: MW-61D2
DATE COMPLETED: March 12, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	- dry to moist at 151.0ft BGS	
155		
160	SAND, brown/orange, saturated - light gray clay inclusions at 161.5ft BGS	-38.85
165		
170		
	- stiff clay at 173.0ft BGS	
175	- stiff clay inclusions at 177.0ft BGS	
180	SAND, with clay inclusions, gray/tan - no clay at 183.5ft BGS	-58.85
185	- Groundwater sample collected at 185.0ft BGS	
190	- dark gray/black with some clay inclusions at 191.0ft BGS	
	CLAY, stiff, light gray/bright orange	-70.35
195	SAND, some clay, light gray/tan orange	-73.85
200	CLAY, stiff, gray, with tan/orange sand	-78.85
	SAND, orange/brown, wet	-79.85
205		
210	- clay inclusions at 210.0ft BGS	
215	- tan/orange at 215.0ft BGS	
220	- stiff sandy clay, tan/orange at 219.0ft BGS - stiff clay inclusions at 220.0ft BGS	



SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
31	☒			0
32	☒			0
33	☒			0
34	☒			0
35	☒			0
36	☒			0
37	☒			0
38	☒			0
39	☒			0
40	☒			0
41	☒			0
42	☒			0
43	☒			0
44	☒			0
45	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61D2
DATE COMPLETED: March 12, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	CLAY, stiff, tan/orange sand, wet	-103.85						
				46				0
230								
				47				0
235	SAND, brown/tan, reddish, wet - clay, stiff at 236.0ft BGS	-113.85	CEMENT/ 6% BENTONITE GROUT					
				48				0
240	CLAY, stiff, dark gray	-118.85						
	- wet at 243.0ft BGS			49				0.4
245								
				50				0
250	SAND, tan/orange, wet	-128.85						
				51				20.1
255	- Groundwater sample collected at 255.0ft BGS							
				52				12.1
260								
				53				13.2
265								
				54				24.4
270			2" Ø BLACK STEEL RISER					
	SANDY CLAY, gray/orange, stiff	-150.85		55				10.3
275								
	SAND, light gray clay inclusions, some red	-156.85		56				6.0
280								
				57				0.8
285	CLAY, very stiff, gray	-163.85						
				58				0
290								
295								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

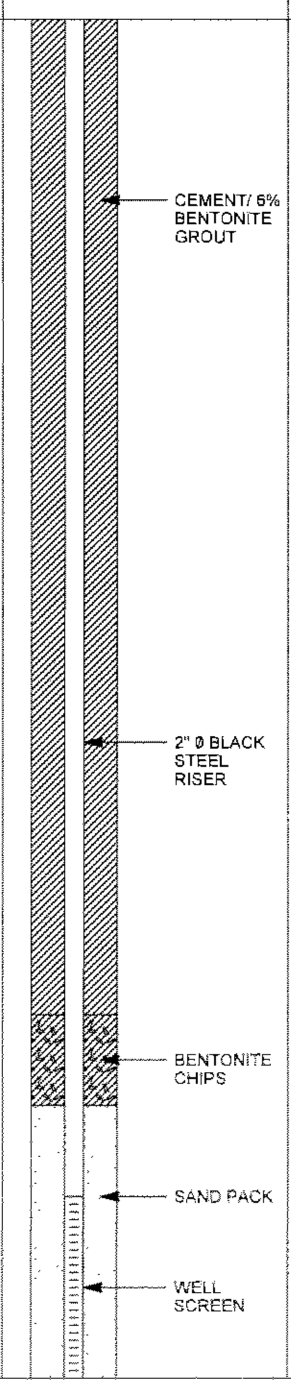
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61D2
DATE COMPLETED: March 12, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
305	SANDY CLAY, pink/red gray, moist. Groundwater sample collected at 305.0ft BGS	-183.85
315	SAND, gray/tan, dry to moist - tan/orange, moist at 320.0ft BGS - some light gray clay inclusions at 321.5ft BGS	-193.85
325	SANDY CLAY, tan/gray, saturated - some clay inclusions, wet at 331.0ft BGS	-203.85
	CLAY, very stiff, tan/gray	-211.85
335	SAND, orange/brown/tan	-213.85
345	SANDY CLAY, firm, tan/orange - very stiff dark gray clay at 346.0ft BGS	-223.85
	SAND, gray/tan - Groundwater sample collected at 355.0ft BGS	-231.85
	CLAY, stiff, gray, moist	-236.85
	SAND, wet, little clay	-244.85

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
59	305-310			0
60	310-315			0
61	315-320			0
62	320-325			0
63	325-330			0
64	330-335			0
65	335-340			0
66	340-345			0
67	345-350			0
68	350-355			0
69	355-360			19.8
70	360-365			10.3
71	365-370			53.1
72	370-375			45.3

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

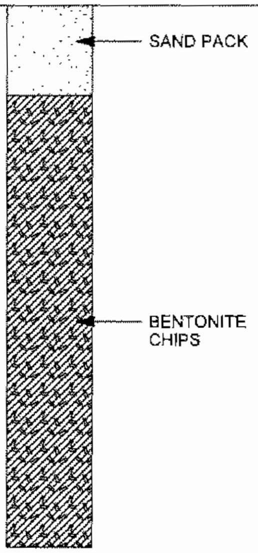
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-61D2
DATE COMPLETED: March 12, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	SANDY CLAY, tan, wet - tan/orange clay, stiff at 376.0ft BGS	-253.85
380	SAND, tan with some gray clay	-257.85
385		
390		
395		
400		
405	- Groundwater sample collected at 405.0ft BGS END OF BOREHOLE @ 405.0ft BGS	-283.85
410		
415		
420		
425		
430		
435		
440		
445		

MONITOR INSTALLATION



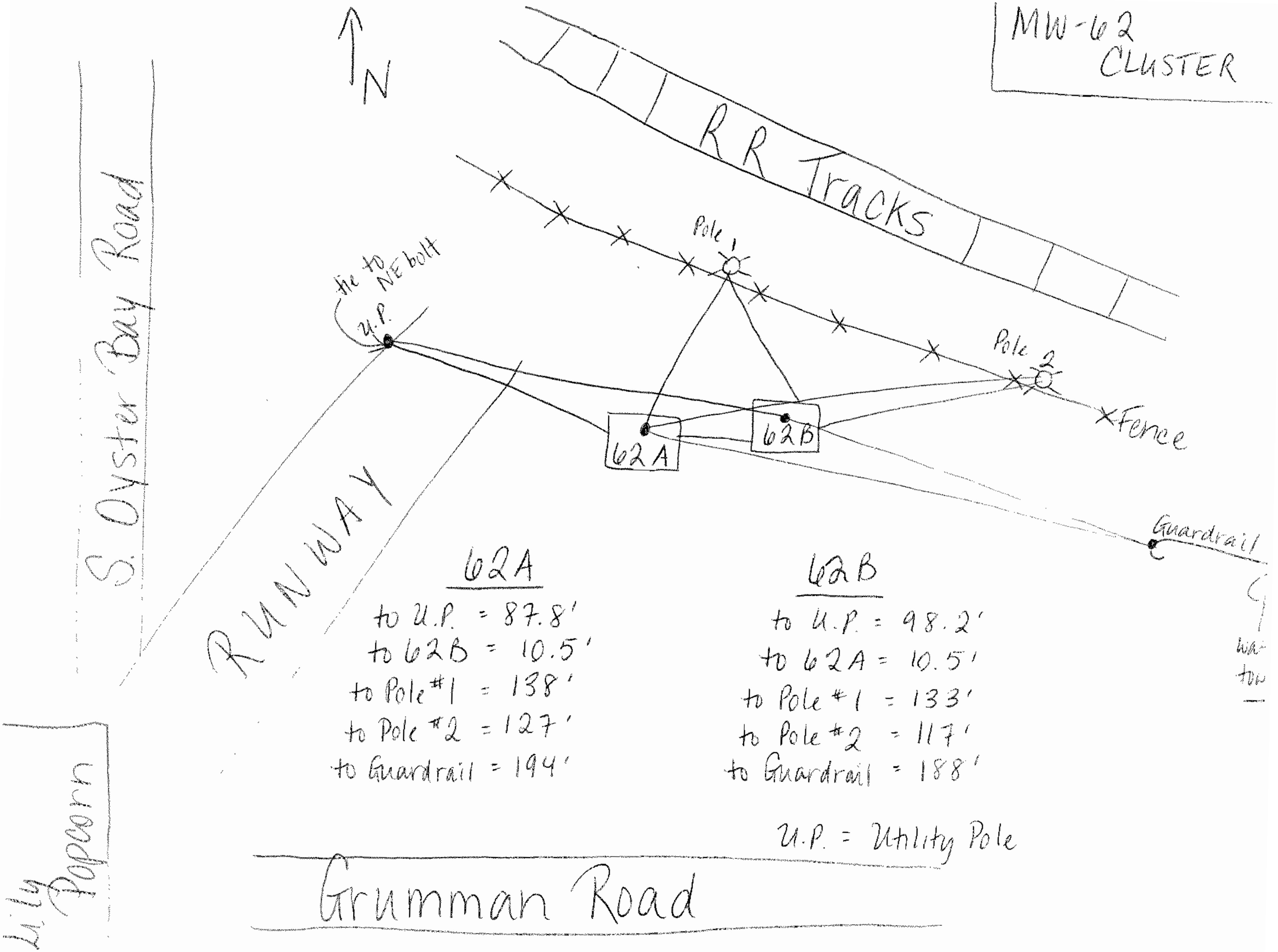
WELL DETAILS
Screened interval:
-243.85 to -253.85ft AMSL
365.00 to 375.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10
Material: S.S.
Sand Pack:
-238.85 to -258.85ft AMSL
360.00 to 380.00ft BGS
Material: SILICA SAND

SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
73	☒			0.3
74	☒			2.7
75	☒			1.4
76	☒			NM
77	☒			0
78	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

MW-62 CLUSTER



62A

to U.P. = 87.8'
to 62B = 10.5'
to Pole #1 = 138'
to Pole #2 = 127'
to Guardrail = 194'

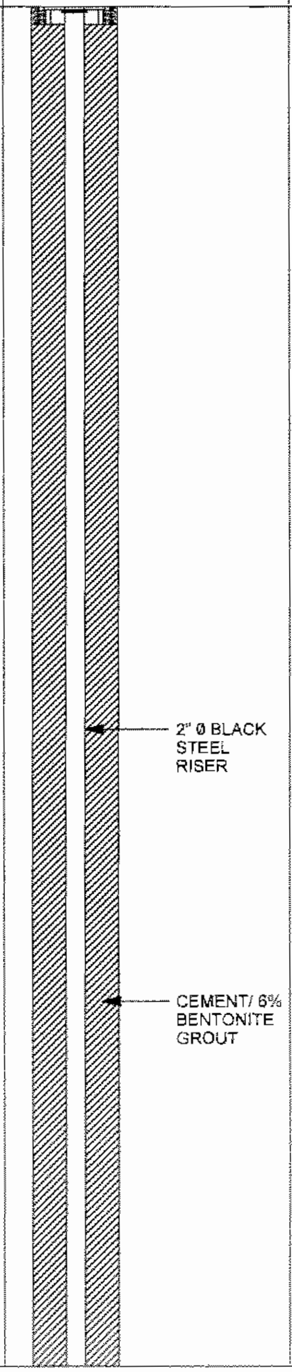
62B

to U.P. = 98.2'
to 62A = 10.5'
to Pole #1 = 133'
to Pole #2 = 117'
to Guardrail = 188'

U.P. = Utility Pole

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-62D
PROJECT NUMBER: 6883	DATE COMPLETED: April 20, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON



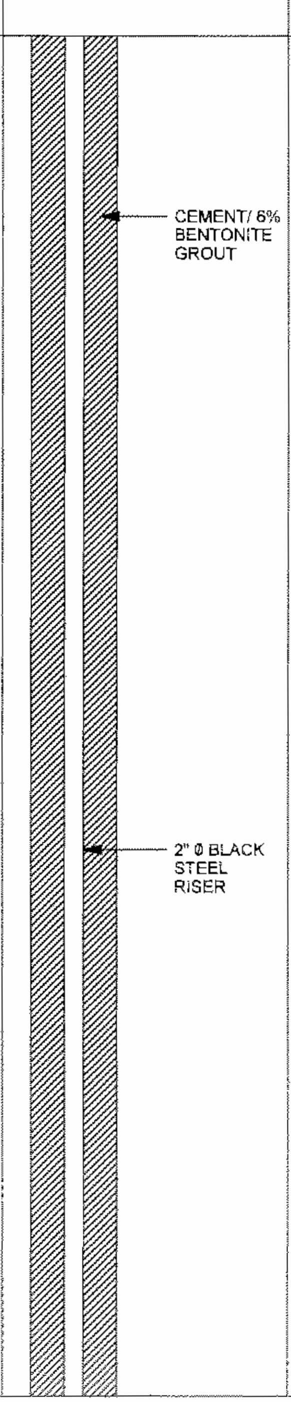
DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	GROUND SURFACE TOP OF RISER	128.03 127.82					
	Rock/gravel/sand, dark brown, moist						
5			1				0
	- dry at 6.0ft BGS						
10							
			2				0
15							
			3				0
20							
	- orange/tan with some black layering at 21.0ft BGS						
			4				0
25	- dark brown, moist at 25.0ft BGS						
			5				0
30	- dry at 30.0ft BGS						
			6				0
35							
			7				0
40							
			8				0
	- dark gray, very firm clay, moist at 43.0ft BGS						
45	SAND, some clay, gray/orange, wet	83.03					
			9				2.9
	- stiff at 48.0ft BGS						
50							
			10				1.2
	- some stiff, light gray clay at 53.0ft BGS						
55	- very stiff, light gray clay at 55.5ft BGS						
			11				0
60							
			12				0
65							
			13				0
	- light gray stiff clay inclusions at 68.0ft BGS						
70	- gray/tan at 70.0ft BGS						
			14				2.5

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE, REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62D
DATE COMPLETED: April 20, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
				15				2.0
80								
				16				1.5
85			CEMENT/ 6% BENTONITE GROUT					
				17				1.3
90								
				18				3.9
95								
				19				1.5
100								
				20				3.8
105	- wet at 105.0ft BGS							
				21				3.6
110								
				22				2.6
115								
				23				3.3
120			2" Ø BLACK STEEL RISER					
				24				3.3
125								
				25				2.1
130								
				26				1.9
135								
				27				0
140								
				28				0
145	SANDY CLAY, firm, dark gray, very moist	-16.97						
				29				0.6

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62D
DATE COMPLETED: April 20, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- little sand, very stiff at 151.0ft BGS			30				1.9
155	- firm, very moist at 155.0ft BGS			31				3.8
160			CEMENT/ 6% BENTONITE GROUT	32				1.5
	SAND, orange/red, brown, moist, with light gray clay inclusions	-34.97						
165				33				1.2
170				34				1.3
175				35				0.3
180	- some clay, gray/pink, moist at 180.0ft BGS			36				1.3
185	- little clay at 185.0ft BGS			37				1.5
190				38				2.8
195			2" Ø BLACK STEEL RISER	39				0
200				40				0
	- little clay at 203.0ft BGS							
205				41				0.9
210				42				3.1
215				43				3.2
220				44				3.6

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

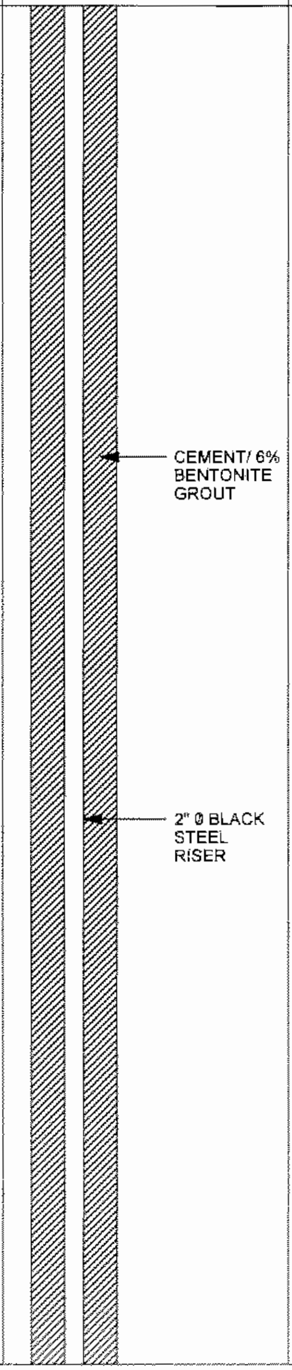
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62D
DATE COMPLETED: April 20, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	SAND, orange/brown, little clay. Groundwater sample collected at 225.0ft BGS	-96.97	45				4.6
230			46				3.3
235	CLAY, firm, little sand, brown/orange, moist - brittle, dry, dark gray, stiff at 236.5ft BGS - very firm, moist at 238.0ft BGS	-106.97	47				38.6
240			48				51.3
245			49				25.6
250	CLAY, very stiff, brittle, dark gray, dry - some sand, less stiff at 253.0ft BGS	-121.97	50				21.3
255	SAND, hard, red/brown, dry	-126.97	51				2.5
260			52				4.1
265	- some clay, stiff, gray/tan, wet at 265.0ft BGS		53				0.7
270	- more clay, saturated at 273.0ft BGS		54				0.2
275	- brown/orange. Groundwater sample collected at 275.0ft BGS		55				113.7
280	- some clay at 280.0ft BGS		56				19.8
285			57				34.3
290			58				17.6
295			59				11.3

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

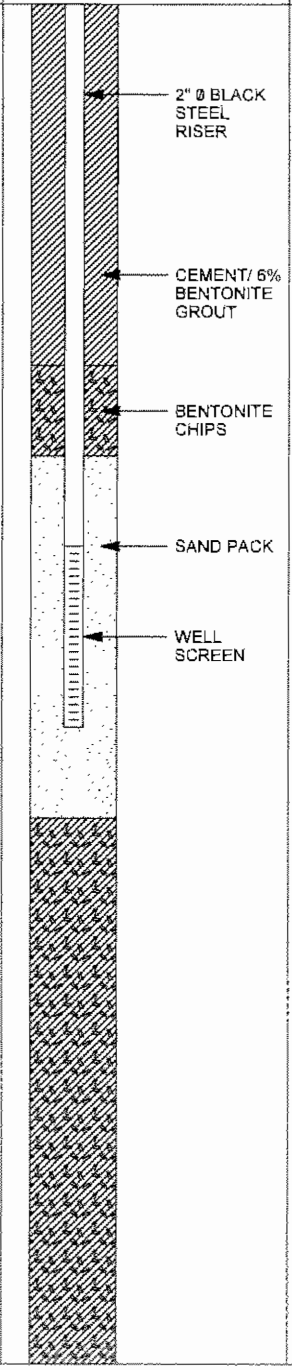
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62D
DATE COMPLETED: April 20, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
			60				14.1
305							
			61				0
310							
			62				0.4
315							
			63				1.6
320	- Groundwater sample collected at 320.0ft BGS						
	SANDY CLAY, gray/pink, moist	-192.97					
			64				1.2
325	SAND, dark brown, wet	-196.97					
			65				193.2
330							
	- clay, stiff, light brown/gray, moist at 332.0ft BGS		66				321.4
335	- stiff, with little clay, gray/brown at 335.0ft BGS						
			67				189.9
340	CLAY, soft, gray	-211.97					
			68				180.1
345							
350	CLAY, very stiff, dark gray, moist	-221.97					
			69				183.2
355	SAND, brown/orange, some stiff clay	-226.97					
	- sandy clay, light brown, wet at 357.0ft BGS		70				175.2
360	- little clay, light brown at 360.0ft BGS						
			71				510.3
365							
	- some brown firm clay, wet at 367.0ft BGS		72				605.2
370							
	CLAY, very stiff, light brown, some sand	-243.47	73				221.4

MONITOR INSTALLATION

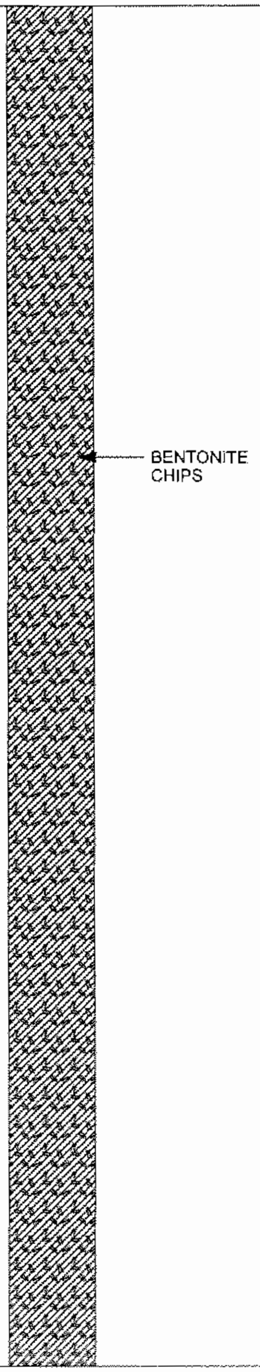


NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62D
DATE COMPLETED: April 20, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	SAND, tan/pink/orange	-246.97						
				74				1.4
380								
	- clay, firm, light gray at 382.0ft BGS			75				5.0
385	- light brown clay inclusions at 385.0ft BGS							
				76				3.0
390								
				77				2.6
395	- brown. Groundwater sample collected at 395.0ft BGS							
				78				58.8
400			BENTONITE CHIPS					
				79				20.4
405								
				80				4.2
410								
				81				3.6
415	- sand, with brown wet clay inclusions at 415.0ft BGS							
				82				3.9
420								
				83				3.7
425								
	- black hard sand inclusions at 428.0ft BGS			84				7.0
430	SANDY CLAY, gray/brown, wet	-301.97						
				85				26.8
435	SAND, gray/tan, some clay	-306.97						
				86				4.1
440								
	- red/pink at 443.0ft BGS			87				4.0
445	- stiff, orange/brown at 445.0ft BGS							
				88				6.1

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-62D
PROJECT NUMBER: 6883	DATE COMPLETED: April 20, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
			▨	89	☒			3.6
455	- Groundwater sample collected at 455.0ft BGS END OF BOREHOLE @ 455.0ft BGS	-326.97	WELL DETAILS Screened interval: -201.97 to -211.97ft AMSL 330.00 to 340.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -196.97 to -216.97ft AMSL 325.00 to 345.00ft BGS Material: SILICA SAND					
460								
465								
470								
475								
480								
485								
490								
495								
500								
505								
510								
515								
520								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE: REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62I
DATE COMPLETED: May 14, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	GROUND SURFACE TOP OF RISER	128.27 128.15						
	Rock/gravel/sand, dark brown, moist							
5				1				0
	- dry at 6.0ft BGS							
10								
				2				0
15			CEMENT/ 6% BENTONITE GROUT					
				3				0
20								
	- orange/tan with some black layering at 21.0ft BGS							
				4				0
25	- dark brown, moist at 25.0ft BGS							
				5				0
30	- dry at 30.0ft BGS							
				6				0
35								
				7				0
40			2" Ø SCH.80 PVC RISER					
	- dark gray, very firm clay, moist at 43.0ft BGS			8				0
45	SAND, some clay, gray/orange, wet	83.27						
	- stiff at 48.0ft BGS			9				2.9
50								
	- some stiff, light gray clay at 53.0ft BGS			10				1.2
55	- very stiff, light gray clay at 55.5ft BGS							
				11				0
60								
				12				0
65								
	- light gray stiff clay inclusions at 68.0ft BGS			13				0
70	- gray/tan at 70.0ft BGS							
				14				2.5

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

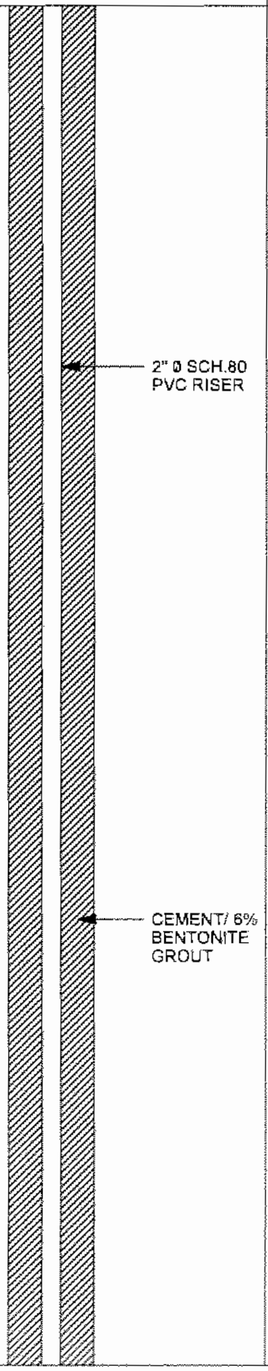
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62I
DATE COMPLETED: May 14, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
			15				2.0
80							
			16				1.5
85							
			17				1.3
90							
			18				3.9
95							
			19				1.5
100							
			20				3.8
105	- wet at 105.0ft BGS						
			21				3.6
110							
			22				2.6
115							
			23				3.3
120							
			24				3.3
125							
			25				2.1
130							
			26				1.9
135							
			27				0
140							
			28				0
145	SANDY CLAY, firm, dark gray, very moist	-16.73					
			29				0.6

MONITOR INSTALLATION



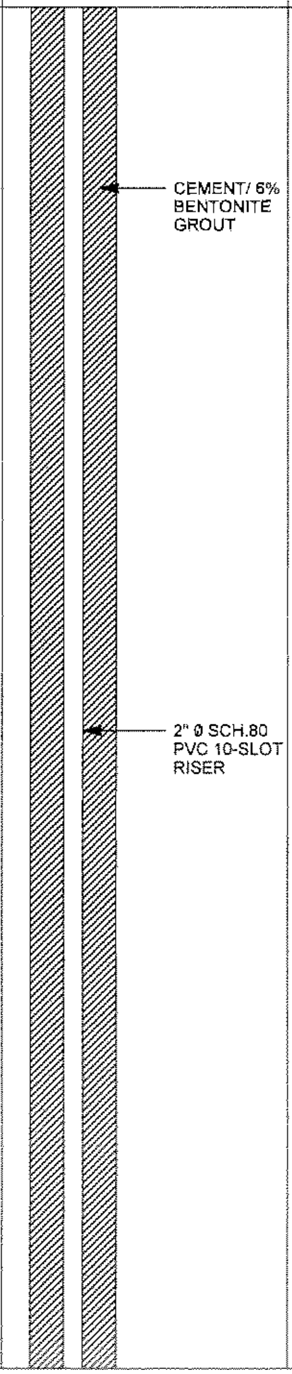
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-62I
PROJECT NUMBER: 6883	DATE COMPLETED: May 14, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- little sand, very stiff at 151.0ft BGS		30	☒			1.9
155	- firm, very moist at 155.0ft BGS		31	☒			3.8
160			32	☒			1.5
	SAND, orange/red, brown, moist, with light gray clay inclusions	-34.73					
165			33	☒			1.2
170			34	☒			1.3
175			35	☒			0.3
180	- some clay, gray/pink, moist at 180.0ft BGS		36	☒			1.3
185	- little clay at 185.0ft BGS		37	☒			1.5
190			38	☒			2.8
195			39	☒			0
200	- little clay at 203.0ft BGS		40	☒			0
205			41	☒			0.9
210			42	☒			3.1
215			43	☒			3.2
220			44	☒			3.6

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

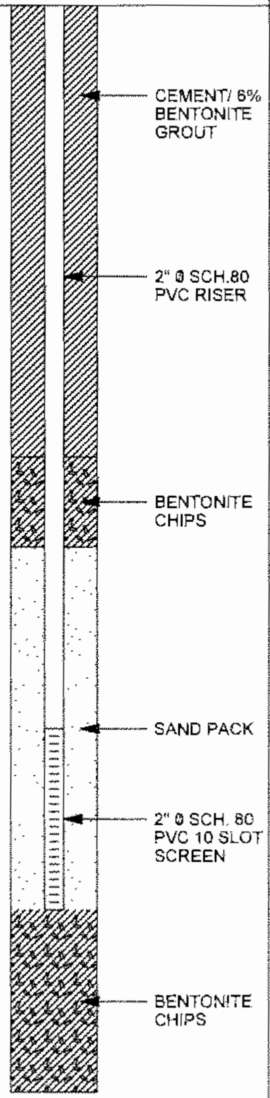
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62I
DATE COMPLETED: May 14, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	SAND, orange/brown, little clay. Groundwater sample collected at 225.0ft BGS	-96.73
230		
235	CLAY, firm, little sand, brown/orange, moist - brittle, dry, dark gray, stiff at 236.5ft BGS - very firm, moist at 238.0ft BGS	-106.73
240		
245		
250	CLAY, very stiff, brittle, dark gray, dry - some sand, less stiff at 253.0ft BGS	-121.73
255	SAND, hard, red/brown, dry	-126.73
260		
265	- some clay, stiff, gray/tan, wet at 265.0ft BGS	
270	- more clay, saturated at 273.0ft BGS	
275	- brown/orange. Groundwater sample collected at 275.0ft BGS	
280	- some clay at 280.0ft BGS	
285	END OF BOREHOLE @ 285.0ft BGS	-156.73
290		
295		

MONITOR INSTALLATION



WELL DETAILS
Screened interval:
-136.73 to -146.73ft AMSL
265.00 to 275.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10
Material: SCH. 80 PVC
Sand Pack:
-126.73 to -146.73ft AMSL
255.00 to 275.00ft BGS

SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
45	☒			4.6
46	☒			3.3
47	☒			38.6
48	☒			51.3
49	☒			25.6
50	☒			21.3
51	☒			2.5
52	☒			4.1
53	☒			0.7
54	☒			0.2
55	☒			113.7
56	☒			19.8

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

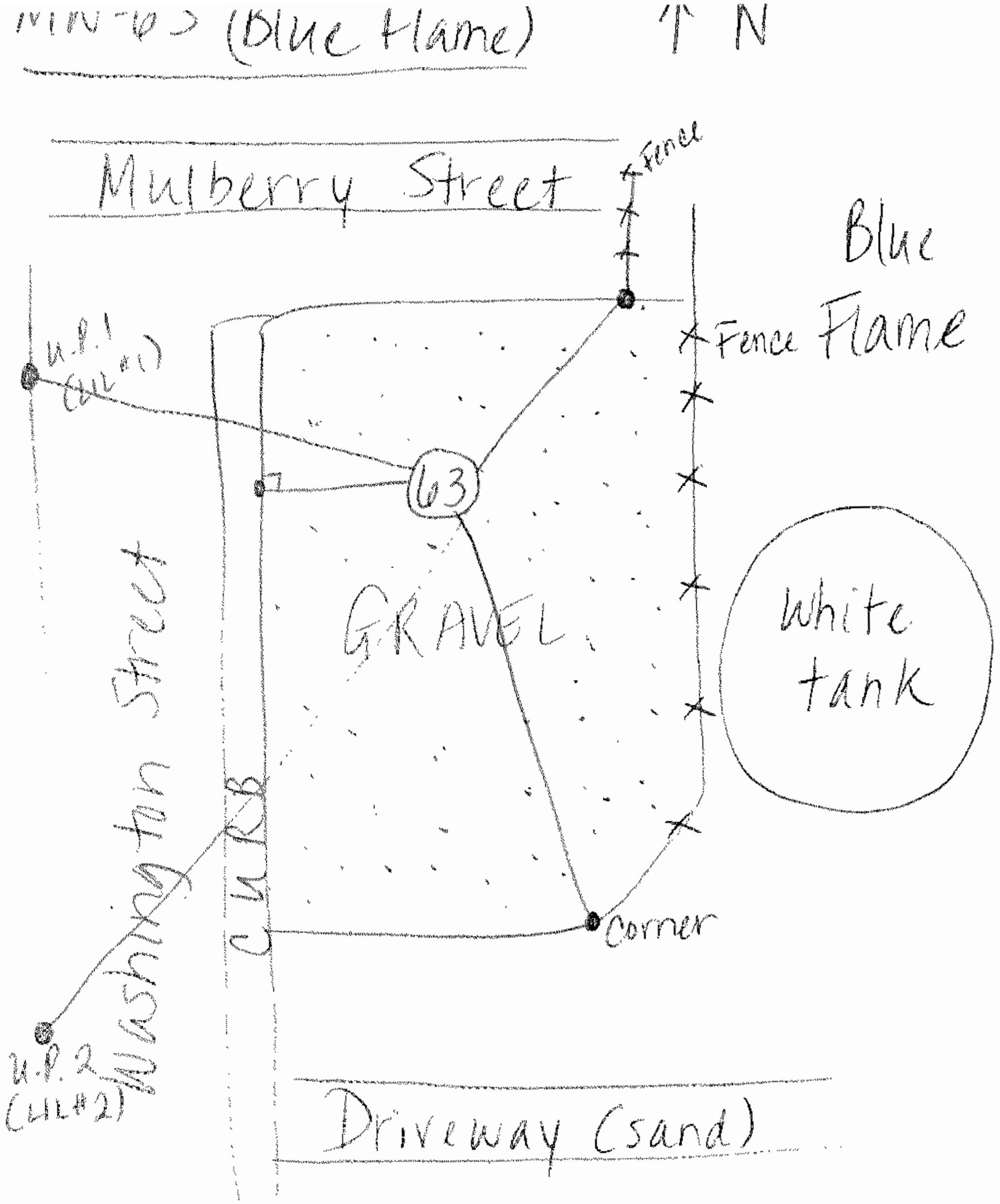
PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-62I
DATE COMPLETED: May 14, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
			Material: SILICA SAND					
305								
310								
315								
320								
325								
330								
335								
340								
345								
350								
355								
360								
365								
370								

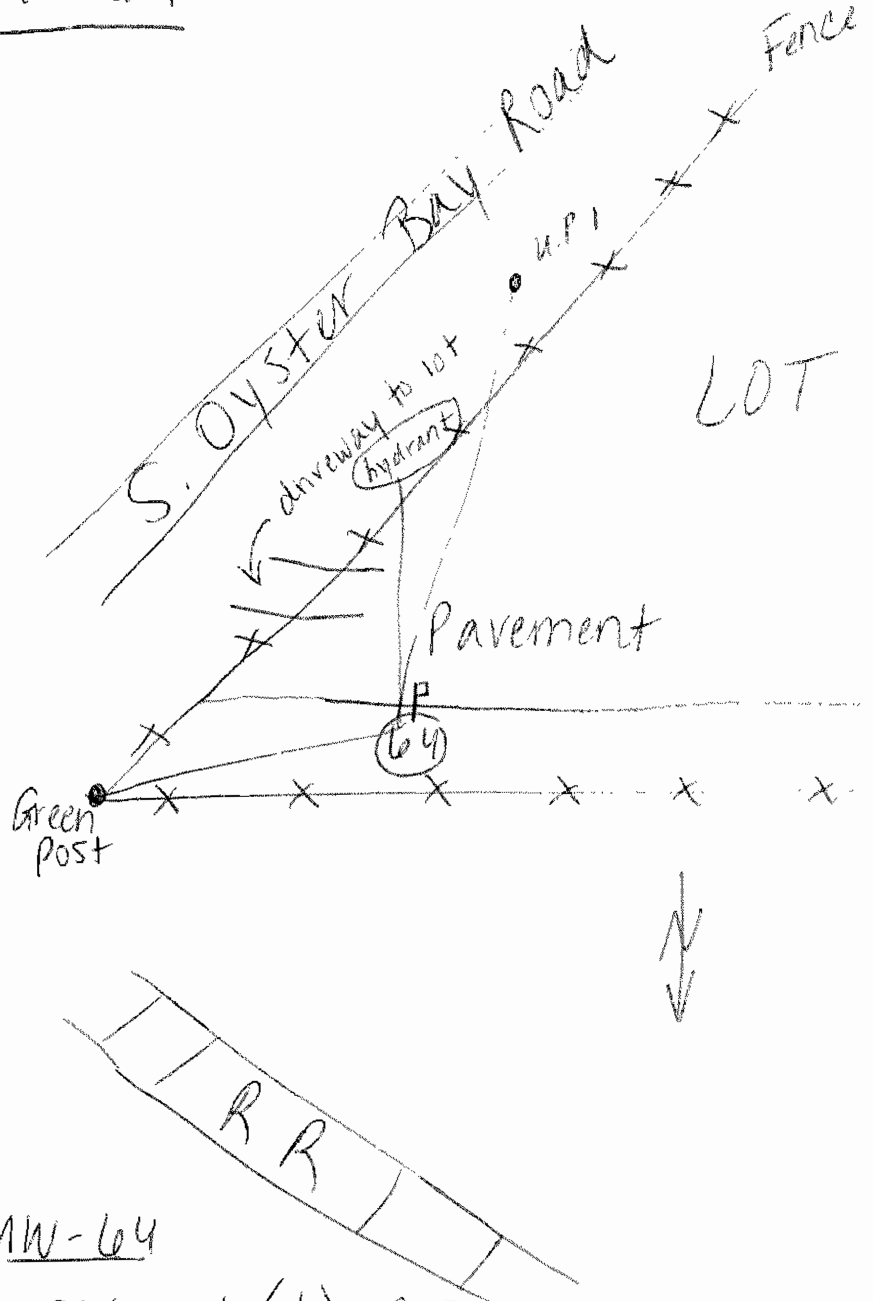
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

MW-63 (Blue Flame)



MW-63
to Fence = 32.8'
to U.P 2 (LIL#2) = 104.5'
to U.P.1 (LIL#1) = 92'
to corner = 49'
to Curb (⊥) = 16.8

MW-64

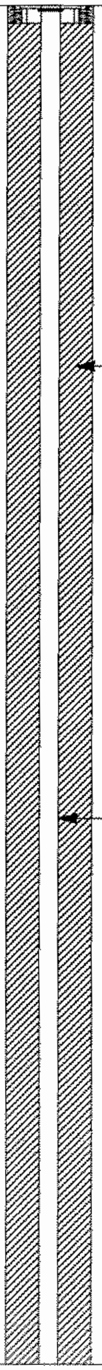


MW-64
to pavement (⊥) = 9.5'
to green post = 69.5'
to hydrant = 91'
to U.P. #1 = 126.5'

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-63 S/I/D1/D2
DATE COMPLETED: February 18, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	GROUND SURFACE TOP OF RISER	118.67 118.45						
	SAND, mixed with gravel and cobbles, dark brown to orange							
5		113.67		1				6.3
	SAND, with gravel, medium grained, orange			2				0
10	- sand with gravel and some larger cobbles, moist at 11.0ft BGS			3				8.3
15				4				6.5
20			CEMENT/ 6% BENTONITE GROUT	5				18.1
25				6				3.1
30	- white, rounded gravel with fine orange sand at 30.0ft BGS			7				17.3
35		83.17						
	SAND, fine grained, tan			8				13.8
40				9				18.3
45	- orange, with gravel at 45.0ft BGS		2" Ø SCH.80 PVC RISER					
	- coarse sand with large gravels at 48.0ft BGS			10				2.8
50		68.67						
	SAND, coarse grained, with gravel, red/orange							
	- fine black/brown sand with some silt at 53.0ft BGS			11				10.6
55		63.67						
	SAND, fine grained with some gravel, tan/orange - coarse sand at 57.0ft BGS			12				0.0
60	- fine sand, some gravel at 60.0ft BGS							
	- tan silt with clay stringers at 63.0ft BGS - medium to coarse, orange sand at 64.0ft BGS			13				4.9
65				14				1.0
70	- fine pink sand, very wet at 70.5ft BGS	48.67						
	SAND, fine, gray/tan - gray, silty clay with red banding at 73.5ft BGS			15				2.3

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

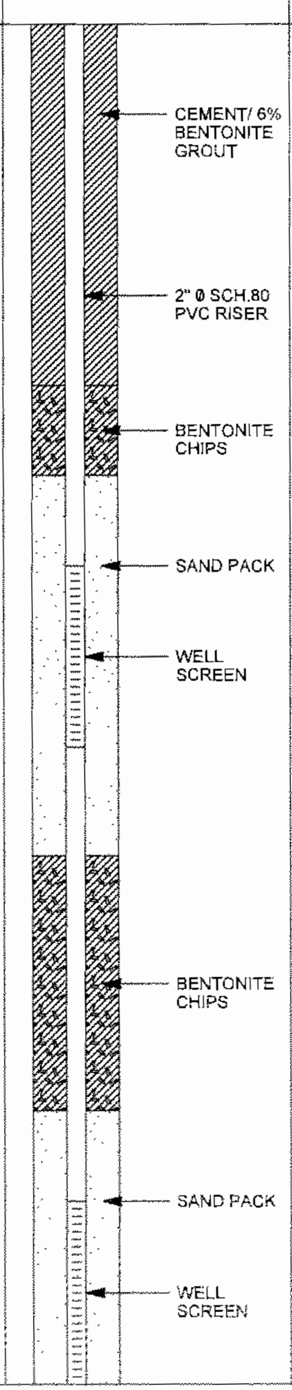
HOLE DESIGNATION: MW-63 S/I/D1/D2
DATE COMPLETED: February 18, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- medium to coarse tan/orange sand at 75.0ft BGS							
				16				0.0
	- with some thin clay, gray at 79.0ft BGS							
80	SAND, fine to medium, gray-white	38.67						
				17				1.5
85			CEMENT/ 6% BENTONITE GROUT					
	CLAY, very stiff, light brown	31.67		18				2.0
90	- dark gray at 90.0ft BGS							
				19				2.5
95	- silty clay, dark gray, stiff at 95.0ft BGS							
				20				1.0
100	- very stiff, dark gray at 100.0ft BGS							
				21				2.0
105								
	SILT, pinkish tan with fine sand	11.67		22				4.2
	SAND, medium to fine, tan	10.67						
110								
				23				9.2
	- yellow/orange at 114.0ft BGS							
115								
				24				4.0
120	- light gray sand with orange inclusions at 120.0ft BGS							
				25				6.1
125			2" Ø SCH.80 PVC RISER					
130								
				26				5.6
135	- Groundwater sample collected at 135.0ft BGS							
				27				NM
140								
	- fine silty sand, tan with orange inclusions at 142.5ft BGS			28				NM
145								
				29				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY
HOLE DESIGNATION: MW-63 S/I/D1/D2
DATE COMPLETED: February 18, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	SILTY SAND, tan/orange	-31.33	30				0
155			31				0
160			32				0
165			33				0
170	- stiff, gray clay inclusions at 170.0ft BGS		34				0
175			35				0
180			36				0
185	SAND, orange/tan. Groundwater sample collected at 185.0ft BGS	-66.33	37				0
190			38				0
195	SILTY/SANDY CLAY, tan/orange	-77.33	39				0
200			40				0
205	SANDY SILT, tan/brown, dry - wet/saturated at 208.0ft BGS	-86.33	41				0
210			42				0
215			43				0
220	SILTY CLAY, gray, wet	-101.33	44				0

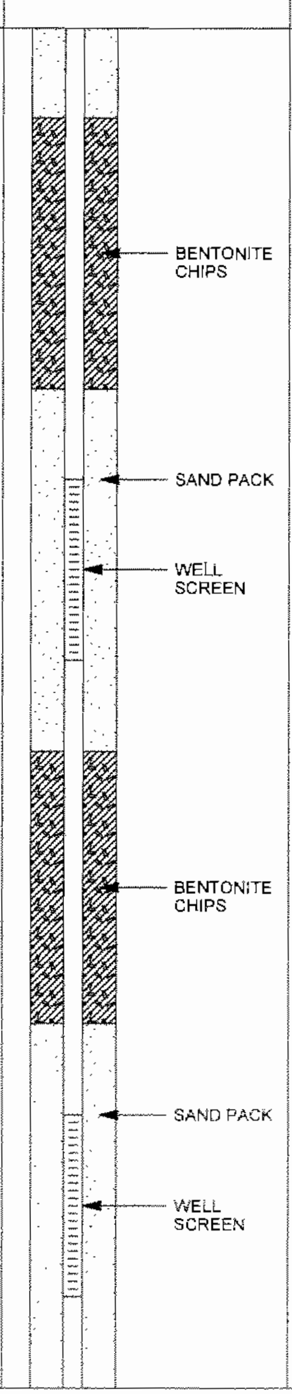
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-63 S/I/D1/D2
PROJECT NUMBER: 6883	DATE COMPLETED: February 18, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
230	SANDY CLAY, brown/orange	-111.83
235	CLAY, stiff, brown/orange, moist. Groundwater sample collected at 235.0ft BGS - saturated at 237.0ft BGS	-116.33
245	SILTY CLAY, very stiff, dark gray	-126.33
250	SANDY CLAY, silty, stiff, brown/gray	-131.33
255	SAND, orange/brown	-136.33
265	SILTY CLAY, brown/orange, stiff	-146.33
275	SAND, tan with orange, wet to saturated	-156.33
285	- Groundwater sample collected at 285.0ft BGS	

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
45				20.5
46				0
47				0
48				0
49				22.6
50				0
51				23.1
52				0
53				0
54				0
55				28.6
56				31.1
57				0
58				0
59				0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-63 S/I/D1/D2
DATE COMPLETED: February 18, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	- moist, not as stiff at 303.5ft BGS	-184.33		60				0
305	CLAY, stiff, pink/gray, dry	-186.33						
	SILTY CLAY, very stiff, dark gray, dry							
310								
315				61				0
320								
325								
			BENTONITE CHIPS	62				0
330	- wet to saturated at 330.0ft BGS							
				63				0
335	SAND, gray, wet	-216.33						
				64				0
340								
				65				0
345								
				66				0
350	- light gray stiff clay inclusions at 350.0ft BGS							
				67				0
355	- Groundwater sample collected at 355.0ft BGS	-236.33						
	END OF BOREHOLE @ 355.0ft BGS							
360								
365								
370								

WELL DETAILS
Screened interval:
-61.33 to -71.33ft AMSL
180.00 to 190.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10
Material: SCH. 80 PVC
Sand Pack:
-56.33 to -76.33ft AMSL
175.00 to 195.00ft BGS
Material: SILICA SAND

Screened interval:
-96.33 to -156.33ft AMSL

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-63 S/I/D1/D2
DATE COMPLETED: February 18, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
380 385 390 395 400 405 410 415 420 425 430 435 440 445			215.00 to 275.00ft BGS Length: 60ft Diameter: 2in Slot Size: #10 Material: SCH. 80 PVC Sand Pack: -91.33 to -111.33ft AMSL 210.00 to 230.00ft BGS Material: SILICA SAND ——— Screened interval: -131.33 to -141.33ft AMSL 250.00 to 260.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: SCH. 80 PVC Sand Pack: -126.33 to -146.33ft AMSL 245.00 to 265.00ft BGS Material: SILICA SAND ——— Screened interval: -166.33 to -176.33ft AMSL 285.00 to 295.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: SCH. 80 PVC Sand Pack: -161.33 to -181.33ft AMSL 280.00 to 300.00ft BGS Material: SILICA SAND					

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

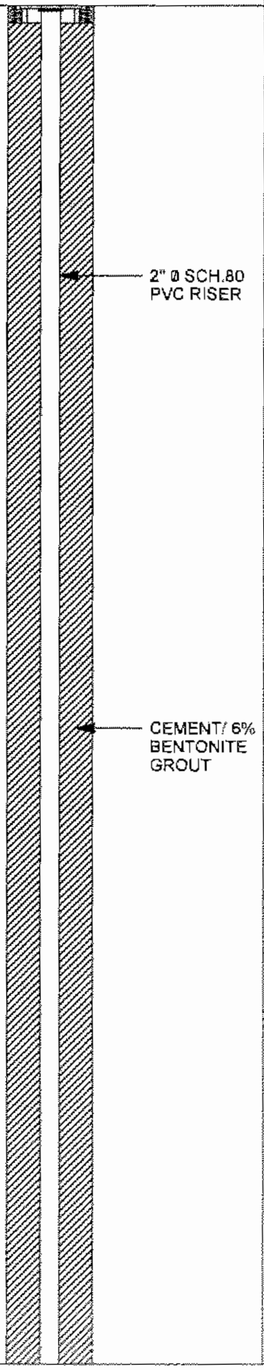
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-64 S/I/D
DATE COMPLETED: February 9, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE	125.66
	TOP OF RISER	125.59
0	SAND, medium to coarse grained, gravelly, rocky, tan, dry to moist	
10.5	- rocky at 10.5ft BGS	
15	GRAVEL, medium to coarse, brown	110.66
20.5	- more gravel at 20.5ft BGS	
25	SAND, tan, some red, no gravel	100.66
30	- gravelly, gray/tan at 30.0ft BGS	
35	- gray clay inclusions at 35.0ft BGS	
45	CLAY, little sand/silt, stiff, gray with red layering	80.66
46	SAND, tan/orange, some gray/red clay inclusions	79.66
50	- brown with rock and gravel, some clay inclusions, brown at 50.0ft BGS	
53	Alternating CLAY and SAND layers, stiff, gray/light brown	72.66
65	SAND, gray/pink - wet at 67.0ft BGS	60.66
70	SANDY CLAY, stiff, orange/tan - clay, stiff at 72.5ft BGS	55.66

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1	☒			0
2	☒			0
3	☒			0
4	☒			0
5	☒			0
6	☒			0
7	☒			0
8	☒			0
9	☒			0
10	☒			0
11	☒			0
12	☒			0
13	☒			0
14	☒			0
15	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

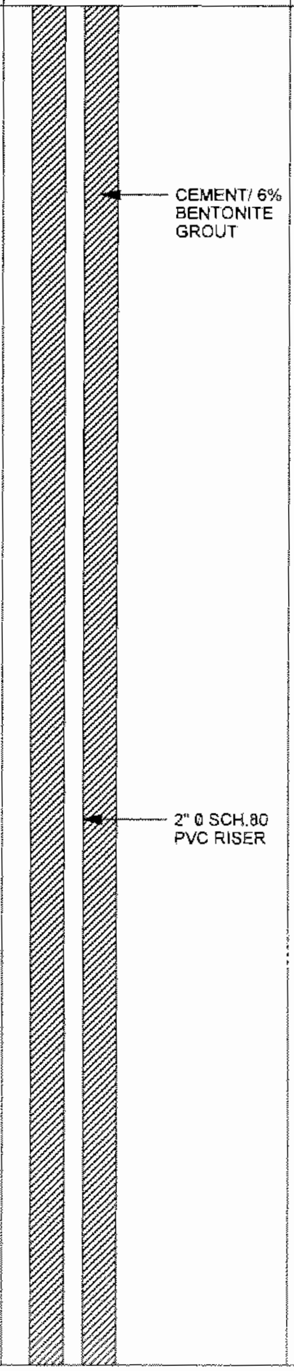
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-64 S/I/D
DATE COMPLETED: February 9, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- stiff gray clay at 75.5ft BGS						
	SAND, gray	50.66	16				0
	- stiff gray clay at 79.0ft BGS						
80							
			17				0
85							
			18				NM
90							
			19				0
95							
			20				0
100							
			21				0
105	- Groundwater sample collected at 105.0ft BGS						
	CLAY, some sand, stiff, tan/orange	18.66	22				0
110	- very stiff, gray at 110.0ft BGS						
			23				0
115	SAND, gray	11.16					
	- orange/tan at 118.0ft BGS		24				0
120							
			25				0
125							
			26				0
130							
			27				0
135							
			28				0
140							
			29				0
145							
			30				0

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

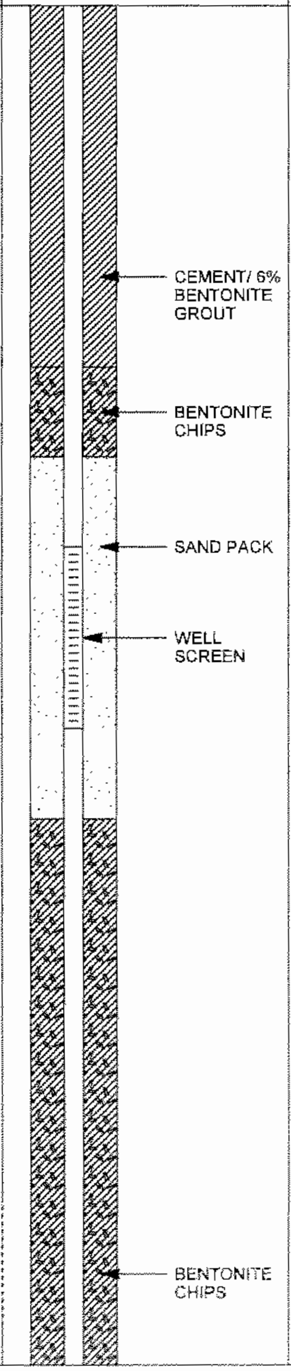
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-64 S/I/D
DATE COMPLETED: February 9, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
155	- Groundwater sample collected at 155.0ft BGS						
			31				0
160							
			32				0
165							
			33				0
170							
			34				0
175							
			35				NM
180							
			36				NM
185							
			37				NM
190							
			38				NM
	- brown/orange clay fragments of medium plasticity at 194.0ft BGS						
195							
	- stiff clay at 198.0ft BGS		39				NM
200	CLAY, gray/orange, stiff, wet	-74.34					
			40				NM
	SAND, orange/tan, some clay	-77.34					
205	SANDY CLAY, tan/red, moist. Groundwater sample collected at 205.0ft BGS	-79.34					
			41				2.6
210							
			42				1.6
215							
			43				0.3
220							
			44				0.2

MONITOR INSTALLATION



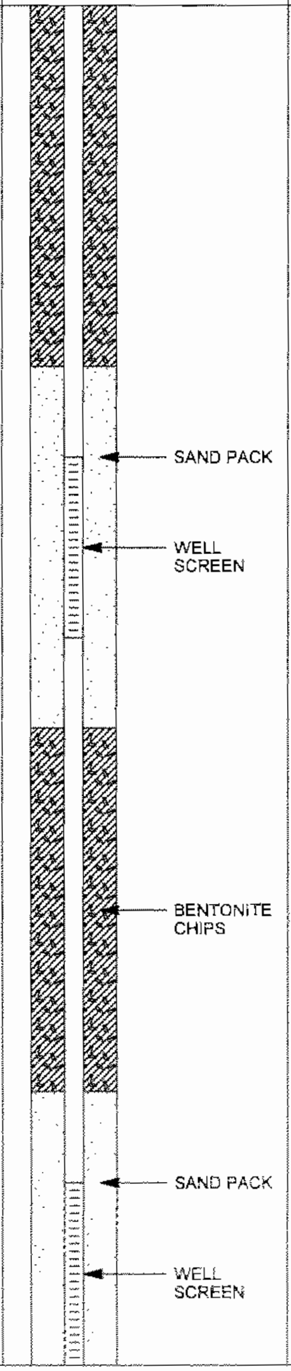
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-64 S/I/D
PROJECT NUMBER: 6883	DATE COMPLETED: February 9, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	SAND, tan/gray, moist	-99.34
230	CLAY, stiff, gray, dry	-103.34
235		
240		
	- very dry, very stiff at 241.5ft BGS	
245	SAND, light gray	-119.34
250	SANDY CLAY, tan/brown/orange. Groundwater and soil for microcosm study collected from 250.0 to 255.0ft BGS - clay, stiff, tan/orange at 254.0ft BGS	-124.34
255	SAND, gray, moist	-129.34
260	- stiff at 260.0ft BGS	
265	- sandy clay at 265.2ft BGS	
270	- clay inclusions at 270.0ft BGS	
275		
280		
285	SANDY CLAY, orange/tan/gray, wet	-159.34
290	SAND, gray/orange - sandy clay at 293.0ft BGS	-164.34
295		

MONITOR INSTALLATION



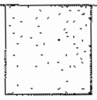
SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
45				5.7
46				6.6
47				5.7
48				5.4
49				2.4
50				8.0
51				24.3
52				15.9
53				28.4
54				24.4
55				5.1
56				4.1
57				4.0
58				5.4
59				8.6

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

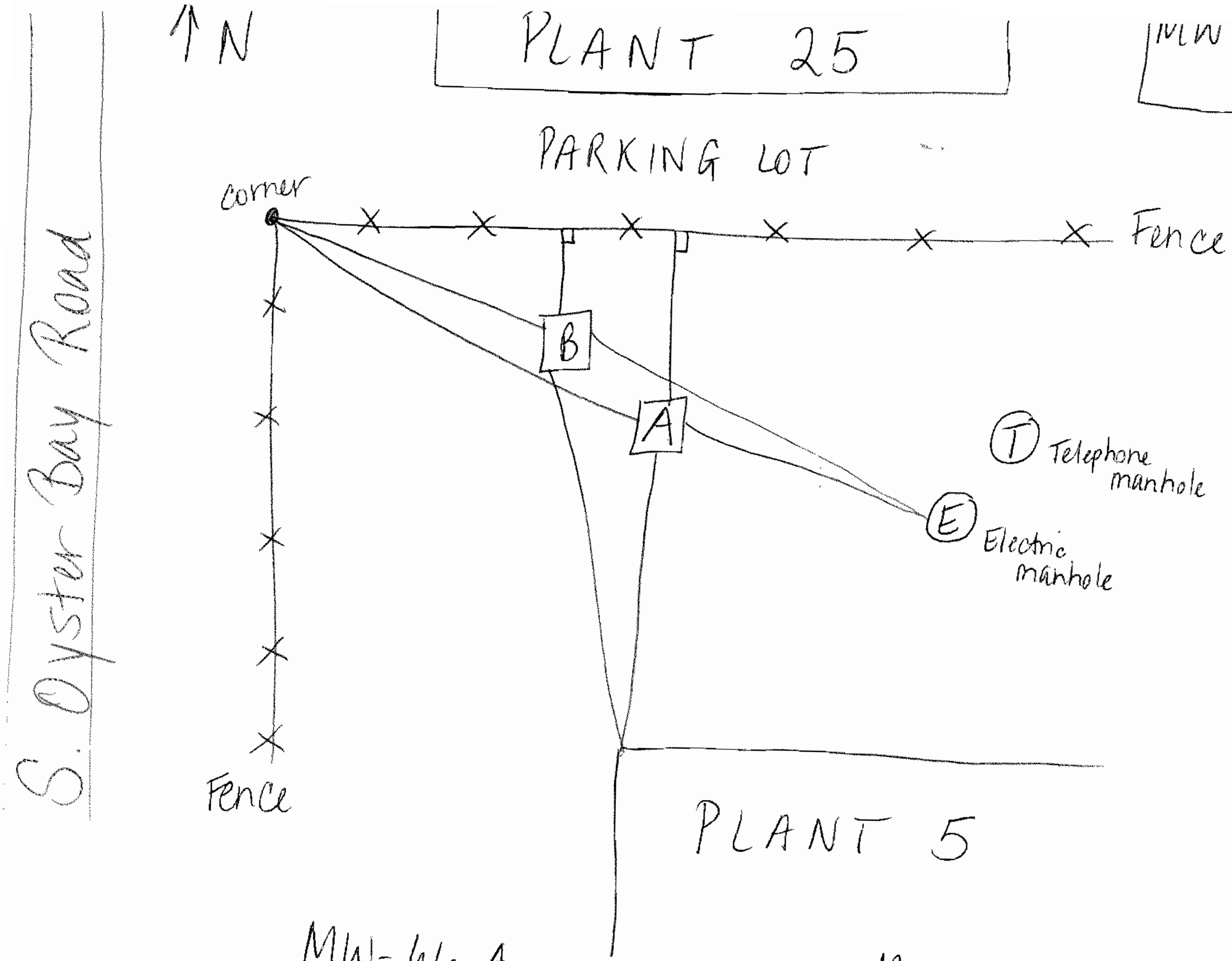
PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-64 S/I/D
DATE COMPLETED: February 9, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	- some clay at 300.0ft BGS			60	☒			5.8
305	- Groundwater sample collected at 305.0ft BGS	-179.34						
	END OF BOREHOLE @ 305.0ft BGS		WELL DETAILS Screened interval: -54.34 to -64.34ft AMSL 180.00 to 190.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: SCH. 80 PVC Sand Pack: -49.34 to -69.34ft AMSL 175.00 to 195.00ft BGS Material: SILICA SAND ------ Screened interval: -124.34 to -134.34ft AMSL 250.00 to 260.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: SCH. 80 PVC Sand Pack: -119.34 to -139.34ft AMSL 245.00 to 265.00ft BGS Material: SILICA SAND ------ Screened interval: -164.34 to -174.34ft AMSL 290.00 to 300.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: SCH. 80 PVC Sand Pack: -159.34 to -179.34ft AMSL 285.00 to 305.00ft BGS Material: SILICA SAND					
310								
315								
320								
325								
330								
335								
340								
345								
350								
355								
360								
365								
370								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

MW-66 CLUSTER



MW-66 A

to corner = 66'
to fence (⊥) = 30.1'
to Electric = 45.7'
to Plant 5 = 159.5
to MW-66 B = 11.7'

MW-66 B

to Corner = 60'
to fence (⊥) = 18.5'
to Electric = 53.0'
to Plant 5 = 171.5'
to MN-66 A = 11.7'

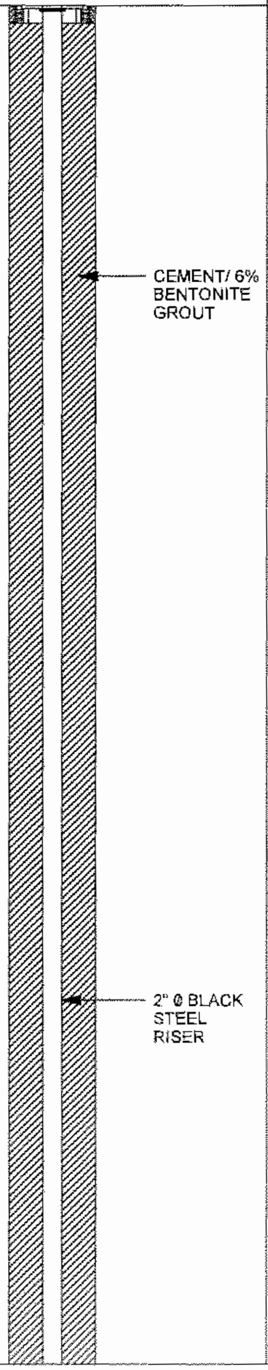
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 D2
DATE COMPLETED: June 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	GROUND SURFACE TOP OF RISER	118.60 118.15
	SAND, orange/brown with rock and gravel, dry	
5		
10		
15		
20		
25		
30	- beige/tan, very little rock and gravel at 30.0ft BGS	
35	- dark brown/tan/little orange at 35.0ft BGS	
40		
	SAND, brown/tan/bright orange, no rock/gravel, dry	76.60
45	CLAY, stiff, gray/brown	73.60
50	SAND, orange/beige	68.60
55		
60		
65		
70	SAND, with little clay, dark brown/orange, wet	48.60

MONITOR INSTALLATION



SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
1	☒			0
2	☒			0
3	☒			0
4	☒			0
5	☒			0
6	☒			0
7	☒			0
8	☒			0
9	☒			0
10	☒			0
11	☒			0
12	☒			0
13	☒			0
14	☒			0
15	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

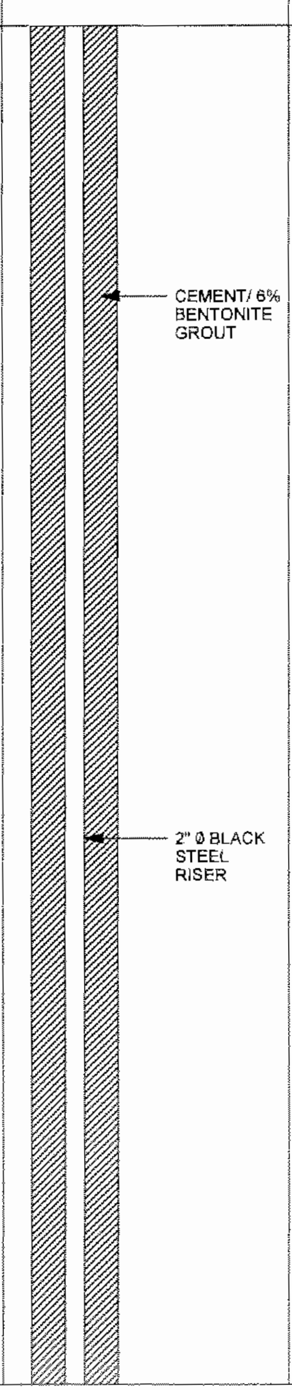
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 D2
DATE COMPLETED: June 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
80		
85		
90		
95	CLAY, very stiff, light gray, some brown sand, wet	23.60
100	SAND, orange/brown, saturated	16.60
105		
110		
115	- some clay at 117.0ft BGS	
120	- light gray clay at 120.0ft BGS	
125		
130		
135	SAND, with little clay, tan/brown/orange	-19.40
140		
145	- some clay at 145.0ft BGS	

MONITOR INSTALLATION



SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
16				0
17				0
18				0
19				0
20				0
21				0
22				0
23				0
24				0
25				1.2
26				1.6
27				4.2
28				15.9
29				112.1
30				51.9

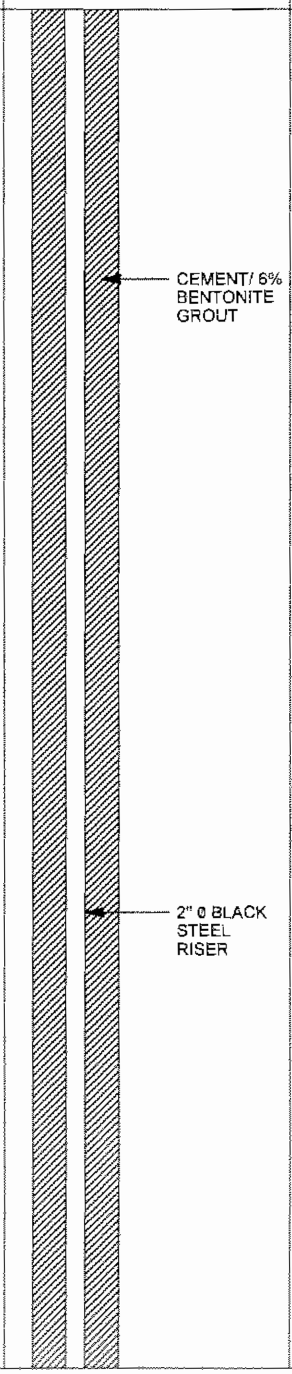
NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 D2
DATE COMPLETED: June 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

MONITOR INSTALLATION



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- with little clay at 150.0ft BGS		31	☒			50.7
155			32	☒			275.1
160	- dark brown/rust orange at 162.0ft BGS - stiff, moist, light brown/light gray clay at 163.0ft BGS		33	☒			>1999
165			34	☒			186.4
170			35	☒			259.7
175	- some clay at 177.0ft BGS		36	☒			450.8
180	- little clay at 182.0ft BGS		37	☒			531.6
185			38	☒			562.1
190	- some clay at 190.0ft BGS		39	☒			912.2
195	SAND, brown/orange. Collected groundwater sample at 195ft BGS.	-76.40	40	☒			409.2
200	- with clay at 200.0ft BGS		41	☒			516.4
205	- very sandy at 208.0ft BGS		42	☒			326.7
210			43	☒			336.0
215			44	☒			376.8
220	CLAY, very stiff, light brown/light gray, moist - with orange/brown sand at 222.0ft BGS	-101.40	45	☒			520.1

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

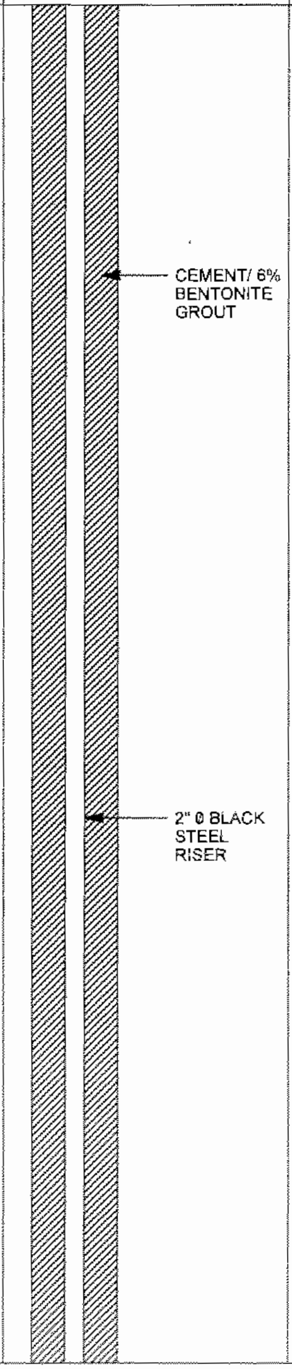
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 D2
DATE COMPLETED: June 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	SAND, tan/brown/orange	-106.40
230	- with light gray stiff clay inclusions at 230.0ft BGS	
235	- with little clay at 235.0ft BGS	
240	- dark gray layering, more clay at 240.0ft BGS	
245	- Collected groundwater sample at 245.0ft BGS	
250		
	CLAY, very stiff, brown/gray	-132.40
255		
	SAND, brown/orange	-136.40
260		
	CLAY, firm, light brown/light gray, wet, some sand	-144.40
265	SAND, rust orange/brown, little clay	-145.40
270		
275		
280	- some light gray clay inclusions with black layering at 280.0ft BGS	
285	- light brown with some orange at 285.0ft BGS	
290		
	CLAY, firm, gray/black	-173.40
	SAND, brown/orange	-174.40
295	- Collected groundwater sample at 295.0ft BGS	

MONITOR INSTALLATION



SAMPLE

NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
46				4.1
47				6.6
48				9.2
49				14.8
50				40.3
51				41.6
52				61.3
53				62.5
54				118.1
55				126.2
56				16.2
57				16.8
58				14.2
59				5.6
60				>1999

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-66 D2
PROJECT NUMBER: 6883	DATE COMPLETED: June 8, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	- dark brown at 304.0ft BGS			61	X			>1999
305				62	X			>1999
310			CEMENT/ 6% BENTONITE GROUT	63	X			>1999
315	- little clay at 318.0ft BGS			64	X			>1999
320	- light gray, stiff, moist sand at 320.0ft BGS - gray sand, some clay at 323.0ft BGS			65	X			>1999
325				66	X			756.2
330				67	X			629.6
335	- some clay at 338.0ft BGS			68	X			421.3
340	CLAY, light brown, stiff, moist. Groundwater sample collected at 340ft BGS	-221.40		69	X			264.8
345	SAND, light gray with some light brown, little clay	-226.40		70	X			>1999
350			2" 0 BLACK STEEL RISER	71	X			>1999
355	- some clay at 359.0ft BGS			72	X			>1999
360				73	X			>1999
365	- very stiff, brown/red clay at 366.0ft BGS			74	X			>1999
370				75	X			>1999

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

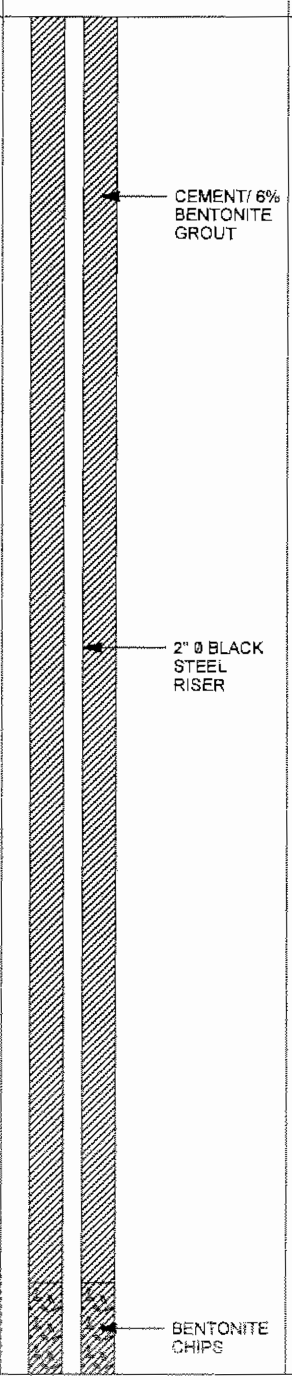
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 D2
DATE COMPLETED: June 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	CLAY/SAND, stiff, light gray/orange	-256.40					
	SAND, gray	-258.40	76				4.8
380	- some rust spotting at 380.0ft BGS						
			77				16.2
385							
			78				13.9
390	SAND/CLAY	-270.40					
	SAND, gray/brown/orange	-273.40	79				22.4
395	- Groundwater sample collected at 395.0ft BGS. Dark gray at 395.0ft BGS						
			80				7.1
400							
			81				11.2
405							
			82				13.0
410	- stiff gray clay inclusions at 410.0ft BGS						
			83				NM
415							
			84				8.0
420	- dark gray clay inclusions at 420.0ft BGS						
			85				7.4
425	- orange/gray at 425.0ft BGS						
			86				923.3
430							
			87				867.1
435	- gray clay inclusions at 435.0ft BGS						
			88				744.2
440							
			89				521.2
445							
			90				561.8

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

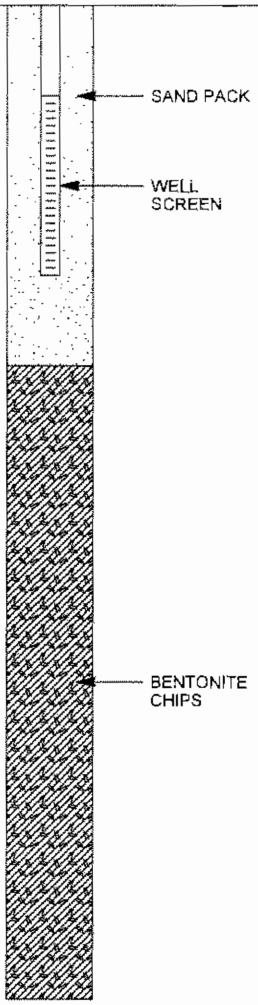
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 D2
DATE COMPLETED: June 8, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
	SAND, tan/light gray	-331.40
	- some clay at 453.0ft BGS	
455	- Groundwater sample collected, some pink inclusions at 455.0ft BGS	
460		
465		
470	- very coarse, brown/orange at 470.0ft BGS	
475	- orange, with gray clay inclusions at 475.0ft BGS	
480		
485	- coarse sand with red and gray clay inclusions at 484.0ft BGS	
490		
495		
500	- Groundwater sample collected at 500.0ft BGS	
	- with gravel and some silt at 502.0ft BGS	
505	END OF BOREHOLE @ 505.0ft BGS	-386.40
510		
515		
520		

MONITOR INSTALLATION



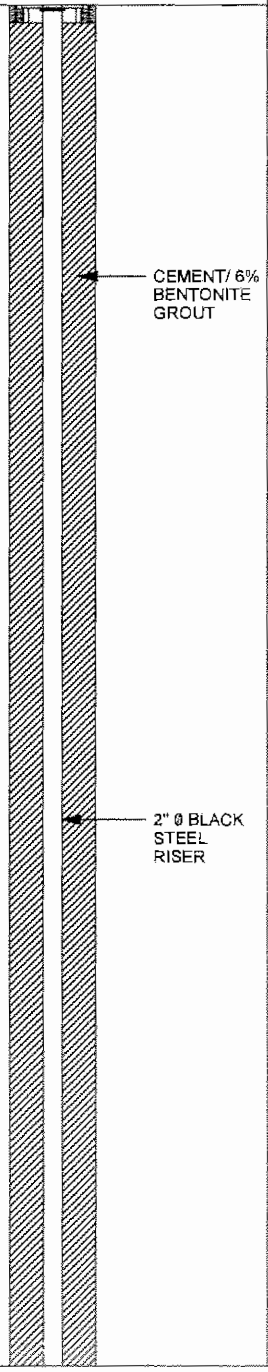
WELL DETAILS
Screened interval:
-336.40 to -346.40ft AMSL
455.00 to 465.00ft BGS
Length: 10ft
Diameter: 2in
Slot Size: #10
Material: S.S.
Sand Pack:
-331.40 to -351.40ft AMSL
450.00 to 470.00ft BGS
Material: SILICA SAND

SAMPLE				
NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
91	☒			565.2
92	☒			135.4
93	☒			3.5
94	☒			0
95	☒			778
96	☒			0
97	☒			14
98	☒			0.9
99	☒			0
100	☒			0
101	☒			31.7

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-66 I/D1
PROJECT NUMBER: 6883	DATE COMPLETED: June 19, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	GROUND SURFACE TOP OF RISER	118.27 118.20					
	SAND, orange/brown with rock and gravel, dry		1	☒			0
5			2	☒			0
10			3	☒			0
15			4	☒			0
20			5	☒			0
25			6	☒			0
30	- beige/tan, very little rock and gravel at 30.0ft BGS		7	☒			0
35	- dark brown/tan/little orange at 35.0ft BGS		8	☒			0
40			9	☒			0
	SAND, brown/tan/bright orange, no rock/gravel, dry	76.27					
45	CLAY, stiff, gray/brown	73.27	10	☒			0
50	SAND, orange/beige	68.27	11	☒			0
55			12	☒			0
60			13	☒			0
65			14	☒			0
70	SAND, with little clay, dark brown/orange, wet	48.27	15	☒			0

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

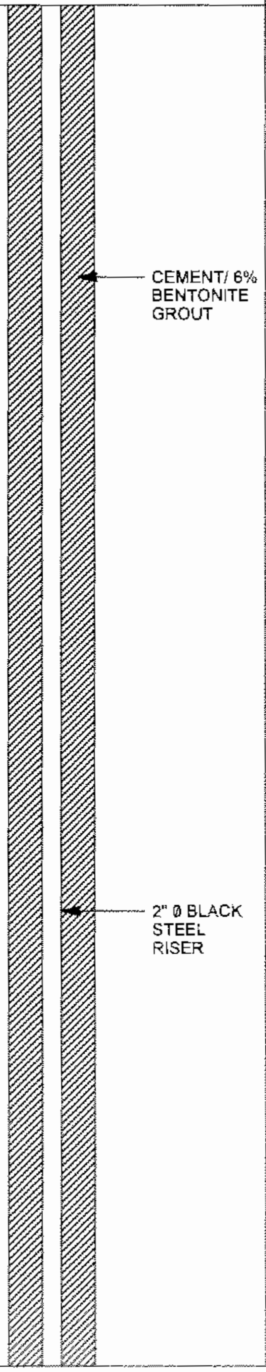
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

Page 2 of 6

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 I/D1
DATE COMPLETED: June 19, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

MONITOR INSTALLATION



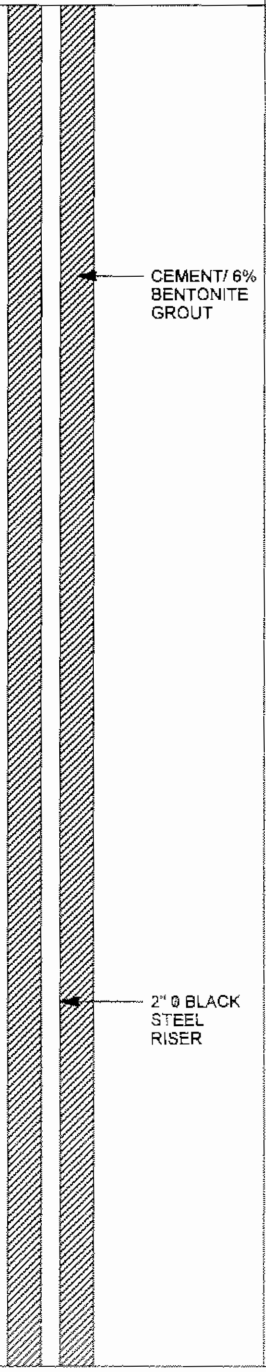
DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
			16	☒			0
80			17	☒			0
85			18	☒			0
90			19	☒			0
95	CLAY, very stiff, light gray, some brown sand, wet	23.27	20	☒			0
100	SAND, orange/brown, saturated	16.27	21	☒			0
105			22	☒			0
110			23	☒			0
115	- some clay at 117.0ft BGS		24	☒			0
120	- light gray clay at 120.0ft BGS		25	☒			1.2
125			26	☒			1.6
130			27	☒			4.2
135	SAND, with little clay, tan/brown/orange	-19.73	28	☒			15.9
140			29	☒			112.1
145	- some clay at 145.0ft BGS		30	☒			51.9

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

OVERBURDEN LOG 6883.GPJ CRA_CORP.GDT 7/15/02

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO	HOLE DESIGNATION: MW-66 I/D1
PROJECT NUMBER: 6883	DATE COMPLETED: June 19, 2002
CLIENT: OCCIDENTAL CHEMICAL CORPORATION	DRILLING METHOD: 6" ID ROTASONIC
LOCATION: HICKSVILLE, NY	FIELD PERSONNEL: L. HAMILTON



DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
	- with little clay at 150.0ft BGS						
			31	☒			50.7
155							
			32	☒			275.1
160							
	- dark brown/rust orange at 162.0ft BGS - stiff, moist, light brown/light gray clay at 163.0ft BGS		33	☒			>1999
165							
			34	☒			186.4
170							
			35	☒			259.7
175							
	- some clay at 177.0ft BGS		36	☒			450.8
180							
	- little clay at 182.0ft BGS		37	☒			531.6
185							
			38	☒			562.1
190	- some clay at 190.0ft BGS						
			39	☒			912.2
195	SAND, brown/orange. Collected groundwater sample at 195ft BGS.	-76.73					
			40	☒			409.2
200	- with clay at 200.0ft BGS						
			41	☒			518.4
205							
	- very sandy at 208.0ft BGS		42	☒			326.7
210							
			43	☒			336.0
215							
			44	☒			376.8
220	CLAY, very stiff, light brown/light gray, moist	-101.73					
	- with orange/brown sand at 222.0ft BGS		45	☒			520.1

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

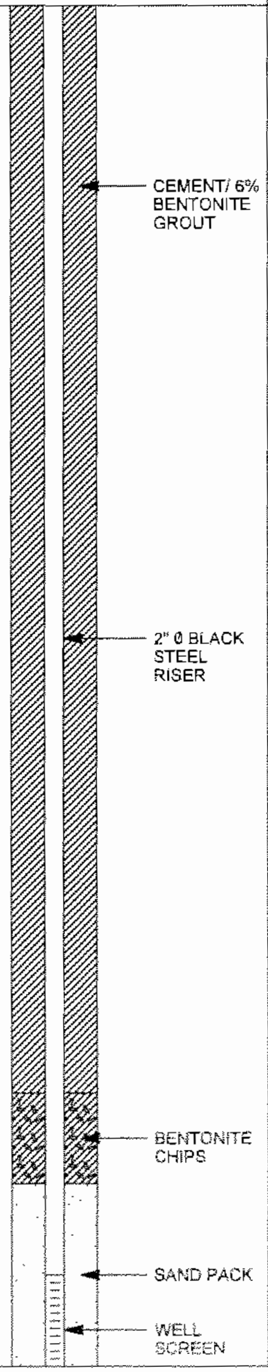
STRATIGRAPHIC AND INSTRUMENTATION LOG (OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 I/D1
DATE COMPLETED: June 19, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE REC (%)	SAMPLE 'N' VALUE	SAMPLE PID (ppm)
	SAND, tan/brown/orange	-106.73					
			46	X			4.1
230	- with light gray stiff clay inclusions at 230.0ft BGS						
			47	X			6.6
235	- with little clay at 235.0ft BGS						
			48	X			9.2
240	- dark gray layering, more clay at 240.0ft BGS						
			49	X			14.8
245	- Collected groundwater sample at 245.0ft BGS						
			50	X			40.3
250							
	CLAY, very stiff, brown/gray	-132.73	51	X			41.6
255	SAND, brown/orange	-136.73					
			52	X			61.3
260							
	CLAY, firm, light brown/light gray, wet, some sand	-144.73	53	X			62.5
265	SAND, rust orange/brown, little clay	-145.73					
			54	X			118.1
270							
			55	X			126.2
275							
			56	X			16.2
280	- some light gray clay inclusions with black layering at 280.0ft BGS						
			57	X			16.8
285	- light brown with some orange at 285.0ft BGS						
			58	X			14.2
290							
	CLAY, firm, gray/black	-173.73	59	X			5.6
295	SAND, brown/orange - Collected groundwater sample at 295.0ft BGS	-174.73					
			60	X			>1999

MONITOR INSTALLATION



NOTES: MEASURING POINT ELEVATIONS MAY CHANGE, REFER TO CURRENT ELEVATION TABLE

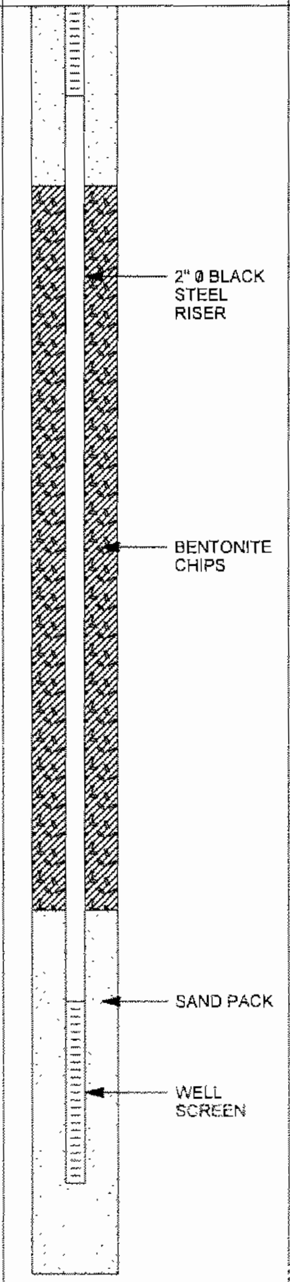
STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 I/D1
DATE COMPLETED: June 19, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL
305	- dark brown at 304.0ft BGS	
310		
315		
	- little clay at 318.0ft BGS	
320	- light gray, stiff, moist sand at 320.0ft BGS	
	- gray sand, some clay at 323.0ft BGS	
325		
330		
335		
	- some clay at 338.0ft BGS	
340	CLAY, light brown, stiff, moist. Groundwater sample collected at 340ft BGS	-221.73
345	SAND, light gray with some light brown, little clay	-226.73
350		
355		
360	- some clay at 359.0ft BGS	
365	- very stiff, brown/red clay at 366.0ft BGS	
370	END OF BOREHOLE @ 370.0ft BGS	-251.73

MONITOR INSTALLATION



WELL DETAILS
Screened interval:
-176.73 to -186.73ft AMSL

SAMPLE NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
61				>1999
62				>1999
63				>1999
64				>1999
65				>1999
66				756.2
67				629.6
68				421.3
69				264.8
70				>1999
71				>1999
72				>1999
73				>1999
74				>1999

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

STRATIGRAPHIC AND INSTRUMENTATION LOG
(OVERBURDEN)

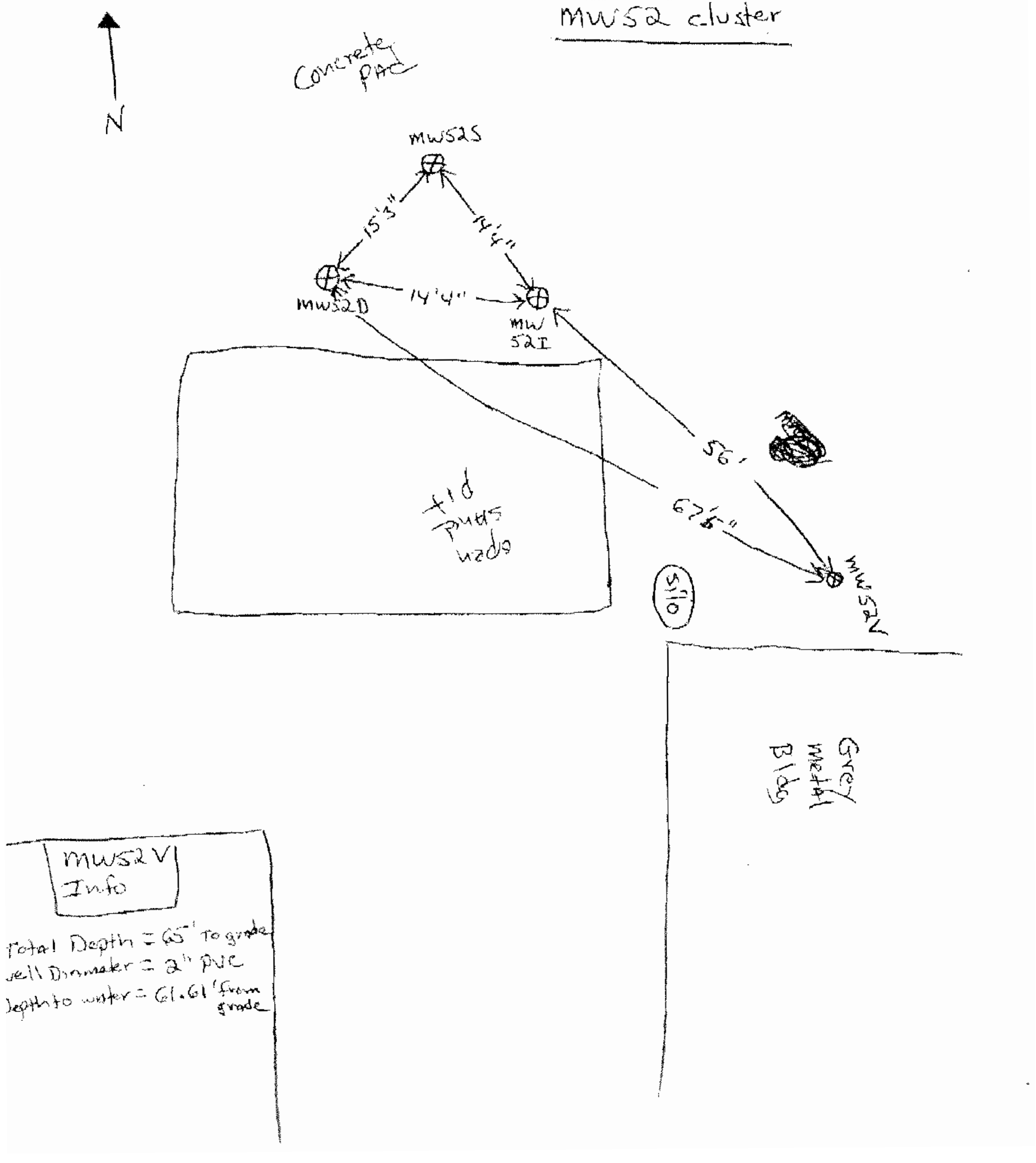
PROJECT NAME: HOOKER/RUCO
PROJECT NUMBER: 6883
CLIENT: OCCIDENTAL CHEMICAL CORPORATION
LOCATION: HICKSVILLE, NY

HOLE DESIGNATION: MW-66 I/D1
DATE COMPLETED: June 19, 2002
DRILLING METHOD: 6" ID ROTASONIC
FIELD PERSONNEL: L. HAMILTON

DEPTH ft BGS	STRATIGRAPHIC DESCRIPTION & REMARKS	ELEV. ft AMSL	MONITOR INSTALLATION	SAMPLE				
				NUMBER	INTERVAL	REC (%)	'N' VALUE	PID (ppm)
			295.00 to 305.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -171.73 to -191.73ft AMSL 290.00 to 310.00ft BGS Material: SILICA SAND —— Screened interval: -236.73 to -246.73ft AMSL 355.00 to 365.00ft BGS Length: 10ft Diameter: 2in Slot Size: #10 Material: S.S. Sand Pack: -231.73 to -251.73ft AMSL 350.00 to 370.00ft BGS Material: SILICA SAND					
380								
385								
390								
395								
400								
405								
410								
415								
420								
425								
430								
435								
440								
445								

NOTES: MEASURING POINT ELEVATIONS MAY CHANGE; REFER TO CURRENT ELEVATION TABLE

Hooker-Ruco #6883
MW52 cluster



MW52V Info

Total Depth = 65' To grade
Well Diameter = 2" PVC
Depth to water = 61.61' from grade

APPENDIX B

ISOFLOW PURGING AND ANALYTICAL RESULTS

TABLE B.1

SUMMARY OF ISOFLOW SAMPLE FINAL PURGE PARAMETERS
OU-3 PREDESIGN ACTIVITIES
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Sample Depth (ft bgs)*	*Volume Purged (Gallon)*	*pH*	*Conductivity (mS/cm)*	*Temperature (°C)*	*Water Quality*
MW-58	195	135	6.37	160	16.5	slightly cloudy
	245	150	6.90	170	17.8	slightly cloudy
	315	150	5.62	160	14.1	orange, slightly cloudy
	365	240	8.34	140	17.6	silty
	415	150	9.61	170	16.7	gray, cloudy
	465	165	8.12	160	14.9	clear, slightly yellow
	515	200	7.22	160	14.7	silty
MW-59	305	150	6.79	130	18.7	clear, orange
	355	120	6.89	140	17.4	clear
	405	200	6.68	130	16.0	clearing, slightly cloudy
	455	140	9.33	480	13.6	gray, cloudy
	515	190	7.25	130	14.6	slightly cloudy
MW-60	145	200	5.12	50	13.8	clearing
	185	400	5.24	250	14.3	clearing
	235	175	5.46	280	16.1	slightly cloudy
	285	225	5.23	250	15.9	clearing
	335	200	6.44	160	13.6	clear
	385	100	8.27	180	11.3	clearing
MW-61	130	210	6.05	170	14.9	yellowish
	185	160	6.01	160	15.1	clear, yellowish
	255	130	7.01	170	14.3	very silty, brown
	305	180	8.40	370	18.3	gray, cloudy
	355	150	9.91	740	18.4	brown, silty
	405	160	6.04	170	15.4	clearing
MW-62	225	200	5.38	250	14.9	orange, slightly cloudy

TABLE B.1

SUMMARY OF ISOFLOW SAMPLE FINAL PURGE PARAMETERS
OU-3 PREDESIGN ACTIVITIES
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Sample Depth (ft bgs)*	*Volume Purged (Gallon)*	*pH*	*Conductivity (mS/cm)*	*Temperature (°C)*	*Water Quality*
	275	130	5.52	160	15.8	clear
	325	130	6.78	120	17.5	clearing
	395	150	9.23	140	18.9	clearing
	455	140	7.89	120	17.1	clearing
MW-63	135	40	8.06	170	8.9	orange, cloudy, slow recovery
	185	140	5.77	200	13.4	clearing
	235	120	6.10	220	13.7	little silt
	285	190	5.95	170	13.1	clearing
	355	240	8.71	170	13.4	clearing
MW-64	105	275	6.32	220	NM	clear
	155	310	6.22	30	NM	clear
	205	260	6.72	172	9.2	clearing
	255	450	6.05	390	13.4	silty, sample collected for microcosm study
	300	300	7.15	150	11.5	
MW-66	195	325	5.23	570	18.3	clear
	245	210	6.86	190	17.6	bright orange
	295	315	5.35	150	18.3	slightly cloudy, yellow, clearing
	345	160	6.12	140	17.5	slightly cloudy
	395	225	5.43	120	17.8	clear
	455	165	5.20	150	17.1	clear
	505	90	5.85	90	17.7	clear

TABLE B.2

ISOFLOW ANALYTICAL RESULTS SUMMARY
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE, NEW YORK
FEBRUARY 2002 TO JUNE 2002

Sample Location:		*MW-58*	*MW-58*	*MW-58*	*MW-58*	*MW-58*	*MW-58*	*MW-5*
Sample ID:		*W-031902-6883-LMH-22*	*W-031902-6883-LMH-23*	*W-032002-6883-LMH-24*	*W-032102-6883-LMH-25*	*W-032102-6883-LMH-26*	*W-032202-6883-LMH-27*	*W-032502-6883*
Sample Date:		*3/19/2002*	*3/19/2002*	*3/20/2002*	*3/21/2002*	*3/21/2002*	*3/22/2002*	*3/25/200*
		195 ft (bgs)	*245 ft (bgs)*	*315 ft (bgs)*	*365 ft (bgs)*	*415 ft (bgs)*	*465 ft (bgs)*	*515 ft (b*
Parameter	*Unit*							
Volatiles								
1,1,1-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,1,2,2-Tetrachloroethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,1,2-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,1-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,1-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,2,4-Trichlorobenzene	ug/L	-	-	-	-	-	-	-
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	-	-	-	-	-	-	-
1,2-Dibromoethane (Ethylene Dibromide)	ug/L	-	-	-	-	-	-	-
1,2-Dichlorobenzene	ug/L	-	-	-	-	-	-	-
1,2-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,2-Dichloroethene (total)	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,2-Dichloropropane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
1,3-Dichlorobenzene	ug/L	-	-	-	-	-	-	-
1,4-Dichlorobenzene	ug/L	-	-	-	-	-	-	-
2-Butanone	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
2-Hexanone	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
4-Methyl-2-pentanone	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Acetone	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	4 J
Benzene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Bromodichloromethane	ug/L	1 J	10 U	10 U	10 U	100 U	10 U	10 U
Bromoform	ug/L	3 J	10 U	2 J	1 J	100 U	1 J	10 U
Bromomethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Carbon disulfide	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Carbon tetrachloride	ug/L	10 U	10 U	10 U	10 U	790	10 U	10 U
Chlorobenzene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Chloroethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Chloroform (Trichloromethane)	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Chloromethane	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	5 J
cis-1,2-Dichloroethene	ug/L	-	-	-	-	-	-	-
cis-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Cyclohexane	ug/L	-	-	-	-	-	-	-
Dibromochloromethane	ug/L	2 J	10 U	1 J	10 U	100 U	1 J	10 U
Dichlorodifluoromethane (CFC-12)	ug/L	-	-	-	-	-	-	-
Ethylbenzene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Isopropylbenzene	ug/L	-	-	-	-	-	-	-
Methyl acetate	ug/L	-	-	-	-	-	-	-
Methyl cyclohexane	ug/L	-	-	-	-	-	-	-
Methyl Tert Butyl Ether	ug/L	-	-	-	-	-	-	-
Methylene chloride	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Styrene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Tetrachloroethene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Toluene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
trans-1,2-Dichloroethene	ug/L	-	-	-	-	-	-	-
trans-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Trichloroethene	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Trichlorofluoromethane (CFC-11)	ug/L	-	-	-	-	-	-	-
Trifluorotrichloroethane (Freon 113)	ug/L	-	-	-	-	-	-	-
Vinyl chloride	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U
Xylene (total)	ug/L	10 U	10 U	10 U	10 U	100 U	10 U	10 U

Notes:
D - Compounds at secondary dilution factor.
J - Estimated
U - Non-detect at associated value.
-- - Not applicable.

TABLE B.2

ISOFLOW ANALYTICAL RESULTS SUMMARY
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE, NEW YORK
FEBRUARY 2002 TO JUNE 2002

Sample Location:		*MW-59*	*MW-59*	*MW-59*	*MW-59*	*MW-60B*	*MW-60B*	*MW-60B*	*MW-60B*
Sample ID:		*W-040302-6883-LMH-29*	*W-040302-6883-LMH-30*	*GW-040402-6883-LMH-32*	*GW-040502-6883-LMM-33*	*GW-022502-6883-LMH-15*	*GW-022602-6883-LMN-16*	*GW-022602-6883-LMN-17*	*GW-022602-6883-LMN-18*
Sample Date:		*4/3/2002*	*4/3/2002*	*4/4/2002*	*4/5/2002*	*2/25/2002*	*2/26/2002*	*2/26/2002*	*2/26/2002*
		305 ft (bgs)	*355 ft (bgs)*	*455 ft (bgs)*	*505 ft (bgs)*	*145 ft (bgs)*	*185 ft (bgs)*	*235 ft (bgs)*	*285 ft (bgs)*
Parameter	*Unit*								
Volatiles									
1,1,1-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	31	44
1,1,2,2-Tetrachloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	13	5 J
1,1-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	43	61
1,2,4-Trichlorobenzene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
1,2-Dibromoethane (Ethylene Dibromide)	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
1,2-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
1,2-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	ug/L	-	-	-	-	10 U	10 U	20	8 J
1,2-Dichloropropane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
1,4-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
2-Butanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	ug/L	10 U	10 U	1 J	1 J	10 U	10 U	10 U	10 U
Bromoform	ug/L	2 J	3 J	2 J	2 J	10 U	10 U	10 U	10 U
Bromomethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform (Trichloromethane)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
cis-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Dibromochloromethane	ug/L	2 J	2 J	2 J	2 J	10 U	10 U	10 U	10 U
Dichlorodifluoromethane (CFC-12)	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Ethylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isopropylbenzene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Methyl acetate	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Methyl cyclohexane	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Methyl Tert Butyl Ether	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Methylene chloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Styrene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	ug/L	10 U	10 U	10 U	10 U	2 J	4 J	100	49
Toluene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
trans-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	ug/L	10 U	10 U	10 U	10 U	25	26	1100 D	580 D
Trichlorofluoromethane (CFC-11)	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Trifluorotrichloroethane (Freon 113)	ug/L	10 U	10 U	10 U	10 U	-	-	-	-
Vinyl chloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylene (total)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Notes:
D - Compounds at secondary dilution factor.
J - Estimated
U - Non-detect at associated value.
-- - Not applicable.

TABLE B.2

ISOFLOW ANALYTICAL RESULTS SUMMARY
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE, NEW YORK
FEBRUARY 2002 TO JUNE 2002

Sample Location:		***MW-60B***	***MW-60B***	***MW-61A***	***MW-61A***	***MW-61A***	***MW-61A***	***MW-61A***	***MW-61B***
Sample ID:		***GW-022702-6883-LMH-19***	***GW-022702-6883-LMH-20***	***GW-022002-6883-LMH-10***	***GW-022002-6883-LMH-11***	***GW-022002-6883-LMH-12***	***GW-022002-6883-LMH-13***	***GW-022102-6883-LMH-14***	***W-031102-6883-LMH-21***
Sample Date:		***2/27/2002***	***2/27/2002***	***2/20/2002***	***2/20/2002***	***2/20/2002***	***2/21/2002***	***2/21/2002***	***3/11/2002***
		335 ft (bgs)	***385 ft (bgs)***	***130 ft (bgs)***	***185 ft (bgs)***	***255 ft (bgs)***	***305 ft (bgs)***	***355 ft (bgs)***	***405 ft (bgs)***
Parameter	***Unit***								
Volatiles									
1,1,1-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	2 J	10 U
1,1,2,2-Tetrachloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	5 J	10 U
1,2,4-Trichlorobenzene	ug/L	-	-	-	-	-	-	-	-
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	-	-	-	-	-	-	-	-
1,2-Dibromoethane (Ethylene Dibromide)	ug/L	-	-	-	-	-	-	-	-
1,2-Dichlorobenzene	ug/L	-	-	-	-	-	-	-	-
1,2-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	40	10 U
1,2-Dichloropropane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	ug/L	-	-	-	-	-	-	-	-
1,4-Dichlorobenzene	ug/L	-	-	-	-	-	-	-	-
2-Butanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	ug/L	10 U	10 U	10 U	10 U	4 J	4 J	12	10 U
Benzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromoform	ug/L	2 J	2 J	10 U	2 J	10 U	1 J	10 U	1 J
Bromomethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	ug/L	10 U	10 U	2 J	2 J	10 U	3 J	10 U	10 U
Chloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	4 J	10 U
Chloroform (Trichloromethane)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	ug/L	-	-	-	-	-	-	-	-
cis-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	ug/L	-	-	-	-	-	-	-	-
Dibromochloromethane	ug/L	2 J	2 J	10 U	1 J	10 U	10 U	10 U	2 J
Dichlorodifluoromethane (CFC-12)	ug/L	-	-	-	-	-	-	-	-
Ethylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isopropylbenzene	ug/L	-	-	-	-	-	-	-	-
Methyl acetate	ug/L	-	-	-	-	-	-	-	-
Methyl cyclohexane	ug/L	-	-	-	-	-	-	-	-
Methyl Tert Butyl Ether	ug/L	-	-	-	-	-	-	-	-
Methylene chloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Styrene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	ug/L	1 J	10 U	10 U	1 J	10 U	10 U	76	10 U
Toluene	ug/L	1 J	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	ug/L	-	-	-	-	-	-	-	-
trans-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	ug/L	28	2 J	10 U	2 J	10 U	10 U	290 D	10 U
Trichlorofluoromethane (CFC-11)	ug/L	-	-	-	-	-	-	-	-
Trifluorotrichloroethane (Freon 113)	ug/L	-	-	-	-	-	-	-	-
Vinyl chloride	ug/L	10 U	10 U	10 U	2 J	10 U	10 U	440 D	10 U
Xylene (total)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Notes:
D - Compounds at secondary dilution factor.
J - Estimated
U - Non-detect at associated value.
-- - Not applicable.

TABLE B.2

ISOFLOW ANALYTICAL RESULTS SUMMARY
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE, NEW YORK
FEBRUARY 2002 TO JUNE 2002

Sample Location:		*MW-62*	*MW-62*	*MW-62*	*MW-62*	*MW-62*	*MW-63*	*MW-63*
Sample ID:		*GW-040802-6883-LMH-34*	*GW-040902-6883-LMH-35*	*GW-040902-6883-LMH-36*	*GW-041802-6883-LMH-37*	*GW-041902-6883-LMH-38*	*GW-021102-6883-RAM-05*	*GW-021102-6883-LMH-06*
Sample Date:		*4/8/2002*	*4/9/2002*	*4/9/2002*	*4/18/2002*	*4/19/2002*	*2/11/2002*	*2/11/2002*
		225 ft (bgs)	*275 ft (bgs)*	*325 ft (bgs)*	*395 ft (bgs)*	*455 ft (bgs)*	*135 ft (bgs)*	*185 ft (bgs)*
Parameter	*Unit*							
Volatiles								
1,1,1-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromoethane (Ethylene Dibromide)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	ug/L	-	-	-	-	-	-	-
1,2-Dichloropropane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	ug/L	10 U	10 U	10 U	2 J	2 J	10 U	10 U
Bromoform	ug/L	10 U	10 U	2 J	3 J	4 J	10 U	10 U
Bromomethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform (Trichloromethane)	ug/L	10 U	10 U	10 U	1 J	1 J	10 U	10 U
Chloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	ug/L	10 U	16	10 U	10 U	10 U	10 U	84
cis-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	ug/L	10 U	10 U	2 J	3 J	4 J	10 U	10 U
Dichlorodifluoromethane (CFC-12)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isopropylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl acetate	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl cyclohexane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl Tert Butyl Ether	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Styrene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	ug/L	2 J	51	10 U	10 U	10 U	10 U	140
Toluene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	ug/L	10 U	11	10 U	3 J	10 U	10 U	120
Trichlorofluoromethane (CFC-11)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trifluorotrichloroethane (Freon 113)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Vinyl chloride	ug/L	10 U	14	10 U	10 U	10 U	10 U	100
Xylene (total)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Notes:
D - Compounds at secondary dilution factor.
J - Estimated
U - Non-detect at associated value.
-- - Not applicable.

TABLE B.2

ISOFLOW ANALYTICAL RESULTS SUMMARY
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE, NEW YORK
FEBRUARY 2002 TO JUNE 2002

Sample Location:		***MW-63***	***MW-63***	***MW-63***	***MW-64***	***MW-64***	***MW-64***	***MW-64***
Sample ID:		***GW-021102-6883-LMH-07***	***GW-021202-6883-LMH-08***	***GW-021302-6883-LMH-09***	***GW-020602-6883-LMH-01***	***GW-020602-6883-LMH-02***	***GW-020702-6883-LMH-03***	***GW-020802-6883-LMH-04***
Sample Date:		***2/11/2002***	***2/12/2002***	***2/13/2002***	***2/6/2002***	***2/6/2002***	***2/7/2002***	***2/8/2002***
		235 ft (bgs)	***285 ft (bgs)***	***355 ft (bgs)***	***105 ft (bgs)***	***155 ft (bgs)***	***205 ft (bgs)***	***300 ft (bgs)***
Parameter	***Unit***							
Volatiles								
1,1,1-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2,4-Trichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromoethane (Ethylene Dibromide)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	ug/L	-	-	-	-	-	-	-
1,2-Dichloropropane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	ug/L	10 U	10 U	10 U	10 U	10 U	17	10 U
Benzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromoform	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	2 J
Bromomethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform (Trichloromethane)	ug/L	10 U	10 U	10 U	10 U	10 U	20	10 U
Chloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	1 J
Dichlorodifluoromethane (CFC-12)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isopropylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl acetate	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl cyclohexane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl Tert Butyl Ether	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methylene chloride	ug/L	10 U	10 U	10 U	10 U	10 U	4 J	10 U
Styrene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	ug/L	38	5.0 J	10 U	10 U	10 U	10 U	10 U
Toluene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	4 J
trans-1,2-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	ug/L	52	5.0 J	10 U	10 U	10 U	10 U	10 U
Trichlorofluoromethane (CFC-11)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trifluorotrichloroethane (Freon 113)	ug/L	10 U	10 U	10 U	10 U	10 U	3 J	10 U
Vinyl chloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Xylene (total)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Notes:
D - Compounds at secondary dilution factor.
J - Estimated
U - Non-detect at associated value.
-- - Not applicable.

TABLE B.2

ISOFLOW ANALYTICAL RESULTS SUMMARY
GLENN SPRINGS HOLDINGS, INC.
HICKSVILLE, NEW YORK
FEBRUARY 2002 TO JUNE 2002

Sample Location:		*MW-66*	*MW-66*	*MW-66*	*MW-66*	*MW-66*	*MW-66*	*MW-66*
Sample ID:		*GW-052202-6883-LMH-39*	*GW-052202-6883-LMH-40*	*GW-052902-6883-LMH-41*	*GW-052902-6883-LMH-42*	*GW-053002-6883-LMH-43*	*GW-053002-6883-LMH-44*	*GW-060102-6883-RAM-45*
Sample Date:		*5/22/2002*	*5/22/2002*	*5/29/2002*	*5/29/2002*	*5/30/2002*	*5/30/2002*	*6/1/2002*
		195 ft (bgs)	*245 ft (bgs)*	*295 ft (bgs)*	*340 ft (bgs)*	*395 ft (bgs)*	*455 ft (bgs)*	*500 ft (bgs)*
Parameter	*Unit*							
Volatiles								
1,1,1-Trichloroethane	ug/L	10 U	10 U	1 J	10 U	10 U	10 U	10 U
1,1,2,2-Tetrachloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1,2-Trichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,1-Dichloroethene	ug/L	10 U	10 U	2 J	1 J	10 U	10 U	10 U
1,2,4-Trichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromo-3-chloropropane (DBCP)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dibromoethane (Ethylene Dibromide)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,2-Dichloroethene (total)	ug/L	-	-	-	-	-	-	-
1,2-Dichloropropane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,3-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
1,4-Dichlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Butanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
2-Hexanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
4-Methyl-2-pentanone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Acetone	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Benzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Bromodichloromethane	ug/L	10 U	10 U	10 U	10 U	1 J	10 U	10 U
Bromoform	ug/L	10 U	1 J	10 U	1 J	4 J	1 J	10 U
Bromomethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon disulfide	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Carbon tetrachloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chlorobenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloroform (Trichloromethane)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Chloromethane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
cis-1,2-Dichloroethene	ug/L	10 U	2 J	3 J	2 J	10 U	10 U	10 U
cis-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Cyclohexane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Dibromochloromethane	ug/L	10 U	10 U	10 U	10 U	3 J	1 J	10 U
Dichlorodifluoromethane (CFC-12)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Ethylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Isopropylbenzene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl acetate	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl cyclohexane	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Methyl Tert Butyl Ether	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	1 J
Methylene chloride	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Styrene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Tetrachloroethene	ug/L	3 J	17	22	17	10 U	10 U	10 U
Toluene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,2-Dichloroethene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
trans-1,3-Dichloropropene	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trichloroethene	ug/L	1 J	6 J	20	64	10 U	10 U	1 J
Trichlorofluoromethane (CFC-11)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U
Trifluorotrichloroethane (Freon 113)	ug/L	10 U	1 J	1 J	10 U	10 U	10 U	10 U
Vinyl chloride	ug/L	10 U	10 U	10 U	10 U	10 U	2 J	10 U
Xylene (total)	ug/L	10 U	10 U	10 U	10 U	10 U	10 U	10 U

Notes:
D - Compounds at secondary dilution factor.
J - Estimated
U - Non-detect at associated value.
-- - Not applicable.

TABLE B.3

ANALYTICAL RESULTS SUMMARY - INITIAL CHARACTERIZATION
VOCS IN GROUNDWATER
LABORATORY TREATABILITY STUDY
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Parameter (mg/L)	*MW-64 (255 ft bgs)*
1,1,1-Trichloroethane	ND (0.1)
1,1,2-Trichloroethane	ND (0.1)
1,1-Dichloroethane	ND (0.1)
1,1-Dichloroethene	ND (0.1)
1,2,4-Trichlorobenzene	ND (0.1)
1,2-Dichlorobenzene	ND (0.1)
1,2-Dichloroethane	ND (0.1)
1,2-Dichloropropane	ND (0.1)
1,3-Dichlorobenzene	ND (0.1)
1,4-Dichlorobenzene	ND (0.1)
3,4-Dichlorotoluene	ND (0.1)
3-Chlorotoluene	ND (0.1)
Benzene	ND (0.1)
Bromodichloromethane	ND (0.1)
Bromoform	ND (0.1)
Carbon tetrachloride	ND (0.1)
Chlorobenzene	ND (0.1)
Chloroform	ND (0.1)
Dibromochloromethane	ND (0.1)
cis-1,2-Dichloroethene	ND (0.1)
trans-1,2-Dichloroethene	ND (0.1)
cis-1,3-Dichloropropene	ND (0.1)
trans-1,3-Dichloropropene	ND (0.1)
Ethylbenzene	ND (0.1)
Methylene chloride	ND (0.1)
Tetrachloroethene	ND (0.1)
Toluene	ND (0.1)
Trichloroethene	ND (0.1)
Vinyl chloride	6.2
m/p-Xylene	ND (0.1)
o-Xylene	ND (0.1)

Notes:

MTBE	Methyl tertiary butyl ether
ND(x)	Not detected at or above x
VOCs	Volatile organic compounds

APPENDIX C

WELL DEVELOPMENT SUMMARY

TABLE C.1

SUMMARY OF WELL DEVELOPMENT DATA
OU-3 PREDESIGN INVESTIGATIONS
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Date Developed (m/d/y)*	*Water Level (ft BTOC)*	*Well Volume (gallon)*	*Cumulative Volume Removed (gallon)*	*pH*	*Conductivity (mS/cm)*	*Temperature (°C)*	*Water Quality*
MW-58	4/21/02	57	72	75[(1)]	8.60	190	15.1	Orange, silty cloudy
				150	8.59	190	15.6	Orange, silty cloudy
				225[(2)]	8.64	190	15.7	Clearing
				300	8.92	190	16.6	Clearing
				375	7.13	190	17.3	Clearing
				450	7.21	190	17.6	Clearing
				525[(3)]	7.18	190	16.9	Clearing
				600	7.16	190	17.2	Clearing
				675	7.19	190	17.4	Clearing
				750	7.19	190	17.3	Clear, no odor
MW-59	4/21/02	57.8	72	75[(1)]	7.78	170	16.5	Orange, cloudy
				150	7.76	160	16.3	Orange, cloudy
				225[(2)]	7.80	160	16.3	Orange, cloudy
				300	7.36	160	17.4	Clearing
				375	7.40	150	17.6	Gray, slightly cloudy
				450	7.01	170	16.4	Gray, slightly cloudy
				525[(3)]	6.99	170	15.2	Gray, slightly cloudy
				600	7.62	170	15.4	Orange, slightly cloudy
				675	7.63	170	15.6	Orange, slightly cloudy
				750	7.65	170	15.9	Orange, slightly cloudy, no odor
MW-60A	4/17/02	57	36	40[(1)]	7.10	350	17.7	yellow/cloudy
				80	6.96	330	17.6	yellow/cloudy
				120[(4)]	6.81	330	17.2	yellow/cloudy
				160	6.79	330	17.5	yellow/cloudy
				200	6.76	330	17.6	yellow/cloudy
				240[(5)]	6.78	330	17.1	yellow/cloudy
				280	6.76	330	17.5	slightly cloudy
				320	6.80	330	17.6	clearing
				360	6.79	330	17.6	clearing

TABLE C.1

SUMMARY OF WELL DEVELOPMENT DATA
OU-3 PREDESIGN INVESTIGATIONS
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Date Developed (m/d/y)*	*Water Level (ft BTOC)*	*Well Volume (gallon)*	*Cumulative Volume Removed (gallon)*	*pH*	*Conductivity (mS/cm)*	*Temperature (°C)*	*Water Quality*
MW-60B	4/17/02	58.1	45	40	6.39	280	20.4	slightly cloudy, no odor
				80	6.35	270	18.8	slightly cloudy, no odor
				120	6.16	260	19.4	slightly cloudy, no odor
				160	6.38	270	18.8	slightly cloudy, no odor
				200	6.40	270	20.2	clear
				240	6.35	270	19.8	clear
				280	6.18	270	18.9	clear
				320	6.22	270	19.2	clear
				360	6.29	270	19.6	clear
				400	6.21	270	19.5	clear
				440	6.32	270	19.6	clear
				480	6.35	270	19.8	clear, no odor
MW-61A	4/16/02	58.3	36	40(1)	5.87	410	18.9	black, gray, cloudy, strong chemical odor
				80	6.60	430	18.8	black, gray, cloudy, strong chemical odor
				120(6)	6.44	430	20.1	black, gray, cloudy, strong chemical odor
				160	6.49	420	19.3	orange/brown clearing slightly
				200	6.59	440	19.9	orange/brown clearing slightly
				240(7)	6.98	420	22.9	orange/brown clearing slightly
				280	6.69	410	22.3	orange/brown clearing slightly
				320	6.65	420	23.4	orange/brown clearing slightly
				360	6.31	420	22.4	clearing, orange, slightly cloudy
MW-61B	4/16/02	58.3	50	50	7.08	220	19.5	dark gray/orange, silty, very cloudy
				100	7.17	240	21.1	dark gray/orange, silty, very cloudy
				150	7.19	220	20.3	dark gray/orange, silty, very cloudy
				200	6.56	220	17.4	clearing slightly
				250	6.57	220	17.6	clearing slightly
				300	6.59	220	17.8	clearing slightly
				350	6.62	220	18.2	clearing slightly
				400	6.60	220	18.0	clearing slightly
				450	6.64	220	17.5	clearing slightly
				500	6.65	220	17.7	clearing
				550	6.62	220	18.1	clearing

TABLE C.1

SUMMARY OF WELL DEVELOPMENT DATA
OU-3 PREDESIGN INVESTIGATIONS
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Date Developed (m/d/y)*	*Water Level (ft BTOC)*	*Well Volume (gallon)*	*Cumulative Volume Removed (gallon)*	*pH*	*Conductivity (mS/cm)*	*Temperature (°C)*	*Water Quality*
MW-62A	5/16/2002	NM	22	25	7.26	230	17.4	dark gray, very silty
				50	7.21	190	17.6	dark gray, very silty
				75	7.18	180	17.2	dark gray, very silty
				100	7.19	190	17.6	clearing
				125	7.16	190	17.1	clearing
				150	7.16	190	17.0	clear
				175	7.10	190	17.2	clear
				200	7.12	190	17.2	clear
				225	7.14	190	17.3	clear
MW-62B	5/15/2002	NM	55	55	7.12	190	17.2	dark gray, very silty
				110	7.16	190	17.3	dark gray, very silty
				165	7.20	190	16.9	dark gray, very silty
				220	7.23	190	17.3	dark gray, very silty
				305	7.18	190	17.5	dark gray, very silty
				360	7.10	190	17.8	starting to clear at 310 gal
				415	6.98	190	17.6	
				470	6.96	190	17.3	clear
				525	6.99	190	17.5	clear
				580	7.05	190	17.3	clear
MW-63	4/19/02	55	39	40(1)	7.18	190	17.7	dark gray, no odor
				80	7.16	190	17.9	dark gray, no odor
				120(8)	7.20	190	18.2	dark gray, no odor
				160	7.16	160	18.5	brown
				200	7.02	160	18.3	brown
				240(9)	6.62	150	17.9	brown
				280	6.59	160	17.6	clearing slightly
				320	6.63	160	17.5	clearing slightly
				360	6.65	160	18.2	clearing slightly
				400	6.63	160	18.0	clearing slightly

TABLE C.1

SUMMARY OF WELL DEVELOPMENT DATA
OU-3 PREDESIGN INVESTIGATIONS
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Well Designation	*Date Developed (m/d/y)*	*Water Level (ft BTOC)*	*Well Volume (gallon)*	*Cumulative Volume Removed (gallon)*	*pH*	*Conductivity (mS/cm)*	*Temperature (°C)*	*Water Quality*
MW-64	4/17/02	61.6	38	40(1)	6.25	270	18.5	orange/yellow, cloudy
				80	6.32	180	18.6	
				120(10)	6.35	140	19.0	strong chemical odor
				160	6.13	140	18.5	strong chemical odor
				200	6.22	140	20.1	strong chemical odor
				240(11)	6.25	130	20.9	strong chemical odor
				280	6.26	140	20.7	clearing
				320	6.21	140	19.9	clearing
				360	6.32	140	20.2	clearing
				400	6.25	140	20.5	yellow, slightly cloudy
MW-66A	7/10/2002	NM	50	50	9.26	1150	20.1	
				100	9.25	1150	20.3	
				150	9.30	1160	20.3	
				200	9.29	1160	20.5	
				250(12)	9.32	1160	20.8	
				300	9.32	1160	20.9	
				350	9.35	1170	20.8	
				400	9.33	1170	21.1	
				450	9.35	1170	21.7	
				500	9.35	1170	21.6	
MW-66B	7/8/2002	NM	65	65	10.12	1250	21.0	
				130	10.09	1200	21.6	
				195	10.00	1190	21.3	
				260	5.27	1190	21.7	
				325	4.95	1190	22.0	
				390	4.86	1190	22.3	
				455	4.52	1180	22.2	
				520	4.35	1180	22.3	
				585	4.34	1180	22.4	
				650	4.35	1180	22.3	

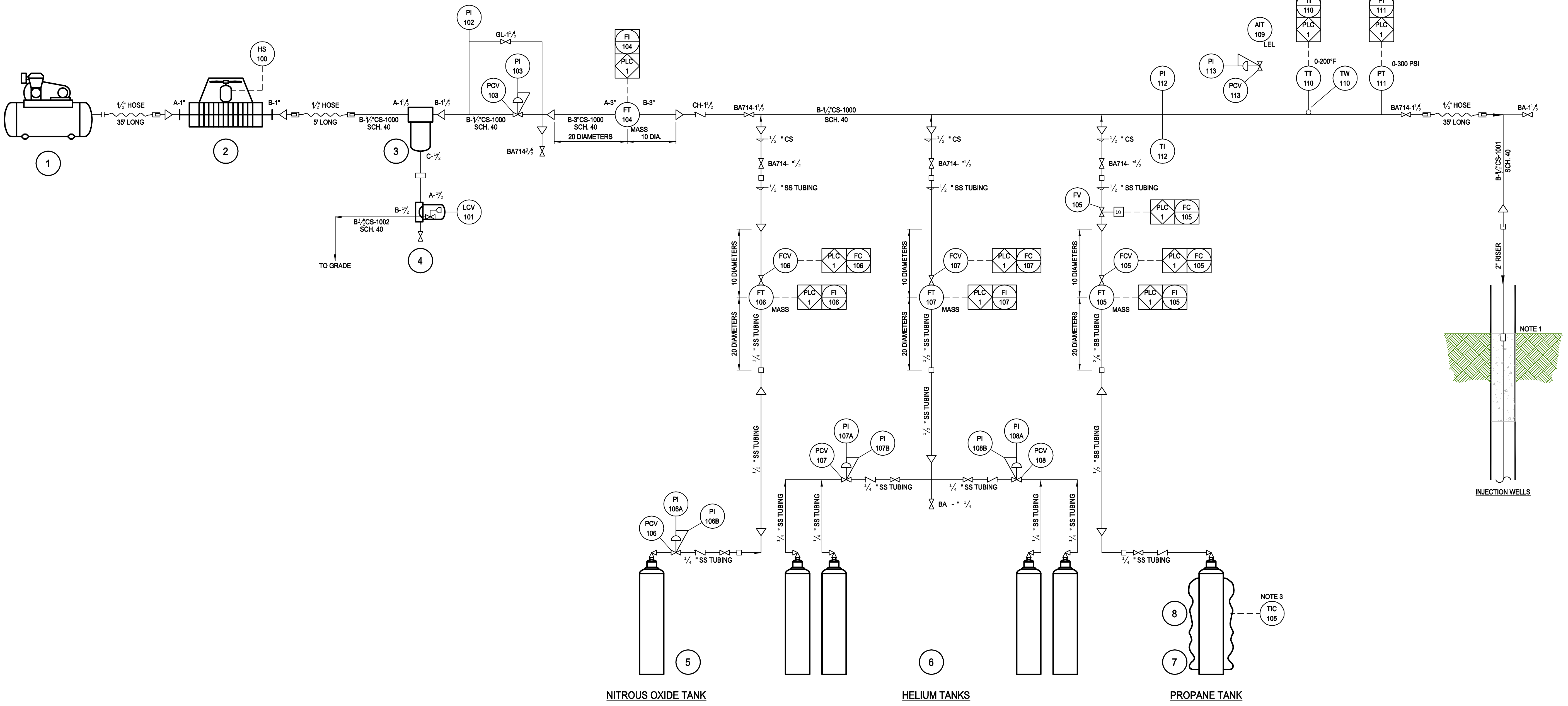
Notes:
(1) Development started with outlet of air lift pump at bottom of well.
(2) Raised air lift pump outlet 50± feet.
(3) Raised air lift pump outlet an additional 55± feet.
(4) Raised air pump outlet 50± feet.
(5) Raised air pump outlet an additional 45± feet.
(6) Raised air lift pump outlet 70± feet.
(7) Raised air lift pump outlet an addition 40± feet.
(8) Raised air lift pump outlet 40± feet.
(9) Raised air lift pump outlet an addition 35± feet.
(10) Raised air lift pump outlet 45± feet.
(11) Raised air lift pump outlet an additional 70± feet.
(12) Raised air lift pump outlet 65± feet.

APPENDIX D

INJECTION TESTING INFORMATION AND PROGRESS MEMOS

LEGEND

AI	???	LEL	LOWER EXPLOSIVE LIMIT
AIT	ANALYSIS INDICATING TRANSMITTER FOR LEL	NC	NORMALLY CLOSED
BA	BALL VALVE	PCV	PRESSURE CONTROL VALVE
CH	CHECK VALVE	PI	PRESSURE INDICATOR
FC	???	PLC	PROGRAMMABLE LOGIC CONTROLLER
FCV	FLOW CONTROL VALVE	S	SOLENOID
FI	FLOW INDICATOR	TAH	???
FT	FLOW TRANSMITTER	TE	TEMPERATURE GAUGE
GL	GLOBE VALVE	TIC	???
HS	???	TT	???
LCV	???	TW	???



PLANT ID.	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫
NAME	COMPRESSOR	AFTER COOLER	MOISTURE SEPARATOR	DRAIN TRAP	NITROUS OXIDE CYLINDER	HELIUM CYLINDERS	PROPANE CYLINDER	PROPANE CYLINDER HEATER				
MATERIAL		ALUMINUM/COPPER		ALUMINUM/BRASS								
SIZE												
CAPACITY	400 SCFM	90°F @ 300 SCFM	400 SCFM	100 GPH @ 100 PSI 123 GPH @ 200 PSI								
TEMP/PRESS	200 PSI							125°F				
HP/V/RPM		1/115/1750										
WEIGHT		200 POUNDS	6 POUNDS									
MANUFACTURE	INGERSOLL-RAND	XCHANGER	MOTIVAIR CORP.	MOTIVAIR CORP.								
MODEL		LC-18-1	TS0015	TS0015								
VENDOR		ELECTROLAB	MOTIVAIR CORP.	MOTIVAIR CORP.								

DESCRIPTION

REVISIONS	
DATE	
APPR. BY	
MADE BY	
DESCRIPTION	
NO.	

Approved

NOTES:
1. ALL WELLS SHALL BE MODIFIED TO HAVE A 2" FEMALE METAL THREADED CONNECTION.
2. GROUND 1 ½" C.S. PIPE RUN.
3. ADJUST HEAT TO MAINTAIN PRESSURE < 240 PSIG.

HOOKER/RUCO SITE
Hicksville, New York

CONESTOGA-ROVERS & ASSOCIATES

OU-3 PREDESIGN ACTIVITIES

ENGINEERING FLOW SHEET
GAS PIPING CONFIGURATION

Drawn by: B.A. BEEBE	Scale: NONE	Date: OCTOBER 2002	File Nº: WA028	Rev.Nº: 0
Designed by: X	Field book:	Project Nº: 06883-00	Drawing Nº: D.1	
Checked by: X				

06883-00(034)GN-WA028 NOV 07/2002

Applied
Hydrology
Associates, Inc.

5514 Decker Drive, Baytown, TX 77520 Tel: (281) 424-1469 Fax: (281) 424-9537

MEMORANDUM

DATE: 4/20/02

TO: Mike Day

FROM: Terry Gulliver

RE: **Ruco Progress Report #1**

This is the first weekly memo reporting field progress at the Hooker Ruco site.

Synopsis

In this week (4/16 through 4/19), shallow well MW-52S was sparged at three flow rates (nominally 100, 150 and 200 scfm), with air and helium tracer, in four-hour tests. Water levels and DO were monitored in the intermediate well MW-52I, located approximately 15 ft away.

Well screen intervals are: MW-52S: 125-140 ft bgs;
MW-52I: 220-235 ft bgs.

Next week, we will sparge the intermediate well and observe impacts in the shallow well.

Observations

1. The formation accepted large air flows. When it was evident that the proposed pressures would take flows higher than the compressor capacity, the plan was modified to test three flow rates (100, 150, 200 scfm) and determine pressures.

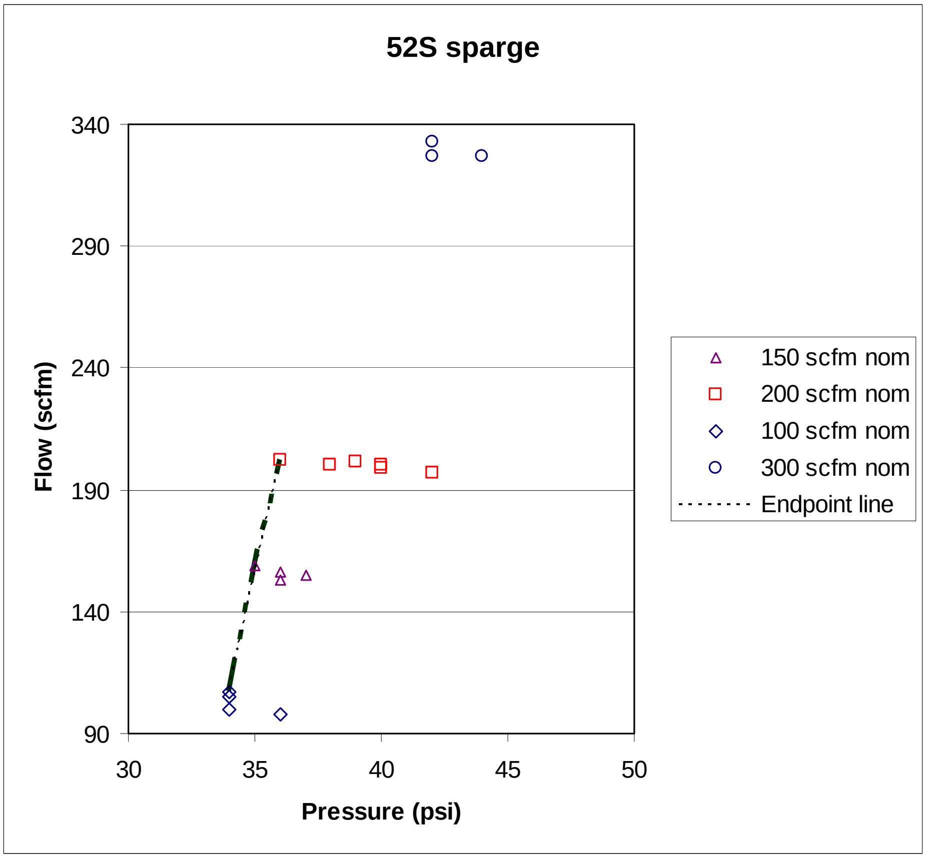
2. No helium leaks were detected at the sparged wellhead, adjacent wells, stormwater drains, under concrete caps, in sand pits, etc. At the end of each test, sustained return flow from the sparged well head (with a slightly cracked valve) indicated a large air reservoir in the formation.

3. The air capacity data for the shallow aquifer are shown in Figure 1. Selected data from the four tests show the pressure declining and the flow increasing slightly (points trend to the left) toward a steady end-point. The line through the end points of the three four-hour tests indicates a capacity of 48 scfm per psi wellhead pressure, after the intitial 29 psi required to depress the water in the well to the top of the screen. The nominal 300 scfm test was run for only 15 minutes on 4/17, before it was decided to scale back pressures. It seems likely that

the 300 scfm flow would have stabilized with an endpoint on the same line as the other tests, although this cannot be reliably extrapolated to higher flows. The equation for the capacity is thus:

Q = 48 x (P-29); Q = flow in scfm, P = wellhead pressure in psi.

(The actual regression equation out of Excel is Q = 47.5 x (P-31)).



4. A small pressure response was seen in the intermediate well MW-52I; the water level rose about half a foot in this well in response to the 40± psi sparge pressure in MW-52S.

5. The DO in the intermediate well was less than 1 mg/L, measured by a flow-through cell with a 30-40 minute purge before DO stabilized.

6. Soil cores from new well MW-63 were logged. Sands were brownish or orange-brown over most of the 300 ft depth, with just a couple of 5-ft grayish, possibly reduced, intervals. The drilled interval of this well thus appears to be mostly aerobic, with abundant available Fe(III). It is not yet known where this well is with regard to the plume. Two 15-ft thick dark gray claystones (dry, non-plastic, friable) are apparent in MW-63. The CRA geologist Lynne says that these claystones are not traceable between wells. They may represent peaty muds of transient small ponds in the outwash aprons, or shoestring channel fills.

Comments

1. The intermediate well MW-52I, that has significant vinyl chloride concentrations, shows anaerobic groundwater conditions.

2. The air capacity of MW-52S is very encouraging.

3. The claystones are not very predictable spatially. Spacial discontinuity of clays may be advantageous in dispersing sparge impacts laterally over limited areas. Screen intervals of new sparge wells possibly should not be pre-determined but be based on the drilled lithology at each well location.

Applied Hydrology Associates, Inc.

5514 Decker Drive, Baytown, TX 77520 Tel: (281) 424-1469 Fax: (281) 424-9537

MEMORANDUM

DATE: 4/29/02

TO: Mike Day

FROM: Terry Gulliver

RE: **Ruco Progress Report #2**

Synopsis

In the previous week (4/23 through 4/25), intermediate well MW-52I was sparged at three flow rates (nominally 100, 150 and 200 scfm), with air and helium tracer, in four-hour tests. Water levels and DO were monitored in the shallow and deep wells MW-52S and D, each located approximately 15 ft away.

Well screen intervals are:		
	MW-52S	(125-140);
	MW-52I	(220-235);
	MW-52D	(371-386) ft bgs

Next week, the baseline DO and other parameters will be measured at the second injection test area (i.e., in the vicinity of the MW-50 nest), where sparging will be conducted next. MW-52D will be sparged later in the program, with various additives.

Observations

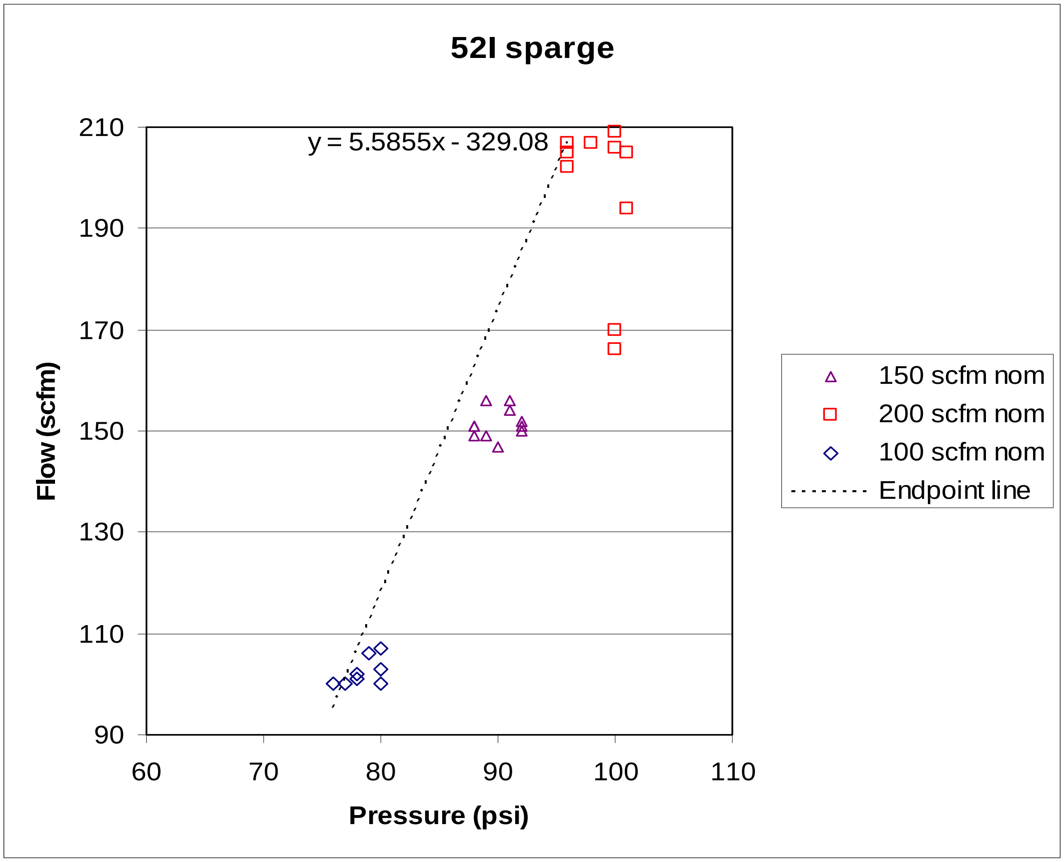
1. The intermediate well MW-52I also accepted large air flows. Three tests were conducted at the same nominal flows (100, 150, 200 scfm) as in the shallow well.

2. No He leaks were detected at the sparged wellhead, adjacent wells, stormwater drains, under concrete caps, in sand pits, etc. At the end of each test, sustained return flow from the sparged well head (with a slightly cracked valve) indicated air-oversaturated aquifer sand. Most of the air seems to be going into the formation.

3. The air capacity data for the intermediate depth well are shown in Figure 1. Selected data from the three four-hour tests show the pressure declining and the flow increasing slightly (points trend to the left) toward an end-point. A line through the end points of the three tests indicates a capacity of 6-8 scfm per psi wellhead pressure (compared to 48 scfm/psi in the

shallow well), after the initial 70 psi required to depress the water in the well to the top of the screen. The linear regression equation for the MW-52I capacity is:

Q = 5.6 x Q x (P-59); Q flow in scfm, P wellhead pressure in psi.



4. Small variations were seen in both MW-52S and MW-52D water levels during sparging of MW-52I. The shallow well level rose and fell symmetrically during and after MW-52I sparging, while the deep well level did not. The response in MW-52D may possibly be due to barometric variation.

5. The DO in the shallow well was 9 mg/L prior to the MW-52I sparge, due to direct sparging of that well the previous week. After each sparging event in MW-52I, the DO in the shallow well was elevated above 12 mg/L and helium was detected, showing that air injected in MW-52I migrated as a gas, not just as a solute, to the MW-52S screen interval.

6. Helium was detected in a water table well (dubbed 52V) approximately 65 ft away, adjacent to the closest building, after the MW-52I sparge tests.

7. The DO and total chlorinated compound concentrations in the MW-52 nest are summarized below. DO values are those measured by sustained micropurging during sparge tests.

Well	MW-52S	MW-52I	MW-52D
Screen interval ft bgs	125-140	220-235	371-386
Σ VOC, ug/L, 09/00	2,225	2,113	60
DO, mg/L	< 1 (1999)	< 1 (4/02)	3 (4/02)

Σ VOC = sum of chlorinated compounds

Discussion

- We may actually have come close to "fracture" pressure in MW-52I tests. Applied pressure can lift the formation when it overcomes effective stress, which is that part of the overburden load borne by the solid matrix. Effective stress is lithologic load minus the water pressure. Lithostatic load can be estimated by integrating density and depth; if we assume a constant porosity of 0.3 with material density of quartz, the density of the aquifer solid is about 1.85 gm/cc, and the pressure gradient is 0.43 x 1.85 psi/ft, or 0.8 psi/ft.

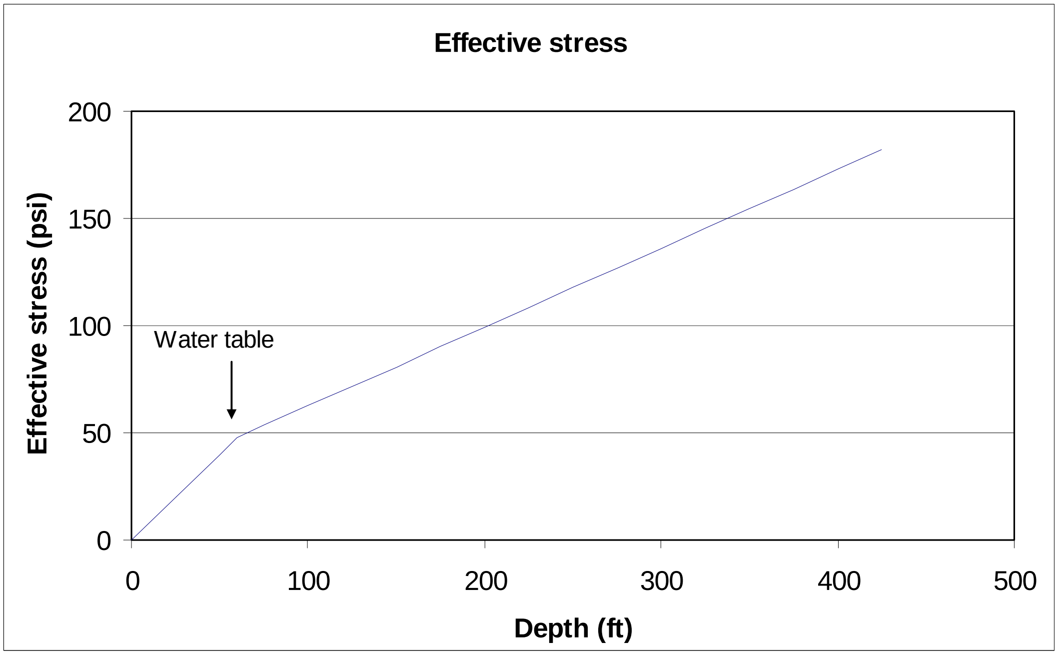
Well	MW-52S	MW-52I	MW-52D
Screen interval ft bgs	125-140	220-235	371-386
Lithostatic pressure, psi	~100	~176	~297
Hydrostatic pressure, psi	29	70	134
Effective stress σ_e, psi	71	106	167
Sparge stress/σ_e, psi	~0.5	0.75 – 0.94	

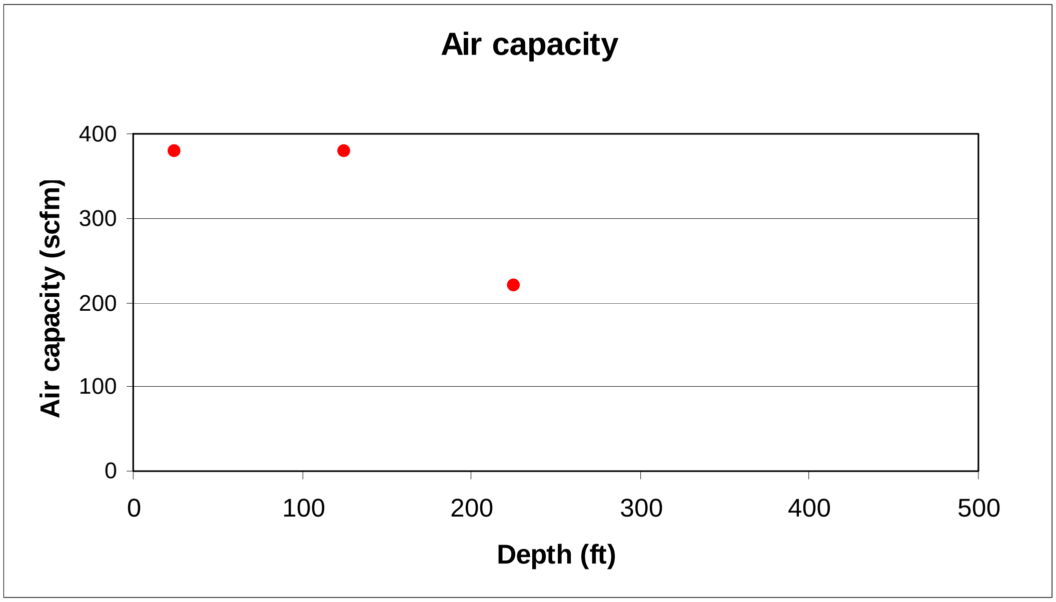
  Note that this puts a limit on applied pressure in the deep well MW-52D, of 167 psi, before the pressure lifts the formation and flows in an injected lens rather than through the sand. It will take about 134 psi to depress the water in the well to the top of the screen. Effective stress is shown in a graph below.

  If effective stress is exceeded, and the well annulus holds, air pressure will overcome matrix pressure, the practically cohesionless sand will rupture, and air will flow unpredictably. In a tight lithology, this may be deliberately forced to inject air wherever it will go. Where the formation has ample capacity, sparging is best controlled by keeping pressures below the effective stress.

- The maximum air flow achievable in any well is governed by several factors, one of which is Reynolds number, R_e. In a porous medium, R_e is typically found to have a ceiling of 1, above which flow is turbulent and resistance to flow increases dramatically. Using a value of kinematic viscosity for air at 30 °C, pore diameter on the order of 0.01 mm, radius of one ft in a 10 ft screen interval accepting the flow, gives a maximum air flow of 380 scfm. While this number is a very crude estimate, it makes the point that the capacity of the shallow well, MW-52S, cannot be extrapolated indefinitely above the pressure range of the experimental data.

  In the plot below of capacity vs depth, the flow estimated above from the R_e consideration (380 scfm) is indicated as a maximum flow in the shallow well, and the flow at 94% σ_e is shown as a maximum in the intermediate well.


Effective stress
Effective stress (psi)
200
150
100
50
0
Water table
0
100
200
300
400
500
Depth (ft)


Air capacity
Air capacity (scfm)
400
300
200
100
0
0
100
200
300
400
500
Depth (ft)

Applied
Hydrology
Associates, Inc.
5514 Decker Drive, Baytown, TX 77520 Tel: (281) 424-1469 Fax: (281) 424-9537

MEMORANDUM

DATE: 5/10/02

TO: Mike Day

FROM: Terry Gulliver

RE: **Ruco Progress Report #3**

Synopsis

In the previous week (5/6 thru 5/10), equipment was moved to the Hooker-Ruco Site, and sparging began on MW-50J2. Sparging this well will be completed Monday 5/13, and post-sparge sampling in adjacent wells will occupy the rest of that week.

Shallow aquifer air injection capacity is similar in the Hooker-Ruco Site to the previously tested Northrop Plant 12.

Groundwater and air immediately above the water table (WT) in the southern portion and immediately downgradient of the Hooker/Ruco Site, is depleted in oxygen and rich in carbon dioxide and methane. These zones are reduced and have methanogenic microbial activity.

Data

The table below shows concentrations of dissolved gases in groundwater in wells screened below the water table, and gas concentrations in wells screened across the water table (that is, are partially open to the vadose zone), in the southern portion and immediately downgradient of the Hooker/Ruco Site. Two well volumes of air were purged from each WT well before measuring gas concentrations with a LandTech meter, and dissolved gases were measured by a QED micropurge flow cell after parameters were stable for at least 15 minutes.

Dissolved oxygen is less than 1 mg/L in all shallow wells, and oxygen is less than 1% in air at the water table at those wells. The presence of methane at up to 20% in air shows methanogenic microbial activity. Detection of some low concentrations of organics in the air, using a 10.6 V PID, which does not detect methane, indicates some BOD residual in the vadose zone. Groundwater from the shallow well MW-50J1 was found, in sampling for DO, to be grayish and have odors of volatile acids.

The BOD and VCM values in the table are from 1998, and do not necessarily correlate closely with the recent data. BOD seems suspiciously low, given the observed odors and methane production.

As at the Plant 12 site, the deeper aquifer is marginally aerobic (DO ~ 3 mg/L at MW-50D1 and D2).

The first sparge test at MW-50J2 yielded air flow at 35 psi (the shut-in pressure of 30 psi suggests some plugging, possibly bentonite, at the top of the screen). A flow of approximately 100 scfm was obtained with a wellhead pressure of 39 – 40 psi. This means 4 psi over breakout pressure gave 100 scfm, compared to 6 psi giving 110 scfm in the Plant 12, MW-52S test.

Isolation of the adjacent shallow well MW-50J1 from the sparge interval was suggested by no change in DO, no detection of He, and a minor water level change without recovery in MW-50J1. Note these two well screen intervals are 53-68 and 119.5-129.5 ft bgs.

Discussion

The subsurface is anaerobic in the southern portion and immediately downgradient of the Hooker/Ruco Site, and at least some part of the shallow zone has high residual BOD. Significant methane indicates ongoing natural attenuation of mixed organic degradation residuals from historic waste streams.

These would be classic conditions for air sparging, if there were any VCM left in this area. No amendments (nutrients) other than oxygen seem to be required to stimulate in situ aerobic degradation of VCM and other organic residual. This is not to recommend abridging the work plan’s substrate addition, which will prove the technology for any zones in which substrate availability limits degradation.

Some difficulty was had with the helium detector this week. The meter would register up to 5% in well I-1, which also showed 20% methane. This was repeatable, was prior to any helium use at this site, and was duplicated by two meters when a new meter (same Mark model 9822) arrived. Both meters reported the injection stream in MW-50J2 to be about 2% He, as designed. Since there appeared to be a vague correlation between the He meter reading and the methane level, various parties were contacted to inquire whether methane could give interference. This question has not yet been resolved, although discussions are ongoing with various equipment distributors and manufacturers.

Applied
Hydrology
Associates, Inc.

5514 Decker Drive, Baytown, TX 77520 Tel: (281) 424-1469 Fax: (281) 424-9537

Baseline dissolved gases, Hooker/Ruco site

Well	Screen ft	Gdwtr DO mg/L	O2 in air %	CO2 in air %	CH4 in air %	PID ppm	Gdwter VCM ppb	BOD mg/L
MW-50J1	WT	0.42	0.3	13	3.6	0	ND	ND
E-1	WT	0.27	0	10.3	3.1	45	17	ND
F-1	WT	0.24	0	9.1	20	0	7	3
I-1	WT	0.21	0	10.3	0.7	2	45	4
K-1	WT	0.25	0.4	8.7	0.4	0	ND	9
P-1	WT	0.25	0	14.6	0.3	7	ND	4
MW-50J2	Sub-WT	0.49	-	-	-	-	250	ND
F-2	Sub-WT	0.27	-	-	-	-	1	2
K-2	Sub-WT	0.49	-	-	-	-	3	6
MW-50D1	Sub-WT	2.98	-	-	-	-	ND	ND
MW-50D2	Sub-WT	2.85	-	-	-	-	ND	ND

Dissolved gases from 5/02 baseline sampling
Vinyl chloride and BOD from 1998 groundwater sampling

Applied Hydrology Associates, Inc.

950 South Cherry St. Suite 810, Denver, CO 80246 Tel: (303) 782-0164 Fax: (303) 782-2560

MEMORANDUM

DATE: 5/17/02

TO: Mike Day

FROM: Terry Gulliver

RE: **Ruco Progress Report #4**
Period: 5/13 to 5/17/02

Synopsis

On Monday (5/13/02) Ed Pinto and I performed the third sparge test at nominal 200 scfm in intermediate depth well MW-50J2 (J2), followed by three days of monitoring water table well gases and DO in groundwater in some wells adjacent to the sparged well.

Data

Sparging capacity data are summarized in Figure 1. Only the end-point data from each of the three tests are shown. Pressures given here are wellhead pressures, and vary slightly from line pressures recorded by the auto-logging PC, which are metered in the manifold inside the trailer, upstream of the exit valve. Recorded pressures in the three sparge tests were in fact all about 38 psi. The zero-flow point on the plot uses the post-sparge, shut-in wellhead pressure, corresponding to the pressure exerted by the water table at the top of the screen. Sparged well J2 has a screen from 119.5 to 129.5 ft bgs, and a water table approximately 63 ft bgs.

The region of the three test pressures yields a sparge capacity of 40 scfm air flow for each psi increase in wellhead pressure. This compares with 45 scfm / psi in well MW-52S, with a screen from 125 to 140 ft bgs.

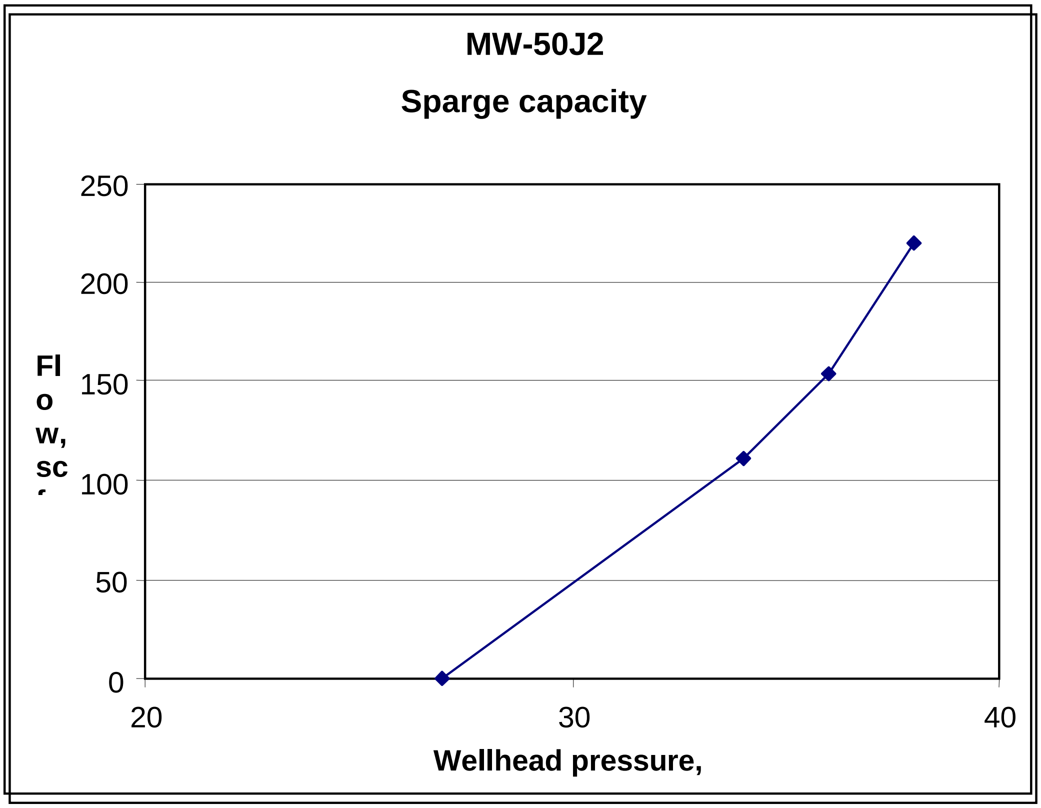


Figure 1 - Sparge capacity in MW-50J2

Concentrations of gas species measured in wells screened across the water table are summarized in the attached figures.

Observed sparging impacts were:

- A passing oxygen spike above the water table in well K1.
- A passing PID (VOC) spike in air above the water table in MW-50J1 (shallow well adjacent to the sparged well). There were also rises in methane and reported helium through and after the sparge. These may be both related to air (mainly nitrogen) stripping these gases from below the water table.

The sparging was too short to show clear evidence of stimulated aerobic respiration (consumption of oxygen, generation of CO_2). Clearly anaerobic respiration is occurring presently at the Hooker-Ruco Site, as residual organics are degraded.

Figure 2 shows the correlation of helium detector readings compared with measured methane concentrations. The correlation is not strong, but it is clear from conversations with the manufacturer (Mark Products) and from meter indications of helium prior to any injection, that methane interferes with the He detector.

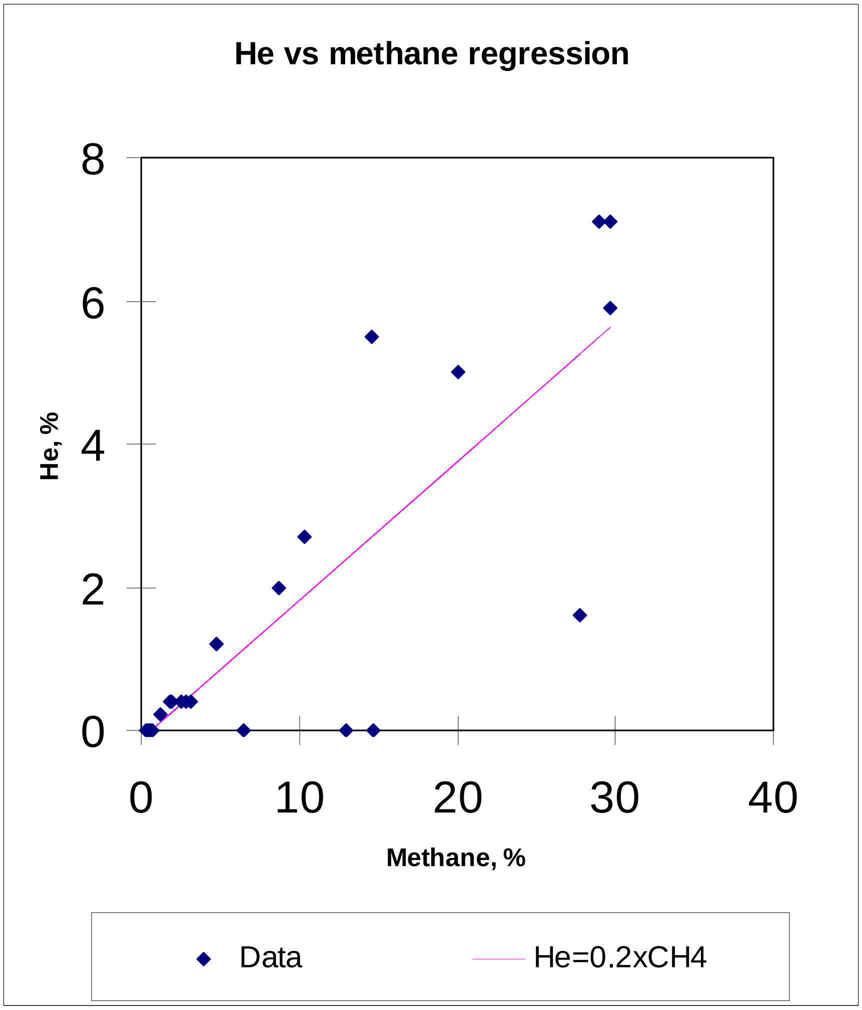


Figure 2 - He detector readings vs methane

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.834405
R Square	0.696231
Adjusted R	0.683574
Standard E	1.341249
Observatio	26

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regressior	1	98.95553	98.95553	55.00741	1.17E-07
Residual	24	43.17478	1.798949		
Total	25	142.1303			

Lower
✓

	Coefficients	*Standard Err* ✓	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*
Intercept	-0.119053	0.35035	-0.339811	0.736955	-0.842138	0.604033	-0.842138
X Variable	0.193787	0.026129	7.416698	1.17E-07	0.139861	0.247714	0.139861

RESIDUAL OUTPUT

Observation	*Predicted Y*	*Residuals*
1	5.636434	0.263566
2	0.109617	0.110383
3	0.365416	0.034584
4	-0.022159	0.022159
5	0.811127	0.388873
6	2.400184	-2.400184
7	0.811127	0.388873
8	0.423552	-0.023552
9	1.566898	0.433102
10	-0.022159	0.022159
11	5.248859	-3.648859
12	2.729623	-2.729623
13	1.876958	0.823042
14	5.636434	1.463566
15	-0.022159	0.022159
16	2.710244	2.789756
17	0.249143	0.150857
18	0.229765	0.180235
19	1.140566	-1.140566
20	-0.00278	0.00278
21	5.500783	1.599217
22	3.756696	1.243304
23	-0.060916	0.060916
24	0.481688	-0.081688
25	0.016599	-0.016599
26	-0.041538	0.041538

Applied Hydrology Associates, Inc.

950 S Cherry St #810, Denver CO 80246 Tel: (303) 782-0164 Fax: ((303) 782-2560

MEMORANDUM

DATE: 6/5/02

TO: Klaus Schmidtke, Jim Kay, Steve Whyte, Mike Day

FROM: Terry Gulliver

RE: **Hooker Ruco Report #5, May 27 through 6/5**

This report covers two weeks, including the long weekend. It has attachments reporting the pneumatic slug tests in 50D2 and 50D1, and a spreadsheet of field data.

Summary of activities

In the week of May 28, following Memorial Day, Russ Mehalick and I sparged well F2 at three flow rates on consecutive days, and post-sparge monitoring will continue through Thursday 6/6.

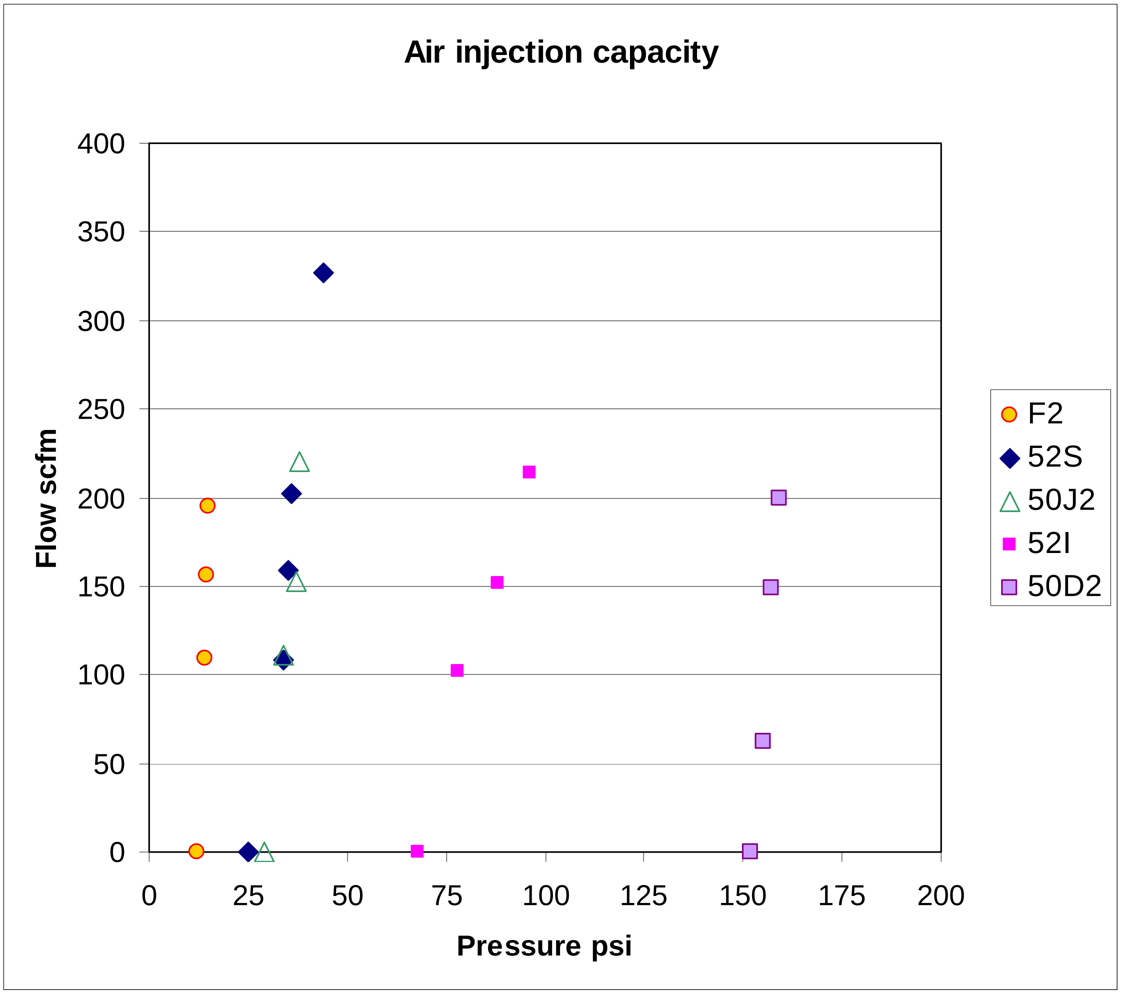
Due to other commitments, no field work will be done in the week of June 13. It is hoped that EPA will give approval for DAP addition in MW-50D2 by June 17, so that we can begin this then. The equipment is presently set up at the MW-50D2 site. If permission to add DAP is not given by June 17, we will move across the fence to sparge the K2 well.

Sparging F2

Well F2 at the Hooker-Ruco site was sparged by running a 100 ft hose extension from the control and instrumentation trailer location adjacent to MW-50D2. Sparging was conducted at three steps with nominal flow rates of 100, 150 and 200 scfm Thursday, Friday and Saturday, 6/1. The air injection capacity of F2 was similar to that of MW-52I and MW-50J2, in terms of incremental flow per psi extra pressure.

The following figure summarizes the air capacity data up to the present. The zero-flow point on each well line is the theoretical breakout pressure (the pressure needed to depress the water to the top of the screen). The gradients of tested wells (rise in flow per pressure increment) are similar, except for MW-52I, which is evidently screened in finer sediments.

The 200 scfm ceiling on the testing is not technically limiting. The brief 300 scfm test on MW-52S suggests extrapolation can be made of the general formation capacity up to the pressure at which rupture occurs (“hydrofracturing”). The test flow range is adequate to establish the gradients, and to develop a remedial system design.



Slug tests

As noted in the previous report, well MW-50D1 was tested and did not accept air at 110 psi sustained over 30 minutes. The lithology log (Leggette, Brashears & Graham, 1995), based on mud rotary cuttings, shows a lot of silt in the screen interval. Pneumatic slug tests were conducted in 50D1 and 50D2 to compare permeabilities and shed light on air injection capacities. In the two slug tests, the water level in the test well was depressed using the compressor, and its recovery monitored with the 100-ft sounding tape after suddenly releasing the pressure. Acrobat pdf files are attached showing preliminary solutions to these tests.

The slug tests show the saturated hydraulic conductivity of the MW-50D2 screened interval is roughly ten times as high as that in MW-50D1. That is, although the air entry pressure of the MW-50D1 interval does not admit air flow at less than rupture pressures, it will transmit water at one tenth the rate of the coarser intervals. This suggests the MW-50D1 screen is in a silty interval rather than a claystone, which (the dense gray claystones seen in other borings) would likely have transmissivity three orders or more lower than the sands.

Monitoring observations

Breakthrough of air and DO from sparged wells to the paired water table wells was seen some days after sparging in both the MW-50J1-J2 and F1-F2 pairs.

ORP has responded dramatically in sparged wells. DO was raised to saturation, with supersaturation of nitrogen evident as effervescence in samples after DO decreased below 100% saturation.

Post-sparge DO uptake and production of carbon dioxide in groundwater is difficult to quantify in a short term test with high BOD, although DO and pH both declined in most sparged wells in the week after the test.

No impacts have been seen in groundwater in observation wells other than shallow twins in the neighborhood of sparged wells.

Some effects have been seen in vadose zone gases following sparge events in wells up to 100 feet away.

Iron in groundwater

Ferrous and total iron were measured in water from the Hooker-Ruco Site this week, using a Hach colorimetric kit on samples collected during DO monitoring. This was prompted by observing rusty iron coating sampling tubing in some wells. Iron is significant as an electron acceptor: iron reducing microbes convert solid Fe (III) oxyhydroxide to relatively soluble Fe (II) by giving up an electron. The high levels of iron found in the shallow wells extend the picture of microbial activity (added to the high levels of carbon dioxide and methane), and also pose an incidental problem to any consideration of groundwater pumping in this area (the iron would tend to plug any treatment equipment when exposed to oxygen).

The following table gives the iron colorimetric test data collected 6/1 through 6/4. Any iron over 1 mg/L is typically due to iron reducing bacteria.

Well	Fe (II), mg/L	Total Fe, mg/L
E1	8	8
F1	14	
F2	7.6	
I1	nd	nd
MW-50J1	102	nd
MW-50J2	nd	nd
K1	70	140
K2	7.6	7.8
P1	12.5	12.5
MW-50D2	nd	nd

Native Fe (III) is initially available to microbes through much of the aquifer, as diagenetic coating of sand grains. Samples from the boring drilled this year show five to eight foot thick cycles of coarse sand grading up to silt down to about 500 ft depth, with orange-brown or red coloration in the coarser bases. There is some evidence in the literature of iron reducers degrading vinyl chloride, and this may be significant in attenuation of downgradient portions of the VCM subplume.

Conclusions

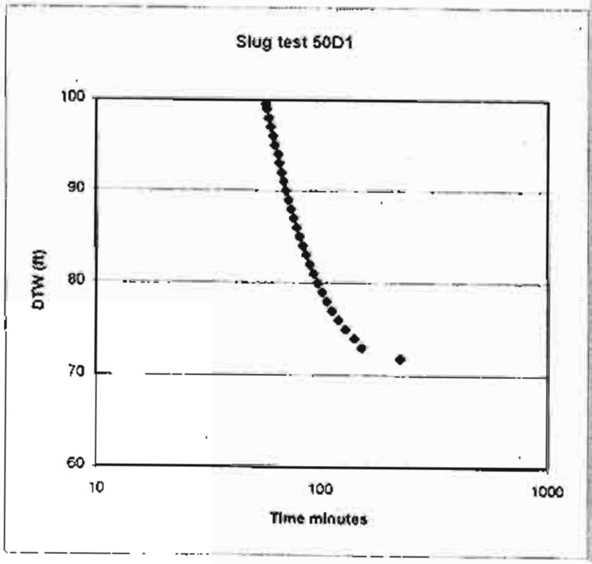
Iron reducing microbes as well as methanogens are in evidence at the Hooker Ruco Site.

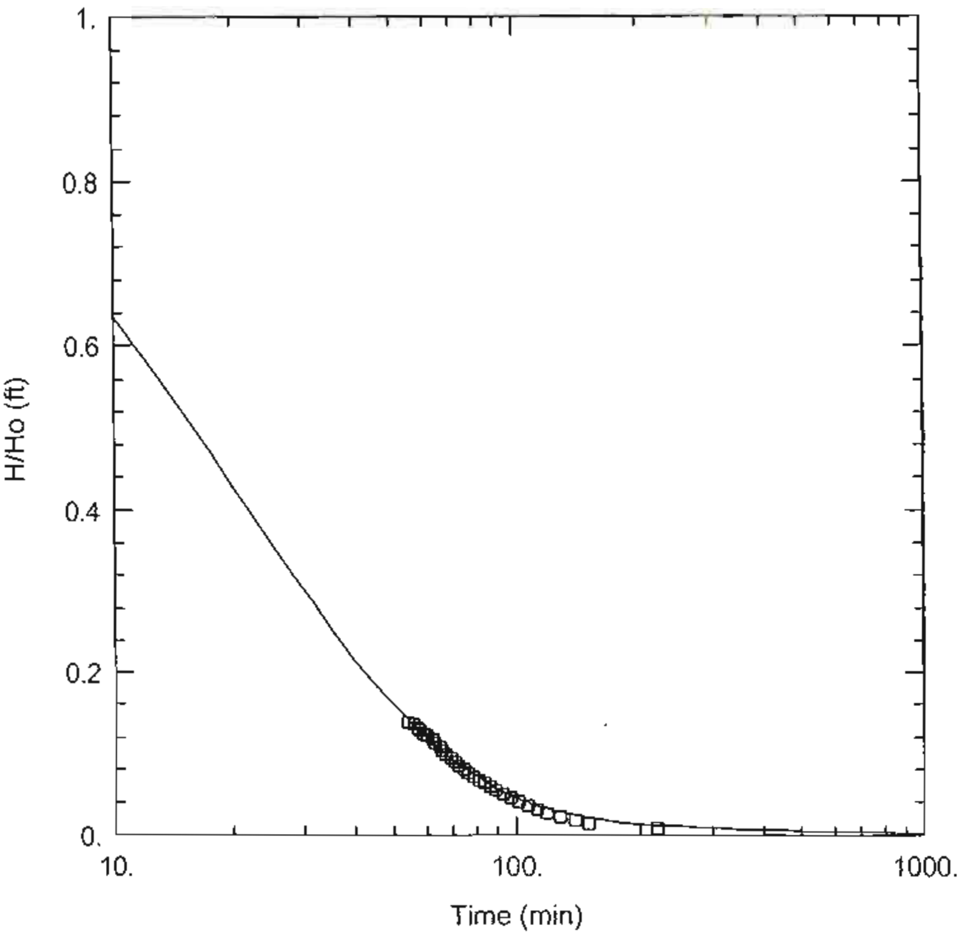
Silt horizons and Fe (III) precipitation created by sparging will both make sparging impacts non-homogeneous. Silts that are relatively permeable to water may be practically impermeable to air.

Time	min	DTW ft
0:00 00	0 0	
0 54 00	54.0	101.0
0.56:00	56 0	100.5
0 57.24	57.4	99 5
0 57.58	58.0	99.0
0:59.10	59.2	98 0
1:00:27	60.5	97 0
1:01:52	61.9	96.0
1.02:57	63.0	95 0
1 05:04	65 1	94 0
1.05.44	65.7	93
1 07:17	67 3	92
1:08 52	68.9	91
1:10.30	70.5	90
1:12:19	72.3	89
1 14.10	74 2	88
1 16:18	76 3	87
1:18:38	78 6	86
1 20.54	80 9	85
1:23:36	83.6	84
1 26 29	86.5	83
1.29 36	89.6	82
1 33.14	93 2	81
1 37:09	97 2	80
1:41:39	101.7	79
1:46 42	106.7	78
1:52 34	112.6	77
1:59:49	119.8	76
2:08 24	128 4	75
2 20.36	140.6	74
2 31:14	151.2	73
3 42 14	222.2	71.82

Slug test 50D1

Well 2" ID with screen 285-305 ft bgs
Stickup 6.0 ft ags
DTW baseline = 69 91 ft
Pressurized to 100 psi for 30 minutes: pressure let off 09:05= 0:00:00
Tape length = 100 ft





WELL TEST ANALYSIS

Data Set: S:\070-Glenn Springs\Data\Slug tests\50D1.aqt
Date: 05/30/02 Time: 10:08:26

PROJECT INFORMATION

Company: Applied Hydrology Associates
Client: Glenn Springs Holdings
Project: 70-1
Test Location: Hicksville, NY
Test Well: 50D1

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (50D1)

Initial Displacement: 225. ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.0833 ft
Well Skin Radius: 0.0833 ft
Screen Length: 20. ft
Total Well Penetration Depth: 20. ft
Gravel Pack Porosity: 0.5

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos

T = 1.392 ft^2/day
S = 7.254E-06

MW-50D1 Aqtesolv pneumatic slug test report

Data Set S:\070-Glenn Springs\Data\Slug tests\50D1.aqt
Date: 10/21/02
Time: 14:31:36

PROJECT INFORMATION

Company: Applied Hydrology Associates
Client: Glenn Springs Holdings
Project: 70-1
Location: Hicksville, NY
Test Well: 50D1

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

SLUG TEST WELL DATA

Initial Displacement: 225. ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.17 ft
Well Skin Radius: 0.17 ft
Screen Length: 20. ft
Total Well Penetration Depth: 20. ft
Gravel Pack Porosity: 0.5

No. of observations: 31

Observation Data

Time (min)	Displacement (ft)	Time (min)	Displacement (ft)	Time (min)	Displacement (ft)
54.	31.09	68.9	21.09	97.2	10.09
56.	30.59	70.5	20.09	101.7	9.09
57.4	29.59	72.3	19.09	106.7	8.09
58.	29.09	74.2	18.09	112.6	7.09
59.2	28.09	76.3	17.09	119.8	6.09
60.5	27.09	78.6	16.09	128.4	5.09
61.9	26.09	80.9	15.09	140.6	4.09
63.	25.09	83.6	14.09	151.2	3.09
65.1	24.09	86.5	13.09	222.2	1.91
65.7	23.09	89.6	12.09		
67.3	22.09	93.2	11.09		

SOLUTION

VISUAL ESTIMATION RESULTS

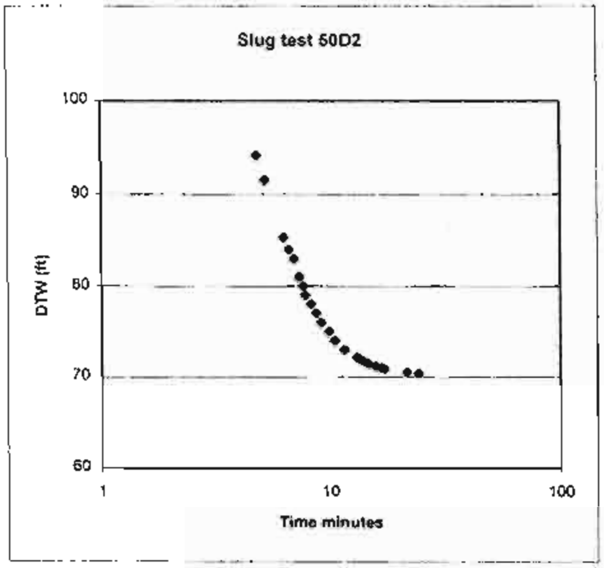
Estimated Parameters

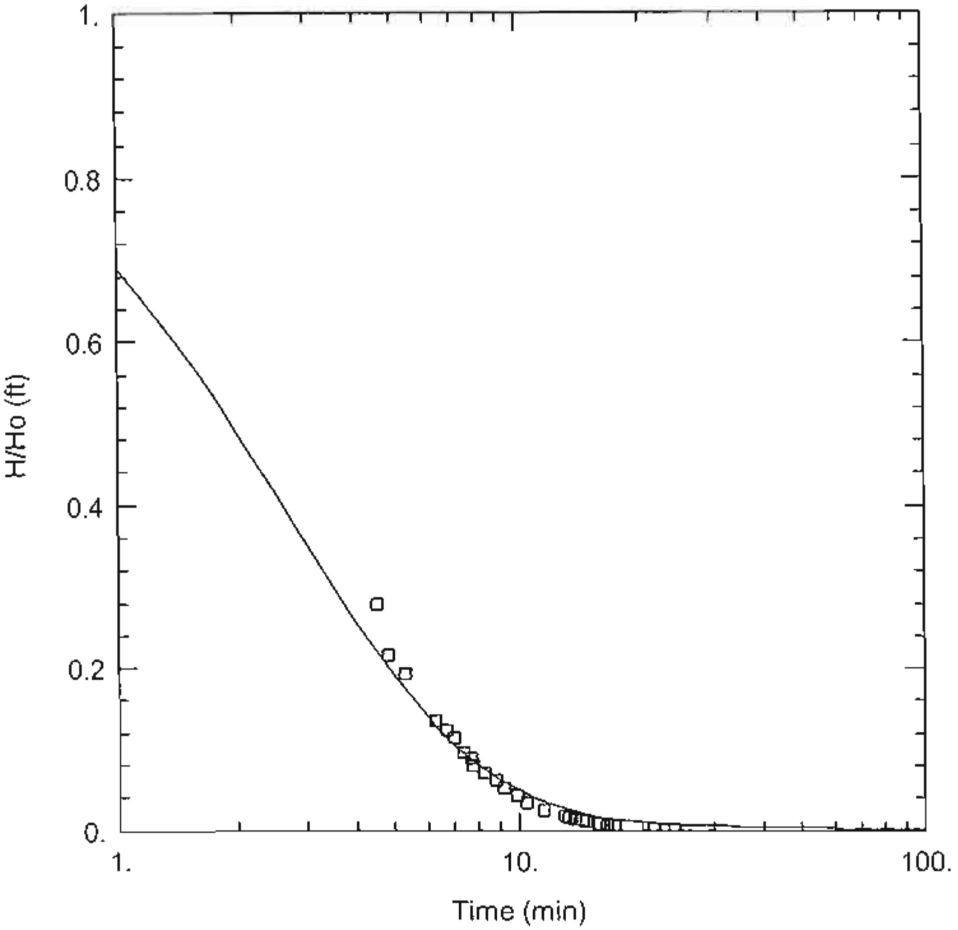
Parameter	Estimate	
Kr	0.08397	ft/day
Ss	3.967E-09	ft^{-1}
Kz/Kr	0.1	

Slug test 50D2

Well 2" ID with screen 415-435 ft bgs
Stickup not measured: you can use difference between 50D1 and D2 to derive, assuming same pot. Elevn.
DTW baseline = 70.31
Pressurized to 50 psi for 30 minutes: pressure let off 1400 = 0:00:00
Tape length = 100 ft

Time	min	DTW ft
0:00.00		
0.04.30	4.5	101.0
0 04.50	4.8	94 1
0 05:15	5.3	91.5
0 06'20	6.3	85.3
0:06'40	6.7	84 0
0'07 00	7.0	83.0
0'07'23	7.4	81.0
0'07'40	7.7	80 0
0.07.50	7.8	79 0
0'08:18	8.3	78 0
0 08 45	8 8	77.0
0'09'10	9.2	76.0
0'09 55	9.9	75.0
0.10:30	10.5	74 0
0:11:30	11 5	73.0
0.13'00	13 0	72.2
0 13'18	13 3	72.0
0.13.40	13 7	71.8
0:14:15	14.3	71 6
0'14:35	14.6	71 5
0.15:40	15.7	71.2
0.16:30	16 5	71.0
0:17:05	17 1	70 9
0:21:22	21.4	70.5
0:24 00	24.0	70 4





WELL TEST ANALYSIS

Data Set: S:\070-Glenn Springs\Data\Slug tests\50D2.aqt
Date: 05/30/02
Time: 10:08:36

PROJECT INFORMATION

Company: Applied Hydrology Associates
Client: Glenn Springs Holdings
Project: 70-1
Test Location: Hicksville, NY
Test Well: 50D2

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

WELL DATA (50D2)

Initial Displacement: 110. ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.0833 ft
Well Skin Radius: 0.0833 ft
Screen Length: 20. ft
Total Well Penetration Depth: 20. ft
Gravel Pack Porosity: 0.5

SOLUTION

Aquifer Model: Confined
Solution Method: Cooper-Bredehoeft-Papadopulos

$T = 22.\ ft^2/day$

S = 1.E-10

MW-50D2 Aqtesolv pneumatic slug test report

Data Set: S:\070-Glenn Springs\Data\Slug tests\50D2.aqt
Date: 10/21/02
Time: 14:32:43

PROJECT INFORMATION

Company: Applied Hydrology Associates
Client: Glenn Springs Holdings
Project: 70-1
Location: Hicksville, NY
Test Well: 50D2

AQUIFER DATA

Saturated Thickness: 20. ft
Anisotropy Ratio (Kz/Kr): 0.1

SLUG TEST WELL DATA

Initial Displacement: 110. ft
Casing Radius: 0.0833 ft
Wellbore Radius: 0.17 ft
Well Skin Radius: 0.17 ft
Screen Length: 20. ft
Total Well Penetration Depth: 20. ft
Gravel Pack Porosity: 0.5

No. of observations: 25

		Observation Data			
Time (min)	Displacement (ft)	Time (min)	Displacement (ft)	Time (min)	Displacement (ft)
4.5	30.69	8.3	7.69	14.3	1.29
4.8	23.79	8.8	6.69	14.6	1.19
5.3	21.19	9.2	5.69	15.7	0.89
6.3	14.99	9.9	4.69	16.5	0.69
6.7	13.69	10.5	3.69	17.1	0.59
7.	12.69	11.5	2.69	21.4	0.19
7.4	10.69	13.	1.89	24	0.09
7.7	9.69	13.3	1.69		
7.8	8.69	13.7	1.49		

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

SOLUTION

Aquifer Model: Confined
Solution Method: KGS Model

VISUAL ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	
Kr	1.051	ft/day
Ss	5.E-12	ft^{-1}
Kz/Kr	0.1	

AUTOMATIC ESTIMATION RESULTS

Estimated Parameters

Parameter	Estimate	Std. Error	
Kr	1.051	0.4216	ft/day
Ss	5.E-12	5.009E-11	ft^{-1}
Kz/Kr	0.1	not estimated	

Parameter Correlations

	Kr	Ss
Kr	1.00	-0.00
Ss	-0.00	0.00

Residual Statistics

for weighted residuals

Sum of Squares	73.61 ft^2
Variance	3.2 ft^2
Std. Deviation	1.789 ft
Mean	-0.04197 ft
No. of Residuals	25.
No. of Estimates	2

Applied
Hydrology
Associates, Inc.

950 S Cherry St #810, Denver CO 80246 Tel: (303) 782-0164 Fax: ((303) 782-2560

MEMORANDUM

DATE: 7/1/02

TO: Klaus Schmidtke, Jim Kay, Steve Whyte, Mike Day

FROM: Terry Gulliver

RE: **Hooker Ruco Report #6, 6/15 through 6/23**

This report has an updated data attachment.

Summary of activities

On 6/18 we injected diammonium phosphate (DAP) in MW-50D2; on 6/19 we sparged this well for eight hours. The rest of the week was spent monitoring for groundwater and soil gas impacts, which will continue through 6/25.

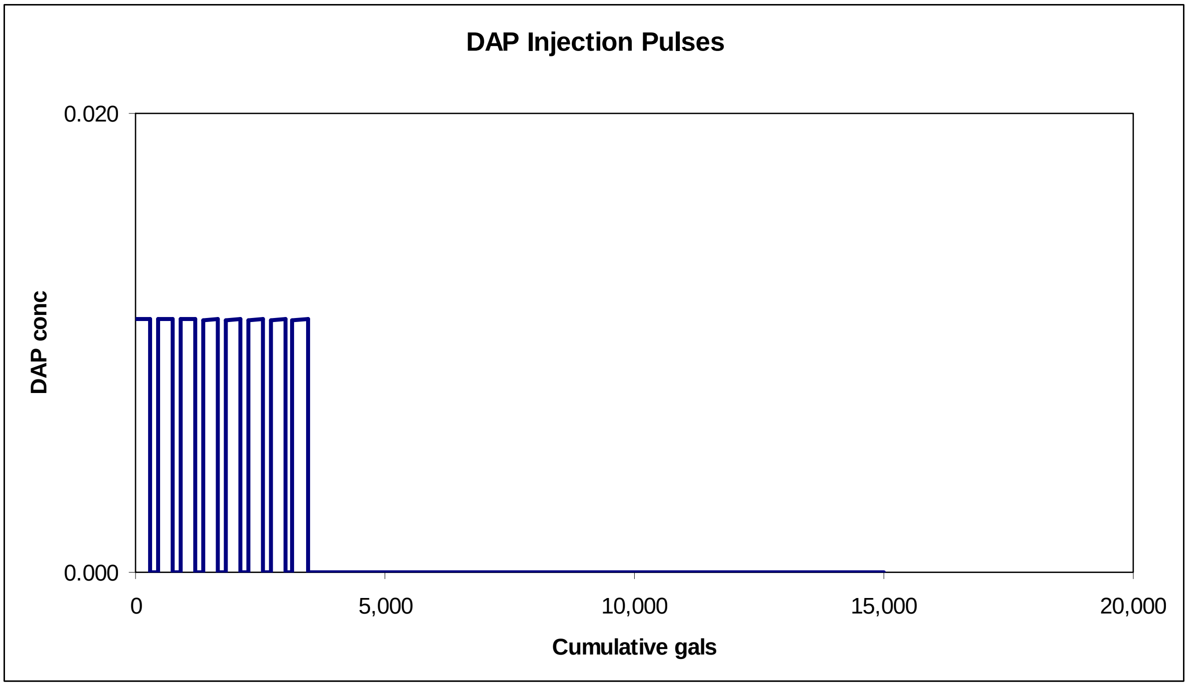
Because sampling of the new wells will extend through 7/3, sparging of K2, located south of the Hooker/Ruco Site on HLA property, will start on 7/8. Thereafter, the equipment will be moved to the Plant 12 site for injection of propane and sparging of MW-52D. We will perform a short step sparge test in MW-52D in this period to confirm that the well will accept the scheduled air flow.

DAP injection

On 6/17 and 18, prior to DAP injection, a cluster of wells was sampled for baseline microbial count, nitrate-nitrite and phosphate. These wells were MW-50D1, MW-50D2, MW-50J1, MW-50J2, F1 and F2. Baseline field parameters in groundwater and water table well gases were also taken.

DAP was mixed in plant tap water in a plastic tank, and gravity-drained to the MW-50D2 well in 300 gallon batches. Half a 25 kg bag of DAP was mixed in each 300 gallons. A low flow of straight water was diverted to the well while the tank was filling; and after the DAP injection was complete, flow to the well was kept up overnight. A total of 15,000 gallons water were injected, with DAP batches at a strength of 0.11%. The following figure summarizes this injection schedule.

Since the MW-50D2 groundwater has a TDS < 200 mg/L (SC ~ 200 uS), there is not likely to be any chemical precipitation. If the MW-50D2 aquifer has as little clay and organic carbon as seen in shallow exposures and deeper cores, there should also be little ionic adsorption, and the DAP should be somewhat mixed across a 20 ft diameter by convective dispersion.



Field parameters (pH, SC, ORP, DO) for the plant supply water were measured. A sample of the plant water was submitted for lab analysis of residual chlorine. Since the local water is supplied from groundwater, the plant water should be chemically similar to that in MW-50D2.

Sparging MW-50D2

Because a brief sparge step test had been conducted in this well in May (5/21) to determine the wells capacity, a single eight-hour test was conducted at a nominal flow of 200 scfm. The earlier step capacity test data were shown on a plot of all wells tested to date, in the last progress report.

Some erroneous flow data were recorded in this test. Flowmeter readings jumped dramatically, and pressures were initially eased to adjust the flow back to the target value of 200 scfm. When the flow became erratic, it was found that water was accumulating in the three-inch air pipe upstream of the flowmeter, causing a reduction in the sectional area of air flow and therefore a rise in the air velocity, which the flowmeter translated to higher flow. This complication is not too significant for this test, in that the preliminary step test of May 21 in MW-50D2 showed the air injection capacity, and an assumption of the nominal flow of 200 scfm in the June test is adequate to evaluate impacts. The moisture trap will be overhauled, and a drainage valve installed in the flowmeter section, prior to the next sparge test.

DAP injection in 50D2

gal	Σ gal	DAP conc
0	0	0.01
300	300	0.011
	301	0.00
150	450	0.00
	451	0.011
300	750	0.01
	751	0.00
150	900	0.00
	901	0.011
300	1200	0.01
	1201	0.00
150	1350	0.00
	1351	0.01
300	1650	0.01
	1651	0.00
150	1800	0.00
	1801	0.01
300	2100	0.01
	2101	0.00
150	2250	0.00
	2251	0.01
300	2550	0.01
	2551	0.00
150	2700	0.00
	2701	0.01
300	3000	0.01
	3001	0.00
150	3150	0.00
	3151	0.01
300	3450	0.01
	3451	0.00
11550	15000	0.00

Post MW-50D2 sparge monitoring

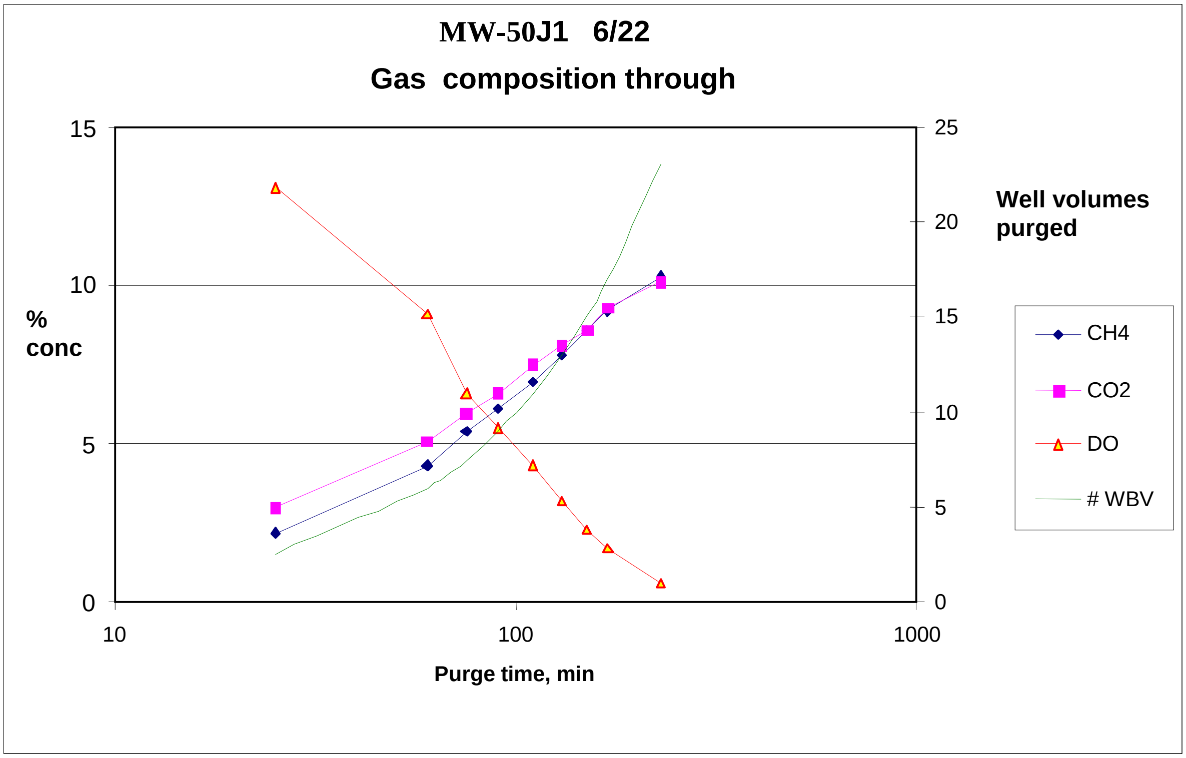
On June 18, prior to the 8-hour sparge in MW-50D2, water in this well still showed DO to be supersaturated from the 5/21, 3.5-hour sparge, a month earlier. This indicates there was little BOD in this well in the first place.

Influences apparently from sparging MW-50D2 were observed in MW-50J1, K1 and P1 water table gases. In each of these, fluctuations in composition suggest movement in a heterogeneous gas mass, and not breakthrough of injected air to the observation well. This sort of fluctuation is more evident following the 5/30 – 6/1 sparging of F2, a shallower well, where positive pressures and gas flows were recorded in the water table wells during sparging.

PID readings had become less than 1 ppm in all water table wells prior to sparging MW-50D2, but rose in E1, I1, J1, K1 and P1 following sparging.

Modest rises (< 1 mg/L) in groundwater DO were detected in MW-50J1 and F1, apart from the sparged well.

Gases in well MW-50J1seemed at first to show sparge air breakthrough. Suspecting the data, we left the air pump purging this water table well for nearly four hours, and obtained the data shown below. The approximate log-linear change in the composition of the gas is characteristic for recovery of a substance entering and dispersing from a well (analogous to injection and pump-back of a tracer to evaluate dispersion; it is theoretically an error function, erf{t}).



We believe this indicates that atmospheric air entered the well in the night after sparging, when the cap was loose and the water table was recovering from its small elevation rise (~ 0.1 ft in this well). This data provides a lesson, which is to keep water table well caps sealed after sparging.

One curious observation is that PID readings (ionizable VOC, IP < 10.6 eV) in water table gases appear to disappear between sparge events, and return immediately after a sparge. This was true even in quite distant well I1. We calibrated the PID daily, and frequently checked its response to calibration gas and magic markers to verify it was working, and reported the data as valid, though the response may be due to moisture raised by sparging.

Comments on radius of influence of sparging

It is worth commenting at this time on what indications we are obtaining from the pilot sparge tests on radius of influence, both above and below the water table. The sparge tests have used existing monitoring wells, and have generated good data on air injection capacity of the aquifer and the fitness of sparging in the source areas. They have not, however, given a lot of quantitative data on radii of influence.

Injected air leaves the top of the well screen at a pressure a little above hydrostatic (only a few psi in the tests to date). The excess pressure is initially an inverse-radial field superimposed on the hydrostatic field, that quickly is channelized as flow begins. This means that upward air flow has very little radial dispersion other than random-walk wiggles, and is typically in narrow cones like the shape of a yew tree. In a homogenous aquifer, the pressure gradient in the air channels is more or less hydrostatic. Where flow is obstructed by, say, a clay or silt layer, pressure will build at the obstruction until breakthrough occurs at the higher pressure, or lateral flow will ensue, breaking vertically again where a window is found. Thus cyclic sand-silt sections, and clay beds, can divert air flow out from the well; but these diversions are not symmetrical, or easily predicted. Episodic operation of a sparge system can hope to create new air paths each time it is restarted, based on the randomness in a relatively homogenous section.

The general slowness of response in shallower wells to deeper sparging in nested locations (e.g. MW-50D2) shows that air flow paths are not simple yew-tree shapes at the Hooker – Ruco site, but are substantially modified by silt and clay lithologies. It is clear that sparging the full section at this site would require injection points at several discreet intervals.

Applied Hydrology Associates, Inc.

950 S Cherry St #810, Denver CO 80246 Tel: (303) 782-0164 Fax: ((303) 782-2560

MEMORANDUM

DATE: 7/17/02

TO: Klaus Schmidtke, Jim Kay, Steve Whyte, Mike Day

FROM: Terry Gulliver

RE: **Hooker Ruco Report #7, 7/8 through 7/17**

Summary of activities

On 7/10 we sparged well K2 at the HLA site, after which groundwater and water table gases were monitored for five days.

Following the K2 test, the sparge trailer was moved to the MW-52 site (Plant 12). A short test for air capacity was performed 7/17 on well MW-52D, in which it is planned to inject carbon supplements, to confirm it is capable of taking 200 scfm. We will resume with propane and nitrous oxide addition in this well in the week of 7/23.

On 7/14, the flow-through cell instruments acted up, and the conductivity, pH and ORP readings of 7/14 and 7/15 are not reliable. A replacement meter was obtained 7/16, in time for baseline sampling of the MW-52 well nest.

K2 test

K2 was sparged on 7/10 for one hour at nominal 100 scfm (30 psi), one hour at nominal 150 scfm (31 psi), and six hours at nominal 200 scfm air flow (32 psi). This well has the top of screen at 121 ft bgs, and breakout pressure was estimated at 24 psi. When the well was shut in overnight, the pressure held at 24 psi.

Before and after the sparge event, DO levels in the sparge well were less than 1 ppm, except when the pump was located at the top of the screen, where DO registered 5 – 6 ppm. In fact the pump became lodged at the top of the screen, apparently due to an offset somehow triggered by sparging, and it has not yet been retrieved.

The higher than expected breakout pressure, and the distribution of DO in the screen (< 1 ppm in mid-screen, 6 ppm at the top of screen), suggest as one possible explanation that the screen interval is silty, and that sparge air was diverted away from the screen to a more permeable channel.

No DO increase was noted in adjacent shallow well K1 groundwater after sparging. K1 water table gas did show a spike in oxygen up to 14%, along with helium tracer at 85% of the injected concentration. The oxygen decreased to 8% by 7/16, although helium persisted (without methane interference).

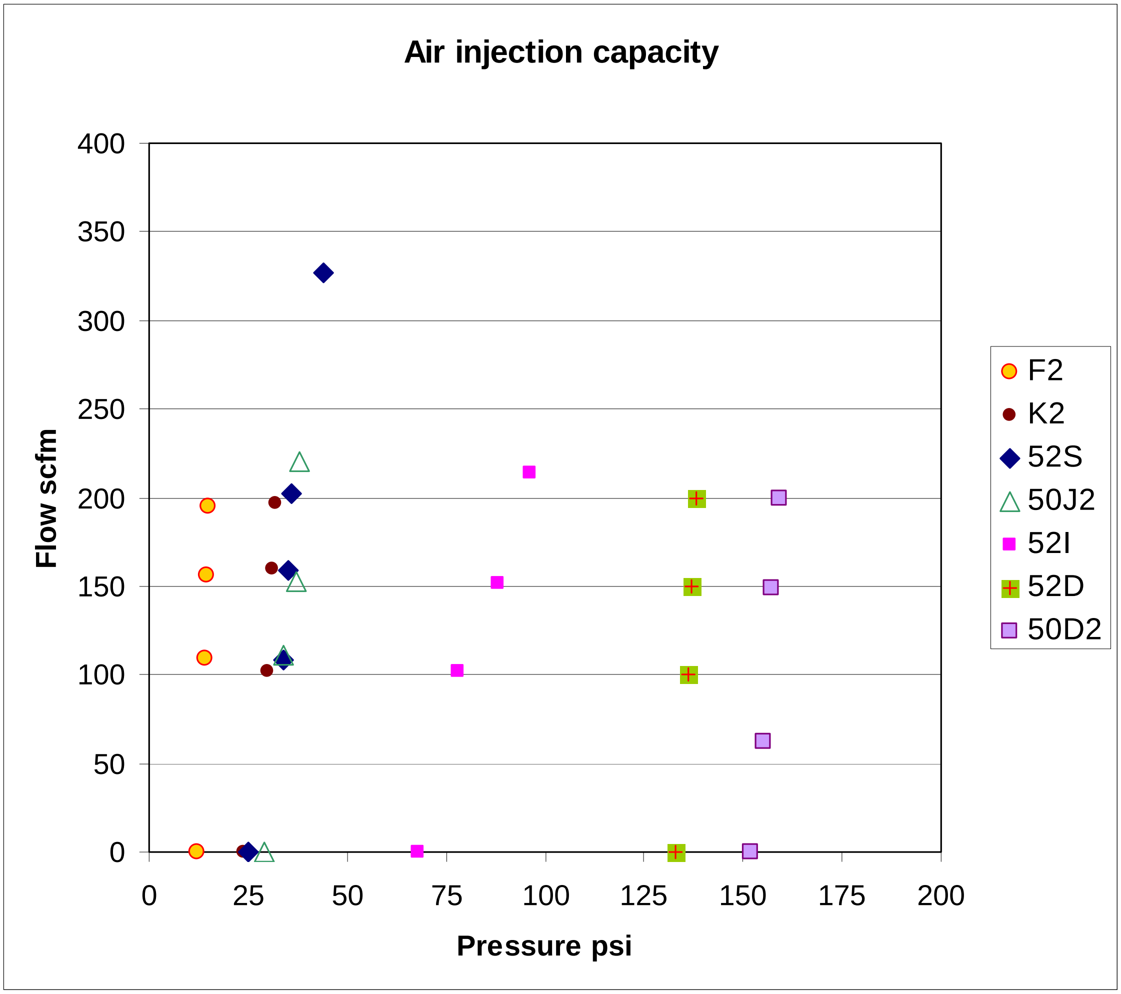
Some apparent responses to K2 sparging may be seen in other water table well gases, most attributable to lateral displacement of air rather than breakout of sparged air from beneath.

MW-52D capacity test

On 7/17, MW-52D was sparged at 100 scfm (136 psi) for ten minutes, 150 scfm (137 psi) for ten minutes, and 200 scfm (138 psi) for fifteen minutes. Top of screen is at 371 ft bgs, and breakout pressure was estimated at 133 psi.

Flow was initially very erratic (bouncing from 70 to 300 scfm), but stabilized after eight minutes.

The air capacities of the two new tests (K2 and MW-52D) have been added to the capacity plot. The gradients of most data sets – the increase in flow per increase in applied pressure – are similar, near 40-50 scfm per psi over the breakout pressure. Silty lithology in MW-52I reduced this capacity, and in MW-50D1 it prevented air flow. Ceilings on air injection capacity are given by formation rupture pressure (effective stress) and by Reynolds number (air velocity in the sand) at the point of injection; these ceilings need to be borne in mind in remedial system design, but they allow ample sparge flows.


Air injection capacity
Flow scfm
400
350
300
250
200
150
100
50
0
0
25
50
75
100
125
150
175
200
Pressure psi
F2
K2
52S
50J2
52I
52D
50D2

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950 S Cherry St #810, Denver CO 80246 Tel: (303) 782-0164 Fax: ((303) 782-2560

MEMORANDUM

DATE: 7/31/02

TO: Klaus Schmidtke, Jim Kay, Steve Whyte, Mike Day

FROM: Terry Gulliver

RE: **Hooker Ruco Report #8, 7/22 through 7/26**

Summary of activities

MW-52D at Northrop Plant 12 was sparged with propane and nitrous oxide amendments July 23, 24 and 25th. Post-sparge monitoring began July 26, and will continue through July 31.

During the next test (beginning August 5), it is planned to inject sugar byproducts in MW-52D, followed by further air sparging.

Propane –nitrous oxide addition at MW-52D

A 100 lb propane tank was heated to as much as 107°F to raise the vapor pressure higher than the sparge pressure, to generate a flow of approximately 0.4% in the sparge air. Nitrous oxide was injected without difficulty from a 2,000 psi compressed gas bottle.

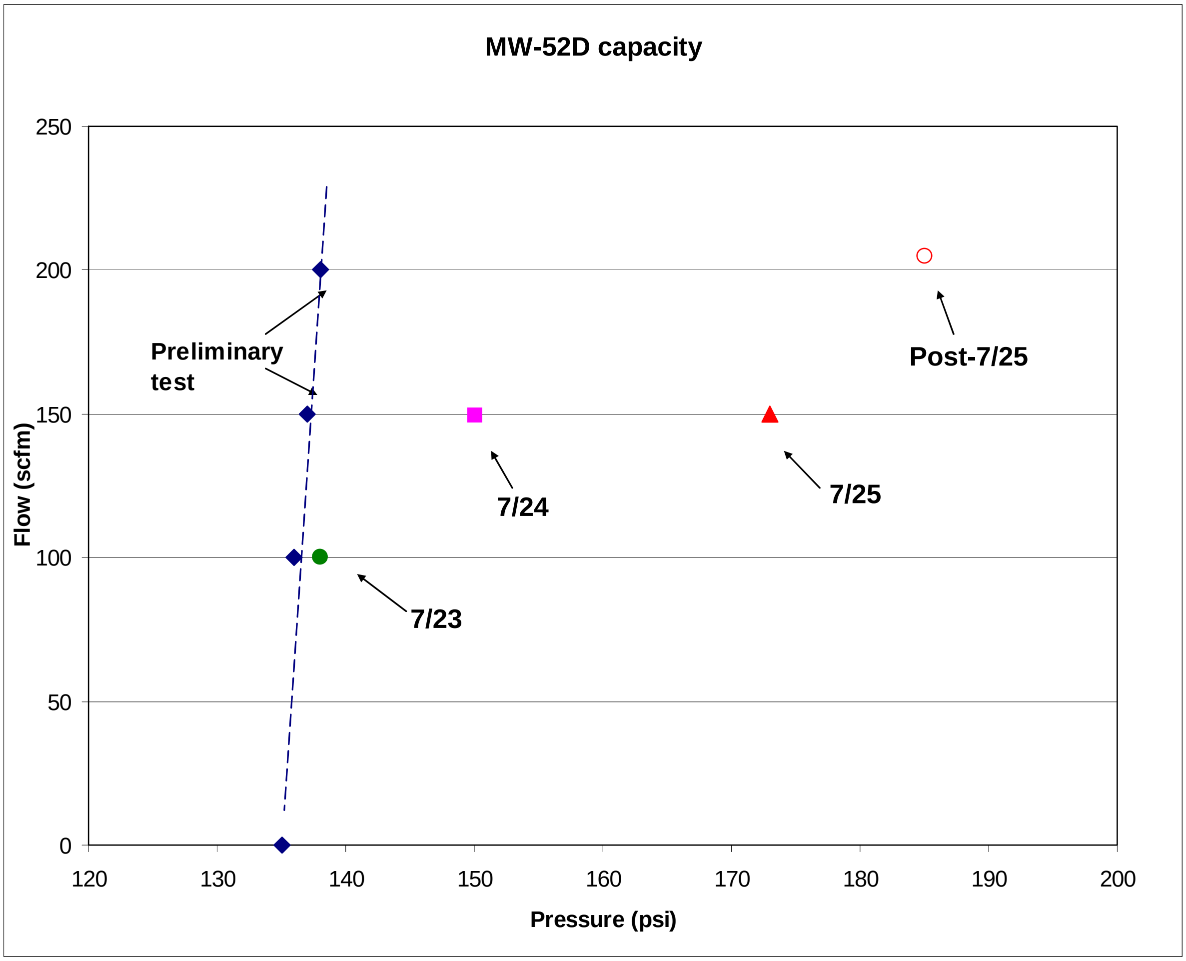
There was some difficulty initiating propane flow. On the second propane test day (nominal 150 scfm sparge), heated gas condensed in a flow control valve, until this was short-circuited. In a full-scale remedial design, all components between the heated source and the point of injection into the sparge air should be heated to prevent this condensation, at least until the gas flow itself maintains the necessary temperature through the system.

Without the flow controller, propane flow was regulated by a bottle valve and air flow to maintain an LEL between 15 and 22%; 25% LEL corresponds to a propane concentration of 0.5%.

This test demonstrated the feasibility of propane injection at some depth.

Air capacity in MW-52D

Air injection capacity decreased in successive sparge tests in MW-52D, as shown below.



The data show capacity in the preliminary testing July 17 (15 min each at 100, 150, 200 scfm), three four-hour tests targeted at 100, 150 and 200 scfm July 23, 24 and 25, and a 10 minute test at maximum compressor capacity (bypassing the pressure regulator) following the four-hour test on July 25. Data show a progressive shift from the Q(P) capacity line of the preliminary data; successive tests required higher pressure to obtain the same flows.

Following sparging, water in the sparged well had a high turbidity due to fine silt with some clay (90% settled in a VOA vial in one hour). This suggests the successive air injection tests caused silting of the screen to reduce the air flow capacity. Water flow back into the well following pressure release should not have been especially violent, since following all tests the well was shut in overnight, and residual pressure (~133 psi) was bled off over 15 or more minutes. It is possible that vibration associated with sparging caused consolidation of annular sand in some places and release and entry of silts.

Sugar byproduct injection

If a sugar byproduct syrup is to be used in this test, it will be necessary to have an energetic mixing system. Sugar byproduct syrup has a higher viscosity and density than water, and will sit at the bottom of a tank without dissolving. A mixer consisting of a drillers' grout mixing pump would be an obvious candidate. The plank stirrer used to dissolve the DAP at MW-50D2 will not work.

Microbes

The reported counts are not high for shallow groundwater, as contaminated groundwater typically shows millions of CFUs (colony forming units) per mL, but they confirm the environment is far from sterile.

The data from before and after the F2 well sparge test show a 50-fold increase in "aerobic" microbe CFUs at the adjacent well F1, and only a ten-fold increase in the sparged well F2. This difference is not unexpected, since sparge air tends to escape at the top of the screen and rise above the interval from which the groundwater samples would be collected, so that the impact of sparging is above the sparge elevation.

Helium in groundwater

Analyses from Microseeps of helium in groundwater before and after sparge tests are not very helpful. The following extraction suggests that the helium detector might have been confused by methane, similar to the Mark gas detector used in the field:

Well	He, ug/L, before sparge*	He, ug/L, after sparge
MW-52S	44	6.5
MW-52I	140	5
F2	13	1.3

* The sparge event for MW-52S and MW-52I is that in MW-52I, conducted 4/24-25; the sparge event for F2 was in F2 itself

Microseeps stated that their detector does not suffer from this methane interference. They are reviewing the data for possible explanations from the lab perspective.

Methanogenic activity is likely in these wells. DO was < 1 mg/L prior to sparging in all of them.

Applied
Hydrology
Associates, Inc.
950 S Cherry St #810, Denver CO 80246 Tel: (303) 782-0164 Fax: ((303) 782-2560

MEMORANDUM

DATE: 8/15/02

TO: Klaus Schmidtke, Jim Kay, Steve Whyte, Mike Day

FROM: Terry Gulliver

RE: **Hooker Ruco Report #9, 8/6 through 8/13**

Summary of activities

MW-52D at Northrop Plant 12 was injected with sugar byproducts and sparged on August 7 - 8. Post-sparge monitoring was performed August 9 through 13. An updated spreadsheet is attached.

The equipment was packed up and taken off site. This brings the sparge tests to a close.

Sugar Byproduct injection at MW-52D

The quantity of sugar byproduct to be added was reduced to 80 lb. This was mixed by pressure hose in 200 gallon batches in a tank on a pickup, with water from the Hooker plant. The water was tested with a Hach colorimetric kit for chlorine, and showed 0.55 mg/L total and 0.35 mg/L free chlorine.

Injection batches were as follows:

Gallons water	Lb sugar
200	20
200	0
200	20
200	20
200	0
200	20
200	0
200	0
1,600	**80**

The concentration of sugar in each batch was 1.2%; if fully mixed, the average injected concentration would have been 0.06%.

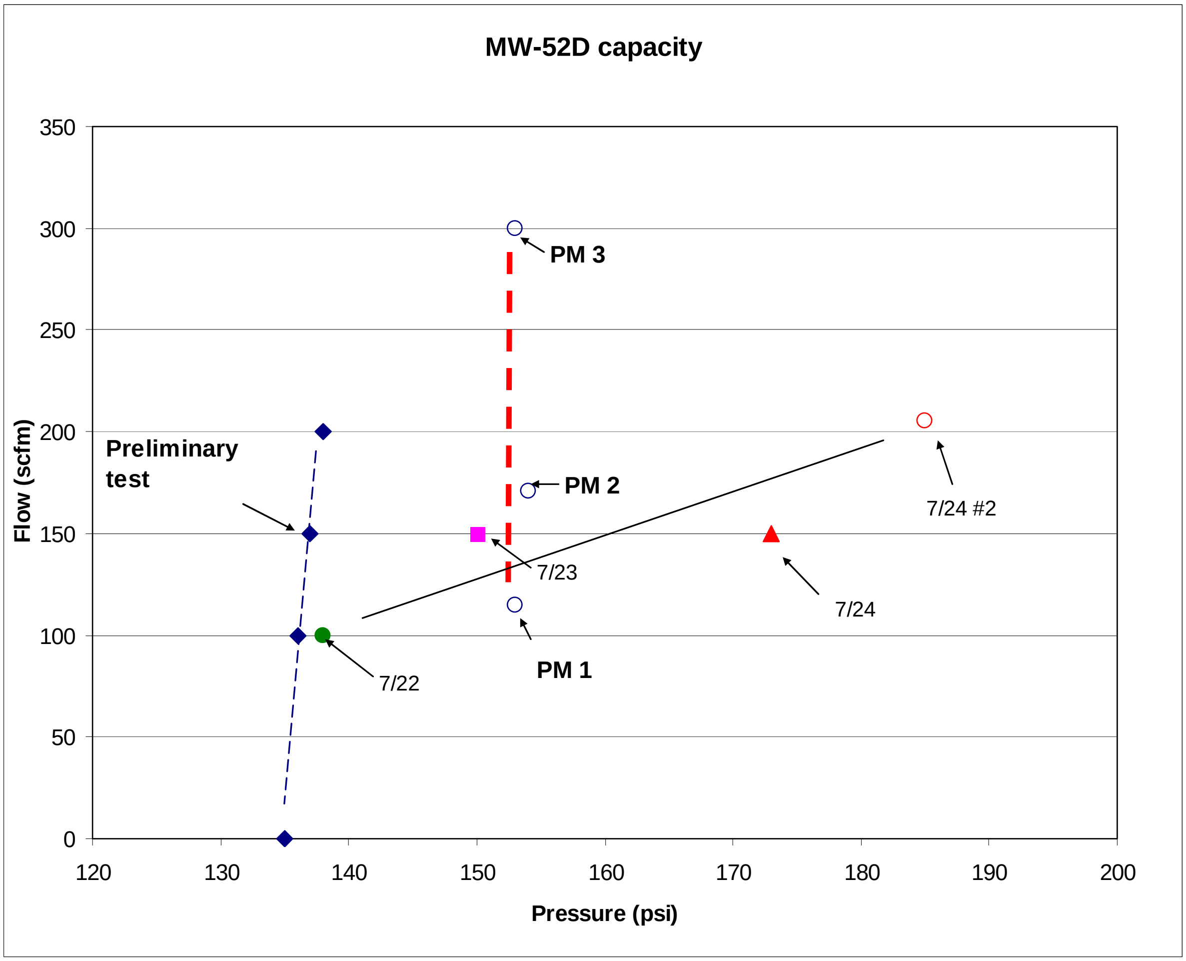
The viscosity of the sugar solution was not tested. The density is estimated as 1.006 – 1.01. The 1.3% solution had a SC 1,650 µmho/cm, and an ORP 230 mV.

There were no problems with the injection.

Post sparge, MW-52D

There had been an apparent decrease in air injection capacity in MW-52D during the post-propane sparge, as reported previously. As the line connecting the three "PS" (post sugar byproduct injection) points shows in the following plot, air capacity was recovered in this test. Pressure was held for an hour each at PS 1 and PS 2 at 153 and 154 psi, then raised to 158 psi and allowed to drift for the remaining six hours. The post-sugar byproduct injection capacity has a steep gradient, like that of the preliminary test in this well, and unlike the post-propane behavior. The post sugar byproduct injection curve is displaced some 15 psi from the preliminary tests.

The most plausible explanation for this vacillation in air capacity is that the sugar byproduct solution injection redeveloped the well, flushing fines away from the screen. Turbidity (shown by settling a jar to be clay) had previously always been high in this well, and cleared up in post-sugar byproduct sampling. We attempted a pre-sugar byproduct slug test on the MW-52D well, but residual gas caused unstable "burping" rather than a steady response.



Post sparge monitoring of groundwater is graphed on the attached figures. Data from the deep well, MW-52D, are shown below. Data points on the left are from earlier sparge tests in the MW-52S and MW-52I wells, and show un-affected baseline. Data on the right encompass the propane sparge (7/22 – 7/24) and the sugar byproduct sparge (8/8).

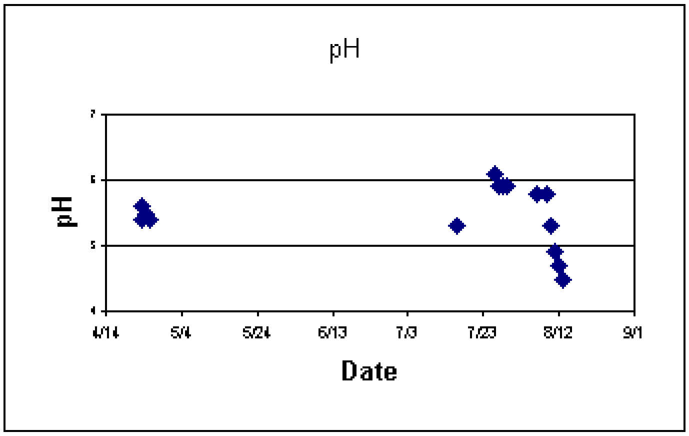
Dramatic decreases in DO and pH in MW-52D followed the sugar byproduct injection. This is due to metabolism of the sugar byproduct, consuming DO and producing carbonic acid (aqueous CO_2). Conductivity rose due to the sugar byproduct.

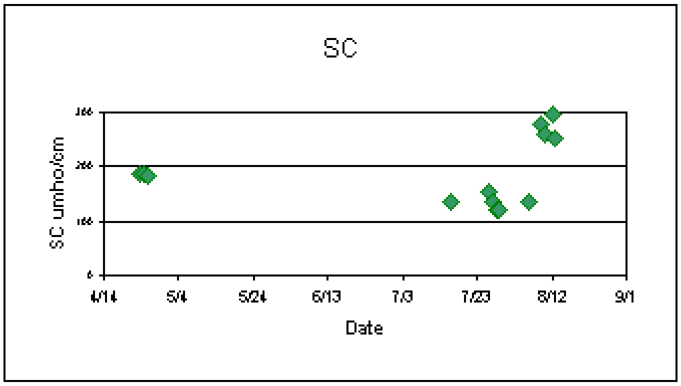
One obvious question is the difference between the propane and sugar byproduct responses. Firstly, the sugar byproduct is more readily metabolized. Secondly, the sugar byproduct solution would have flowed laterally from the well due to its approximately neutral density (its slightly higher relative density countered by higher viscosity than for water), and be reacting in the vicinity of the screen; the propane would have followed the sparged air path upward (down the pressure gradient), and away from the screen.

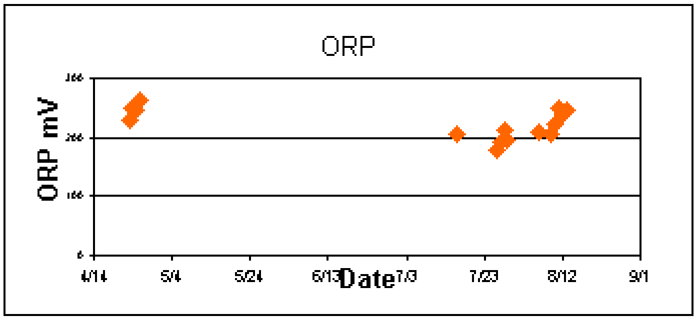
The C1 through C4 analyses from before and after propane sparging in MW-52D show that ethene was elevated before and after sparging (15, 79 μg/L) in MW-52S. This is strong evidence for degradation of VCM in the aquifer, the double carbon bond being a signature link (though other sources of ethene are possible). Note that the pre-propane sparge value in MW-52S follows April sparging in MW-52S itself, so that we cannot say whether the ethene is related to stimulating MW-52S directly, or to pre-testing natural attenuation. DO was consumed after sparging in MW-52S.

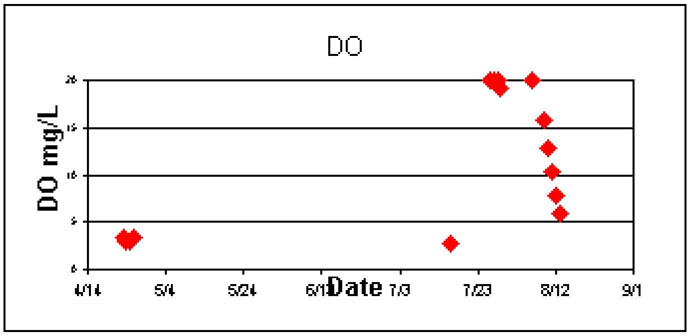
A small response in pH and DO was seen in the intermediate well MW-52I following the propane and sugar byproduct sparges. No significant increase in propane was seen in MW-52I. This muted response is likely due to diversion of ascending air by intervening silts or clays. It highlights the need for strategic placement of sparge points at the base of impacted zones, with attention to lithology.

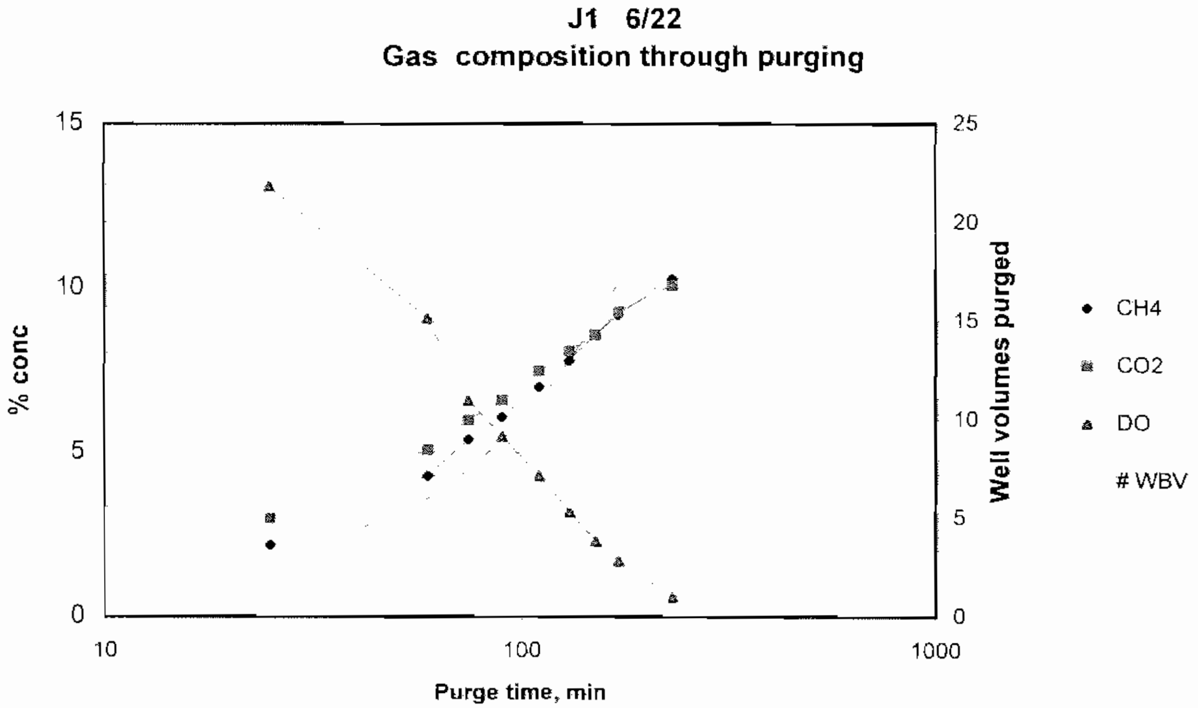
MW-52D

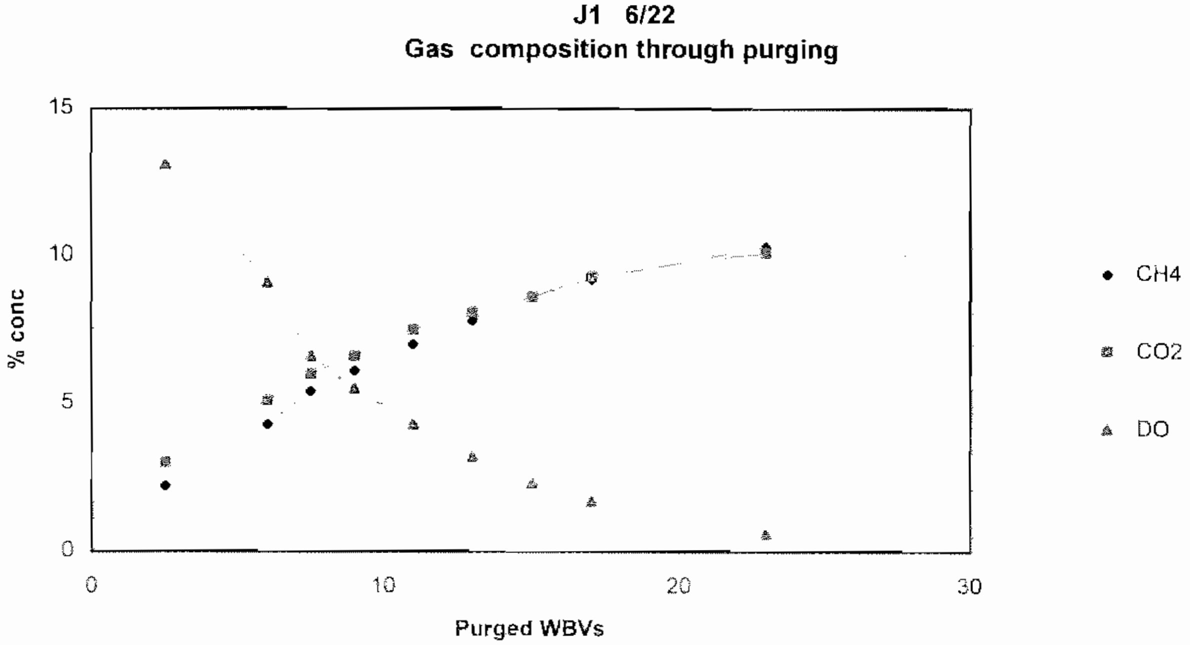

pH


SC


ORP


DO


J1 6/22
Gas composition through purging
15
10
5
0
% conc
10
100
1000
Purge time, min
25
20
15
10
5
0
Well volumes purged
CH4
CO2
DO
WBV


J1 6/22
Gas composition through purging
15
10
5
0
% conc
0
10
20
30
Purged WBVs
CH4
CO2
DO

J1 6/22

Minutes purged	CH4	CO2	DO	# WBV
25	2.2	3	13.1	2.5
60	4.3	5.1	9.1	6
75	5.4	6	6.6	7.5
90	6.1	6.6	5.5	9
110	7	7.5	4.3	11
130	7.8	8.1	3.2	13
150	8.6	8.6	2.3	15
170	9.2	9.3	1.7	17
230	10.3	10.1	0.6	23

Plant 12 Water Data

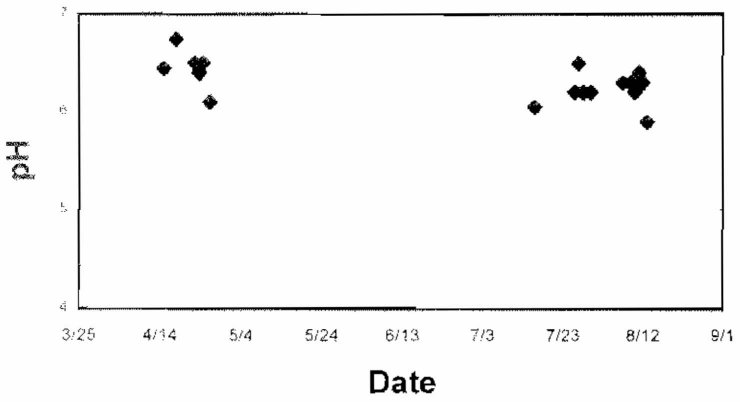
MW-52S

Date	pH	SC (umhos/cm)	ORP (mV)	DO (mg/L)
04/15/02	6.44	86	246	13.7
04/18/02	6.74	103	208	14.8
04/22/02	6.5	109	195	9.38
04/23/02	6.4	109	216	11.3
04/24/02	6.5	108	217	11.25
04/26/02	6.1	106	240	20
07/16/02	6.05	101	138	2.9
07/26/02	6.2	142	158	2.5
07/27/02	6.5	109	167	2.6
07/28/02	6.2	199	176	2.5
07/30/02	6.2	96	183	2.3
08/07/02	6.3	94	133	1.7
08/09/02	6.3	110	161	1.7
08/10/02	6.2	94	161	2.1
08/11/02	6.4	94	134	2.2
08/12/02	6.3	99	119	2
08/13/02	5.9	99	150	1.9

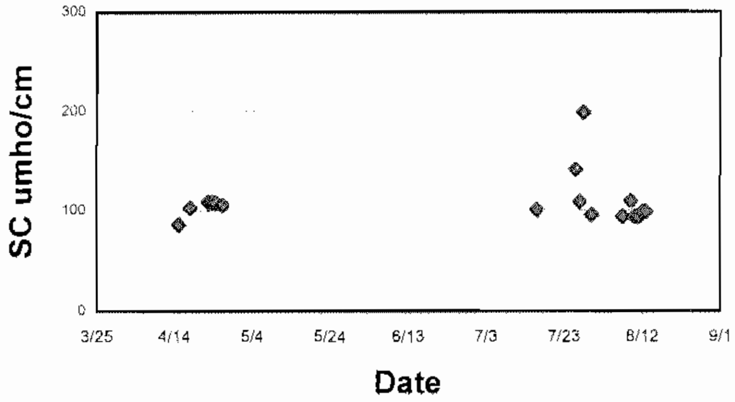
Sparge events

Well	Date
MW-52S	04/17/02
MW-52S	04/18/02
MW-52I	04/23/02
MW-52I	04/24/02
MW-52I	04/25/02
MW-52D	07/17/02
MW-52D	07/22/02
MW-52D	07/23/02
MW-52D	07/24/02
MW-52D	08/08/02

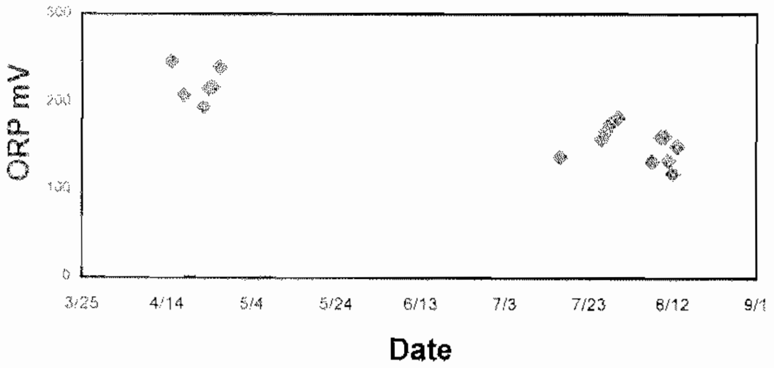
MW-52S
pH



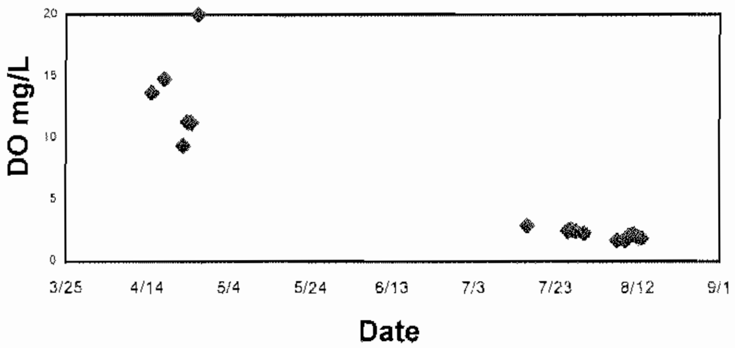
MW-52S
SC



MW-52S
ORP



MW-52S
DO

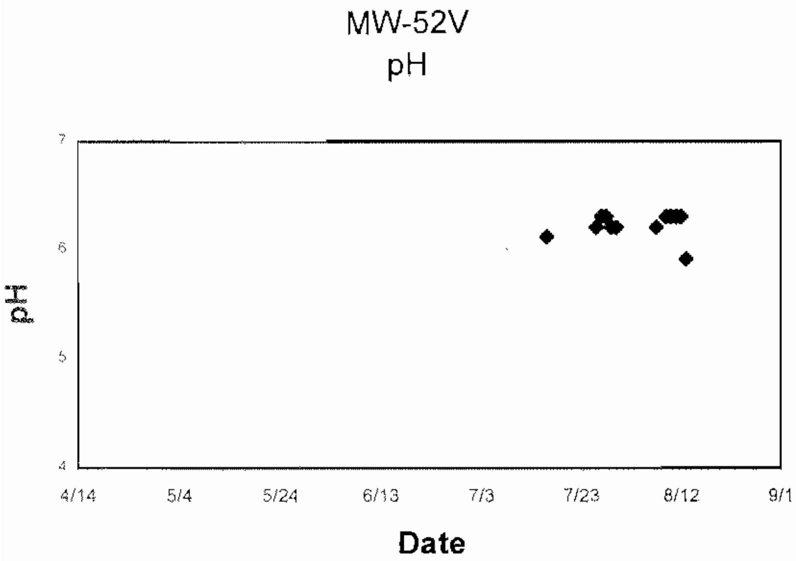


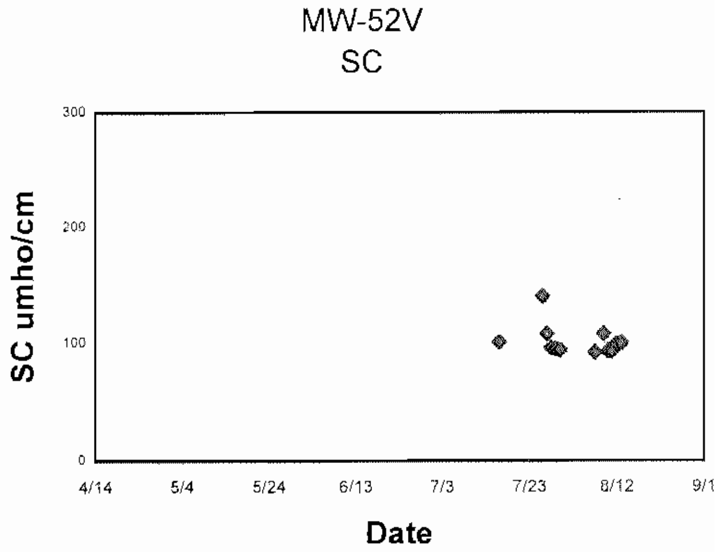
MW-52V

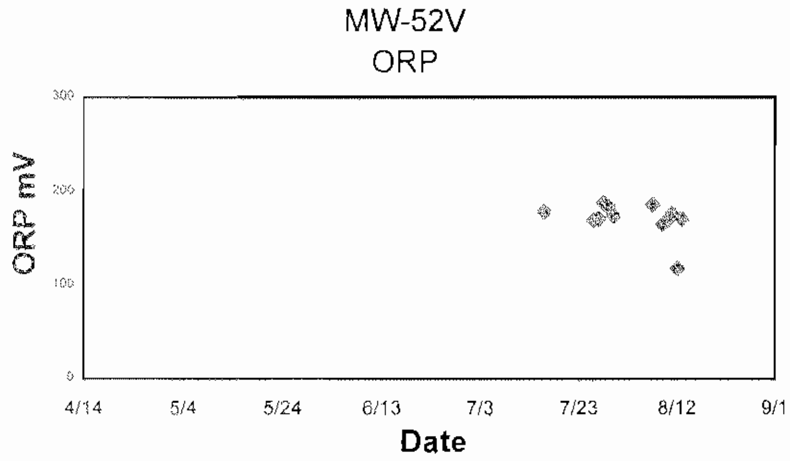
Date	pH	SC (umhos/cm)	ORP (mV)	DO (mg/L)
07/16/02	6.11	101	179	6
07/26/02	6.2	140	170	7.1
07/27/02	6.3	108	171	6.5
07/28/02	6.3	96	188	6.1
07/29/02	6.2	95	184	6.2
07/30/02	6.2	94	175	6.5
08/07/02	6.2	92	186	6.3
08/09/02	6.3	108	166	6.3
08/10/02	6.3	93	170	6.6
08/11/02	6.3	93	177	6.6
08/12/02	6.3	99	119	6.6
08/13/02	5.9	100	171	6.8

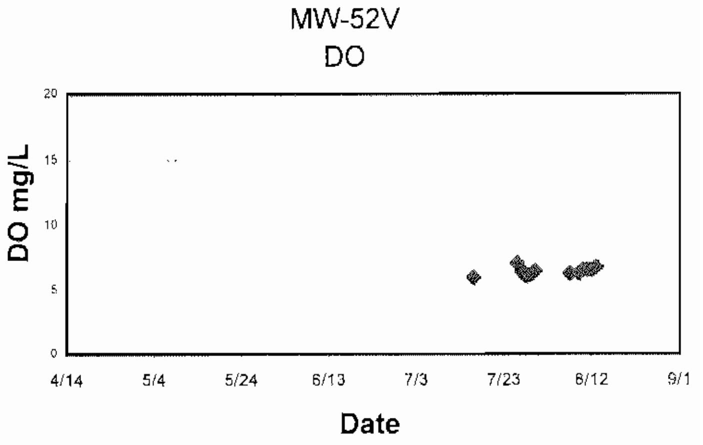
Sparge events

Well	Date
MW-52S	04/17/02
MW-52S	04/18/02
MW-52I	04/23/02
MW-52I	04/24/02
MW-52I	04/25/02
MW-52D	07/17/02
MW-52D	07/22/02
MW-52D	07/23/02
MW-52D	07/24/02
MW-52D	08/08/02


MW-52V
pH
pH
7
6
5
4
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date


MW-52V
SC
SC umho/cm
300
200
100
0
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date


MW-52V
ORP
ORP mV
300
200
100
0
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date


MW-52V
DO
DO mg/L
20
15
10
5
0
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date

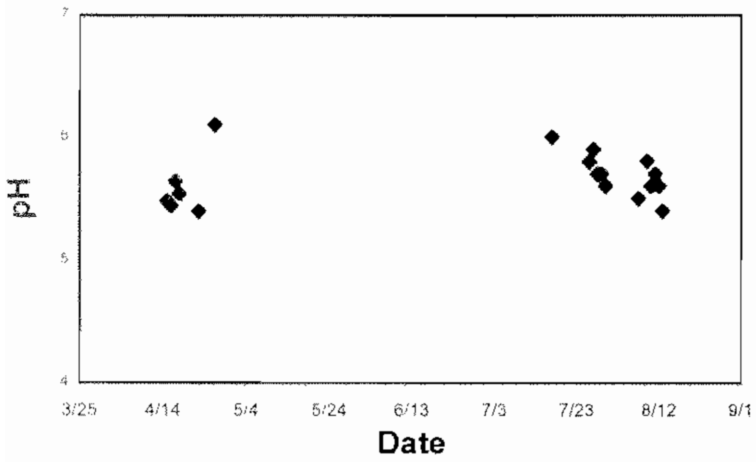
MW-52I

Date	pH	SC (umhos/cm)	ORP (mV)	DO (mg/L)
04/15/02	5.48	72	203	1.89
04/16/02	5.44	55	230	0.91
04/17/02	5.64	84	220	0.82
04/18/02	5.54	80	228	0.7
04/22/02	5.4	81	211	0.54
04/26/02	6.1	106	240	20
07/17/02	6	89	175	17
07/26/02	5.8	112	188	20
07/27/02	5.9	186	197	18.1
07/28/02	5.7	76	206	16.9
07/29/02	5.7	74	212	18
07/30/02	5.6	74	217	16.9
08/07/02	5.5	71	221	17.2
08/09/02	5.8	84	197	18.5
08/10/02	5.6	73	208	18.5
08/11/02	5.7	73	205	20
08/12/02	5.6	76	187	19.7
08/13/02	5.4	78	187	19

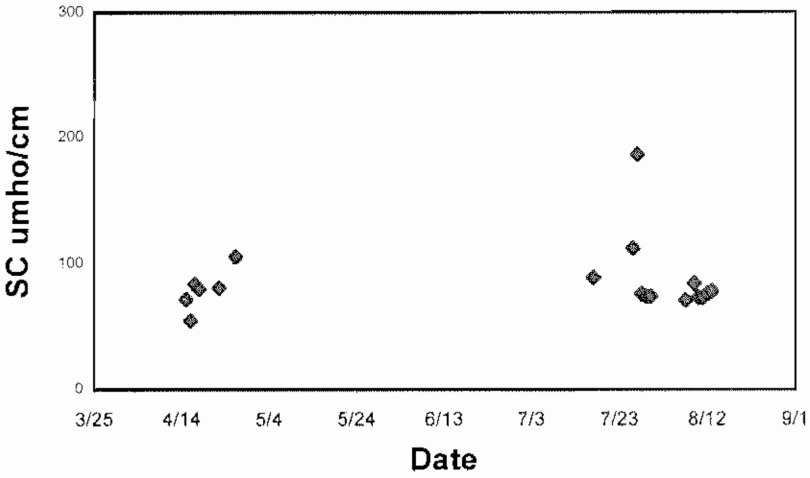
Sparge events

Well	Date
MW-52S	04/17/02
MW-52S	04/18/02
MW-52I	04/23/02
MW-52I	04/24/02
MW-52I	04/25/02
MW-52D	07/17/02
MW-52D	07/22/02
MW-52D	07/23/02
MW-52D	07/24/02
MW-52D	08/08/02

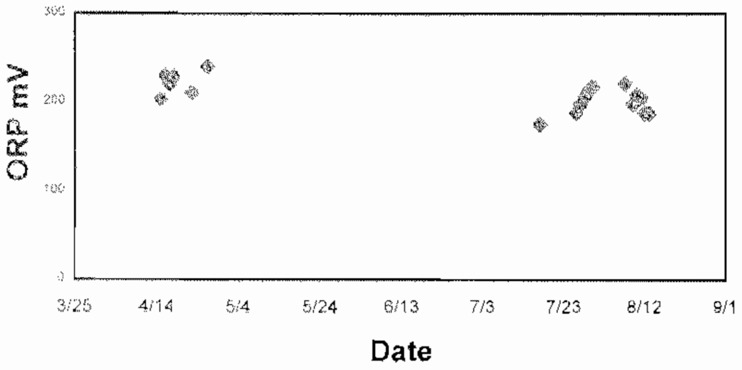
MW-52I
pH



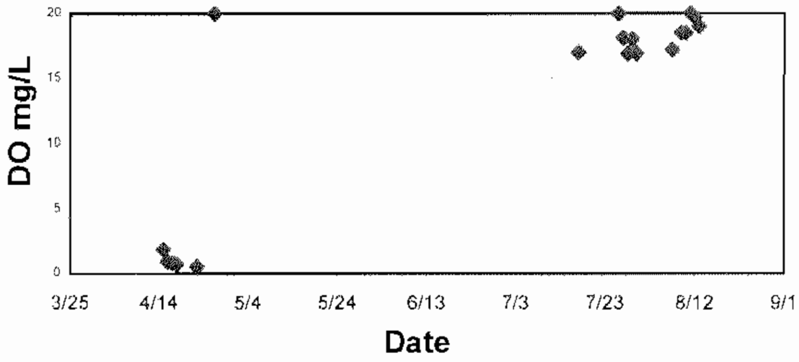
MW-52I
SC



MW-52I
ORP



MW-52I
DO

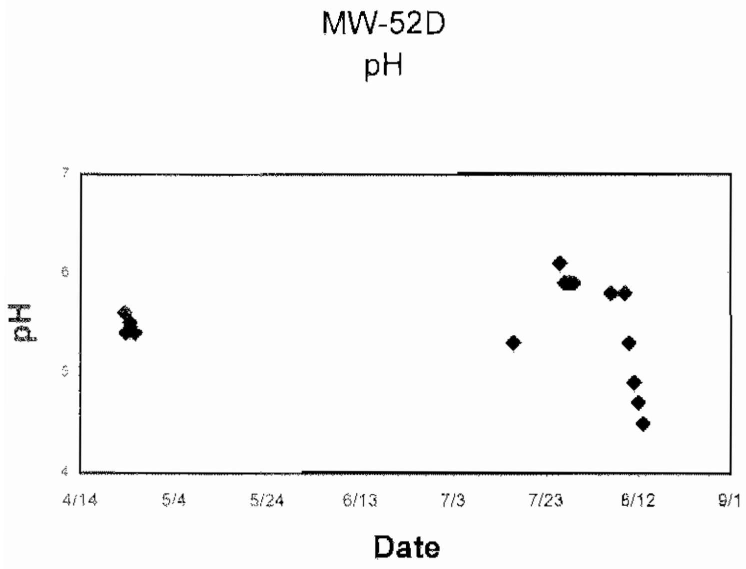


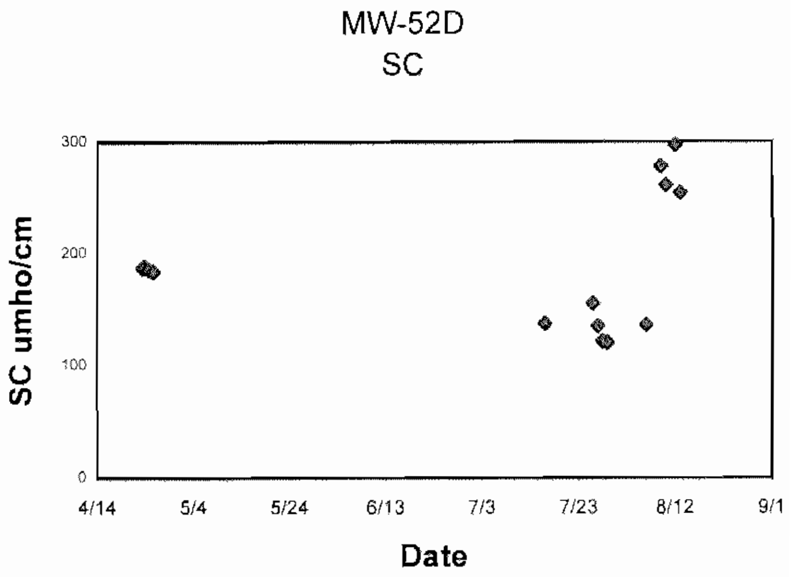
MW-52D

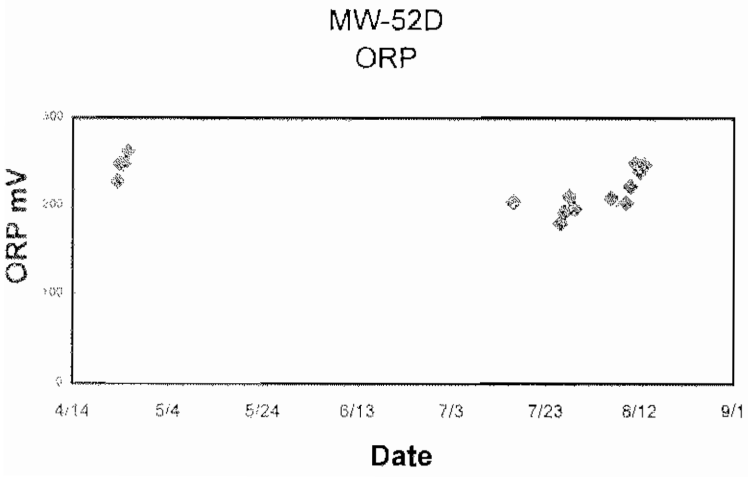
Date	pH	SC (umhos/cm)	ORP (mV)	DO (mg/L)
04/23/02	5.4	188	248	2.99
04/23/02	5.6	187	228	3.42
04/24/02	5.5	186	247	3.02
04/25/02	5.4	184	262	3.31
07/16/02	5.3	137	205	2.7
07/26/02	6.1	155	180	20
07/27/02	5.9	135	193	20
07/28/02	5.9	121	211	20
07/29/02	5.9	120	197	19.2
08/06/02	5.8	136	209	20
08/09/02	5.8	278	204	15.7
08/10/02	5.3	261	222	12.9
08/11/02	4.9	309	249	10.4
08/12/02	4.7	297	239	7.7
08/13/02	4.5	254	247	5.8

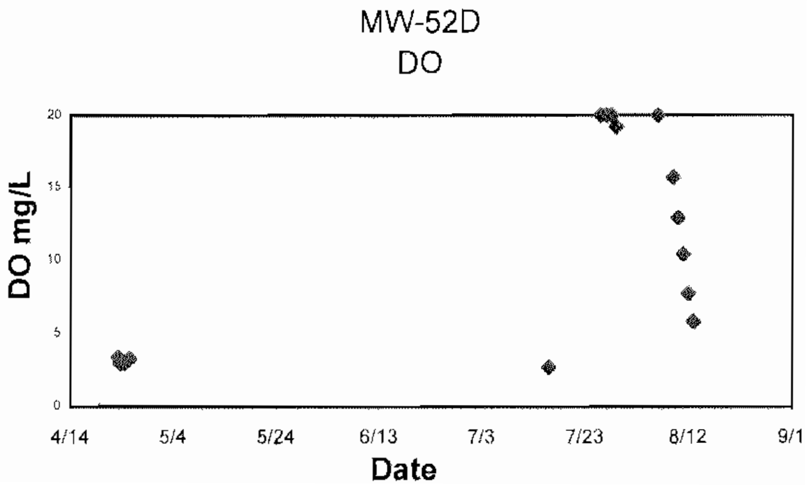
Sparge events

Well	Date
MW-52S	04/17/02
MW-52S	04/18/02
MW-52I	04/23/02
MW-52I	04/24/02
MW-52I	04/25/02
MW-52D	07/17/02
MW-52D	07/22/02
MW-52D	07/23/02
MW-52D	07/24/02
MW-52D	08/08/02


MW-52D
pH
pH
7
6
5
4
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date


MW-52D
SC
SC umho/cm
300
200
100
0
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date


MW-52D
ORP
ORP mV
300
200
100
0
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date


MW-52D
DO
DO mg/L
20
15
10
5
0
4/14
5/4
5/24
6/13
7/3
7/23
8/12
9/1
Date

Hooker - Ruco Water Data

⑨

Well	E1				
Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/01/02	5.75	65	-83	0.27	
06/02/02	5.1	81	3	0.46	
6/4/ 12:30					8
06/21/02	5.4	168	-10	0.41	
06/23/02	5.3	172	48	0.42	
07/11/02	5.5	137	42	0.3	

Spare Event	
Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

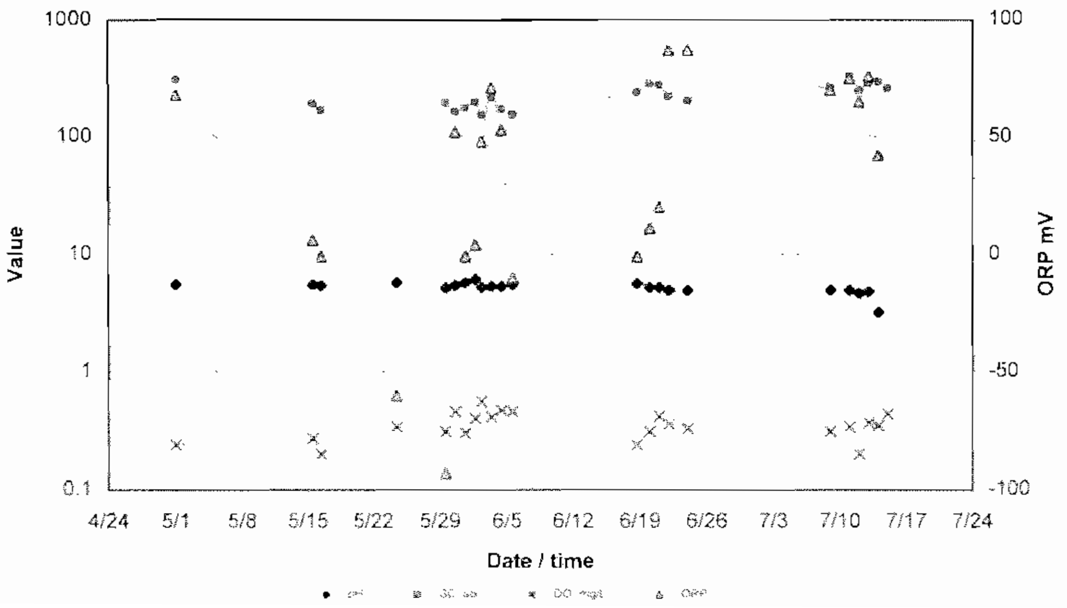
9

Well	**F1**				
Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/01/02	5.48	311	68	0.24	
05/15/02	5.5	193	6	0.27	
05/16/02	5.4	170	-1	0.2	
05/24/02	5.7		-60	0.34	
05/29/02	5.16	195	-93	0.31	
05/30/02	5.41	164	52	0.46	
05/31/02	5.68	177	-1	0.3	
06/01/02	6.05	198	4	0.4	
06/02/02	5.2	154	48	0.56	
06/03/02	5.3	218	71	0.41	14
06/04/02	5.3	173	53	0.47	
06/05/02	5.49	154	-10	0.46	
06/18/02	5.6	241	-1	0.24	
06/20/02	5.2	284	11	0.31	
06/21/02	5.2	277	20	0.42	
06/22/02	4.9	222	87	0.36	
06/24/02	4.9	204	87	0.33	
07/09/02	4.9	268	70	0.31	
07/11/02	4.9	329	75	0.34	
07/12/02	4.6	251	65	0.2	
07/13/02	4.8	288	76	0.37	
07/14/02	3.2	296	42	0.35	
07/15/02		260		0.44	

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

F1 Groundwater



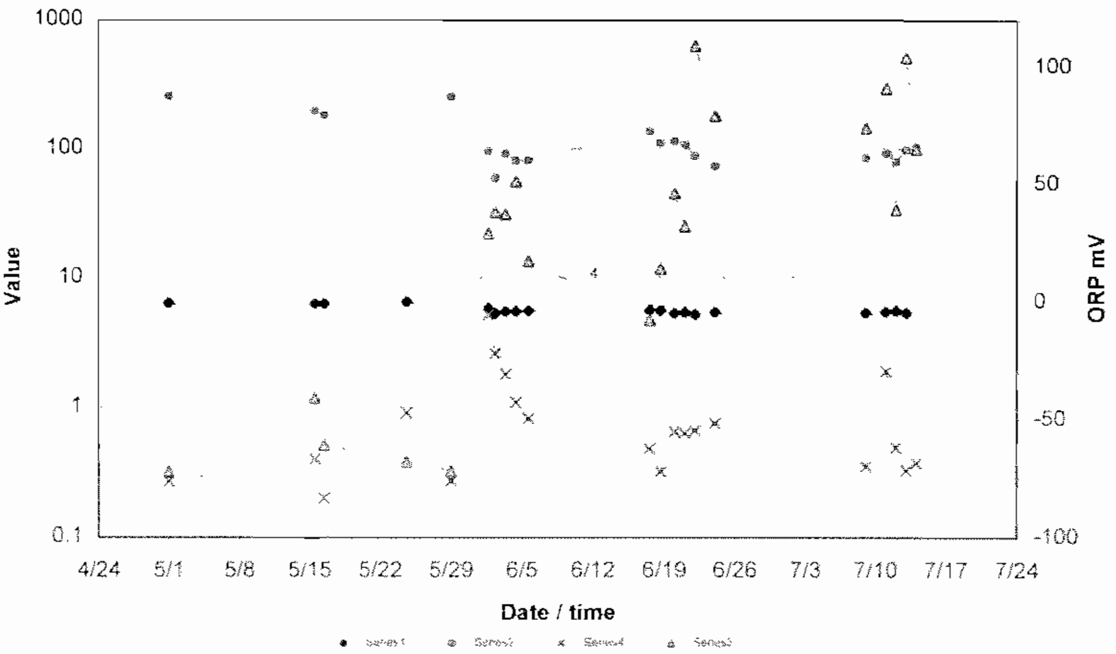
Well	F2				
Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
5/1/02 0:00	6.34	255	-72	0.27	
5/15/02 12:50	6.3	197	-41	0.4	
5/16/02 10:30	6.3	181	-61	0.2	
5/24/02 14:30	6.5		-68	0.91	
5/29/02 0:00		255	-72	0.27	
6/1/02 16:00	5.8	96	29	5.2	
6/2/02 9:00	5.3	59	38	2.6	7.6
6/3/02 9:00	5.5	91	37	1.8	
6/4/02 10:00	5.5	81	51	1.1	
6/5/02 15:00	5.55	81	17	0.82	
6/17/02 13:00	5.6	137	-8	0.48	
6/18/02 15:00	5.6	110	14	0.32	
6/20/02 0:00	5.3	114	46	0.65	
6/21/02 0:00	5.4	108	32	0.63	
6/22/02 0:00	5.2	88	109	0.66	
6/24/02 0:00	5.4	73	79	0.75	
7/9/02 0:00	5.4	85	74	0.35	
7/11/02 0:00	5.48	92	91	1.9	
7/12/02 0:00	5.5	79	39	0.49	
7/13/02 0:00	5.4	98	104	0.33	
7/14/02 0:00		103	65	0.37	

9

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

F2 Groundwater



(9)

Well **I1**

Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/02/02	5.81	102	126	0.21	
06/03/02	5.7	146	139	0.29	nd
06/20/02	5.5	141	76	0.25	
06/23/02	5.3	128	81	0.37	
07/13/02	5.4	96	164	0.36	

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

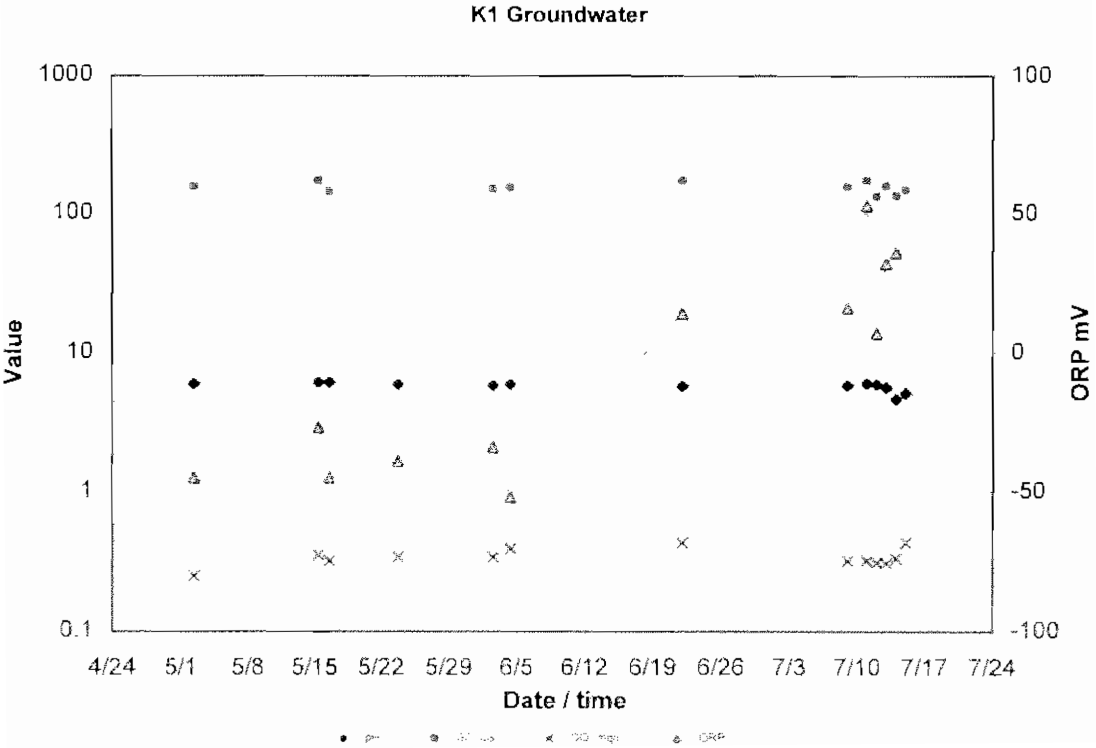
Well **K1**

Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/02/02	5.92	157	-45	0.25	
05/15/02	6.1	174	-27	0.35	
05/16/02	6.1	145	-45	0.32	
05/23/02	5.9		-39	0.34	
06/02/02	5.8	152	-34	0.34	
06/04/02	5.9	155	-52	0.39	70
06/22/02	5.7	174	14	0.43	
07/09/02	5.8	157	16	0.32	
07/11/02	6	175	53	0.32	
07/12/02	5.9	134	7	0.31	
07/13/02	5.6	160	32	0.31	
07/14/02	4.6	135	36	0.33	
07/15/02	5.1	149		0.43	

?

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02



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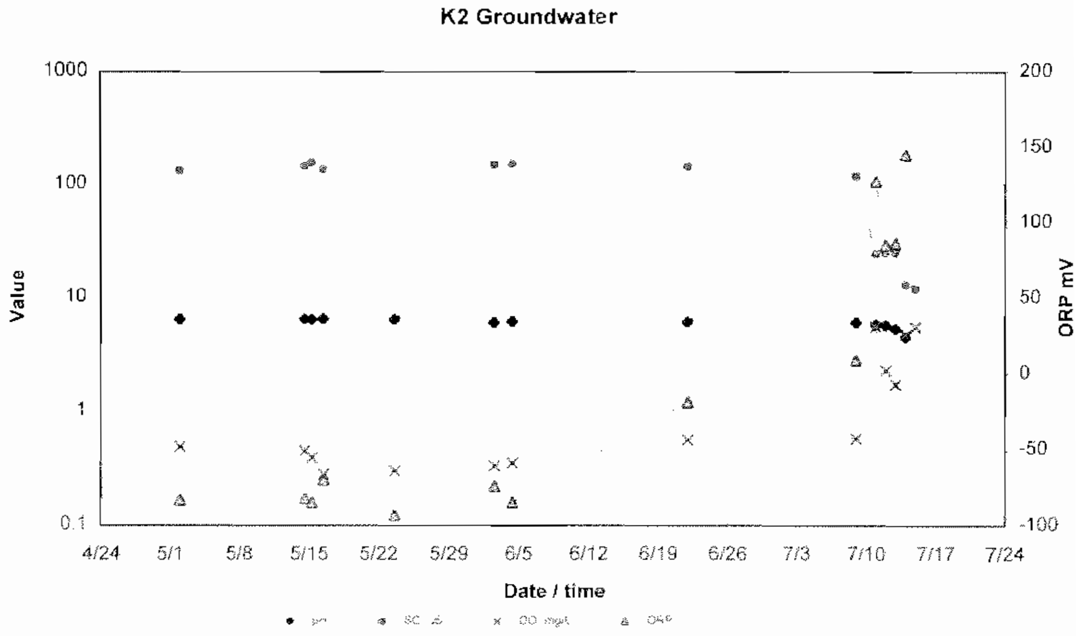
Well Date	**K2** pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/02/02	6.47	133	-83	0.49	
05/14/02	6.5	146	-82	0.45	
05/15/02	6.4	157	-85	0.39	
05/16/02	6.5	136	-70	0.28	
05/23/02	6.4		-93	0.3	
06/02/02	6.1	149	-74	0.33	7.6
06/04/02	6.2	152	-85	0.35	
06/22/02	6.08	143	-19	0.56	
07/09/02	6.1	118	9	0.58	
07/11/02	5.8	24.5	127	5.58	
07/12/02	5.7	25	85	2.3	
07/13/02	5.3	25	86	1.7	
07/14/02	4.5	13	145	4.7	
07/15/02		12		5.5	

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

Pump stuck at top of screen 7/10



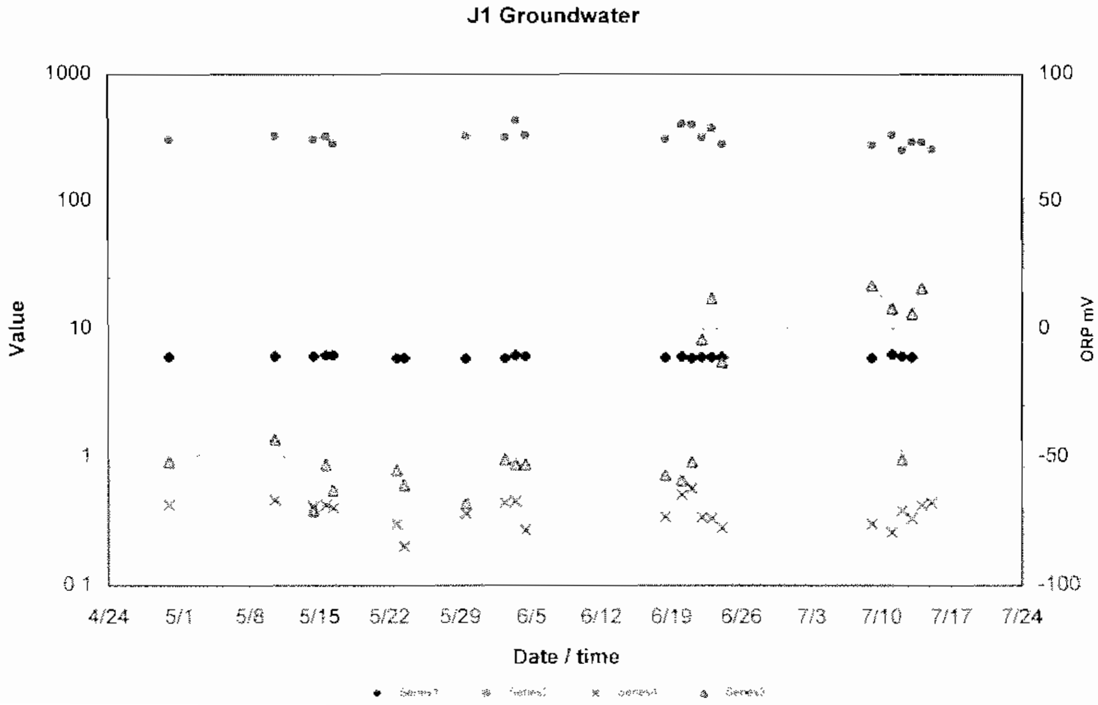
(9)

MW-50J1

Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
04/30/02	6.01	305	-52	0.42	
05/10/02	6.1	326	-43	0.46	
05/14/02	6.1	305	-71	0.41	
05/15/02	6.2	324	-53	0.42	
05/16/02	6.2	285	-63	0.4	
05/22/02	5.9		-55	0.3	
05/23/02	5.9		-61	0.2	
05/29/02	5.79	326	-68	0.36	
06/02/02	5.9	318	-51	0.44	
06/03/02	6.2	434	-53	0.45	102
06/04/02	6.1	329	-53	0.27	
06/18/02	5.96	308	-57	0.34	
06/20/02	6.05	407	-59	0.51	
06/21/02	5.9	401	-52	0.57	
06/22/02	6	317	-4	0.34	
06/23/02	6	379	12	0.33	
06/24/02	6	281	-13	0.28	
07/09/02	5.89	277	17	0.3	
07/11/02	6.3	334	8	0.26	
07/12/02	6.1	252	-51	0.38	
07/13/02	6	293	6	0.33	
07/14/02		293	16	0.42	
07/15/02		257		0.44	

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02



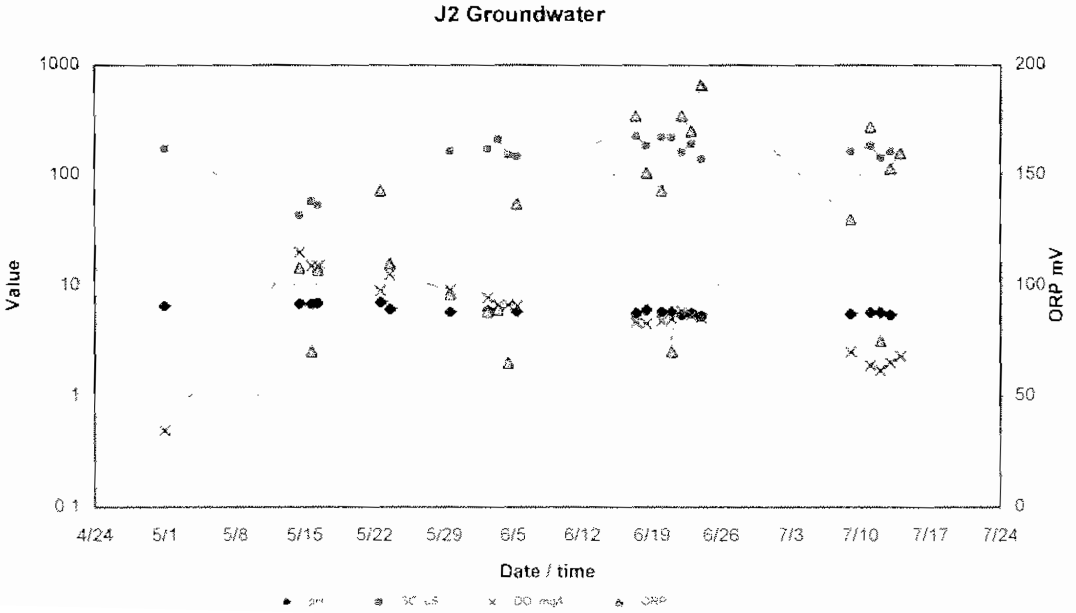
9

MW-50J2

Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/01/02	6.5	175	-79	0.49	
05/14/02	6.8	43	108	20	
05/15/02	6.8	58	70	15	
05/16/02	6.9	53	107	15	
05/22/02	7		143	8.9	
05/23/02	6.1		110	12.5	
05/29/02	5.72	164	96	9.1	
06/02/02	5.9	172	88	7.7	
06/03/02	6	212	89	6.6	nd
06/04/02	5 .9	153	65	6.7	
06/05/02	5.83	148	137	6.54	
06/17/02	5.6	226	177	4.6	
06/18/02	6	187	151	4.5	
06/20/02	5.76	220	143	4.8	
06/21/02	5.7	219	70	5	
06/22/02	5.4	161	177	5.8	
06/23/02	5.6	192	170	5.4	
06/24/02	5.3	139	191	5.1	
07/09/02	5.5	165	130	2.5	
07/11/02	5.7	184	172	1.9	
07/12/02	5.7	144	75	1.7	
07/13/02	5.4	165	153	2	
07/14/02		150	160	2.3	

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02



8

MW-50D1

Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe II mg/L
05/02/02	7.59	224	130	2.98	
06/18/02	8.44	283	66	0.45	
06/20/02	8.4	317	66	1.4	
06/21/02	8.05	300	73	1.28	
06/22/02	7.56	237	51	1.53	
06/23/02	6.4	277	117	4.1	
06/24/02	6.3	205	117	4.1	
06/25/02	6.2	198	150	4.6	
06/26/02	6.3	224	135	4.2	
06/27/02	6.4	198	203	4.5	
07/12/02	7.06	177	34	2.6	
07/15/02		177		4.2	

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

recalib ORP 6/22 -> bump in all wells

MW-50D2

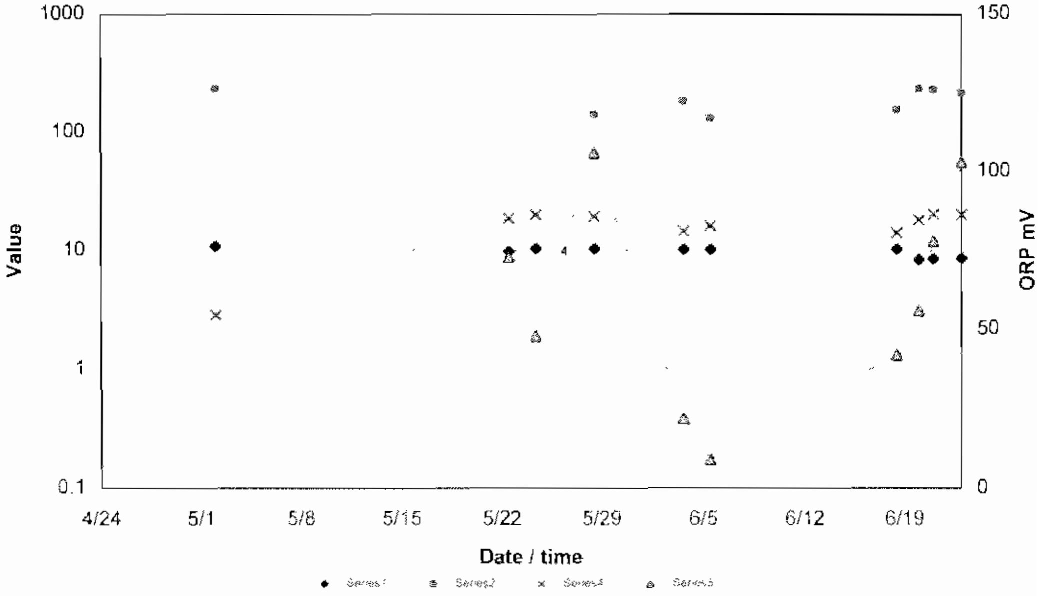
Date	pH	SC uS/cm	ORP mV	DO mg/L	Fe mg/L
05/02/02	10.9	235	-22	2.85	
05/22/02	9.8		73	18.6	
05/24/02	10.4		48	20	
05/28/02	10.3	142	106	19.3	
06/03/02	10.2	184	22	14.5	nd
06/05/02	10.2	132	9	16	
06/18/02	10.2	155	42	14	
06/20/02	8.3	233	56	18	
06/21/02	8.42	229	78	20	
06/23/02	8.6	215	103	20	
07/12/02	8.8	205	88	16.9	
07/15/02		270		20	

9

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

50D2 Groundwater

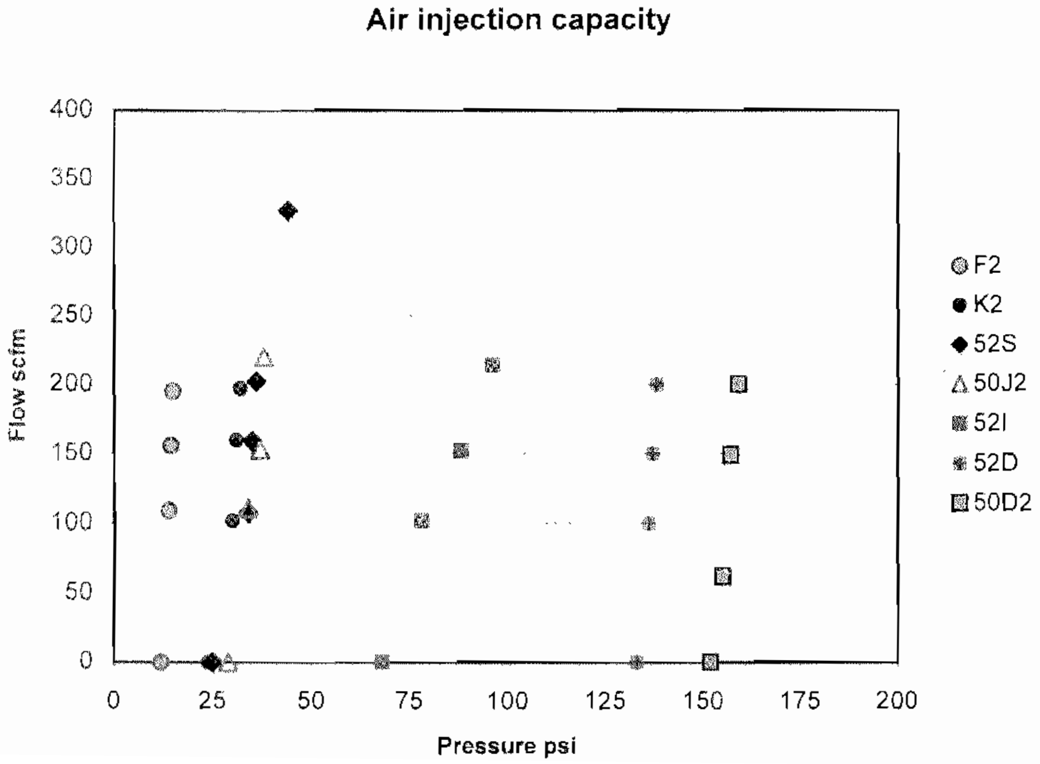


Well	**P1**				
Date	**pH**	**SC**	**ORP**	**DO**	**Fe II**
		uS/cm	**mV**	**mg/L**	**mg/L**
05/01/02	5.83	171	-86	0.25	
06/02/02	5.5	200	-64	0.35	
06/04/02	5.7	211	-66	0.32	12.5
06/21/02	5.7	262	-73	0.43	
06/23/02	5.6	231	2	0.4	
07/11/02	5.8	194	10	0.25	

Spare Event

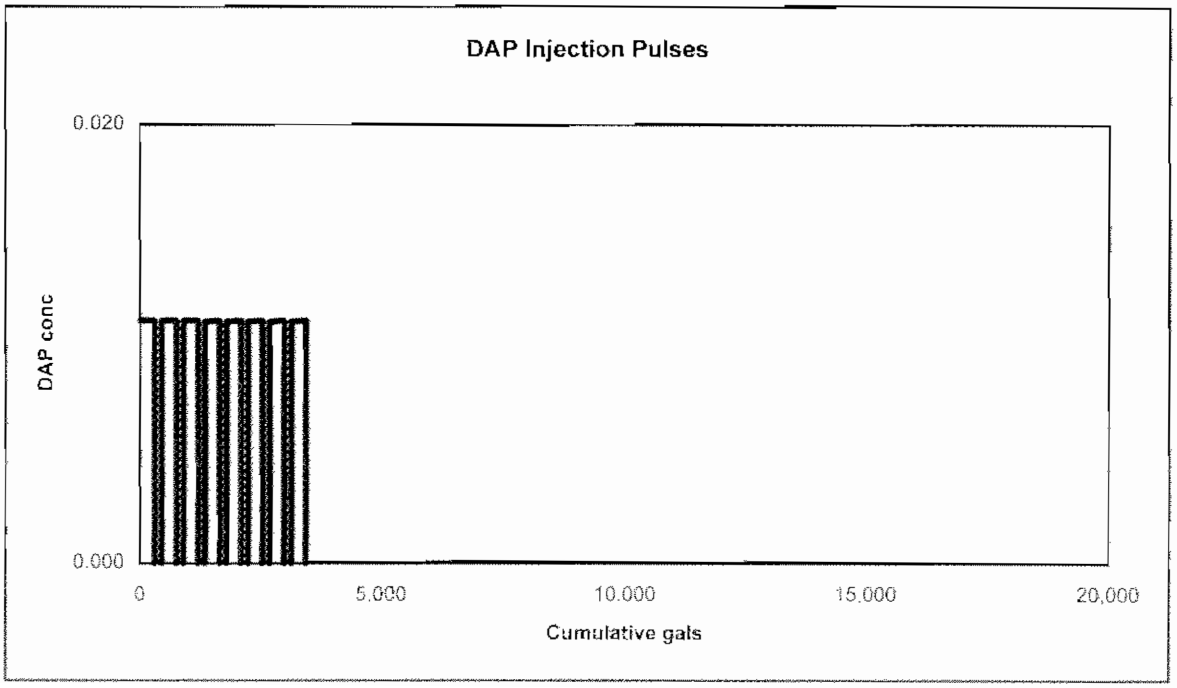
Well	**Date**
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

52S		52I		50J2		50D2		F2		K2		52D	
P	Q	P	Q	P	Q	P	Q	P	Q	P	Q	P	Q
25	0	68	0	29	0	152	0	12	0	24	0	133	0
34	108	78	102	34	111	155	62	14	109	30	102	136	100
35	159	88	152	37	153	157	149	14.5	156	31	160	137	150
36	202	96	214	38	220	159	200	15	195	32	197	138	200
44	327												



DAP injection in 50D2

gal	Σ gal	DAP conc
0	0	0.01
300	300	0.011
	301	0.00
150	450	0.00
	451	0.011
300	750	0.01
	751	0.00
150	900	0.00
	901	0.011
300	1200	0.01
	1201	0.00
150	1350	0.00
	1351	0.01
300	1650	0.01
	1651	0.00
150	1800	0.00
	1801	0.01
300	2100	0.01
	2101	0.00
150	2250	0.00
	2251	0.01
300	2550	0.01
	2551	0.00
150	2700	0.00
	2701	0.01
300	3000	0.01
	3001	0.00
150	3150	0.00
	3151	0.01
300	3450	0.01
	3451	0.00
11550	15000	0.00



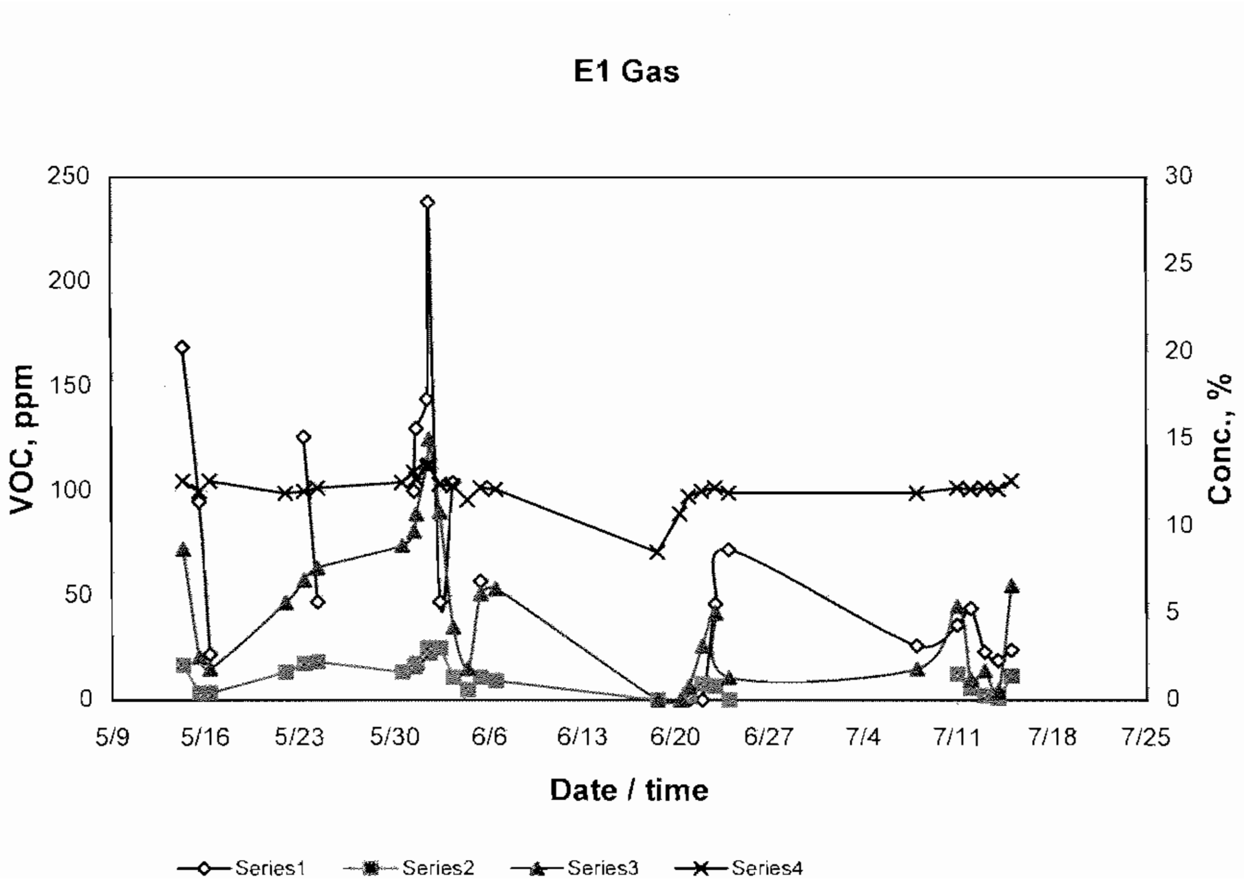
Hooker-Ruco gas data

Well **E1**

Date/time	PID ppm	He %	CH4 %	CO2 %	O2 %
05/07/02		0.4	3.1	10.3	0
05/14/02	169	2	8.7	12.6	0
05/15/02	95	0.4	2.5	12	0
05/16/02	22	0.41	1.8	12.6	0
05/22/02		1.6	5.6	11.9	0
05/23/02	126	2.1	6.9	12	0
05/24/02	47	2.2	7.6	12.2	0
05/30/02		1.6	8.9	12.5	0
05/31/02	100	1.9	9.7	13.1	0
05/31/02	130	2.1	10.7	12.7	0
06/01/02	144	3	13.6	13.4	0
06/01/02	238	2.7	15	13.5	0
06/02/02	47	3	10.8	12.4	0
06/03/02	104	1.3	4.2	12.3	0
06/04/02		0.58	1.8	11.5	0
06/05/02	57	1.3	6.1	12.2	0
06/06/02		1.1	6.4	12.1	0
06/18/02	0	0	0	8.5	3.3
06/20/02			0	10.7	1
06/21/02	0	0.26	0.8	11.7	0
06/22/02	0	0.92	3.1	12	0
06/23/02	46	0.8	5	12.2	0
06/24/02	72	0	1.3	11.9	0
07/08/02	26		1.8	11.9	0
07/11/02	36	1.5	5.4	12.2	0
07/12/02	44	0.69	1.2	12.1	0
07/13/02	23	0.26	1.7	12.2	0.2
07/14/02	19	0.1	0.5	12.1	0.9
07/15/02	24	1.4	6.6	12.6	0

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02



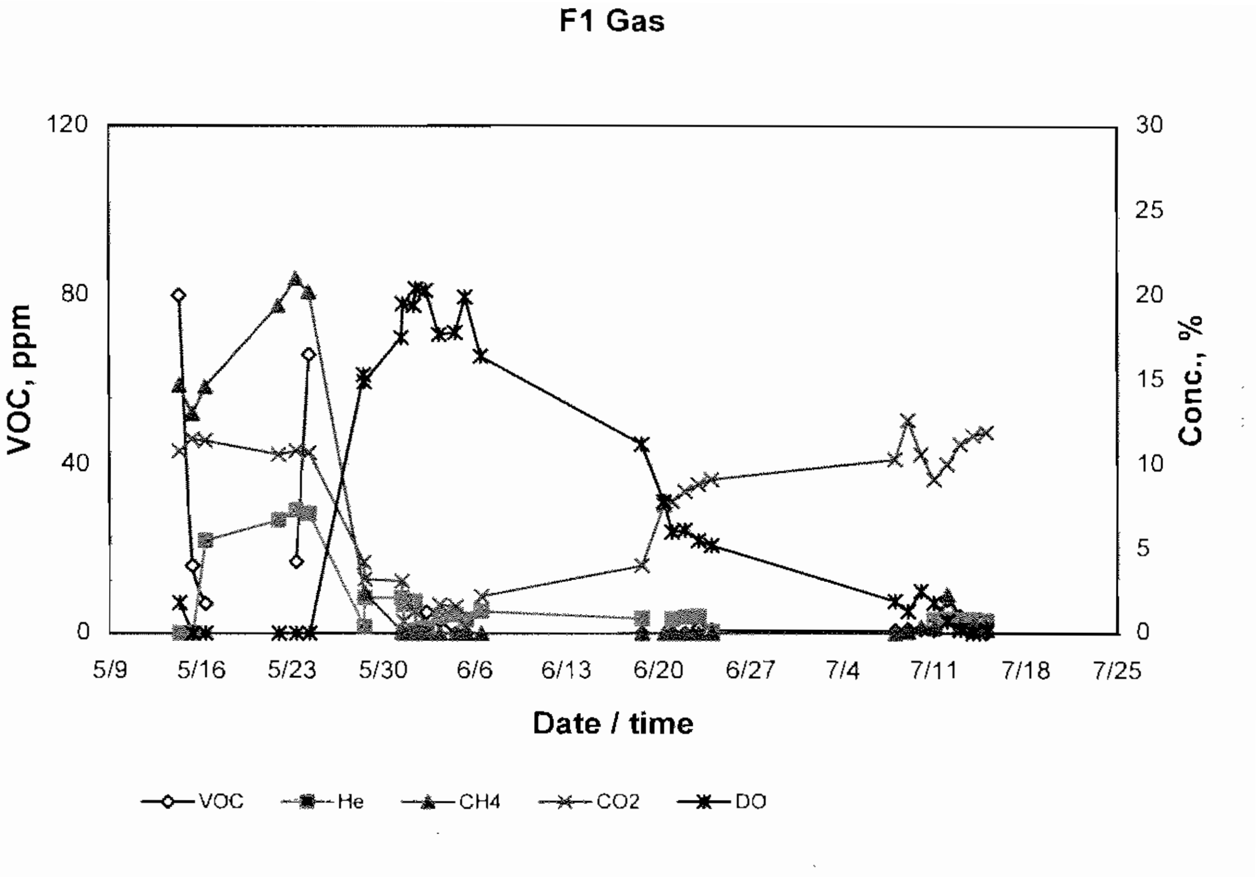
E1 Gas
VOC, ppm
250
200
150
100
50
0
Conc., %
30
25
20
15
10
5
0
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
7/11
7/18
7/25
Date / time
Series1
Series2
Series3
Series4

Well **F1**

Date/time	PID ppm	He %	CH4 %	CO2 %	O2 %
05/02/02		5	20	9.1	0
05/14/02	80	0	14.7	10.8	1.8
05/15/02	16	0	13	11.5	0
05/16/02	7	5.5	14.6	11.4	0
05/22/02		6.7	19.4	10.6	0
05/23/02	17	7.3	21	10.8	0
05/24/02	66	7.1	20.2	10.7	0
05/28/02		0.37	2.4	4.2	15.3
05/28/02		2.1	2.4	3.2	14.9
05/31/02	0	2.1	0.1	3.1	17.5
05/31/02	0	1.7	0	0.7	19.5
06/01/02	0	1.9	0	1.3	19.4
06/01/02	0	0.18	0.1	0	20.4
06/02/02	5	0.29	0	0	20.3
06/03/02	3	1	0	1.7	17.7
06/04/02	0	1.1	0	1.6	17.8
06/05/02	0.1	0.82	0	0.4	19.9
06/06/02		1.3	0	2.2	16.4
06/18/02	0	0.87	0	4	11.2
06/20/02			0	7.6	7.8
06/21/02	0	0.83	0	7.8	6
06/22/02	0	0.97	0	8.4	6.1
06/23/02	1.3	1	0	8.8	5.5
06/24/02	0.8	0.11	0	9.1	5.2
07/08/02	0.7		0	10.3	1.9
07/09/02	1		0.1	12.6	1.3
07/10/02	1		0.4	10.6	2.5
07/11/02	0.8	0.8	0.3	9.1	1.8
07/12/02	8	0.86	2.3	10	0.7
07/13/02	4	0.82	0.5	11.2	0.2
07/14/02	0.3	0.82	0.5	11.7	0
07/15/02	0	0.75	0.4	11.9	0.2

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

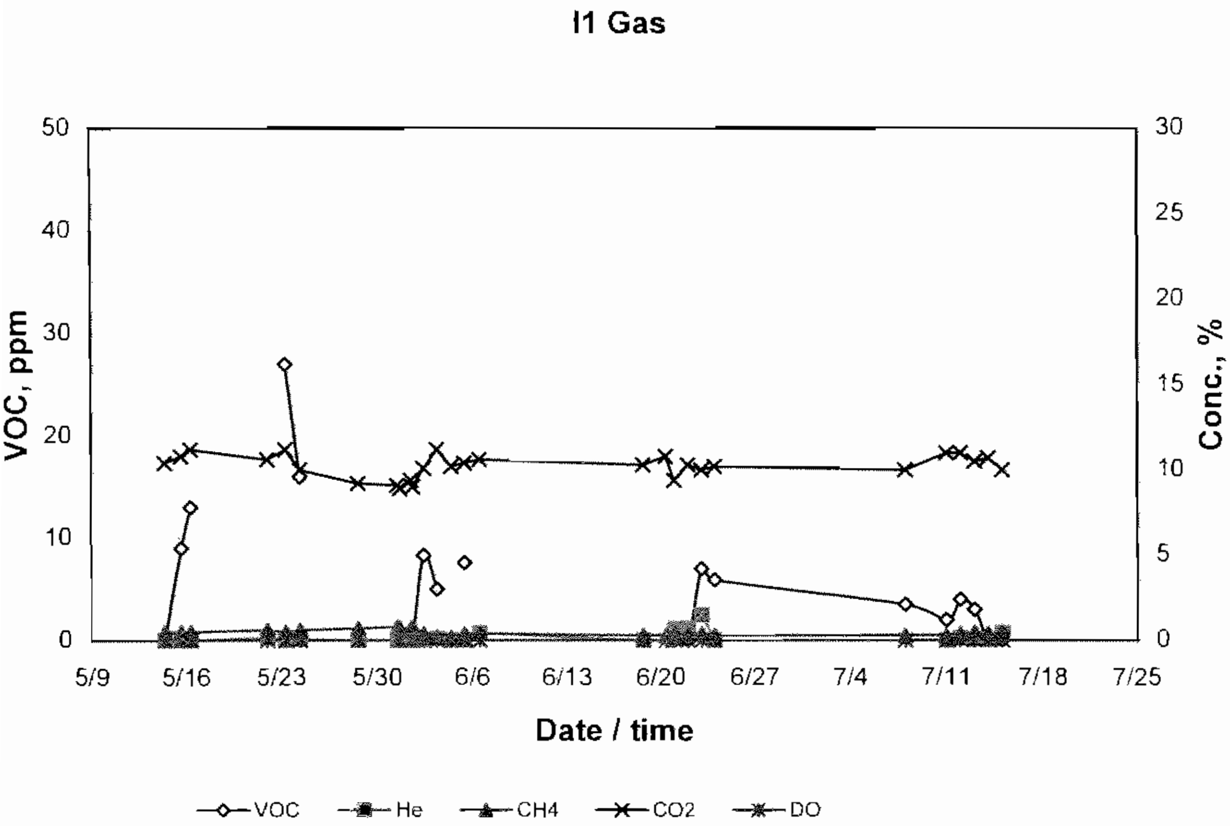

F1 Gas
VOC, ppm
120
80
40
0
Conc., %
30
25
20
15
10
5
0
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
7/11
7/18
7/25
Date / time
VOC
He
CH4
CO2
DO

Well **I1**

Date/time	PID	He	CH4	CO2	O2
	ppm	%	%	%	%
05/02/02		0	0.7	10.3	0
05/14/02	0	0	0.5	10.4	0
05/15/02	9	0	0.5	10.8	0
05/16/02	13	0	0.5	11.2	0
05/22/02		0.16	0.6	10.6	0
05/23/02	27	0	0.5	11.2	0
05/24/02	16	0.05	0.6	10	0
05/28/02		0	0.7	9.2	0
05/31/02	0	0	0.8	9.1	0
05/31/02	0	0	0.7	8.9	0
06/01/02	0	0	0.7	9.4	0
06/01/02	0	0.05	0.8	9	0
06/02/02	8.3	0.03	0.4	10.1	0
06/03/02	5	0.1	0.2	11.2	0
06/04/02		0	0.2	10.2	0
06/05/02	7.6	0	0.4	10.4	0
06/06/02		0.42	0.4	10.6	0
06/18/02	0	0	0.3	10.3	0
06/20/02			0.3	10.8	0
06/21/02	0	0.69	0.4	9.4	0
06/22/02	0	0.71	0.3	10.3	0
06/23/02	7	1.5	0.4	10	0
06/24/02	5.9	0	0.3	10.2	0
07/08/02	3.5		0.3	10	0
07/11/02	2	0	0.3	11	0
07/12/02	4	0.12	0.4	11	0
07/13/02	3	0.05	0.5	10.5	0
07/14/02	0	0.03	0.4	10.7	0
07/15/02	0	0.42	0.5	10	0

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

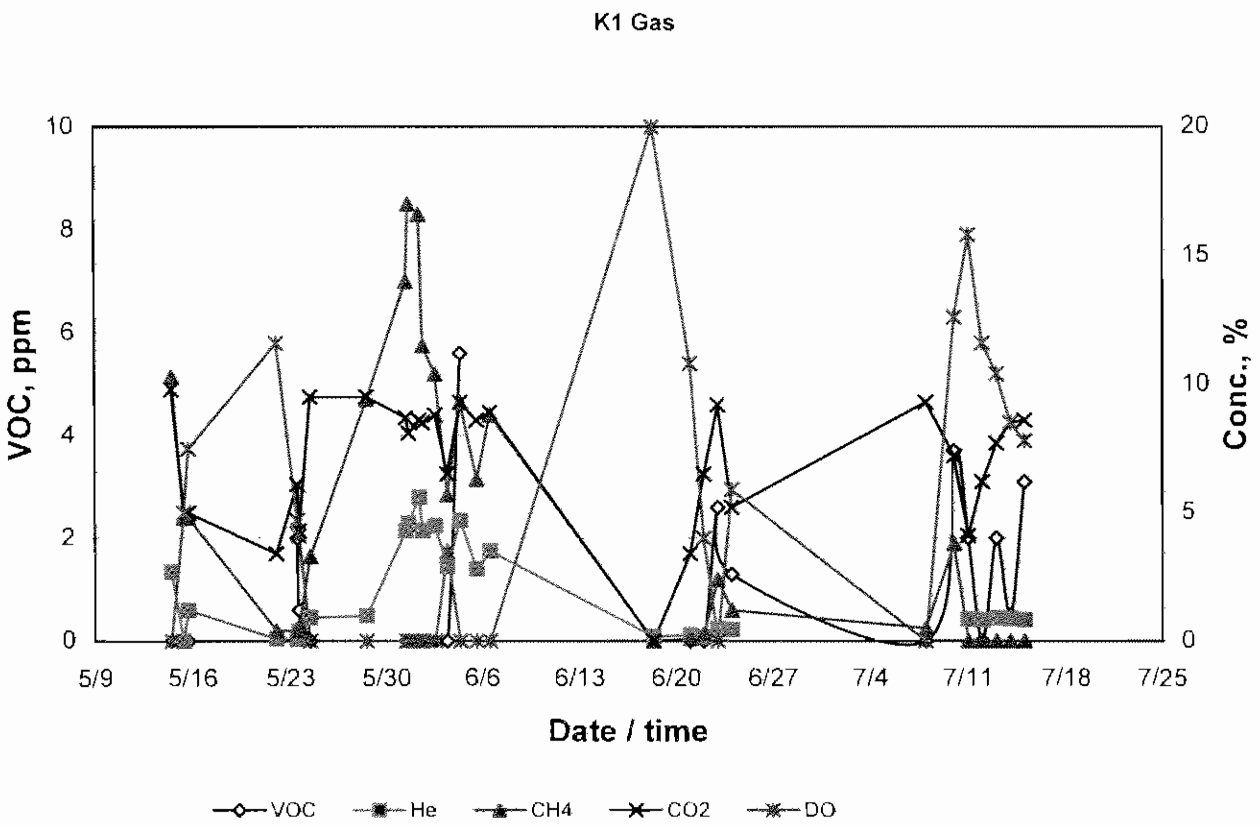

I1 Gas
VOC, ppm
50
40
30
20
10
0
Conc., %
30
25
20
15
10
5
0
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
7/11
7/18
7/25
Date / time
VOC
He
CH4
CO2
DO

Well K1

Date/time	PID	He	CH4	CO2	O2
	ppm	%	%	%	%
05/02/02		0	0.4	0.7	0.7
05/14/02	0	2.7	10.3	9.8	0
05/15/02	0	0	4.8	5	5
05/15/02	0	1.2	4.8	5	7.5
05/22/02		0.08	0.4	3.4	11.6
05/23/02	2	0.06	0.4	6.1	4.7
05/23/02	0.6	0.38	0.6	4.3	4.1
05/24/02	0	0.92	3.3	9.5	0
05/28/02		0.98	9.4	9.5	0
05/31/02	0	4.3	14	8.7	0
05/31/02	0	4.6	17	8.1	0
06/01/02	0	5.6	16.6	8.6	0
06/01/02	0	4.3	11.5	8.5	0
06/02/02	0	4.5	10.4	8.8	0
06/03/02	0	2.9	5.7	6.5	3.5
06/04/02	5.6	4.7	9.3	9.3	0
06/05/02		2.8	6.3	8.6	0
06/06/02		3.5	8.8	8.9	0
06/18/02	0	0.17	0	0	20
06/21/02	0	0.25	0.1	3.4	10.8
06/22/02	0	0.15	0.3	6.5	4
06/23/02	2.6	0.47	2.4	9.2	0
06/24/02	1.3	0.44	1.2	5.2	5.9
07/08/02	0		0.5	9.3	0
07/10/02	3.7		3.8	7.2	12.6
07/11/02	2	0.85	0	4.1	15.8
07/12/02	0	0.82	0	6.2	11.6
07/13/02	2	0.9	0	7.7	10.4
07/14/02	0.5	0.86	0	8.5	8.5
07/15/02	3.1	0.82	0	8.6	7.8

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

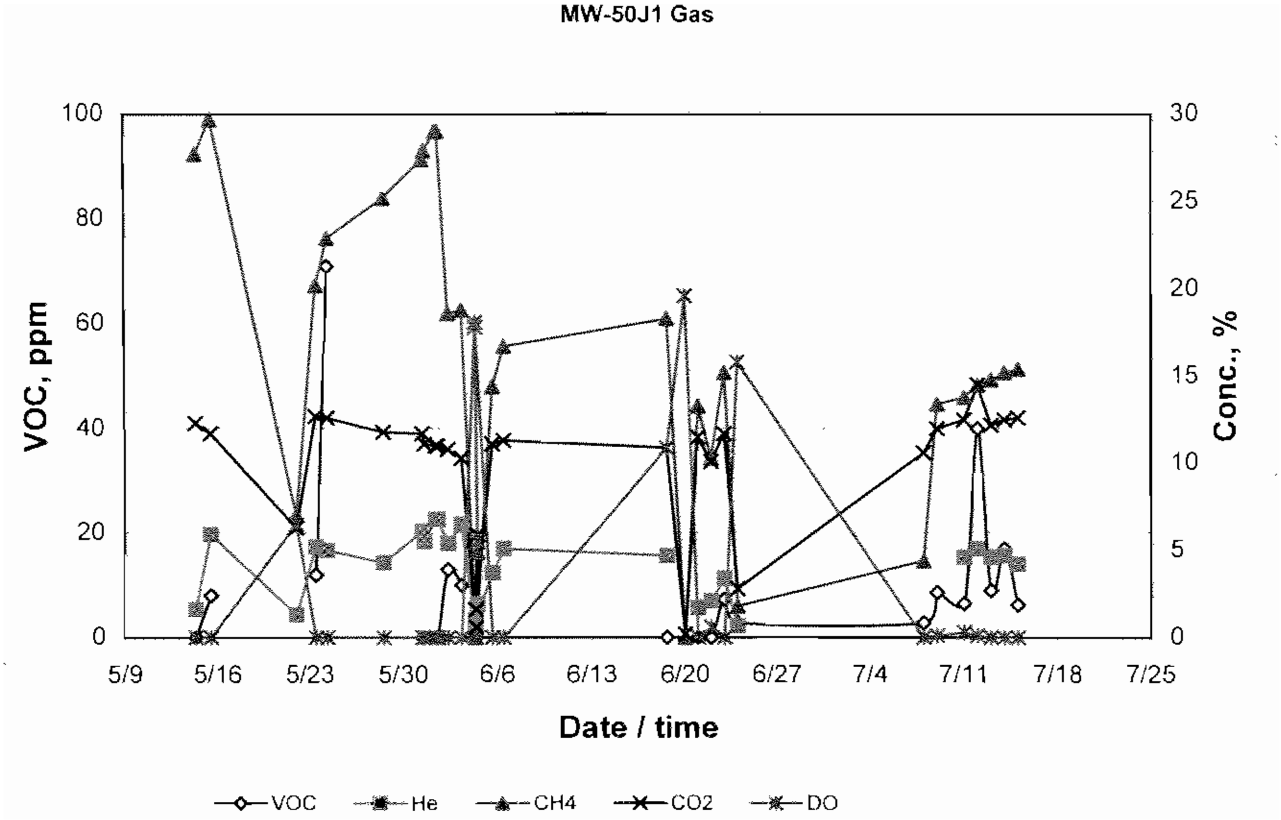

K1 Gas
VOC, ppm
Conc., %
Date / time
10
8
6
4
2
0
20
15
10
5
0
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
7/11
7/18
7/25
VOC
He
CH4
CO2
DO

Well **MW-50J1**

Date/time	PID	He	CH4	CO2	O2
	ppm	%	%	%	%
05/07/02		1	3.6	13	0.3
05/14/02	0	1.6	27.7	12.3	0
05/15/02	8	5.9	29.7	11.7	0
05/22/02		1.3	7	6.3	6.5
05/23/02	12	5.2	20.2	12.7	0
05/24/02	71	5	22.9	12.6	0
05/28/02		4.3	25.2	11.8	0
05/31/02	0	6.1	27.4	11.7	0
05/31/02	0	5.5	27.9	11.1	0
06/01/02	0	6.8	29	11	0
06/01/02	0	6.8	29	11	0
06/02/02	13	5.4	18.6	10.8	0
06/03/02	10	6.5	18.8	10.3	0
06/04/02		0.59	0.3	0.6	18.1
06/04/02		1.9	4.9	5.9	5.5
06/04/02	0	1.1	0	1.6	17.8
06/05/02		3.7	14.4	11.1	0
06/06/02		5.1	16.7	11.3	0
06/18/02	0	4.7	18.3	10.9	10.9
06/20/02			0	0.2	19.6
06/21/02	0	1.7	13.3	11.5	0
06/22/02	0	2.1	10.3	10.1	0.6
06/23/02	7.3	3.4	15.2	11.7	0
06/24/02	2.8	0.66	1.8	2.8	15.8
07/08/02	2.8		4.4	10.6	0
07/09/02	8.6		13.4	12	0.1
07/11/02	6.5	4.6	13.8	12.5	0.3
07/12/02	40	5.1	14.5	14.5	0.1
07/13/02	9	4.6	14.8	12.2	0
07/14/02	17	4.7	15.2	12.5	0
07/15/02	6.2	4.2	15.4	12.6	0

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

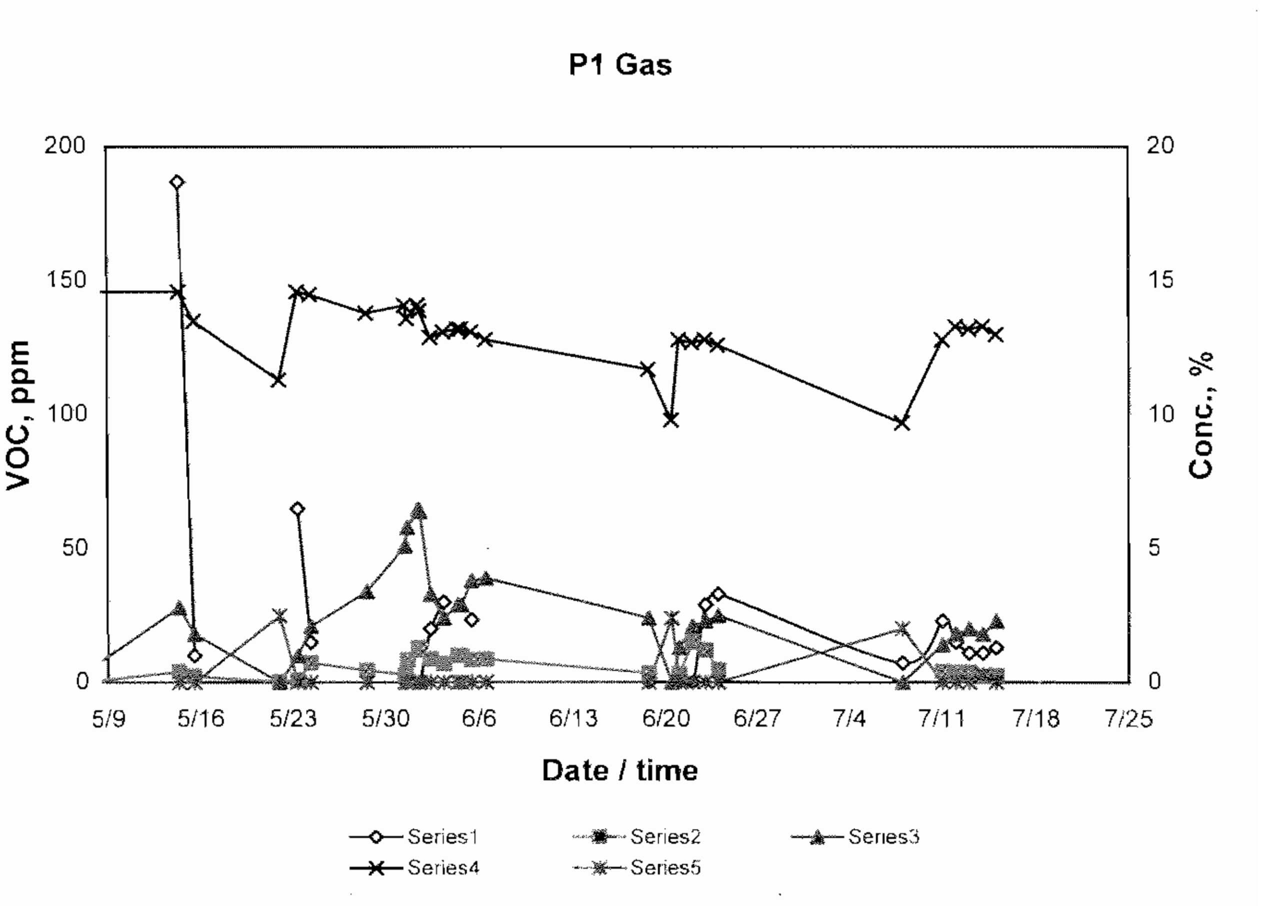

MW-50J1 Gas
VOC, ppm
100
80
60
40
20
0
Conc., %
30
25
20
15
10
5
0
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
7/11
7/18
7/25
Date / time
VOC
He
CH4
CO2
DO

Well **P1**

Date/time	PID ppm	He %	CH4 %	CO2 %	O2 %
05/07/02		0	0.3	14.6	0
05/14/02	187	0.4	2.8	14.6	0
05/15/02	10	0.22	1.8	13.5	0
05/22/02		0.02	0	11.3	2.5
05/23/02	65	0.08	1	14.6	0
05/24/02	15	0.73	2.1	14.5	0
05/28/02		0.45	3.4	13.8	0
05/31/02	0	0.3	5.1	14.1	0
05/31/02	0	0.84	5.8	13.6	0
06/01/02	0	1.3	6.5	14.1	0
06/01/02	0	1.2	6.4	13.9	0
06/02/02	20	0.87	3.3	12.9	0
06/03/02	30	0.7	2.4	13.1	0
06/04/02		1	2.9	13.2	0
06/04/02		1	2.9	13.2	0
06/05/02	23.3	0.83	3.8	13.1	0
06/06/02		0.86	3.9	12.8	0
06/18/02	0	0.34	2.4	11.7	0
06/20/02			0	9.8	2.4
06/21/02	0	0.3	1.3	12.8	0
06/22/02	0	1.5	2.1	12.7	0
06/23/02	29	1.2	2.3	12.8	0
06/24/02	33	0.46	2.5	12.6	0
07/08/02	7.2		0	9.7	2
07/11/02	23	0.4	1.4	12.8	0
07/12/02	15	0.36	1.8	13.3	0
07/13/02	11	0.38	2	13.2	0
07/14/02	11	0.21	1.8	13.3	0.3
07/15/02	13	0.25	2.3	13	0

Spare Event

Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02

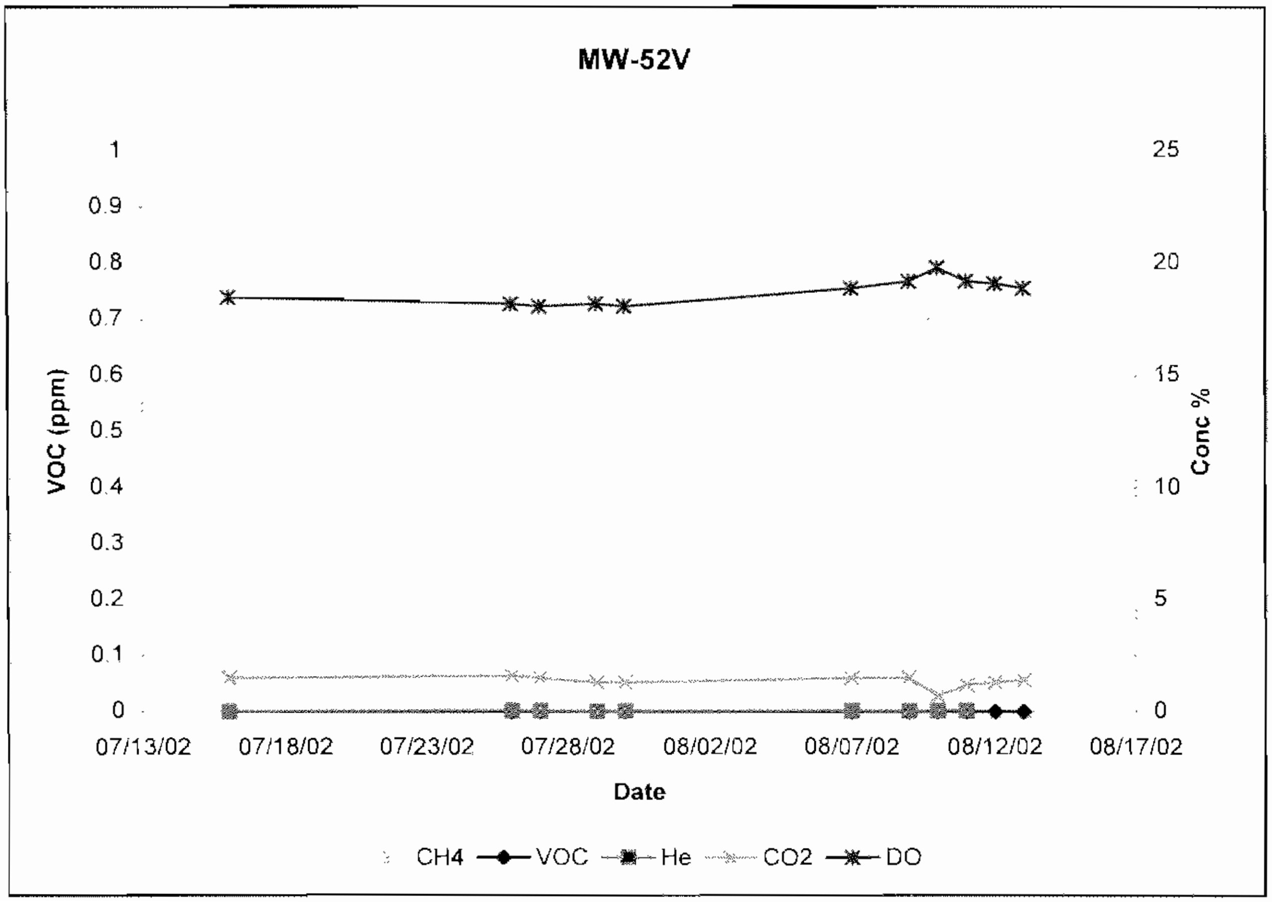

P1 Gas
VOC, ppm
200
150
100
50
0
Conc., %
20
15
10
5
0
5/9
5/16
5/23
5/30
6/6
6/13
6/20
6/27
7/4
7/11
7/18
7/25
Date / time
Series1
Series2
Series3
Series4
Series5

Well MW-52V

Date/time	PID	He	CH4	CO2	O2
	ppm	%	%	%	%
07/16/02	0	0	0	1.5	18.5
07/26/02	0	0.06	0	1.6	18.2
07/27/02	0	0.04	0	1.5	18.1
07/29/02	0	0.02	0	1.3	18.2
07/30/02	0	0.03	0	1.3	18.1
08/07/02	0	0.04	0	1.5	18.9
08/09/02	0	0.03	0	1.5	19.2
08/10/02	0	0.04	0	0.7	19.8
08/11/02	0	0.04	0	1.2	19.2
08/12/02	0		0	1.3	19.1
08/13/02	0		0	1.4	18.9

Spare Event

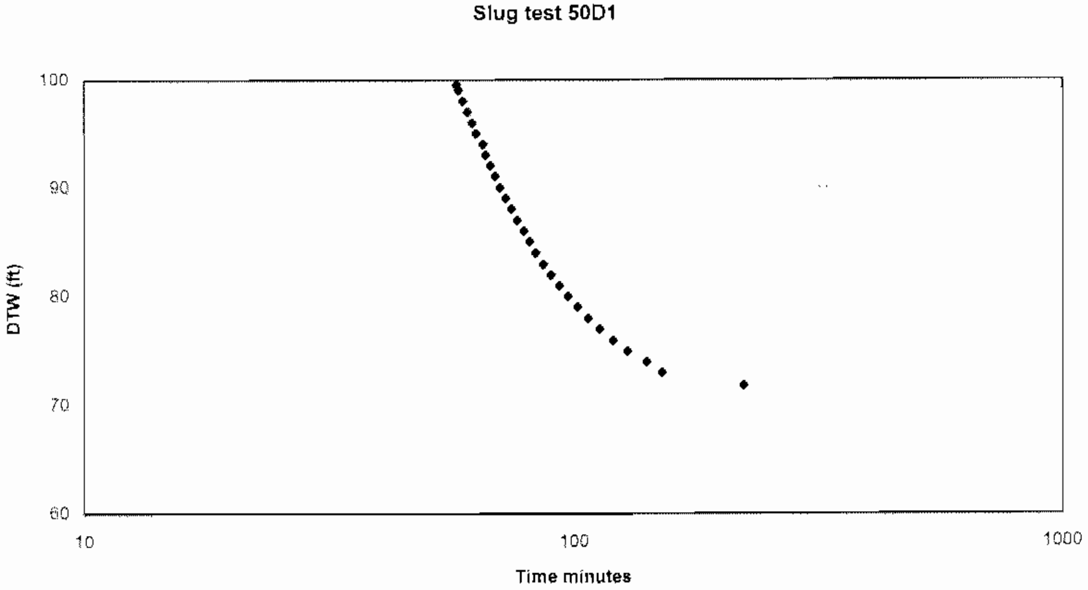
Well	Date
MW - 50J2	05/09/02
MW - 50J2	05/10/02
MW - 50J2	05/13/02
MW-50D2	05/21/02
MW-50D2	06/19/02
F2	05/30/02
F2	05/31/02
F2	06/01/02
K2	07/10/02


MW-52V
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
VOC (ppm)
25
20
15
10
5
0
Conc %
07/13/02
07/18/02
07/23/02
07/28/02
08/02/02
08/07/02
08/12/02
08/17/02
Date
CH4
VOC
He
CO2
DO

Time	min	DTW ft
0 00 00	0 0	
0 54 00	54 0	101 0
0 56 00	56 0	100 5
0 57 24	57 4	99 5
0 57 58	58 0	99 0
0 59 10	59 2	98 0
1 00 27	60 5	97 0
1 01 52	61 9	96 0
1 02 57	63 0	95 0
1 05 04	65 1	94 0
1 05 44	65 7	93
1 07 17	67 3	92
1 08 52	68 9	91
1 10 30	70 5	90
1 12 19	72 3	89
1 14 10	74 2	88
1 16 18	76 3	87
1 18 38	78 6	86
1 20 54	80 9	85
1 23 36	83 6	84
1 26 29	86 5	83
1 29 36	89 6	82
1 33 14	93 2	81
1 37 09	97 2	80
1 41 39	101 7	79
1 46 42	106 7	78
1 52 34	112 6	77
1 59 49	119 8	76
2 08 24	128 4	75
2 20 36	140 6	74
2 31 14	151 2	73
3 42 14	222 2	71 82

Slug test 50D1

Well 2" ID with screen 285-305 ft bgs
Stickup 6 0 ft ags
DTW baseline = 69.91 ft
Pressurized to 100 psi for 30 minutes pressure let off 09.05= 0 00 00
Tape length = 100 ft



Time	min	DTW ft
0 00 00		
0 04 30	4 5	101 0
0 04 50	4 8	94 1
0 05 15	5 3	91 5
0 06 20	6 3	85 3
0 06 40	6 7	84 0
0 07 00	7 0	83 0
0 07 23	7 4	81 0
0 07 40	7 7	80 0
0 07 50	7 8	79 0
0 08 18	8 3	78 0
0 08 45	8 8	77 0
0 09 10	9 2	76 0
0 09 55	9 9	75 0
0 10 30	10 5	74 0
0 11 30	11 5	73 0
0 13 00	13 0	72 2
0 13 18	13 3	72 0
0 13 40	13 7	71 8
0 14 15	14 3	71 6
0 14 36	14 6	71 5
0 15 40	15 7	71 2
0 16 30	16 5	71 0
0 17 05	17 1	70 9
0 21 22	21 4	70 5
0 24 00	24 0	70 4

Slug test 50D2

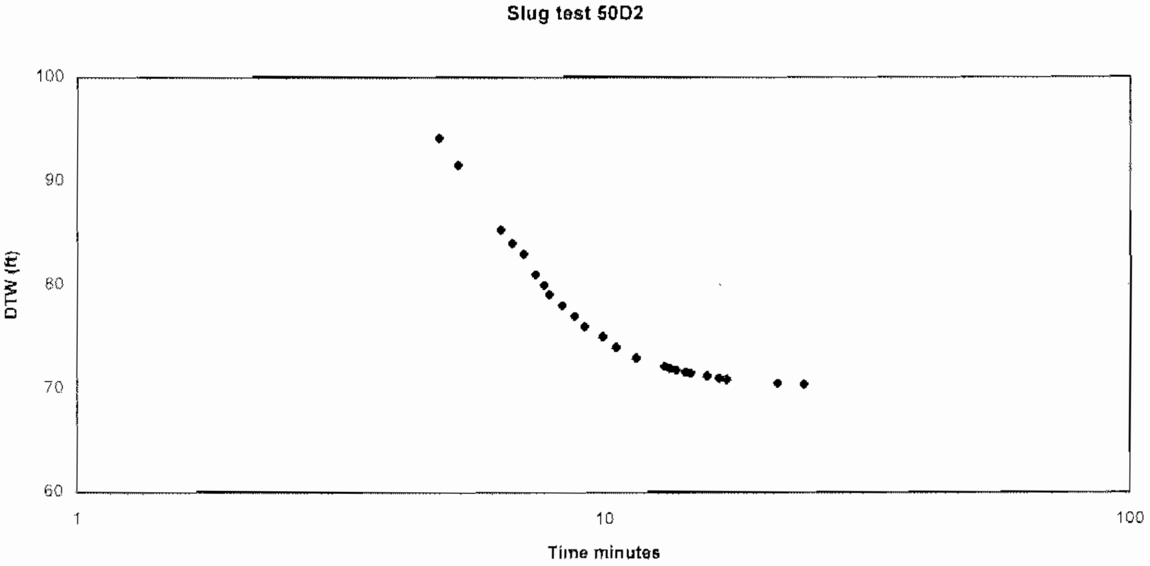
Well 2" ID with screen 415-435 ft bgs

Stickup not measured, you can use difference between 50D1 and D2 to derive, assuming same pot Elevn

DTW baseline = 70 31

Pressurized to 50 psi for 30 minutes pressure let off 1400 = 0:00:00

Tape length = 100 ft



prelim	P	Q
	135	0
	136	100
	137	150
	138	200
	138	100
	150	150
	173	150
	185	205
	153	115
	154	171
	153	300

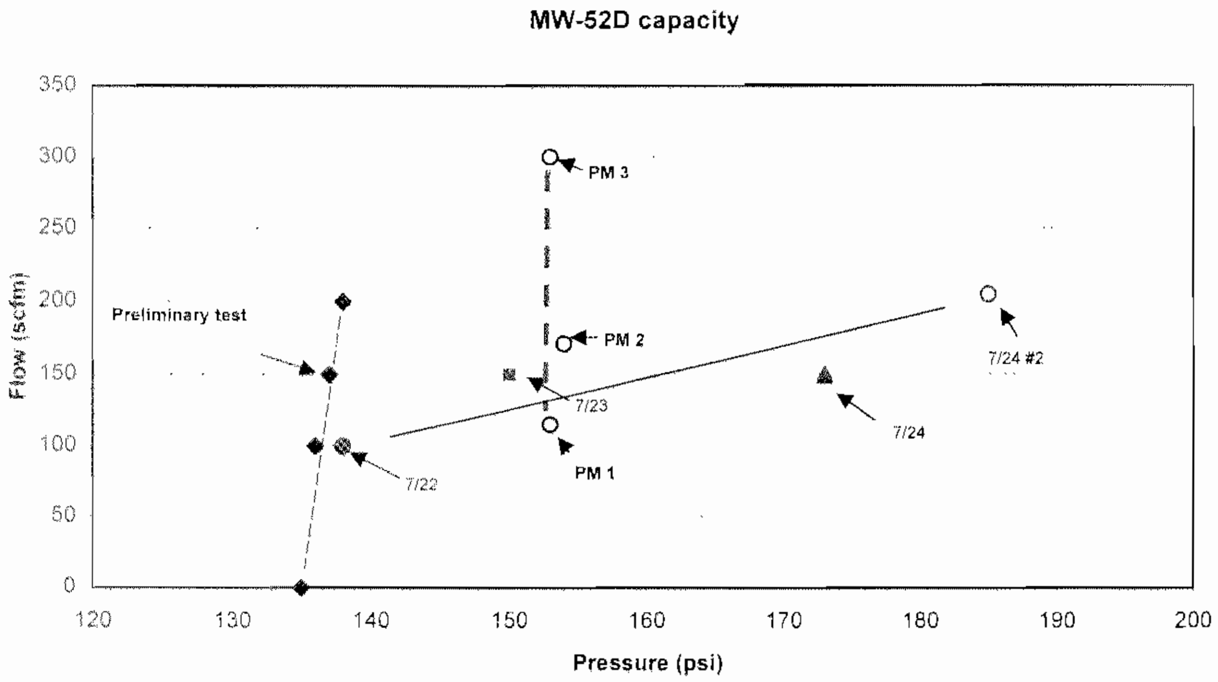


TABLE D.1

GROUNDWATER HELIUM CONCENTRATIONS (µg/L)
OU-3 BIOSPARGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

Sample Well	*Injection Well*	*Sample Date*					
		4/15/02 (Pre-Injection)	*4/18/02 (Post-Injection)*	*4/22/02 (Pre-Injection)*	*4/26/02 (Post-Injection)*	*4/30 to 5/03/02 (Pre-Injection)*	*5/14/02 (Post-Injection)*
MW-52S	MW-52S	ND 1.2	2.3				
	MW-52I			44	6.5		
	MW-52D						
MW-52I	MW-52S	ND 1.2	ND 1.2				
	MW-52I			140	5.0		
	MW-52D						
MW-50J1	MW-50J2					8.4	4.4
MW-50J2	MW-50J2					1.4	ND 1.2
MW-50D1	MW-50D2					ND 1.2	
MW-50D2	MW-50D2					ND 1.2	
E1						ND 1.2	
F1	F2					4.8	
F2	F2					13	
K1						1.6	
K2						1.4	
I1						ND 1.2	
P1						1.9	
MW-52D	MW-52D						
MW-52V	MW-52D						

TABLE D.1

GROUNDWATER HELIUM CONCENTRATIONS (μg/L)
OU-3 BIOSPARGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

Sample Well	*Injection Well*	*Sample Date* *5/30/02 (Pre-Injection)*	*6/2/02 (Post-Injection)*	*6/20/02 (Post-Injection)*	*7/11/02 (Post-Injection)*	*7/16/02 (Pre-Injection)*	*7/26/02 (Post-Injection)*	*8/9/02 (Post-Injection)*
MW-52S	MW-52S MW-52I MW-52D					ND0.60	0.79	ND0.60
MW-52I	MW-52S MW-52I MW-52D					0.64/ND0.60	ND0.60	ND0.60
MW-50J1	MW-50J2							
MW-50J2	MW-50J2							
MW-50D1	MW-50D2			ND 1.2				
MW-50D2	MW-50D2			ND 1.2				
E1								
F1	F2	2.3	ND 1.2					
F2	F2	1.3	ND 1.2					
K1					1.4			
K2					0.65			
I1								
P1								
MW-52D	MW-52D					ND0.60	ND0.60	ND0.60/ND0.60
MW-52V	MW-52D					ND0.60	0.65	ND0.60

TABLE D.2

DISSOLVED GASES PRELIMINARY ANALYTICAL RESULTS
OU-3 BIOSPARGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

Well	*Date*	*Compound*						
		Ethane (ng/L)	*Ethene (ng/L)*	*Iso-Butane (ng/L)*	*Methane (µg/L)*	*N-Butane (ng/L)*	*Propane (ng/L)*	*Propene (ng/L)*
MW-52V (1)	07/16/02 (2)	16	5.7	ND25	0.33	ND25	ND25	ND25
	08/01/02 (3)	43	34	73	0.13	140	69	80
	08/12/02 (4)	17	170	ND25	0.32	ND25	ND25	ND25
MW-52S	07/16/02 (2)	280	15000	52	20	38	ND25	ND25
	08/01/02 (3)	320	79000	ND25	31	ND25	180	34
	08/12/02 (4)	370	120000	ND25	42	ND25	ND25	ND25
MW-52I	07/16/02 (2)	8.9	420	43	1.3	ND25	ND25	ND25
	08/01/02 (3)	ND5	360	ND25	1.3	ND25	130	ND25
	08/12/02 (4)	19	540	ND25	1.7	ND25	ND25	ND25
MW-52D	07/16/02 (2)	15/13	18/25	31/ND25	0.20/0.37	68/ND25	ND25/ND25	ND25/ND25
	08/01/02 (3)	610/560	230/200	230/210	0.12/0.12	ND25/ND25	180000/160000	35000/32000
	08/12/02 (4)	46/37	480/520	ND25/ND25	0.60/0.72	ND25/ND25	3300/3800	470/410

Notes:

(1) MW-52V is a water table well located approximately 56 feet southwest of MW-52I.
(2) Pre-Injection of MW-52D propane testing.
(3) Post-Injection of MW-52D propane testing.
(4) Post-Injection of MW-52D molasses testing.

TABLE D.3

MICROBIAL POPULATION COUNTS
PREDESIGN INJECTION TESTING
HICKSVILLE, NEW YORK

MW-50D2 INJECTION TESTING

	Sample Date			*Sample Date*			*Sample Date*	
	6/18/02			*6/24/02*			*6/18/02*	
Well	*(Pre-Injection) Aerobic Microbial Population (CFUs/mL)*	*ORP (mV)*	*DO (mg/L)*	*(Post-Injection) Aerobic Microbial Population (CFUs/mL)*	*ORP (mV)*	*DO (mg/L)*	*(Pre-Injection) Anaerobic Microbial Population (CFUs/mL)*	*(Pre-Injection) Anaerobic vs Total Population (Percent)*
MW-50J1	$1.1 \times 10^{3}/1.3 \times 10^{3}$	-73	0.30	$3.4 \times 10^{4}/2.9 \times 10^{4}$	-13	0.28	$4.0 \times 10^{2}/4.8 \times 10^{2}$	36.7
MW-50J2	$1.2 \times 10^{3}/1.1 \times 10^{3}$	151	4.51 (1)	$2.9 \times 10^{4}/3.6 \times 10^{4}$	191	5.11	$5.2 \times 10^{2}/5.2 \times 10^{2}$	31.1
MW-50D1	$1.3 \times 10^{4}/1.2 \times 10^{4}$	69	0.45	$1.8 \times 10^{4}/1.3 \times 10^{4}$	117	4.11	$4.4 \times 10^{2}/6.0 \times 10^{2}$	4
MW-50D2	$1.5 \times 10^{4}/1.6 \times 10^{4}$	42	14.3 (2)	$3.4 \times 10^{4}/3.6 \times 10^{4}$	128	>20	$8.0 \times 10^{2}/6.4 \times 10^{2}$	4.4
F1	$6.0 \times 10^{2}/8.0 \times 10^{2}$	-1	0.24	$2.8 \times 10^{4}/2.9 \times 10^{4}$	87	0.33	$6.0 \times 10^{2}/8.4 \times 10^{2}$	51
F2	$1.8 \times 10^{3}/2.2 \times 10^{3}$	14	0.32	$2.9 \times 10^{4}/2.7 \times 10^{4}$	79	0.75	$7.2 \times 10^{2}/5.6 \times 10^{2}$	24.6

MW-52D INJECTION TESTING

	Sample Date			*Sample Date*			*Sample Date*			*Sample Date*	
	7/16/02			*7/29/02*			*8/12/02*			*7/16/02*	
Well	*(Pre-Injection) Aerobic Microbial Population (CFUs/mL)*	*ORP (mV)*	*DO (mg/L)*	*(Post-Injection) Aerobic Microbial Population (CFUs/mL)*	*ORP (mV)*	*DO (mg/L)*	*(Post-Injection) Aerobic Microbial Population (CFUs/mL)*	*ORP (mV)*	*DO (mg/L)*	*(Pre-Injection) Anaerobic Microbial Population (CFUs/ml)*	*(Pre-Injection) Anaerobic vs Total Population (Percent)*
MW-52V	$3.5 \times 10^{3}/4.6 \times 10^{3}$	179	5.95	$1.2 \times 10^{4}/1.1 \times 10^{4}$	184	6.2	$2.4 \times 10^{3}/2.1 \times 10^{3}$	132	6.80	$8.4 \times 10^{2}/8.4 \times 10^{2}$	17
MW-52S (3)	$7.8 \times 10^{3}/8.0 \times 10^{3}$	138	2.94	$1.5 \times 10^{3}/1.8 \times 10^{3}$	171	2.08	$1.7 \times 10^{3}/1.5 \times 10^{3}$	119	2.03	$6.8 \times 10^{2}/7.6 \times 10^{2}$	8.3
MW-52I (4)	$6.4 \times 10^{3}/7.5 \times 10^{3}$	180	17	$2.2 \times 10^{3}/1.6 \times 10^{3}$	212	18	$1.9 \times 10^{4}/2.0 \times 10^{4}$	187	19.7	$8.4 \times 10^{2}/8.8 \times 10^{2}$	11
MW-52D	$7.0 \times 10^{3}/7.0 \times 10^{3}$ $8.8 \times 10^{3}/8.2 \times 10^{3}$	205	2.73	$9.8 \times 10^{3}/9.9 \times 10^{3}$ $7.0 \times 10^{3}/5.9 \times 10^{3}$	197	19.2	$2.1 \times 10^{4}/1.9 \times 10^{4}$ $1.7 \times 10^{4}/1.5 \times 10^{4}$	239	7.68	$5.6 \times 10^{2}/7.6 \times 10^{2}$	8.9

Notes:

CFUs	-	Colony Forming Units
(1)	-	Residual of injection in well MW-50J2 on May 28, 2002
(2)	-	Residual of trial injection in well MW-50D2 on May 30, 2002
(3)	-	Injection testing of well MW-52S was performed on April 16 to 18, 2002
(4)	-	Injection testing of well MW-52I was performed on April 23 to 25, 2002

TABLE D.4

MW-52V RESULTS FOR MW-52D INJECTION TESTING
OU-3 BIOSPRAGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

Date	*Depth to Water (ft)*	*Parameter*									
		pH	*Cond (uS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Pressure (in. H_2O)*	*Vapor O_2 (%)*	*Vapor (CO_2) (%)*	*Vapor He (%)*	*Vapor CH_4 (%)*	*Vapor TOC (ppm)*
07/16/02	61.05	6.11	101	179	5.95		18.5	1.5	0.0	0.0	0
07/23/02 (1)	61.23					0					
07/24/02 (2)	61.25					0					
07/25/02 (3)	61.26					0					
07/26/02	61.28	6.18	140	170	7.05		18.2	1.6	0.06	0.0	0
07/27/02	61.32	6.34	108	171	6.48		18.1	1.5	0.04	0.0	0
07/28/02	61.365	6.27	96	188	6.06						
07/29/02	61.35	6.15	95.2	184	6.20		18.2	1.3	0.02	0.0	0
07/30/02	61.39	6.23	94.4	175	6.46		18.1	1.3	0.03	0.0	0
08/07/02	61.59	6.21	91.6	186	6.25		18.9	1.5	0.04	0.0	0.0
08/08/02 (4)	61.61					0					
08/09/02	61.64	6.25	108	166	6.31		19.2	1.5	0.03	0.0	0.0
08/10/02	61.65	6.28	92.5	170	6.63		19.8	0.7	0.04	0.0	0.0
08/11/02	61.66	6.33	93.1	177	6.63		19.2	1.2	0.04	0.0	0.0
08/12/02	61.66	6.05	99.5	132	6.80		19.1	1.3	NM	0.0	0.0
08/13/02	61.75	5.91	100	171	6.85		18.9	1.4	NM	0.0	0.0

Notes:

(1)	100 scfm injecting testing.
(2)	150 scfm injecting testing.
(3)	200 scfm injecting testing.
(4)	150 and 200 scfm injection testing for 1 hour each. Approximately 300 scfm for 6± hours thereafter.
NM	Not Monitored.

TABLE D.5

MW-52S RESULTS FOR MW-52D INJECTION TESTING
OU-3 BIOSPARGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

Date	*Depth to Water (ft)*	*Parameter* *pH*	*Cond (uS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Pressure (in. H_2O)*
07/16/02	62.11	6.05	101	138	2.94	
07/23/02 (1)	62.17					0
07/24/02 (2)	62.17					0
07/25/02 (3)	62.18					0
07/26/02	62.20	6.11	142	158	2.53	
07/27/02	62.25	6.20	109	167	2.56	
07/28/02	62.20	6.15	98.5	176	2.48	
07/29/02	62.30	6.11	97.2	171	2.08	
07/30/02	62.35	6.13	96.3	183	2.29	
08/07/02	62.68	6.31	94.3	133	170	
08/08/02 (4)	62.52					0
08/09/02	62.57	6.26	110	161	1.74	
08/10/02	62.59	6.24	93.8	161	2.11	
08/11/02	62.63	6.38	94.2	134	2.20	
08/12/02	62.67	6.27	99.0	119	2.03	
08/13/02	62.70	5.89	99.2	150	1.92	

Notes:

(1) 100 scfm injecting testing.
(2) 150 scfm injecting testing.
(3) 200 scfm injecting testing.
(4) 150 and 200 scfm injection testing for 1 hour each. Approximately 300 scfm for 6± hours thereafter.

TABLE D.6

MW-52I RESULTS FOR MW-52D INJECTION TESTING
OU-3 BIOSPARGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

		Parameter				
Date	*Depth to Water (ft)*	*pH*	*Cond (uS/cm)*	*ORP (mV)*	*DO (mg/L)*	*Pressure (in. H_2O)*
07/16/02	61.75	5.91	88.1	180	17	
07/23/02 (1)	61.83					0
07/24/02 (2)	61.84					0
07/25/02 (3)	61.86					0
07/26/02	61.92	5.83	112	188	> 20	
07/27/02	61.91	5.93	86	197	18.1	
07/28/02	61.91	5.74	76	206	16.9	
07/29/02	62.04	5.65	74.1	212	17.97	
07/30/02	62.08	5.61	73.8	217	16.86	
08/07/02	62.25	5.54	71.2	221	17.15	
08/08/02 (4)	62.18					0
08/09/02	62.25	5.76	84.1	197	18.5	
08/10/02	62.27	5.63	73.3	208	18.5	
08/11/02	62.32	5.71	73.2	205	>20	
08/12/02	62.39	5.61	76.3	187	19.7	
08/13/02	62.40	5.36	78.0	187	18.9	

Notes:

(1) 100 scfm injecting testing.
(2) 150 scfm injecting testing.
(3) 200 scfm injecting testing.
(4) 150 and 200 scfm injection testing for 1 hour each. Approximately 300 scfm for 6± hours thereafter.

TABLE D.7

MW-52D RESULTS FOR MW-52D INJECTION TESTING
OU-03 BIOSPARGE PREDESIGN TESTING
HICKSVILLE, NEW YORK

		Parameter			
Date	*Depth to Water (ft)*	*pH*	*Cond (uS/cm)*	*ORP (mV)*	*DO (mg/L)*
07/16/02	63.70	5.27	137	205	2.73
07/26/02	63.53	5.75	175	207	> 20
07/27/02	63.81	5.93	135	193	> 20
07/28/02	63.91	5.86	121	211	> 20
07/29/02	64.05	5.86	120	197	19.15
07/30/02	64.15	5.79	120	218	> 20
08/06/02	63.91	5.81	136	209	> 20
08/09/02	64.60	5.77	278	204	15.7
08/10/02	64.40	5.33	261	222	12.9
08/11/02	64.61	4.90	309	249	10.4
08/12/02	64.72	4.74	297	239	7.68
08/13/02	64.85	4.46	254	247	5.83

APPENDIX E

EFFECT OF CARBON SUPPLEMENTATION ON ENHANCEMENT OF VINYL CHLORIDE DEGRADATION IN GROUNDWATER LABORATORY TREATABILITY STUDY

EFFECT OF CARBON SUPPLEMENTATION ON ENHANCEMENT OF VINYL CHLORIDE BIODEGRADATION IN GROUNDWATER LABORATORY TREATABILITY STUDY

HOOKER CHEMICAL/RUCO POLYMER SUPERFUND SITE
HICKSVILLE, NEW YORK

NOVEMBER 2002
REF. NO. 6883 (38)
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TABLE OF CONTENTS

Page

LIST OF TABLES
(Following Text)

EXECUTIVE SUMMARY

The results of environmental investigations performed at the Hooker/Ruco Site have identified a vinyl chloride monomer (VCM) subplume located within the regional groundwater volatile organic compound (VOC) plume. A field pilot study to investigate the feasibility of injecting air, propane, sugar byproducts, nitrous oxide, and diammonium phosphate (DAP) into Hooker/Ruco Site wells in conjunction with biosparging has been undertaken. To complement the field program, a laboratory study involving microcosm slurry testing was performed to examine the effect of supplementation with air, inorganic nutrients, and carbon sources on the VCM biodegradation rate.

Sugar byproducts, propane, and methane were selected as the supplemental carbon sources for the laboratory microcosm study. The additions of sugar byproducts and propane were expected to stimulate the growth and microbial activity of the heterotrophic microbial population. The addition of methane was expected to stimulate the biodegradation of VCM via a co-metabolic pathway where methane would be used as a co-carbon source by methylotrophic bacteria. Unamended microcosms were also included in the study to provide base case results.

The water used for the microcosm tests was collected from well MW-64 at a depth of 255 feet bgs and initially contained 6200 μg/L of VCM. The soil used to make up the slurry for the microcosm tests was also collected from well MW-64 from the 250 to 255-foot bgs interval. The act of blending of the water and soil to make up the batch of slurry for the microcosm tests reduced the VCM concentration from 6200 μg/L to on the order of 300 to 400 μg/L. This reduction provides some indication of how sensitive the VCM concentrations in the water are to simple manipulative processes such as mixing and oxygen injection. These are the exact sorts of conditions that the injection system is intended to create.

With respect to the actual microcosm results, both aerobic and anaerobic samples were tested.

The anaerobic microcosms had no headspace with which the micrososms had to equilibriate. The microcosms with no air (no headspace) showed 13 percent VCM degradation , suggesting conditions were not optimal for the anaerobic pathway.

The aerobic microcosms showed an initial rapid decline of VCM concentration. This was observed in both the treatment microcosms (Sets #2 to 6) and the poisoned controls which had head space(Set #7). However, this initial rapid decline in VCM concentration was not observed in the microcosm which did not have head space(Set #1). This pattern suggests that the initial rapid decrease in VCM could have been caused by non-biological oxidative degradation mechanisms, such as photo-oxidation or other oxidative catalytic reactions involving the presence of oxygen and VCM in the vapor phase. The subsequent rate of VCM concentration reduction in Sets #2 to 6 is slightly higher than degradation rates in the poisoned control, reflecting the typical rate of VCM aerobic biodegradation process even under optimized nutrient and oxygen conditions. The important result of the microcosm study is that degradation was initiated, and continued throughout the 20-week test period. Given the conditions that were created, it is expected that the degradation process would have continued well beyond the 20 weeks of the test and shown that biodegradation of VCM is a viable alternative for implementation at the Hooker/Ruco Site.

The microcosms amended with carbon sources all showed significant VCM degradation, indicating that organic carbon supplementation enhances VCM degradation. Two percent methane amendment produced the largest VCM reduction (42 percent), followed by sugar byproducts and 0.4 percent propane (40 and 38 percent reduction, respectively), while 2 percent propane was less effective (16 percent reduction). Methane was not significantly reduced in the headspace in the methane-amended microcosms, suggesting that the methane cometabolic pathway may not have been occurring or that its acclimation period was longer than 20 weeks. VCM degradation in the microcosms amended with carbon was more significant after week 4, suggesting that there may be an acclimation period before aerobic degradation is enhanced. It is anticipated that the enhanced biodegradation of VCM would have continued after week 20 until either the carbon, nutrient, or oxygen sources were exhausted.

Full-scale design of the Hooker/Ruco Site biosparging remedy is now underway. Based on the results of this laboratory study, it is recommended that carbon supplementation be included in the design. The most effective forms of carbon sources for supplementation were low concentrations of sugar byproducts and propane. The two sources were very similar in their ability to increase VCM degradation; therefore, the choice of the source can be made based on the ease of field addition and the need for lateral (sugar byproducts) vs. vertical (propane) distribution. There will likely be a significant acclimation period before VCM degradation begins to accelerate.

While the rate of VCM degradation in the microcosms were not limited by nutrients, (because DAP was added to each microcosm), it is believed that nutrients may become a limiting factor for degradation of the VCM subplume as those nutrients already present in the formation are consumed by the biodegradation processes, especially when it is accelerated. Thus, it is recommended that supplementation with minor amounts of nutrients also be performed.

1.0 INTRODUCTION

The Hooker Chemical/Ruco Polymer Superfund Site (Hooker/Ruco Site) is located in Hicksville, New York. Environmental investigations performed at the Hooker/Ruco Site have identified a vinyl chloride monomer (VCM) subplume located within the regional groundwater volatile organic compound (VOC) plume.

Evaluations of potential remedial actions to address the VCM subplume selected biosparging as the preferred remedy. Biosparging is an enhancement of the natural attenuation (NA) processes already occurring in the VCM subplume.

A review of groundwater data generated between 1998 and 2002 has identified that:

1. the groundwater in the Bethpage area was generally aerobic (except in the center of the concentrated VCM subplume);
2. NA of VCM in the groundwater was occurring;
3. NA was not necessarily limited by a lack of dissolved oxygen (except in the center of the concentrated VCM subplume but could be limited by a lack of carbon sources; and
4. NA of VCM by the oxidation pathway could likely be enhanced by the addition of additional oxygen and carbon sources.

A field pilot study to investigate the feasibility of injecting air, propane, sugar byproducts, nitrous oxide, and diammonium phosphate (DAP) into Hooker/Ruco Site wells has been undertaken. To complement the field program, a laboratory study involving microcosm slurry testing was proposed using sugar byproducts, propane, and methane as carbon sources. It was also proposed to examine the effect of supplementation with inorganic nutrients and organic carbon sources on the VCM biodegradation rate.

This report presents a description of the activities conducted and the results of the laboratory study.

2.0 STUDY OBJECTIVE AND EXPERIMENTAL DESIGN AND PROCEDURE

The objective of the laboratory study was to assess the effect of oxygen, organic carbon, and inorganic nutrient supplementation on the biodegradation rate of VCM in groundwater to complement the field program. Sugar byproducts, propane, and methane were selected as the carbon sources for the laboratory study. The addition of sugar byproducts and propane was expected to stimulate the growth and microbial activities of the heterotrophic microbial population. The addition of methane was expected to stimulate the biodegradation of VCM via a co-metabolic pathway where methane would be used as a co-carbon source by methylotrophic bacteria. DAP was used in all of the microcosm tests as the supplement source of inorganic nitrogen (N) and phosphorus (P). The concentrations of sugar byproducts, propane, and DAP were selected to be equivalent to those being used in the field pilot study, i.e., 0.01 percent, 0.4 percent, and 50 parts per million (PPM), respectively to simulate the concentrations that could potentially be used for the biosparge remedy. The field propane concentration (0.4 percent) was set at 20 percent of the lower explosion limit (LEL) in response to concerns regarding the explosion potential of air and propane mixtures under the field pressure conditions. However, previously reported field studies for other sites have used a concentration of 2 percent propane for organic carbon supplementation. Therefore, this concentration was also selected for laboratory testing.

The study was conducted by Conestoga-Rovers & Associates (CRA) at their treatability laboratory in Niagara Falls, NY. Representative samples of soil (one gallon) and groundwater (9 gallons) were collected from monitoring well MW-64 and shipped to the laboratory for use in the study. The water was collected from a depth of 255 ft bgs and the soil was collected from a depth of 250 to 255 ft bgs.

2.1 INITIAL CHARACTERIZATION

The groundwater and soil were initially analyzed for VOCs, pH, moisture content, ammonia nitrogen, orthophosphate phosphorus, total microbial population, and VCM-specific microbial populations. The results are described in Section 3.0 of this report.

2.2 SLURRY MICROCOSMS

In order to replicate aerobic and anaerobic conditions, the slurry microcosms were prepared in two ways; one with headspace (for aerobic) and one without headspace (for anaerobic). Each slurry microcosm was prepared in glass serum bottles (160 mL) using the Hooker/Ruco Site soil (12 g) and groundwater (114 mL) (i.e., 10 percent soil, w/v), and the amendments shown below. The following treatments were tested in triplicate:

Set 1 - without headspace (anaerobic);

Set 2 - with 50 PPM DAP and headspace (air only);

Set 3 - with 50 PPM DAP, 0.01 percent sugar byproducts, and headspace (N, P, and air);

Set 4 - with 50 PPM DAP, propane, and headspace (N, P, and air with 0.4 percent propane);

Set 5 - with 50 PPM DAP, propane, and headspace (N, P, and air with 2 percent propane);

Set 6 - with 50 PPM DAP, methane, and headspace (N, P, and air with 2 percent methane); and

Set 7 - with 50 PPM DAP, headspace (air only), and 2 percent mercuric chloride (abiotic control).

The serum bottles were sealed with Teflon-lined caps, inverted, shaken thoroughly, and stored in the dark. They were shaken on a weekly basis during the incubation period. The microcosms were sacrificed and analyzed according to the following schedule:

- VCM in headspace, soil, and groundwater combined, monitored at T=0, 2, 4, 10, and 20 weeks;
- Total Microbial Counts in soil and water, monitored at T=0,4, 10 and 20 weeks; and
- Methane and carbon dioxide headspace gas sampling at T= 10 and 20 weeks.

3.0 RESULTS

3.1 INITIAL CHARACTERIZATION

The results of the initial characterization conducted on the groundwater and soil samples are provided in Tables 3.1 and 3.2, respectively. The only VOC present in the groundwater above 0.1 mg/L was VCM at a concentration of 6.2 mg/L. In the groundwater, the pH was neutral (7.3) and the ammonia nitrogen, orthophosphate phosphorus, and total microbial population were all low at 0.8 mg/L, 0.6 mg/L, and 5.2×10^2 colony forming units/mL (CFUs/mL), respectively. The only VOCs in the soil were trichloroethylene (TCE, 0.32 mg/Kg) and m,p-xylene (0.20 mg/Kg). In the soil, the pH was neutral (7.6); the ammonia nitrogen and total microbial population were low at 6.1 mg/Kg and 1.0×10^3 CFUs/mL, respectively. The soil orthophosphate phosphorus was 49.5 mg/Kg, which was considered in the normal range and did not suggest the need for supplementation.

Furthermore, the results for the well stabilization parameters measured during purging of well MW-64I (well screen located from 250 to 260 feet bgs) showed that the groundwater conditions in this interval were anaerobic.

3.2 SLURRY MICROCOSMS

The results of the microcosm analyses for VCM, total microbial population, and headspace gases (methane, carbon dioxide, and ethene) are shown in Tables 3.3, 3.4, and 3.5, respectively.

3.2.1 VCM MONITORING

The VCM and headspace gas data are averages of the individual microcosm results; either two, or in most cases, three results have been averaged. A complete matrix of microcosms was not analyzed for VCM at time T=0 because they were all expected to be the same. Instead, microcosms selected from 5 sets were analyzed. The results presented in Table 3.3 show that, contrary to the expected result, there was variability in the microcosm VCM concentrations immediately following preparation of the microcosm specimens.

The VCM results in Table 3.3 show that for the 5 sets of aerobic samples, significant reductions in VCM concentrations occurred between time T=0 and T=2 weeks. The specific process(es) which caused these decreases/increase are uncertain. Thus, the time period from T=0 to T=2 weeks is believed to be the period during which the microcosms achieved equilibrium after preparation of the microcosm specimens and the data for time T=2 weeks is used as the base condition (i.e., no longer subject to impacts due to microcosm preparation).

The Set 1 (anaerobic) data show that the VCM concentrations slowly decreased from time T=2 to T=20 weeks. Some of the differences in the results could be the result of sampling/analytical variability. The 13 percent reduction in VCM between weeks 2 and 20, if not the result of sampling/analytical variability, suggests that VCM degradation in the absence of additional oxygen was slow. The Set 2 data, with nutrients and oxygen but no carbon source, showed no reduction in VCM over the last 18 weeks, suggesting that biosparging alone may not enhance VCM degradation. The Set 7 data (abiotic control), also showed no reduction in the VCM concentration.

The microcosm tests that included the addition of supplemental carbon sources (i.e., Sets 3, 4, 5, and 6) resulted in reductions of VCM in all four cases. Sugar byproducts, 0.4 percent propane, 2 percent propane, and 2 percent methane showed reductions of 40, 38, 16, and 42 percent, respectively. After an initial decrease ranging from 76 to 184 µg/L between time T=0 and T=2 weeks, the VCM concentrations appeared to remain relatively constant until after week 4. The most significant declines occurred after week 4, which suggests that there may be an acclimation period before biodegradation enhancement becomes significant. Sugar byproducts, 2 percent methane, and 0.4 percent propane were equally effective in stimulating biodegradation.

3.2.2 MICROBIAL COUNTS MONITORING

The total microbial counts data support the trends indicated by the VCM data. Set 3, which was amended with sugar byproducts, showed the highest increase in microbial populations compared to the initial populations for soil (10^3 CFUs/mL increase) and groundwater (10^2 CFUs/mL increase). Set 2, which was amended with DAP, showed the next highest population increase. However, the stimulated microbial growth appears not to be of VCM degraders. This is based on the fact that both Set 2 and Set 7 had no VCM reductions and Set 7 had no microbial growth. Therefore, it is doubtful that the ~~VCM~~ microbial growth is of a variety that supports VCM degradation. Sets 4, 5, and 6 showed similar population characteristics, which supports the suggestion that other factors in addition to VCM degradation can affect the microbial population size. Set 7, the abiotic control showed no microbial growth. The anaerobic microbial populations in the absence of oxygen (no headspace) were measured in Set 1 and are not directly comparable to the aerobic populations measured in the other sets.

3.2.3 HEADSPACE GAS MONITORING

The headspace gas sampling also supported the VCM biodegradation data. The carbon dioxide data for Sets 2-6 were compared to Set 7, because Set 7 showed no microbial activity and therefore is expected to be representative of background levels of carbon dioxide. Set 2 (DAP) showed an increase in carbon dioxide suggesting some enhancement in the aerobic microbial activities by the supplementation of oxygen and inorganic nutrients. Set 3 (sugar byproducts) showed the highest increase in carbon dioxide, suggesting that aerobic degradation had been successfully stimulated, which was in agreement with the microbial counts and VCM data. Set 4 showed the second highest increase in carbon dioxide, suggesting that 0.4 percent propane was also effective in stimulating aerobic degradation. Set 5 (2 percent propane) showed a smaller increase in carbon dioxide. In Set 6 (methane), a significant reduction in carbon dioxide was observed between weeks 10 and 20, suggesting acetogenic microbial activities (where carbon dioxide fixation to acetic acid is acting as a sink for carbon dioxide thereby reducing its concentrations). It is uncertain by which pathway the reduction in VCM occurred in Set 6. However, because the methane concentration did not change significantly, these data suggest that the methane cometabolic pathway was not significant.

4.0 DISCUSSION

For the time period from 2 to 20 weeks, the microcosms without air supplementation (no headspace) showed 13 percent VCM degradation suggesting conditions were not optimal for this anaerobic pathway. The aerobic microcosms showed an initial rapid decline of VCM concentration. This was observed in both the treatment microcosms (Sets #2 to 6) and the poisoned controls which had head space(Set #7). However, this initial rapid decline in VCM concentration was not observed in the microcosm which did not have head space(Set #1). This pattern suggests that the initial rapid decrease in VCM could have been caused by non-biological oxidative degradation mechanisms, such as photo-oxidation or other oxidative catalytic reactions involving the presence of oxygen and VCM in the vapor phase. Similar observations describing the rapid degradation of VCM in the head space in contact with Teflon and oxygen have been made by other researchers (Dr. R. Lewis, HSA). The preparation of the microcosms involved the use of teflon-lined stoppers to prevent VCM adsorption on the septum. The microcosm preparation involved shaking the microcosm bottles vigorously to ensure good mixing. It was performed in the laboratory under fluorescent lighting, which could possibly have enhanced these abiotic reactions leading to the rapid initial loss in VCM concentration shown in the two-week results. Subsequently, the microcosms were incubated upside down (no contact between the Teflon liner and the headspace) in the dark (no photo-oxidation). The subsequent rate of VCM concentration reduction in Sets #2 to 6 is slightly higher than degradation rates in the poisoned control, reflecting the typical rate of VCM aerobic biodegradation process even under optimized nutrient and oxygen conditions. The important result of the microcosm study is that degradation was initiated, and continued throughout the 20-week test period. Given the conditions that were created, it is expected that the degradation process would have continued well beyond the 20 weeks of the test and shown that biodegradation of VCM is a viable alternative for implementation at the Hooker/Ruco Site.

The carbon amended microcosms all showed significant VCM degradation, indicating that carbon supplementation enhances VCM degradation. Two percent methane amendment produced the largest VCM reduction (42 percent), followed by 0.4 percent propane, and sugar byproducts (40 and 38 percent, respectively) while 2 percent propane was less effective (16 percent). Methane was not significantly reduced in the headspace in the methane-amended microcosms nor was there an increase in carbon dioxide production (actually $C0_2$ decreased), suggesting that VCM biodegradation via the methane cometabolic pathway may not have been occurring due to the lack of methylotrophic bacteria or that its acclimation period was longer than 20 weeks is required. VCM degradation in the microcosms amended with carbon was more significant after week 4, suggesting that there may be an acclimation period before aerobic degradation is enhanced. It is anticipated that enhanced biodegradation of VCM would have continued after week 20 until either the carbon source, nutrients or oxygen were exhausted.

5.0 RECOMMENDATIONS

Full-scale design of the Hooker/Ruco Site biosparging remedy is now underway. Based on the results of this laboratory study, it is recommended that, in addition to air injection, carbon supplementation be included in the design. The most effective forms of carbon sources for supplementation were low concentrations of sugar byproducts and propane. The two sources were very similar in their ability to increase VCM degradation. Therefore, the choice of the source can be made based on the ease of field addition and the need for lateral (sugar byproducts) vs. vertical (propane) distribution. Based on the laboratory results there will likely be a significant acclimation period before VCM degradation begins to accelerate.

While the rate of VCM degradation in the microcosms were not limited by nutrients (because DAP was added to each micrososm) it is believed that nutrients may become a limiting factor for degradation of the VCM subplume as those nutrients already present in the formation are consumed by the biodegradation processes, especially when it is accelerated. Thus, it is recommended that supplementation with minor amounts of nutrients also be performed.

TABLE 3.1

INITIAL CHARACTERIZATION - GROUNDWATER
VINYL CHLORIDE BIODEGRADATION LABORATORY TREATABILITY STUDY
HOOKER CHEMICAL/RUCO POLYMER SUPERFUND SITE
HICKSVILLE, NEW YORK

Parameter	*Units*	*Results*
1,1,1-Trichloroethane	mg/L	ND (0.1)
1,1,2-Trichloroethane	mg/L	ND (0.1)
1,1-Dichloroethane	mg/L	ND (0.1)
1,1-Dichloroethene	mg/L	ND (0.1)
1,2,4-Trichlorobenzene	mg/L	ND (0.1)
1,2-Dichlorobenzene	mg/L	ND (0.1)
1,3-Dichlorobenzene	mg/L	ND (0.1)
1,4-Dichlorobenzene	mg/L	ND (0.1)
1,2-Dichloroethane	mg/L	ND (0.1)
1,2-Dichloropropane	mg/L	ND (0.1)
3,4-Dichlorotoluene	mg/L	ND (0.1)
3-Chlorotoluene	mg/L	ND (0.1)
Benzene	mg/L	ND (0.1)
Bromodichloromethane	mg/L	ND (0.1)
Bromoform	mg/L	ND (0.1)
Carbon Tetrachloride	mg/L	ND (0.1)
Chlorobenzene	mg/L	ND (0.1)
Chloroform	mg/L	ND (0.1)
cis-1,2-Dichloroethene	mg/L	ND (0.1)
trans-1,2-Dichloroethene	mg/L	ND (0.1)
cis-1,3-Dichloropropene	mg/L	ND (0.1)
trans-1,3-Dichloropropene	mg/L	ND (0.1)
Dibromochloromethane	mg/L	ND (0.1)
Ethylbenzene	mg/L	ND (0.1)
Methylene chloride	mg/L	ND (0.1)
Tetrachloroethane	mg/L	ND (0.1)
Toluene	mg/L	ND (0.1)
Trichloroethene	mg/L	ND (0.1)
Vinyl chloride	mg/L	6.2
m,p-Xylene	mg/L	ND (0.1)
o-Xylene	mg/L	ND (0.1)
pH	S.U.	7.3
Ammonia Nitrogen	mg/L	0.8
Orthophosphate Phosphorus	mg/L	0.6
Total Microbial Population	CFUs/mL	5.2×10^2

Notes:

CFUs	Colony forming units.
ND(x)	Not detected at or above x.
S.U.	Standard units.

TABLE 3.2

INITIAL CHARACTERIZATION - SOIL
VINYL CHLORIDE BIODEGRADATION LABORATORY TREATABILITY STUDY
HOOKER CHEMICAL/RUCO POLYMER SUPERFUND SITE
HICKSVILLE, NEW YORK

Parameter	*Units*	*Results*
1,1,1-Trichloroethane	mg/Kg	ND (0.05)
1,1,2-Trichloroethane	mg/Kg	ND (0.05)
1,1-Dichloroethane	mg/Kg	ND (0.05)
1,1-Dichloroethene	mg/Kg	ND (0.05)
1,2,4-Trichlorobenzene	mg/Kg	ND (0.05)
1,2-Dichlorobenzene	mg/Kg	ND (0.05)
1,3-Dichlorobenzene	mg/Kg	ND (0.05)
1,4-Dichlorobenzene	mg/Kg	ND (0.05)
1,2-Dichloroethane	mg/Kg	ND (0.05)
1,2-Dichloropropane	mg/Kg	ND (0.05)
3,4-Dichlorotoluene	mg/Kg	ND (0.05)
3-Chlorotoluene	mg/Kg	ND (0.05)
Benzene	mg/Kg	ND (0.05)
Bromodichloromethane	mg/Kg	ND (0.05)
Bromoform	mg/Kg	ND (0.05)
Carbon Tetrachloride	mg/Kg	ND (0.05)
Chlorobenzene	mg/Kg	ND (0.05)
Chloroform	mg/Kg	ND (0.05)
cis-1,2-Dichloroethene	mg/Kg	ND (0.05)
trans-1,2-Dichloroethene	mg/Kg	ND (0.05)
cis-1,3-Dichloropropene	mg/Kg	ND (0.05)
trans-1,3-Dichloropropene	mg/Kg	ND (0.05)
Dibromochloromethane	mg/Kg	ND (0.05)
Ethylbenzene	mg/Kg	ND (0.05)
Methylene chloride	mg/Kg	ND (0.05)
Tetrachloroethane	mg/Kg	ND (0.05)
Toluene	mg/Kg	ND (0.05)
Trichloroethene	mg/Kg	0.32
Vinyl chloride	mg/Kg	ND (0.1)
m,p-Xylene	mg/Kg	0.20
o-Xylene	mg/Kg	ND (0.05)
pH	S.U.	7.6
Moisture content	%	19.5
Ammonia Nitrogen	mg/Kg	6.1
Orthophosphate Phosphorus	mg/Kg	49.5
Total Microbial Population	CFUs/g	1.0×10^3

Notes:

CFUs	Colony forming units.
ND(x)	Not detected at or above x.
S.U.	Standard units.

TABLE 3.3

VINYL CHLORIDE ANALYTICAL RESULTS
VINYL CHLORIDE BIODEGRADATION LABORATORY TREATABILITY STUDY
HOOKER CHEMICAL/RUCO POLYMER SUPERFUND SITE
HICKSVILLE, NEW YORK

	Supplements	*T=0 weeks*	*T=2 weeks*	*T=4 weeks*	*T=10 weeks*	*T=20 weeks*	*% Reduction in VCM After 20 Weeks* [1]
SET 1	None	284	446	404	418	390	13
SET 2	Air, DAP	327	189	170	250	221	0
SET 3	Air, DAP, Sugar Byproducts	NA	192	184	194	115	40
SET 4	Air, DAP, 0.4% Propane	297	221	266	209	137	38
SET 5	Air, DAP, 2% Propane	299	198	243	210	166	16
SET 6	Air, DAP, 2% Methane	NA	269	253	199	157	42
SET 7	Air, DAP, Mercuric Chloride	375	191	225	203	201	0

Notes:
All results shown are µg/sample.

1	Percent reduction calculated as the difference between T=2 and T=20 concentrations.
NA	Not applicable.
VCM	Vinyl chloride monomer.
DAP	Diammonium Phosphate.

TABLE 3.4

MICROBIAL POPULATION COUNTS
VINYL CHLORIDE BIODEGRADATION LABORATORY TREATABILITY STUDY
HOOKER CHEMICAL/RUCO POLYMER SUPERFUND SITE
HICKSVILLE, NEW YORK

SOIL (CFUs/g)	*Initial*	*T=4 weeks*	*T=10 weeks*	*T=20 weeks*
SET 1	1.0×10^3	5.2×10^4	4.9×10^4	4.1×10^4
SET 2	1.0×10^3	1.1×10^5	1.1×10^5	1.2×10^5
SET 3	1.0×10^3	2.3×10^6	2.6×10^6	2.7×10^6
SET 4	1.0×10^3	7.2×10^4	5.7×10^4	5.0×10^4
SET 5	1.0×10^3	6.1×10^4	6.1×10^4	6.0×10^4
SET 6	1.0×10^3	2.2×10^4	2.2×10^4	5.6×10^4
SET 7	1.0×10^3	No growth	No growth	No growth

WATER (CFUs/mL)	*Initial*	*T=4 weeks*	*T=10 weeks*	*T=20 weeks*
SET 1	5.2×10^2	6.2×10^3	4.3×10^3	4.6×10^3
SET 2	5.2×10^2	1.3×10^4	1.2×10^4	9.4×10^3
SET 3	5.2×10^2	3.2×10^4	2.4×10^4	1.7×10^4
SET 4	5.2×10^2	1.3×10^4	4.3×10^3	3.4×10^3
SET 5	5.2×10^2	1.1×10^4	5.3×10^3	4.9×10^3
SET 6	5.2×10^2	5.3×10^4	4.0×10^3	5.7×10^3
SET 7	5.2×10^2	No growth	No growth	No growth

Notes:

CFUs	Colony forming units.

TABLE 3.5

HEADSPACE INJECTION RESULTS
VINYL CHLORIDE BIODEGRADATION LABORATORY TREATABILITY STUDY
HOOKER CHEMICAL/RUCO POLYMER SUPERFUND SITE
HICKSVILLE, NEW YORK

	SET 2		**SET 3**		**SET 4**	
	T=10 weeks	*T=20 weeks*	*T=10 weeks*	*T=20 weeks*	*T=10 weeks*	*T=20 weeks*
Methane	ND (0.25)	ND (0.25)	ND (0.25)	ND (0.25)	ND (0.25)	ND (0.25)
Carbon dioxide (CO_2)	4.4	5.1	7.4	7.1	5.6	4.7

	SET 5		**SET 6**		**SET 7**	
	T=10 weeks	*T=20 weeks*	*T=10 weeks*	*T=20 weeks*	*T=10 weeks*	*T=20 weeks*
Methane	ND (0.25)	ND (0.25)	1.0	1.2	ND (0.25)	ND (0.25)
Carbon dioxide (CO_2)	4.8	3.8	5.4	2.7	1.7	1.3

Notes:

Results shown are percentage averages of duplicate or triplicate samples.

NDx	Not detected at or above x.

APPENDIX F

ESTIMATION OF TOTAL OXYGEN DEMAND

APPENDIX F

ESTIMATION OF TOTAL OXYGEN DEMAND

Table F.1 gives a preliminary estimate of the oxygen demand present in the groundwater within the VCM subplume for the purpose of assessing sparging requirements. Major known constituents of total oxygen demand in groundwater (TOD) are listed with the oxygen demand each presents. Concentrations are averages of those reported in the June-July 2002 sampling, for the wells in the VCM subplume. Where more than one interval was sampled in a well, the sample with the highest VCM concentration was used to calculate the inter-well averages. The averages are thus biased to attempt to represent the core of the subplume, which is the sparging target.

It was calculated that VCM comprises more than 90 percent of the VOCs in the subplume but represents 4 percent or less of the TOD. Dissolved iron ($Fe^{++}(aq)$) is a chemical oxygen demand, that creates one-tenth of the TOD, and methane accounts for 79 percent of the TOD.

The following estimates the TOD in groundwater in a 60 ft radius circle per foot of thickness based on the concentration values in Table F.1. A 60-foot radius is a little more than half the anticipated well spacing of 100 feet, to give overlap between adjacent wells.

The TOD of reported analytes in groundwater in the VCM subplume is approximately 34 mg/L. In a circle of radius 60 ft, or area $\pi \times 60^2$ sq.ft., that is one foot thick, and with porosity 0.3, the volume of water is:

28 L/cu.ft. x 0.3 x $\pi \times 60^2$ sq.ft = 96,000 L

and the 34 mg/L TOD in this volume is:

96,000 L x 34 mg/L x 10^{-3} mg/gm/454 gm/lb
~ 7.3 lb/ft thickness

In an impacted zone 50 ft thick, the oxygen demand in a circle of 60 ft radius is thus 370 lb. This represents a volume of 4,000 scf, which would be delivered in a 100 scfm flow of 20 percent oxygen in 3.3 hours. That is, a sparge point with a flow of 100 scfm would deliver enough oxygen in 3 to 4 hours to meet the oxygen demand in groundwater in a 60-foot radius circle if it were distributed with 100 percent efficiency.

Efficiency of oxygen delivery to and uptake by groundwater oxygen demand is low. Further, as noted above, a significant chemical oxygen demand must be overcome before DO becomes available to aerobic microbial processes. A rule of 1 percent efficiency is often used in sparging requirement estimates, but this efficiency does not typically include an assessment of the oxygen demand other than that of the target chemicals, as is done here. The oxygen demand of methane is also overstated here, since some methane will be partially displaced by air flow out of the target zone.

The target chemical is VCM. As shown on Table F.1, VCM represents 1 mg/L or 4.2 percent of the TOD. The air volume needed to address the VCM in the cylinder 50-foot thick with a 60-foot radius at 1 percent efficiency would be 4,000 scf x 0.042 x $\frac{100}{1}$ = 17,200 sfm.

For the calculated TOD of 34 mg/L and using a 10 percent efficiency, the air volume for the cylinder would be 40,000 scf. Thus, the method used herein calculates a larger air volume which provides an additional safety factor that sufficient air will be injected.

As a result, an assumed efficiency of 10 percent is expected to be reasonable. This suggests that 30 to 40 hours of sparging is required in a single well to meet the initial oxygen demand presented in a 60-foot radius from the well.

Groundwater flows past the well at a pore velocity of approximately twelve feet per month. This brings a new volume of upstream plume water into the sparging zone, that is 12 ft x 120 ft wide x 0.3 porosity, into the sparging area of a particular well every month. This volume is 8,300 L/month/vertical ft. This volume is 8.6 percent of the volume estimated in our single well's 60 ft sparge radius. This means that an extra 8.6 percent of 40 hours, or 3 to 4 hours of sparging, is required per month to keep up with incoming groundwater flow.

While the 3 to 4 hours per month maintenance is a reasonable schedule, the 40 hours of initial sparging will have to be divided into smaller time increments based on what is practically achievable, according to the remedial system capacity and operating restrictions (e.g., at night, on weekends, etc.). The need to stop and start the injections is not detrimental to the desire for widespread distribution of the oxygen. Stop and starts are valuable in establishing different air flow paths through the groundwater formation thus improving oxygen distribution.

Table F.2 summarizes the assumptions and air flow requirements for the VCM subplume.

TABLE F.1

ELEMENTS OF OXYGEN DEMAND IN VCM SUBPLUME
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Constituent	*Formula*	*Oxidation equation*	*Weight O_2/ Constituent*	*Conc mg/L*	*TOD mg/L*	*% TOD*
Methane	CH_4	$CH_4 + 3/2O_2 \rightarrow CO_2 + 2H_2O$	48/16	9	27	79
Dissolved iron	$Fe^{2+}(aq)$	$3Fe^{++}(aq) + 2O_2 \rightarrow Fe_3O_4(s)$	64/168	9	3	10
Dissolved Mn	$Mn^{2+}(aq)$	$Mn^{2+}(aq) + O_2 \rightarrow MnO_2\ (s)$	32/55	0.2	0.1	0.3
non-volatile TOC	CH_2O	$CH_2O + O_2 \rightarrow CO_2 + H_2O$ (microbial metabolism)	32/30	2	2	6.3
VCM	C_2H_3Cl	$C_2H_3Cl + 5.5O_2 \rightarrow 2CO_2 + 1.5H_2O + Cl^-$ (microbial metabolism)	176/124	1	1	4.2
				ΣTOD	34	99.8

TOD = groundwater oxygen demand = biological (BOD) + chemical (COD) demand

- Methane is about 90% of the oxygen demand; dissolved iron 5 to 10%; the non-volatile, TOC is 6%; and vinyl chloride (the bulk of the VOC) is 4% or less.
- Methane represents a fraction of the VOC that has already degraded beneath the site, which is substantially greater than the chlorinated hydrocarbon residual.
- Dissolved iron poses a greater chemical oxygen demand than VCM does biological demand.
- Previous TOC values, and unreported volatile breakdown products, outweigh VCM BOD.

TABLE F.2

ESTIMATED SPARGE REQUIREMENTS
HOOKER/RUCO SITE, HICKSVILLE, NEW YORK

Parameter	*Value*	*Unit*
Volume of water in plume cylinder with radius 60′, porosity 0.3, per foot thickness	96,000	L
Concentration of total oxygen demand in plume	34	mg/L
Total oxygen demand in plume cylinder 50′ thick	370	lb
Oxygen demand for plume cylinder as volume	4,000	scf*
Time to deliver oxygen demand in 100 scfm flow, at 10% efficiency	40	hours
Groundwater pore velocity	12	ft/month
Monthly flow of plume to single well, over 160′ width	8,300	L / vertical ft
Monthly advection as fraction of initial cylinder	0.086	-
Monthly sparging maintenance per well @ 100 scfm	4	hours

* scf = cubic feet at standard temperature and pressure