GW - 40

WORK PLANS

WORKPLAN

BIOVENTING PILOT TEST

MAY 1995

GIANT INDUSTRIES ARIZONA, INC.
FORMER BLOOMFIELD REFINERY
SAN JUAN COUNTY, NEW MEXICO

PREPARED FOR

NEW MEXICO OIL CONSERVATION DIVISION
SANTA FE, NEW MEXICO

Project 14111

PREPARED BY

PHILIP ENVIRONMENTAL

4000 Monroe Road
Farmington, New Mexico 87401
(505) 326-2262

TABLE OF CONTENTS

LIST OF FIGURES

Giant Industries Arizona, Inc. (Giant) is pleased to present this proposed workplan for an in-situ soil remediation pilot test for the south diesel spill area within Giant's former Bloomfield Refinery. Giant has prepared the following technical approach and work plan for the implementation of this pilot test.

1.0 TECHNICAL APPROACH

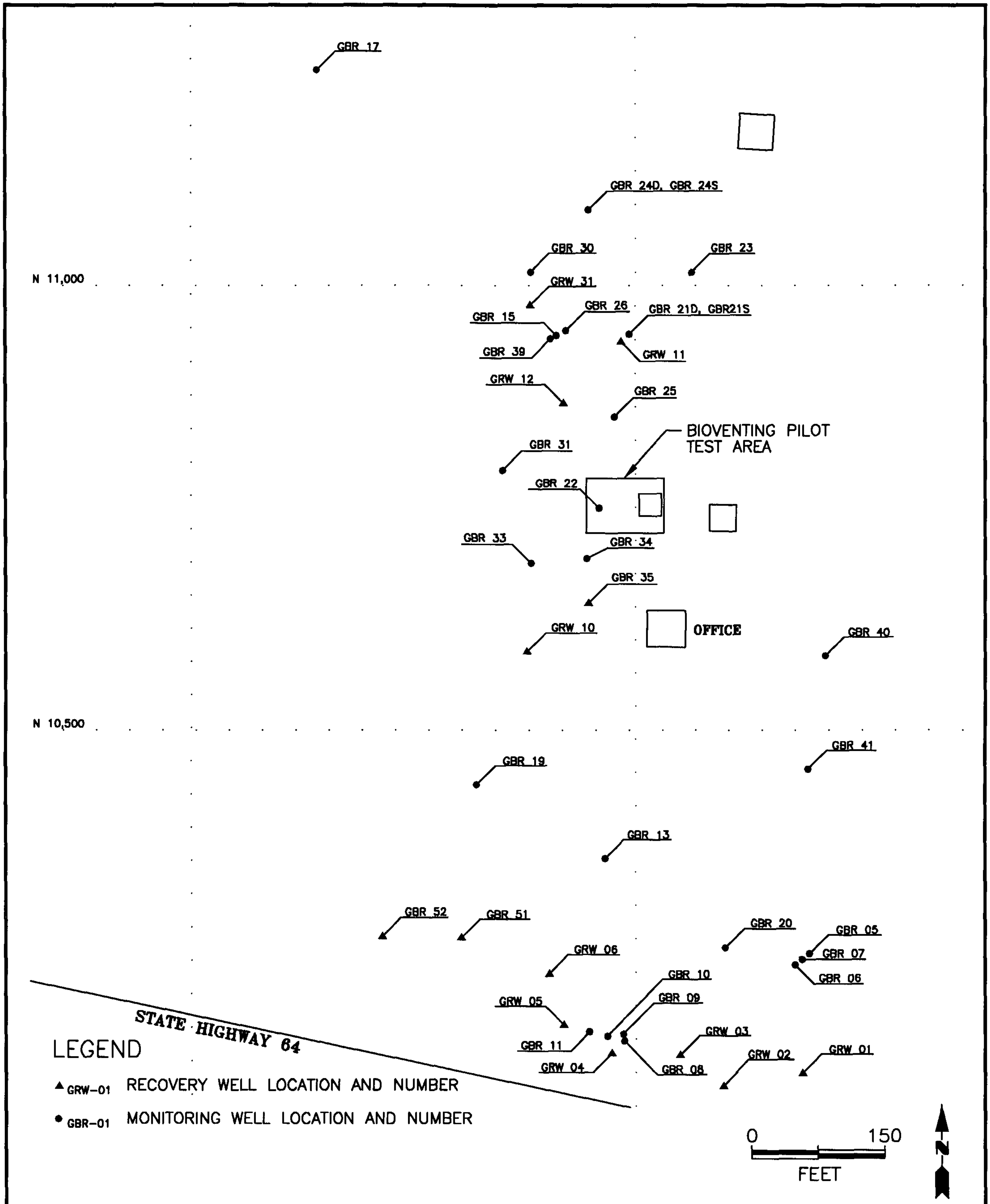
The conditions at the former Bloomfield Refinery appear to be suitable for the application of in-situ soil remediation through bioventing. A pilot test will be used to determine the effectiveness of the bioventing technique at this site. The south diesel spill area within the former Bloomfield Refinery, shown on Figure 1, appears suitable for the pilot test.

The area proposed for the pilot test is approximately 60 feet by 60 feet. The pilot test will serve two purposes. First, it will test the applicability of bioventing at the former Bloomfield Refinery; and second, it will allow for additional characterization of the vadose zone.

The success of air injection for enhancing biodegradation relies on airflow through the contaminated soils. The air supply must be at rates and configurations that will provide adequate oxygenation for aerobic biodegradation, while minimizing or eliminating the production of a hydrocarbon-contaminated off-gas. To increase biodegradation rates, the addition of nutrients and moisture may be desirable. However, documented research does not indicate the necessity of these additions for remediation.

The bioventing system involves an air-injection blower and air-injection wells. Air is injected at low-flow rates, generally 10-cubic feet per minute (cfm) or less, into shallow contaminated soils. Soil-gas monitoring points are drilled into the contaminated soil to monitor system performance. These narrowly screened monitoring points are used to sample soil-gas in discrete intervals of the subsurface. These points are required to monitor local respiration rates in the vadose zone.

An estimate of the soil's permeability to air flow and the radius of influence of air-injection wells are both important elements of pilot testing and full-scale bioventing design. On-site testing will be used to determine the radius of influence that can be achieved for a given well configuration, as well as the optimum flow rate and air pressure.



PHILIP ENVIRONMENTAL	TITLE: Proposed Bioventing Test Area	SCALE 1=150	DATE	PROJECT NO: 14111 GIANT INDUSTRIES BLOOMFIELD, NM
		DWN: TMM		
		DES:		FIGURE 1
		CHKD:		REV:
		APPD:		

COL. 14111A-001

1.1 System Installation

Sample soil borings will be completed to characterize the area targeted for bioventing. Once this target area is characterized, the bioventing well and soil-gas monitoring points can be more accurately placed.

One air-injection vent-well will be installed. This well will be placed as close to the center of the contaminated area as possible. It will be constructed of 2-inch diameter, schedule-40 polyvinyl chloride (PVC). The screened interval will extend through as much of the contaminated soil profile as possible. The bottom of the screen will be placed at the top of the capillary fringe. The annular space will be sealed with bentonite from ground surface to 5 feet beneath the ground surface, to prevent short circuiting of injection air to the atmosphere.

Three soil-gas monitoring (respiration) points will be installed in a line progressively further away from the vent-well. Each monitoring point will be constructed with 2-inch diameter, schedule-40 PVC, screened at three different depths. These monitoring points will allow the soil-gas to be sampled from three different levels of the contaminated soil profile. This information will help to monitor the movement of the introduced oxygen through the soils and to estimate biodegradation rates at the different depths.

1.2 Soil Samples

One soil sample will be collected from each vent-well and monitoring point borings. These samples will be analyzed for total petroleum hydrocarbons (TPH), and benzene, toluene, ethylbenzene, and xylene (BTEX).

1.3 Soil-Gas Permeability Test

A soil-gas permeability test (similar to a water-well pump test) will be conducted to determine the site's air permeability and the radius of influence of the vent-wells. These data will be used to determine the site's suitability for bioventing and to ensure that the entire pilot test site receives a supply of oxygen-rich air to sustain in-situ biodegradation. This test will take approximately eight hours to complete.

1.4 In-Situ Respiration Test

This test provides a rapid field measurement of the in-situ biodegradation rates. Oxygen utilization and carbon dioxide production are measured at each vent-well during this test to determine if biodegradation is taking place, and if so, at what rate.

1.5 Bioventing Test

If the soil-gas permeability test and the in-situ respiration test indicate that bioventing is applicable and useful at the site, the bioventing test will begin. This test consists of performing quarterly monitoring of soil-gas oxygen, carbon dioxide, and hydrocarbon concentrations during air injection. The pilot bioventing test will continue for a period of one year, or until microbial processes stop, as indicated by decreased oxygen utilization and/or decreased carbon dioxide production. After one year, the data gathered will be assessed to evaluate the success of the pilot test. At this time, soil samples may be collected to aid in evaluating the effectiveness of the pilot test.

1.6 Monitoring

The system will be monitored intensively for the first two or three days of operation, during the soil-gas permeability test and the in-situ respiration test. After these tests are satisfactorily completed, the system will be put on a quarterly monitoring schedule.

1.7 Reporting

Giant will prepare a report evaluating the success of the pilot test at the end of one year's operation, or at system shutdown, whichever occurs first.

2.0 SCHEDULE

Upon approval by the New Mexico Oil Conservation Division the design of the pilot test will require three weeks to complete. Giant wishes to initiate bioventing in June 1995.

Installation of the bioventing wells and ancillary hardware can be completed in one week. The soil-gas permeability test and the in-situ respiration test will be run immediately upon installation of the system. The soil remediation pilot test will run for approximately one year, at which point the data will be reviewed. Upon this review, a decision can be made on expanding the project to other areas requiring treatment.

Technical Proposal for Bioremediation Pilot Project

Giant Bloomfield Refinery
Giant Industries Arizona, Inc.
P.O. Box 256
Farmington, New Mexico 87499

August 23, 1993

RECEIVED
AUG 26 1993
OIL CONSERVATION DIV.
SANTA FE

Technical Proposal for Bioremediation Pilot Project

Pursuant to New Mexico Oil Conservation Division (NMOCD) discharge plan GW-40, Giant Industries Arizona, Inc. (Giant) is permitted to infiltrate air stripper effluent to the subsurface. Giant proposes the addition of nutrients to the air stripper effluent to promote additional indigenous microorganism growth to reduce dissolved phase petroleum hydrocarbons in the groundwater.

To evaluate the feasibility of enhancing bioremediation, Giant collected groundwater samples from upgradient Monitor Well GBR-40, Monitor Well GBR-41 at the former storm water containment pond, and downgradient Monitor/Recovery Well GBR-6 (Figure 1). The samples were analyzed for the following constituents:

- hydrocarbon degrader bacteria;
- total heterotrophic bacteria;
- dissolved oxygen;
- pH;
- conductivity;
- potassium;
- iron;
- manganese;
- ammonium nitrogen;
- orthophosphorus;
- nitrate;
- benzene/toluene/ethylbenzene/xylene (BTEX); and
- total petroleum hydrocarbons (TPH).

The analytical results are included in Attachment 1. Giant's consultant, Burlington Environmental Inc., is of the opinion that indigenous bacteria are present in the groundwater at the site in sufficient numbers for nutrient addition to enhance bacterial growth, thereby reducing concentrations of petroleum hydrocarbons in groundwater.

Based on chemical analyses, Giant needs to increase the dissolved oxygen concentration of the groundwater beneath the infiltration gallery to encourage increased microorganism growth. Based on the high iron content of the groundwater, hydrogen peroxide would be unstable and degrade easily, and therefore should not be used. Instead, the air stripper effluent will be used to increase the dissolved oxygen concentrations within the groundwater.

To calculate the concentrations of ammonium-nitrogen and phosphate-phosphorous required to promote microorganism growth, Giant will use a typical carbon to nitrogen to phosphorous ratio of 200:10:1 for the nutrient additives. To account for other hydrocarbon compounds likely to be present, the total organic carbon (TOC) content was assumed to be twice that of the carbon contained in the combined concentrations of BTEX in the groundwater at Monitor Well GBR-41. Using these assumptions the TOC concentration would be approximately 6,000 parts per billion. However, because we know free-phase hydrocarbons exist on top of the groundwater in the vicinity of the storm water containment area and most likely are also present directly beneath the infiltration gallery, we chose to use a TOC concentration equal to 1,000 parts per million (ppm). At 1,000 ppm TOC, the concentrations required to mineralize the hydrocarbons are 50 ppm (0.005 percent) nitrogen and 5 ppm (0.0005 percent) phosphorous.

To treat the area directly underneath the infiltration gallery Giant makes the following assumptions:

- the volume of groundwater to be treated has the same horizontal dimensions as the infiltration gallery (100 ′ x 100′);
- the plume extends to 10 feet beneath the surface of the groundwater; and
- the groundwater fills the estimated 23 percent pore space of the soil.

Using these dimensions the volume of groundwater to be treated is estimated to be 170,000 gallons.

Giant will infiltrate a 0.059 percent (590 ppm) nitrogen and 0.0059 percent (59 ppm) phosphorous solution through the infiltration system at a rate of 25 gallons per minute for one 10-day period. A Venturi injection system will be used to add the nitrogen and phosphorous to the air stripper effluent prior to infiltration.

Groundwater samples will be collected from Monitor Wells GBR-6, GBR-41, and GBR-20 and analyzed according to the following schedule.

FIELD ANALYSIS

Parameter	Schedule
Temperature	Twice monthly for first quarter then monthly
Specific Conductivity	Twice monthly for first quarter then monthly
pH	Twice monthly for first quarter then monthly
Dissolved Oxygen	Twice monthly for first quarter then monthly

LABORATORY ANALYSIS

Parameter	Schedule
Hydrocarbon degrader bacteria	Twice monthly for first quarter then Quarterly
Total heterotrophic bacteria	Twice monthly for first quarter then Quarterly
BTEX	Twice monthly for first quarter then Quarterly
TPH	Twice monthly for first quarter then Quarterly
TOC	Twice monthly for first quarter then Quarterly
Ammonium nitrogen	Twice monthly for first quarter then Quarterly
Orthophosphorus	Twice monthly for first quarter then Quarterly
Nitrate	Twice monthly for first quarter then Quarterly
Potassium	Quarterly
Iron	Quarterly
Manganese	Quarterly

In addition to the monitoring proposed above, the analytical results from Giant's existing quarterly sampling program at the southern refinery boundary will be used for system evaluation. Based on the results of the first year's operations, recommendations will be made for continued in-situ bioremediation.

Recommendations and evaluations will be based on groundwater sampling analytical results. Burlington will evaluate the bioremediation program quarterly. Burlington will make verbal recommendations to Giant for modification of nutrient addition, if necessary, on a quarterly basis. An in-situ bioremediation evaluation report will be submitted to the NMOCD at the end of a one-year period of nutrient injection. Any recommended changes to the nutrient injection program will be submitted to the NMOCD for approval.

ATTACHMENT 1

ANALYTICAL RESULTS

GTEL
ENVIRONMENTAL
LABORATORIES, INC.
4080 Pike Lane
Concord, CA 94520
(510) 685-7852
(800) 544-3422 Inside CA
(800) 423-7143 Outside CA
(510) 825-0720 FAX

Client Number: GBR01GBR01
Project ID: Refinery Remediation 9834
Work Order Number: C3-06-0493

July 12, 1993

Tim Kinney
Bloomfield Refinery Remediation
5764 Highway 64
Post Office Box 256
Farmington, New Mexico 87499

Enclosed please find the analytical results for samples received by GTEL Environmental Laboratories, Inc. on 06/25/93.

A formal Quality Assurance/Quality Control (QA/QC) program is maintained by GTEL, which is designed to meet or exceed the EPA requirements. Analytical work for this project met QA/QC criteria, unless otherwise stated in the footnotes.

GTEL is certified by the California State Department of Health Services, Laboratory certification number E1075, to perform analyses for drinking water, wastewater, and hazardous waste materials according to EPA protocols.

If you have any questions concerning this analysis or if we can be of further assistance, please call our Customer Service Representative.

Sincerely,
GTEL Environmental Laboratories, Inc.

Eileen F. Bullen

Eileen F. Bullen
Laboratory Director

Client Number: GBR01GBR01
Project ID: Refinery Remediation 9834
Work Order Number: C3-06-0493

Table 1

ANALYTICAL RESULTS

Aromatic Volatile Organics in Water

EPA Methods 5030 and 602[a]

GBR40 6 41

GTEL Sample Number		01	02	03	070693
Client Identification		9306241030	9306241135	9306241300	METHOD BLANK
Date Sampled		06/24/93	06/24/93	06/24/93	–
Date Analyzed		07/05/93	07/07/93	07/06/93	07/06/93
Analyte	Detection Limit, ug/L	Concentration, ug/L			
Benzene	0.3	<0.3	7	440	<0.3
Toluene	0.3	<0.3	1	7	<0.3
Ethylbenzene	0.3	1	0.8	1400	<0.3
Xylene, total	0.5	1	3	1300	<0.5
BTEX, total		2	12	3100	–
Detection Limit Multiplier		1	1	5	1
BFB surrogate, % recovery		107	102	128	96.0

a. Test Methods for Evaluating Solid Waste, SW-846, Third Edition, Revision 0, US EPA November 1986. Bromofluorobenzene surrogate recovery acceptability limits are 70-130%.

Client Number: GBR01GBR01
Project ID: Refinery Remediation 9834
Work Order Number: C3-06-0493

ANALYTICAL RESULTS

Matrix: Water

				Sample Number	01	02	03	070693 MET
				Sample Identification	9306241030	9306241135	9306241300	METHOD BLANK
				Date Sampled	06/24/93	06/24/93	06/24/93	--
Test Description	Units	Detection Limit	Method	Date Analyzed	Test Result (ug/L)			
Potassium	ug/L	1000	EPA 6010	07/08/93	9300	4800	1500	<1000
Iron	ug/L	100	EPA 6010	07/08/93	10000	130	110000	<100
Manganese	ug/L	5	EPA 6010	07/08/93	1500	820	640	<5

Note: Test Methods for Evaluating Solid Waste, SW-846, 3rd edition, Rev. O, U.S. EPA, November, 1986.

GTEL Concord, CA
C3060493.GE

GTEL ENVIRONMENTAL LABORATORIES, INC.

Client Number: GBR01GBR01
Project ID: Refinery Remediation 9834
Work Order Number: C3-06-0493

ANALYTICAL RESULTS

Matrix: Water

				Sample Number	01	02	03	070693
				Sample Identification	9306241030	9306241135	9306241300	METHOD BLANK
				Date Sampled	06/24/93	06/24/93	06/24/93	--
Test Description	Units	Detection Limit	Method	Date Analyzed	Test Result			
Nitrate	mg/L	1	EPA 300.0	07/01/93	<1	<1	<1	<1
Nitrite	mg/L	1	EPA 300.0	07/01/93	<1	<1	<1	<1
Ammonia-N	mg/L	0.02	EPA 350.3	07/06/93	<0.02	0.08	0.14	<0.02
O-Phosphate	mg/L	1	EPA 300.0	07/01/93	<1	<1	<1	<1
Dissolved Oxygen	mg/L	0.1	EPA 360.1	06/25/93	3.4	2	0.75	NA

Note: Standard Methods for the Examination of Water and Wastewater, 17th edition, 1989, American Public Health Association.
NA = Not Applicable.

GTEL ENVIRONMENTAL LABORATORIES, INC

Client Number: GBR01GBR01
Project ID: Refinery Remediation 9834
Work Order Number: C3-06-0493

Table 1

ANALYTICAL RESULTS

Total Petroleum Hydrocarbons in Water by Infrared Spectrometry

EPA Method 418.1[1] (SM 5520 FC[2])

1. Methods for Chemical Analysis of Water and Wastes, EPA 600/4-79-202, Revised March 1983, U.S. Environmental Protection Agency.
2. Standard Methods for the Examination of Water and Wastewater, 17th ed., 1989, American Public Health Association.

GTEL Sample Number		40 01	6 02	41 03	070293TPH
Client Identification		9306241030	93060241135	9306241300	METHOD BLANK
Date Sampled		06/24/93	06/24/93	06/24/93	--
Date Prepared		06/30/93	06/30/93	06/30/93	06/30/93
Date Analyzed		07/01/93	07/01/93	07/01/93	07/01/93
Analyte	Detection Limit, mg/L	Concentration, mg/L			
Total Petroleum Hydrocarbons	1	<1	<1	<1	<1
Detection Limit Multiplier		1	1	1	1

GTEL ENVIRONMENTAL

GIANT

Bloomfield Refinery Remediation
5764 Highway 64
Post Office Box 256
Farmington, New Mexico 87499

CHAIN OF CUSTODY

Date: 6-24-93 Page 1 of 1

LABORATORY ADDRESS: GTEL Environmental

Telephone ( ) -

SAMPLER'S SIGNATURE: Jeany Overman

REQUESTED ANALYSIS

	SAMPLE NUMBER	MATRIX	LOCATION	POLYNUCLEAR AROMATICS 610/8310	HALOGENATED VOLATILES 601/8010	~~AROMATIC VOLATILES 602/8020~~ CB 6/25/93	GENERAL WATER CHEMISTRY	BTEX 602 CB 6/25	CONDUCTIVITY	PRIORITY POLLUTANT METALS	TPH 418.1 CB 6/25	Nitrate/NITRITE Amonia Nitrogen CB	Iron Manganese	Ortho Phosphate Potassium CB	Hydrocarbon degraders + Total Heterotrophs	Disolved Oxygen	NUMBER OF CONTAINERS
1	9306241030	Water	GBR- 40			~~✓~~		✓			✓	✓	✓	✓	✓	✓	11
2	9306241135	Water	GBR-6/RW9			~~✓~~		✓			✓	✓	✓	✓	✓	✓	11
3	9306241300	Water	GBR 41			~~✓~~		✓			✓	✓	✓	✓	✓	✓	11

RTL

U. Valvano 2/13

PROJECT INFORMATION	
PROJECT:	Refinery Remediation 9834
PROJECT MANAGER:	Tim Kinney
SHIPPING I.D. NO.	730 940 0125
SHIPPED VIA	AirBorne Ex

SAMPLE RECEIPT	
TOTAL NO. OF CONTAINERS	33
CHAIN OF CUSTODY SEALS	Y
REC'D GOOD CONDITION/COLD	6°
CONFORMS TO RECORD	Y
LABORATORY NUMBER:	C306049 3 GTEL

SPECIAL INSTRUCTIONS OR COMMENTS
Return original Chain of Custody to Giant

C3060494

1004

RELINQUISHED BY: (Signature) 1.	RELINQUISHED BY: (Signature) 2.	RELINQUISHED BY: (Signature)
Jeany Overman		
(Printed Name) Jeany Overman	(Printed Name)	(Printed Name)
(Company) Giant Refining	(Company)	(Company)
DATE AND TIME: 6-24-93	DATE AND TIME:	DATE AND TIME:
RECEIVED BY: (Signature) 1.	RECEIVED BY: (Signature) 2.	RECEIVED BY: (Signature) LABORATORY
(Printed Name)	(Printed Name)	(Printed Name) Brian E. Cox
(Company)	(Company)	(Company) GTEL
DATE AND TIME:	DATE AND TIME:	DATE AND TIME: 6/25/93 0900

san juan repro Form 101

REMEDIATION TECHNOLOGY LABORATORY

4080 Pike Lane Concord, CA 94520 510-685-7852

Results of Bacteria Enumeration

Client Name:	Refinery Remediation 9834	Sampling Date:	6/24/93
ID Number:	7309400125	Date Received:	6/25/93
Client Location:	Farmington, NM	Date Completed:	7/25/93
Project Manager:	Tim Kinney	Report Date:	8/3/93
Matrix:	Water	Login Number:	C3060434

Lab No.	Sample ID	Contaminant Utilizing Bacteria	Total Heterotrophic Bacteria
6184	9306241030	6.4×10^4	1.6×10^5
6185	9306241135	1.6×10^4	3.3×10^5
6186	9306241300	1.0×10^6	4.9×10^3

Plate counts reported in colony-forming units per mL of water. Spread plate technique based on Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties, Amer. Soc. of Agronomy, Soil Science Soc. of Amer., 1982, Madison, WI chapter 37; Standard Methods for the Examination of Water and Wastes, 17th edition, AWWA, APHA, WPCF, 1989, Method 9215C.

Laurie Princiotto

Laurie A. Princiotto, Group Leader
Remediation Technology Laboratory

b:comptables.Giantref.cub

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

29 June, 1993

Mr. Tim Kinney
Giant Bloomfield Refinery
PO Box 256
Farmington, NM 87499

Dear Mr. Kinney:

Enclosed are the analytical results for the water samples received at Inter-Mountain Labs, Farmington, NM on June 24, 1993.

Tests were conducted in accordance with 40 CFR 136, "Guidelines Establishing Test Procedures for Analysis", as amended.

If you have any questions or comments concerning the analyses, please contact me at your convenience.

Sincerely,

Jeff A. Thomas
Water Quality, Farmington

cc:file

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Giant Refinery		
Sample ID:	GBR-40	Date Reported:	06/29/93
Laboratory ID:	2986	Date Sampled:	06/24/93
Sample Matrix:	Water	Time Sampled:	NA
Condition:	Cool/Intact	Date Received:	06/24/93

Parameter	Analytical Result	Units
Lab Conductivity @ 25° C	4,710	umhos/cm
Lab pH	7.28	s.u.

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Reviewed by JI

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Giant Refinery		
Sample ID:	GBR-6/RW9	Date Reported:	06/29/93
Laboratory ID:	2987	Date Sampled:	06/24/93
Sample Matrix:	Water	Time Sampled:	NA
Condition:	Cool/Intact	Date Received:	06/24/93

Parameter	Analytical Result	Units
Lab Conductivity @ 25° C	3,620	umhos/cm
Lab pH	6.99	s.u.

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Reviewed by ____

Inter-Mountain Laboratories, Inc.

2506 W. Main Street
Farmington, New Mexico 87401

Client:	Giant Refinery		
Sample ID:	GBR-41	Date Reported:	06/28/93
Laboratory ID:	2988	Date Sampled:	06/24/93
Sample Matrix:	Water	Time Sampled:	NA
Condition:	Cool/Intact	Date Received:	06/24/93

Parameter	Analytical Result	Units
Lab Conductivity @ 25° C	3,120	umhos/cm
Lab pH	7.07	s.u.

Reference: U.S.E.P.A. 600/4-79-020, "Methods for Chemical Analysis of Water and Wastes", 1983.
"Standard Methods For The Examination Of Water And Waste Water", 17th ed., 1989.

Reviewed by ____

RECEIVED

MAR 15 1991

OIL CONSERVATION DIV.
SANTA FE

File Copy

WORK PLAN
GIANT-BLOOMFIELD REFINERY

BIOREMEDIATION PILOT TEST
CONTAMINATED SOILS

March 11, 1991

Prepared for:

Giant Refining Company, Inc.
P.O. Box 256
Farmington, New Mexico 87499
(505) 632-3306

Prepared by:

GEOSCIENCE CONSULTANTS, LTD

CORPORATE OFFICE
SOUTHWEST REGIONAL OFFICE
500 Copper Avenue, NW
Suite 200
Albuquerque, New Mexico 87102
(505) 842-0001
FAX (505) 842-0595

ROCKY MOUNTAIN REGIONAL OFFICE
13111 E. Briarwood Avenue
Suite 250
Englewood, CO 80112
(303) 649-9001
FAX (303) 649-9004

EASTERN REGIONAL OFFICE
4221 Forbes Boulevard
Suite 240
Lanham, MD 20706
(301) 459-9677
FAX (301) 459-3064

TABLE OF CONTENTS

LIST OF FIGURES

Figure

LIST OF TABLES

Table

1.0 EXECUTIVE SUMMARY

Pilot test evaluation of enhanced biological degradation of contaminated subsurface soils is proposed for the Giant-Bloomfield Refinery site. Bioremediation may be a remedial technique that can cost-effectively treat contaminated soils and thereby achieve Giant-Bloomfield Refinery's long-term remedial action objectives for source removal/reduction. This work plan provides an outline of proposed work activities needed to evaluate whether or not biological degradation is indeed a feasible remedial option for the in situ treatment of hydrocarbon-contaminated soils.

In the course of the proposed work, two types of bioremediation approaches will be evaluated against a control. The first test plot will be used to evaluate the effectiveness of stimulating hydrocarbon degradation by indigenous populations by the addition of oxygenated water and nutrients. The second test plot will use a commerical microbial consortium and substrate formulation provided by MicroKey Sciences, Inc. (MicroKey) to evaluate whether or not the addition of exogenous (non-native) microorganisms results in more efficient and cost-effective remediation than merely enhancing the degradation rate of indigenous microorganisms. The third plot will receive only water applications similar in nature to that applied to the first two test plots. This third test plot will provide a control plot to serve as a baseline comparison on whether or not bioremediation results in increased hydrocarbon removal from subsurface soils. All test plots will be sampled for hydrocarbon constituents and the presence of bacterial populations.

2.0 STATEMENT OF THE PROBLEM

Hydrocarbon-contaminated soils and ground water have been detected at the Giant-Bloomfield Refinery site. Free product recovery and containment activities are in progress. In an effort to shorten the time required to remediate contaminated ground water, Giant-Bloomfield Refinery is seeking to identify means by which source reduction and/or removal can be achieved and thus minimize sources of continuing ground water contamination.

A Controlled Water Application (CWA) was initiated in October 1990 to evaluate the effects of water infiltration on mobilizing hydrocarbon constituents in contaminated soils. The goals of the CWA were to displace hydrocarbons held in the soil and drive them into the underlying ground water, where they could be recovered by the existing hydraulic recovery and containment system. Preliminary results of the CWA were encouraging in that increases in product thickness and ground-water elevation were observed in ground-water monitoring wells surrounding the application area. The results of the CWA pilot test were presented in the February 1991 report prepared by GCL and entitled "Evaluation of Controlled Water Application Pilot Test, Giant-Bloomfield Refinery.

Bioremediation harnesses the metabolic activity of microorganisms to degrade and/or transform the contaminants of concern. The effectiveness of biological remediation relies on modifying the subsurface environment to one that is conducive to microbial growth and reproduction. For the remediation of petroleum hydrocarbons, aerobic degradation processes have been demonstrated to have the most rapid degradation rates and greater ease of environmental manipulations. In addition, aerobic processes offer the potential for complete mineralization of the hydrocarbons to carbon dioxide and water, thereby destroying the contaminant and eliminating future liabilities associated with contaminant recovery from ground water.

Two bioremediation processes will be evaluated in the proposed pilot testing program at the Giant-Bloomfield Refinery: 1) enhanced bioremediation by indigenous microorganisms and 2) bioremediation using commerical microbial consortia grown in specialized substrate (provided by MicroKey). A third control plot will be evaluated to provide a baseline for comparison of hydrocarbon removal by bioremediation versus water infiltration. Details of the proposed pilot test are provided in the following sections.

3.0 TECHNICAL APPROACH

The pilot-scale evaluation of two bioremediation alternatives: 1) enhanced bioremediation using indigenous microorganisms and 2) bioremediation using commercial cultures of specialized hydrocarbon-degrading microorganisms, will be conducted in the controlled water application area of the Giant-Bloomfield Refinery. This bioremediation pilot test will be conducted under spring conditions for a total test duration of six to eight weeks (depending on sampling results). The pilot test will provide a comparative evaluation of the degradative capabilities of the indigenous microbial populations and MicroKey's commercially available microbial consortia against a control plot receiving only water applications.

Prior to the initiation of the bioremediation pilot test experiments, two soil samples will be obtained from depths of 1 to 2 feet and 3 to 4 feet (using a hand auger or backhoe) from each designated test area (three test plots of about 625 ft^2) prior to the construction of each bermed test plot. These six soils samples will be analyzed for TPH and BTEX (Modified 8015), PAHs (EPA Method 8310) and total bacteria (plate counts) to provide an evaluation of baseline conditions prior to microbial stimulation or application.

Three test plots will be constructed in the controlled water application area (south cell) as shown on figure 1. Each test plot will be approximately 25 by 25 feet in size (625 ft^2) and will be surrounded by a one-foot earthen berm to prevent runoff during nutrient or microbe applications.

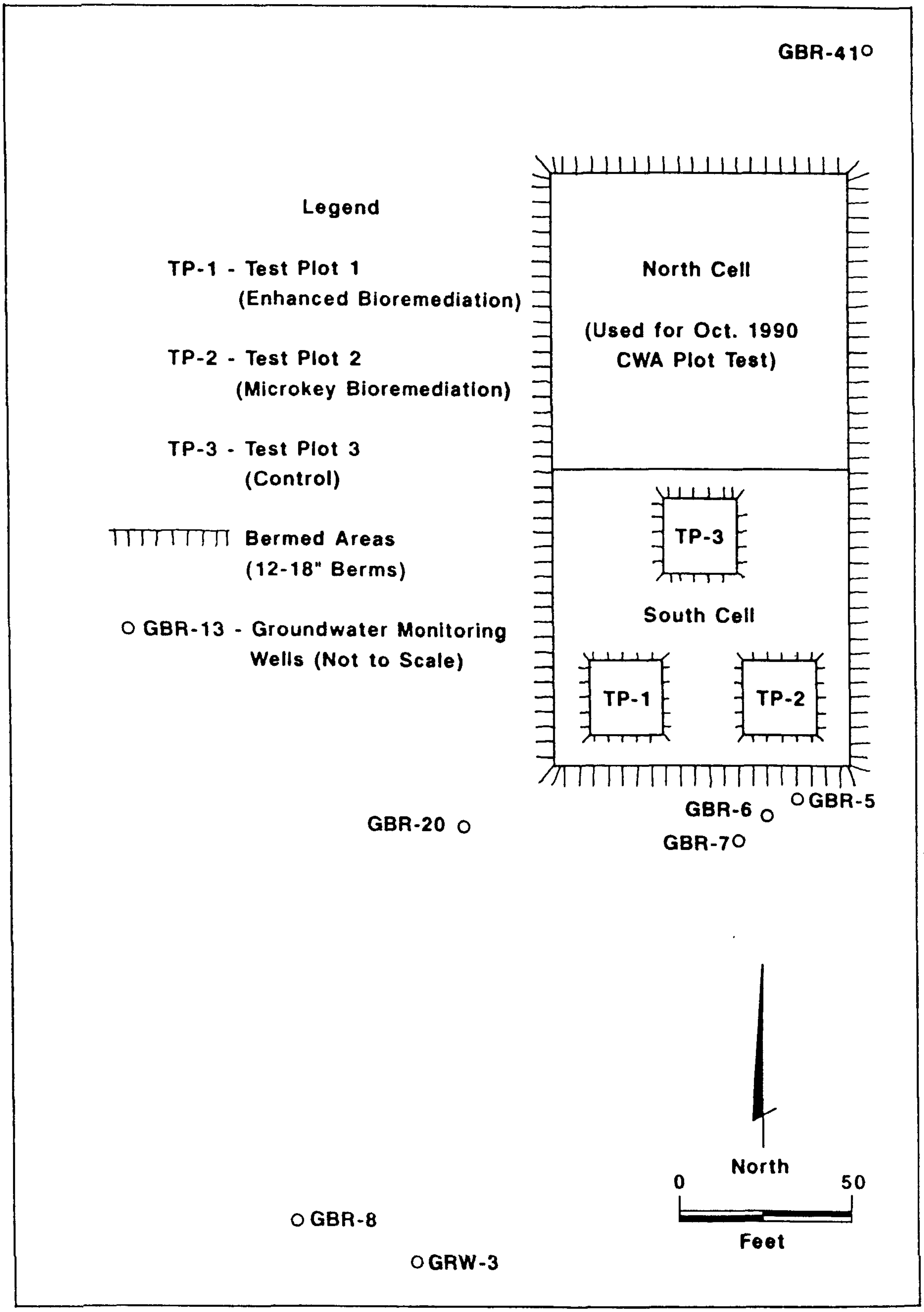
Approximately 3,000 gallons of water (air stripper effluent) should be applied to each test plot three days prior to the scheduled start of the pilot test to increase subsurface moisture content and allow the easier infiltration of applied nutrients and/or microorganisms.

For the enhanced in situ degradation plot (test plot 1), nutrients (in the form of a water-based solution of a nitrogen-phosphate fertilizer mixed with oxygenated air stripper effluent) will be added in 1,500 gallon applications at three-day intervals. The nutrient solution containing no more than 10 ppm ammonia nitrogen and 5 ppm phosphate will be applied to the test plot and allowed to infiltrate into the soil profile. Two hand-augered soil samples from depths of 1 to 2 feet and 3 to 4 feet will be obtained from the test plot at bi-weekly intervals (during dry surface conditions) for laboratory analysis of TPH, BTEX, and total bacterial populations.

MicroKey's commercial microbial consortia will be evaluated in test plot 2 using test procedures similar to that described above. Only water (no nutrients) will be applied to test plot 2 and the commercial microbe-substrate formulation will be added to the soil surface as directed by MicroKey personnel. The frequency of microbe-substrate applications will also

Figure 1

Controlled Water Application Cell
and Proposed Bioremediation Test Plots



be subject to specification by MicroKey staff. Two hand-augered soils samples will be obtained from depths of 1 to 2 feet and 3 to 4 feet at bi-weekly intervals (during dry surface conditions) for analysis of TPH, BTEX, and total bacterial populations.

The third test plot will receive only water applications using the same volume as that applied to test plots 1 and 2. Two hand-augered soils samples will be obtained from depths of 1 to 2 feet and 3 to 4 feet at bi-weekly intervals. These samples will also be analyzed for TPH, BTEX, and total bacterial populations.

Monitoring of wells adjacent to the controlled water application area will also be conducted at weekly intervals to evaluate water level fluctuations and free product thicknesses (to evaluate the effects of fluids short-circuiting and channelization), dissolved oxygen content (to evaluate the efficiency of water applications), and TDS (effects on general aqueous geochemistry). Suggested sampling and monitoring requirements are summarized in table 1. Recommended equipment is listed in table 2.

At the conclusion of the test (as determined by total TPH analyses), two soil samples from each test plot will be obtained (at depths of 1 to 2 feet and 3 to 4 feet) for confirmatory analysis of TPH, BTEX, PAHs, and total bacterial populations.

If successful, full-scale implementation of the best-performing and most cost-effective bioremediation technique may be considered as a possible adjunct to the OCD-approved controlled water applications. Appropriate modifications to the controlled water application plan pertaining to bioremediation will be submitted to NMOCD for approval, prior to full-scale implementation.

Table 1

Summary Of Sampling And Monitoring Requirements
Bioremediation Pilot Test

SAMPLES FOR LABORATORY ANALYSES:

Sample Type	Sample Location	TPH & BTEX (Mod. 8015)	PAHs (8310)	Total Bacteria (Plating)	HC Degraders (Plating)
Baseline					
	Test Plot 1	2	1	2	1
	Test Plot 2	2	1	2	1
	Test Plot 3	2	1	2	1
Week 2					
	Test Plot 1	2		2	
	Test Plot 2	2		2	
	Test Plot 3	2		2	
Week 4					
	Test Plot 1	2		2	
	Test Plot 2	2		2	
	Test Plot 3	2		2	
Week 6					
	Test Plot 1	2		2	
	Test Plot 2	2		2	
	Test Plot 3	2		2	
Week 8					
	Test Plot 1	2		2	
	Test Plot 2	2		2	
	Test Plot 3	2		2	
Confirmatory					
	Test Plot 1	2	1	2	1
	Test Plot 2	2	1	2	1
	Test Plot 3	2	1	2	1
TOTAL SAMPLES:		36	6	36	6

Notes: TPH = Total Petroleum Hydrocarbons
BTEX = Benzene, Toluene, Ethylbenzene, and Xylenes
PAHs = Polynuclear Aromatic Hydrocarbons
HC = Hydrocarbons
( ) = Analytical Method

Table 1

Summary Of Sampling And Monitoring Requirements
Bioremediation Pilot Test

WEEKLY GROUND WATER MONITORING:

Monitoring Well Number	Ground-water Elevation (ft)	Free Product Thickness (ft)	pH (Units)	Temperature (oC)	Specific Conductance (umhos/cm)	Dissolved Oxygen (ppm)
GBR-6	X	X	X	X	X	X
GBR-41	X	X	X	X	X	X
GBR-20	X	X	X	X	X	X
GWR-3	X	X	X	X	X	X
GBR-5	X	X				
GBR-7	X	X				
GBR-8	X	X				
GBR-13	X	X				

NOTE: pH, Temperature, Specific Conductance, and Dissolved Oxygen will be measured with field instrumentation only.

Table 2

Equipment Needed For Bioremediation Pilot Test

Site Preparation

- Hand Auger and Stainless Steel Trowel/Spoon (soil sampling)
- Sample Jars, Labels, Shipping Containers, Ice, C of C forms, etc. .
- Stakes and Flagging (designate two 625 ft^2 test plots)
- Backhoe (berm construction and/or soil sampling)

Pilot Test

- Water from air stripper effluent (on demand)
- Application hoses (from mixing tank and from air stripper effluent piping)
- pH/EC/Temperature meter
- Dissolved Oxygen meter
- Sampling Equipment (as listed in Site Preparation)

4.0 SCHEDULE AND COSTS

The proposed schedule for the bioremediation test is shown on figure 2. As shown on the schedule, the duration of field site activities is anticipated to last approximately 10 weeks from the time baseline soil samples are collected and the test plots are prepared until the time that final confirmatory samples are collected. Projected analytical laboratory turnaround is two weeks from the time samples are delivered to the time results are provided to GCL. Following receipt of all analytical results, GCL will prepare a report summarizing test results. The total bioremediation pilot test duration is anticipated to last 14 to 16 weeks.

The bioremediation pilot testing program outlined herein will be conducted on a shared-cost basis between Giant-Bloomfield Refinery, GCL, Microkey, and New Mexico State University. Giant-Bloomfield Refinery will prepare the test plots, perform water/nutrient/microbe applications, and perform sampling activities. GCL will provide oversight and guidance to Giant-Bloomfield Refinery during the initial phases of the bioremediation pilot test. Following receipt of analytical data, GCL will evaluate the results of the test and prepare a written summary report. MicroKey will provide their commercial bacterial cultures and instructions on how best to apply their formulation. NMSU will provide analytical laboratory support.

Figure 2
Bioremediation Pilot Test Schedule

TASK	APRIL Week: 1	2	MAY 3	4	5	6	JUNE 7	8	9	10	JULY 11	12	13	14	AUGUST 15	16
BASELINE SAMPLING	GCL/G															
TEST PLOT PREPARATION	GCL/G															
INITIAL WATER APPLICATION	GCL/G															
NUTRIENT FORMULATION		GCL/M	G	G	G	G	G	G	G							
NUTRIENT/MICROBE APPLICATIONS		GCL/G/M	G	G	G	G	G	G	G							
SAMPLING/GROUNDWATER MONITORING		G	G	G	G	G	G	G	G							
CONFIRMATORY SAMPLING										G						
LABORATORY ANALYSES			N	N	N	N	N	N	N	N	N	N				
DATA EVALUATION							GCL	GCL	GCL	GCL	GCL					
DRAFT REPORT											GCL	GCL	GCL			
GIANT/MICROKEY REVIEW														G/M	G/M	
FINAL REPORT															GCL	GCL

ABBREVIATIONS:

G = Giant Industries
GCL = Gesocience Consultants, Ltd.
M = MicroKey Sciences, Inc.
N = New Mexico State University

File Copy

EVALUATION OF CONTROLLED WATER APPLICATION PILOT TEST GIANT BLOOMFIELD REFINERY

RECEIVED

FEB 27 1991

OIL CONSERVATION DIV.
SANTA FE

February 21, 1991

Prepared for:

GIANT REFINING COMPANY
P.O. Box 256
Farmington, New Mexico 87499

Prepared by:

GEOSCIENCE CONSULTANTS, LTD

CORPORATE OFFICE
SOUTHWEST REGIONAL OFFICE
500 Copper Avenue, NW
Suite 200
Albuquerque, New Mexico 87102
(505) 842-0001
FAX (505) 842-0595

ROCKY MOUNTAIN REGIONAL OFFICE
13111 E. Briarwood Avenue
Suite 250
Englewood, CO 80112
(303) 649-9001
FAX (303) 649-9004

EASTERN REGIONAL OFFICE
4221 Forbes Boulevard
Suite 240
Lanham, MD 20706
(301) 459-9677
FAX (301) 459-3064

Table of Contents

List of Figures

Figure

List of Tables

Table

List of Appendices

Appendix

1.0 Executive Summary

In October 1990, Giant Industries, Inc. (Giant) initiated a pilot test to evaluate the effectiveness of controlled water application as a means of remediating soils impacted by hydrocarbons at their Bloomfield Refinery (GBR). Ground water, treated by air stripping to meet the standards specified in Giant's 1988 Discharge Plan, was applied to a bermed area (approximately 10,450 ft^2) at weekly intervals, in three, three-day stages (approximately 80,000 gallons per stage), for a total applied water volume of about 250,600 gallons. Measurements of depth to ground water, depth to free product, free product thickness, and specific conductance were obtained from a network of monitoring wells near the controlled flood test area. Wells with a measured hydraulic response and a 20% or greater increase in specific conductance were sampled for pH, total dissolved solids, and major ions.

Results of the controlled water application pilot test suggest that controlled water application is a viable technique for enhancing the accumulation of free product in recovery wells. Free product thicknesses increased up to 6.5 feet in wells immediately adjacent to the water applicationed areas. Where hydrocarbon thicknesses were sustained by the controlled water application (i.e., a critical hydrocarbon height was not exceeded), maximum free product thicknesses in the recovery wells remained stable for several weeks after the cessation of controlled water application. It is anticipated that full-scale operations in various locations at the refinery could be implemented since hydraulic control is achieved by the existing free product and ground-water recovery system, and the effective radius of controlled water application impacts can be estimated from field-monitored parameters.

2.0 Purpose and Scope

Giant is remediating hydrocarbon-contaminated soils and ground water at the Giant Bloomfield Refinery near Farmington, New Mexico. The hydrogeologic conditions at this site have been described in previous reports prepared by Geoscience Consultants, Limited (GCL); some of the pertinent investigations are listed below:

- Geoscience Consultants, Limited, 1986, Preliminary Report on Ground Water Investigation for Giant Industries, Inc.
- Geoscience Consultants, Limited, 1987, Soil and Ground Water Investigation and Remedial Action Plan

Ongoing remedial activities at the Giant-Bloomfield Refinery include free product recovery and hydraulic containment. Hydrocarbon contaminated ground water is collected from a network of recovery wells and air stripped. The treated effluent is discharged to an up-gradient infiltration gallery.

To enhance the rate of hydrocarbon removal from the subsurface, Giant submitted an amendment to its 1988 Discharge Plan to the New Mexico Oil Conservation Division (NMOCD). The amendment was submitted to NMOCD in October 1989 and approved, with revisions in April 1990. The amendment proposed the use of controlled water application as a means of remediating petroleum contaminated soil. Controlled water application consists of applying treated ground water to a bermed area of land which overlies soils that contain hydrocarbons. Water infiltrating into the soil profile displaces the mobile free-phase hydrocarbons, thereby increasing the accumulation of free product at the ground-water surface. Free product is recovered using recovery wells. The existing network of free product recovery wells provides ground-water capture and site-wide hydraulic control. All ground water recovered from the recovery wells is treated by air stripping prior to discharge to the infiltration galleries, thereby creating a closed recirculation cell. Giant initiated controlled water application in October 1990 as discussed in the following sections.

3.0 Controlled Water Application Methodology

Following verbal notification of NMOCD staff, Giant initiated controlled water application in October 1990, in accordance with the procedures outlined in the 1989 *Plan for Controlled Application of Water to Remediate Hydrocarbons in the Soil at the Giant-Bloomfield Refinery.*

The application site in the Southern Refinery Area was delineated and berms were constructed to create two cells of 95 feet by 110 feet (total surface area of 20,900 square feet) as shown on figure 1. Each cell was disked and graded to provide a level application surface and facilitate water infiltration into the soil profile. The berms prevent runoff of applied water.

Prior to initiating the first water applications, GCL sampled monitor wells (see figure 1 for well locations) to determine the depth to ground water, free product thickness, and specific conductance. Monitoring wells GBR-41, GBR-20, and GBR-6 were also sampled for total dissolved solids (TDS), major ions, and specific conductance. Air stripper effluent was also sampled prior to the start of the controlled water application. Analytes for air stripper effluent included halogenated volatile organic compounds (EPA 601), aromatic volatile organic compounds (EPA 602), total dissolved solids, major ions, and specific conductance.

The controlled water application pilot test was initiated in the north cell (see figure 1). The first water application was started on October 10, 1990. As stated in table 1, approximately 85,000 gallons (or about 6.5 inches of water) were applied to the north cell. Hydraulic response was monitored (as summarized in table 2) to evaluate the effects of controlled water application on free product thickness and the water table elevation. Parameters measured in the observation wells shown on figure 1 included depth to ground water and depth to free product.

Successive applications of treated water were initiated as air stripper effluent was processed. A total of three water applications of 6.48, 6.72, and 6 inches were performed on October 9-12, October 16-18, and October 23 and 24, 1990. A total of 250,565 gallons of treated ground water was applied to the north cell (or about 1.60 feet of water).

Figure 1

Map Of Controlled Water Application Test Area

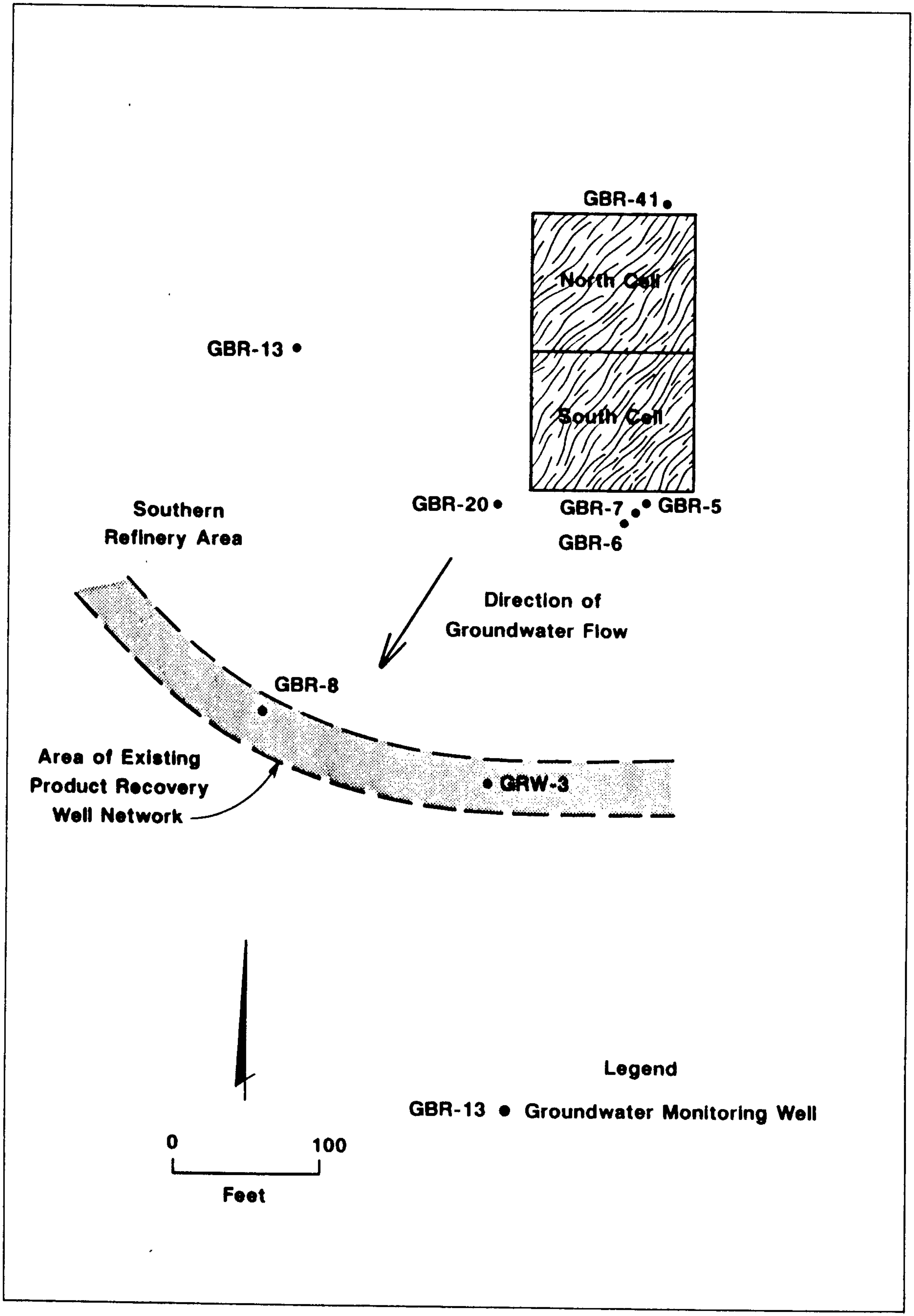


Table 1

Controlled Water Application Record

Date	Action (ON/OFF)	Discharge Meter Reading (bbl)	Volume Applied (gal)	Total Volume Applied (gal)
10/9/90	ON	101-22817.58		
10/10/90	ON	101-24011.52	50,145	50,145
10/11/90	ON	101-24824.72	34,154	84,299
10/12/90	ON	101-24844.22	819	85,118
10/13/90	OFF	101-24844.22		85,118
10/14/90	OFF	101-24844.72		85,118
10/14/90	OFF	101-24844.72		85,118
10/16/90	ON	101-26061.29	51,117	136,235
10/17/90	ON	101-26924.72	36,264	172,499
10/18/90	ON	101-26929.33	194	172,693
10/19/90	OFF	101-26929.33		172,693
10/20/90	OFF	101-26929.33		172,693
10/21/90	OFF	101-26929.33		172.693
10/22/90	OFF	101-26929.33		172,693
10/23/90	ON	101-27982.77	44,244	216,937
10/24/90	ON	101-28783.43	33,628	250,565
10/25/90	OFF	101-28783.43		250,565

On – Water source on
Off – Water source off

Table 2

Ground-Water Monitoring Data

Well	DATE / Time	10/09/90	10/10/90	10/11/90 AM	10/11/90 3:30 PM	10/12/90 8:30 AM	10/12/90 3:30 PM	10/15/90	10/16/90 10:00 AM	10/16/90 3:45 PM	10/17/90 8:30 AM	10/17/90 3:30 PM	10/18/90 8:30 AM	10/18/90 3:30 AM
GBR 5	DTW	36.90	39.10	39.19	39.22	39.28	39.42	40.07	42.60	40.55	40.75	40.83	41.20	41.21
	DTP	33.60	33.98	32.87	32.85	32.83	32.83	32.77	32.80	32.77	32.79	32.78	32.81	32.78
	PT	3.30	5.12	6.32	6.37	6.45	6.59	7.30	9.80	7.78	7.96	8.05	8.39	8.43
GBR 6	DTW	40.02	40.78	40.25	40.25	40.24	40.16	40.06	40.68	40.44	40.47	40.48	40.55	40.40
	DTP	40.02	40.78	40.25	40.25	40.24	40.16	40.06	40.68	40.44	40.47	40.48	40.55	40.40
	PT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GBR 7	DTW	35.65	35.51	35.60	35.50	35.45	35.43	35.50	35.55	35.54	35.56	35.53	35.53	35.46
	DTP	34.34	34.41	34.64	34.61	34.58	34.54	34.56	34.59	34.57	34.62	34.57	34.58	34.52
	PT	1.31	1.10	0.96	0.89	0.87	0.89	0.94	0.96	0.97	0.94	0.96	0.95	0.94
GBR 8	DTW	45.00	44.18	44.26	44.25	44.23	44.28	44.57	44.65	44.65	44.71	44.73	44.82	44.88
	DTP	43.40	43.70	43.65	43.65	43.67	43.64	43.61	43.61	43.60	43.63	43.61	43.60	43.59
	PT	1.60	0.48	0.61	0.60	0.56	0.64	0.96	1.04	1.05	1.08	1.12	1.22	1.29
GBR 13	DTW	43.20	43.00	42.07	42.62	42.84	42.99	43.17	43.17	43.17	43.18	43.12	43.20	43.20
	DTP	41.64	41.78	41.73	41.74	41.75	41.78	41.72	41.70	41.69	41.70	41.69	41.72	41.70
	PT	1.56	1.22	0.34	0.88	1.09	1.21	1.45	1.47	1.48	1.48	1.43	1.48	1.50
GBR 20	DTW	41.60	39.95	40.81	40.84	40.89	40.84	40.81	40.86	40.72	40.88	40.93	41.04	40.93
	DTP	*	*	*	*	*	*	*	*	*	*	*	*	*
	PT	*	*	*	*	*	*	*	*	*	*	*	*	*
GBR 41	DTW	29.25	29.24	29.24	29.24	29.24	29.24	27.92	27.60	27.53	27.42	27.23	26.56	26.10
	DTP	*	*	*	*	*	*	*	*	*	*	*	*	*
	PT	*	*	*	*	*	*	*	*	*	*	*	*	*

Well	DATE / Time	10/19/90 9:30 AM	10/19/90 3:10 PM	10/22/90 11:00 AM	10/23/90 3:00 PM	10/25/90 11:00 AM	10/31/90	11/02/90	11/05/90	11/07/90	11/09/90	11/19/90	11/21/90
GBR 5	DTW	41.14	41.12	41.93	42.08	42.43	42.29	40.08	35.15	33.95	33.78	33.25	33.23
	DTP	32.72	32.70	32.71	32.68	32.66	32.40	32.23	32.04	31.58	31.41	30.91	30.88
	PT	8.42	8.42	9.22	9.40	9.77	9.89	7.85	3.11	2.37	2.37	2.34	2.35
GBR 6	DTW	40.13	39.98	40.26	40.23	40.33	40.60	40.04	40.01	39.73	39.73	39.40	39.63
	DTP	40.13	39.98	40.26	40.23	40.33	40.60	40.04	40.01	39.73	39.73	39.40	39.63
	PT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
GBR 7	DTW	35.42	35.54	35.46	35.42	35.42	35.35	35.12	34.88	34.77	34.69	34.34	34.34
	DTP	34.48	34.46	34.50	34.46	34.47	34.26	34.02	33.79	33.68	33.60	33.25	33.26
	PT	0.94	1.08	0.96	0.96	0.95	1.09	1.10	1.09	1.09	1.09	1.09	1.08
GBR 8	DTW	44.90	44.88	45.11	45.15	45.22	45.36	45.47	45.54	45.53	45.43	45.63	45.62
	DTP	43.60	43.58	43.56	43.55	43.54	43.35	43.54	43.55	43.55	43.55	43.56	43.63
	PT	1.30	1.30	1.55	1.60	1.68	2.01	1.93	1.99	1.98	1.88	2.07	1.99
GBR 13	DTW	43.23	43.23	43.28	43.29	43.31	43.35	43.40	43.49	43.53	43.57	43.45	43.48
	DTP	41.71	41.71	41.74	41.75	41.76	41.82	41.83	41.88	41.90	41.91	41.96	41.95
	PT	1.52	1.52	1.54	1.54	1.55	1.53	1.57	1.61	1.63	1.66	1.49	1.53
GBR 20	DTW	40.73	40.57	40.96	40.72	41.04	40.95	40.70	40.88	40.88	41.05	40.59	40.74
	DTP	*	*	*	*	*	*	*	*	*	*	*	*
	PT	*	*	*	*	*	*	*	*	*	*	*	*
GBR 41	DTW	26.25	25.03	24.87	25.09	24.24	23.94	24.42	24.98	25.27	25.53	26.20	26.32
	DTP	*	*	*	*	*	*	*	*	*	*	*	*
	PT	*	*	*	*	*	*	*	*	*	*	*	*

DTW = Depth-to-ground water
DTP = Depth-to-free product
PT = Free product thickness
* No free product present

Free product increase in GBR-5, 8 only

0348/CFARPTD

Monitoring modifications to the 1989 controlled water application plan were made on October 12, 1990, and approved by NMOCD (as verified by the NMOCD letter dated October 17, 1990).

Because ground-water sampling procedures disturb free product thickness (the parameter of interest in measuring the effectiveness of the controlled water application), ground-water sampling was modified as follows:

- Monitor wells GBR-41, GBR-20, GBR-6, and GRW-3 were sampled for specific conductance based on the observed hydraulic response.

- Monitor wells GBR-41, GBR-20, GBR-5, GBR-6, GBR-7, GBR-8, and GBR-13 were monitored for depth to water and free product thickness.

These proposed changes enabled Giant to distinguish hydraulic responses due to the controlled water application from those caused by sampling disturbances.

Additional water applications were not recommended for November 1990 due to the onset of cold weather and the potential freezing of applied water. However, ground-water elevation, free product thickness, and specific conductance measurements were periodically obtained from the monitoring well network through November 21, 1990, to evaluate the hydraulic response to the controlled water application. The results of the controlled water application pilot test are presented in section 4.0.

4.0 Results

A summary of the volume of water applied during the controlled water application pilot test is provided in table 1. Three successive applications of water were made at approximately weekly intervals. Water application timing was controlled by the frequency of batch processing of recovered ground water in the on-site air stripper. The water applications lasted slightly over two days in length; approximately six inches of water was applied to the north cell during each application stage. A total of 250,565 gallons of water (or 1.60 feet) was applied during the three-week controlled water application pilot test.

The results of monitor well measurements for depth to ground water, depth to free product, and free product thickness are presented in table 2. While water applications were terminated on October 24, 1990, ground-water monitoring was extended to November 21, 1990, to evaluate aquifer response in the absence of further water application.

The results of water quality analyses for specific conductance are summarized in table 3. Supporting laboratory analyses for pH, specific conductance, TDS, alkalinity, acidity, hardness, sodium adsorption ratio (SAR), and major anions and cations are provided in appendix A.

Results of the controlled water application pilot test are discussed in section 5.0.

Table 3

Specific Conductance Monitoring Results

Well	Date Sampled	Specific Conductance (μmhos/cm)	Average[1] (μmhos/cm)	Standard Deviation[1] (μmhos/cm)
GBR-6	10/09/90	4700*		
		4030	4060	±22.8
	10/15/90	4085		
	10/29/90	4066		
GBR-41	10/09/90	5130*		
		4620		
	10/15/90	4710	5612	±968
	10/29/90	6280		
	11/02/90	6840		
GBR-20	10/09/90	4240*		
		3120		
	10/15/90	3226	3209	±66
	10/29/90	3281		
GBR-5	10/09/90	4970*		
		NM	NA	NA
GBR-7	10/09/90	3700*		
		NM	NA	NA
GBR-8	10/09/90	5090*		
		NM	NA	NA
GBR-13	10/09/90	5580*		
		NM	NA	NA
Background Well				
GRW-3	10/09/90	NM		
	10/04/90	3970	4128	±112
	10/15/90	4197		
	10/29/90			

[1]Calculated from lab values only
*Field-measured specific conductance
NM - Not measured
NA - Not applicable

5.0 Discussion

5.1 Hydraulic Response to Controlled Water Application

The magnitude of response to controlled water application measured in ground-water monitor wells is, as expected, a function of distance from the water applicationed cell. Hydraulic responses were observed in the four monitor wells closest to the north cell (GBR-41, GBR-5, GBR-6, and GBR-7). Changes in free product thickness attributed to controlled water application were observed in monitor wells GBR-5 and GBR-7. Free product response in monitor well GBR-13 is not readily distinguished from the re-equilibration process following an unidentified decrease in free product thickness on October 11, 1990. Monitor well GBR-20 did not show any readily discernible response to the controlled water application. Monitor well GBR-8 showed a measurable increase in free product thickness; however, due to the location of this well, the increase in free product was probably attributable to nearby recovery well operations and not the controlled water application. Table 4 summarizes the hydraulic responses observed during the controlled water application test.

Figures 2 through 8 show the ground-water and free product elevations and free product thicknesses as they change with time. Controlled water application applications were performed as follows:

- Stage I = 85,118 gallons, October 10-12, 1990
- Stage II = 87,575 gallons, October 16-18, 1990
- Stage III = 77,872 gallons, October 23-24, 1990

As shown on figure 2, a noticeable increase in ground-water elevation was observed in monitor well GBR-41 in response to the successive stages of water application. A net increase of 5.30 feet was observed over the duration of the controlled water application test. Incremental increases of 0.85 to 1.32 feet were observed at a lag time of approximately two to three days from the start of a water application stage, suggesting that noticeable infiltration of water had occurred within a very short lag time. The maximum effects of the total applied water were observed at day 22, approximately one week after the end of the water applications. The resulting 5.3-foot ground-water mound dissipated by 45%, 21 days after the peak ground-water mound height was achieved. The slow rate of mound

Figure 2

GBR-41 Hydraulic Response vs. Time

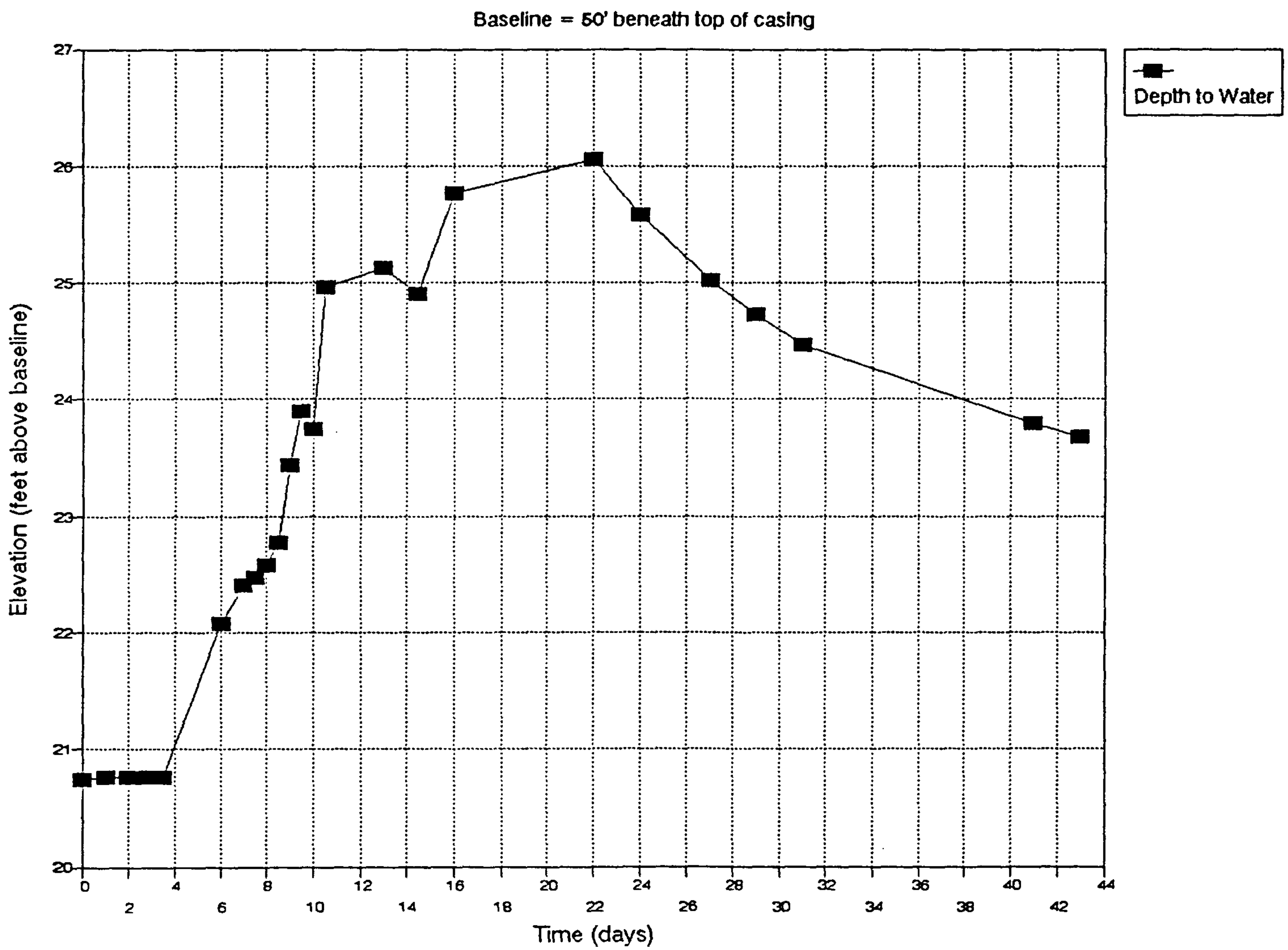


Figure 3

GBR-5 Hydraulic Response vs. Time

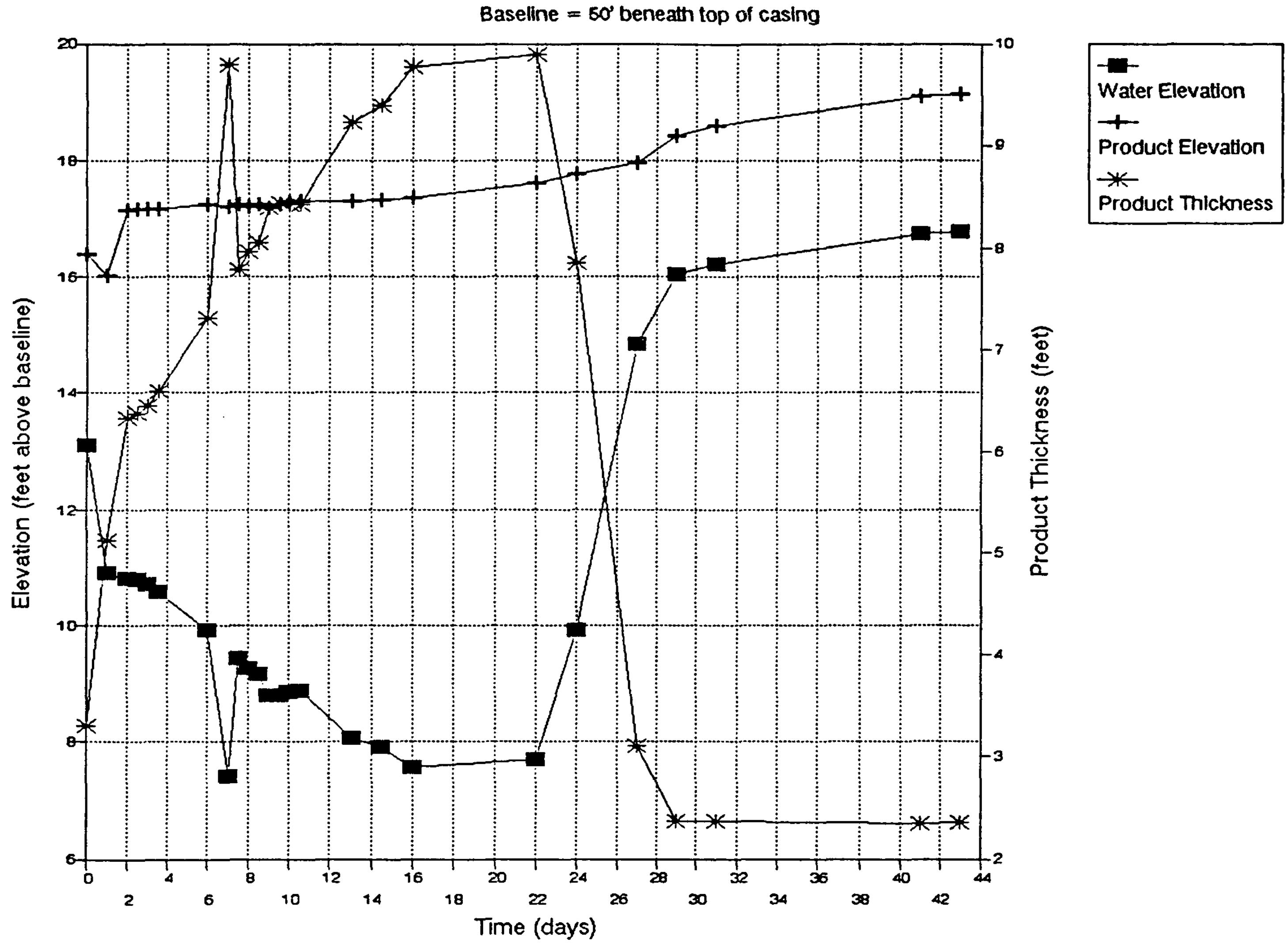


Figure 4

GBR-6 Hydraulic Response vs. Time

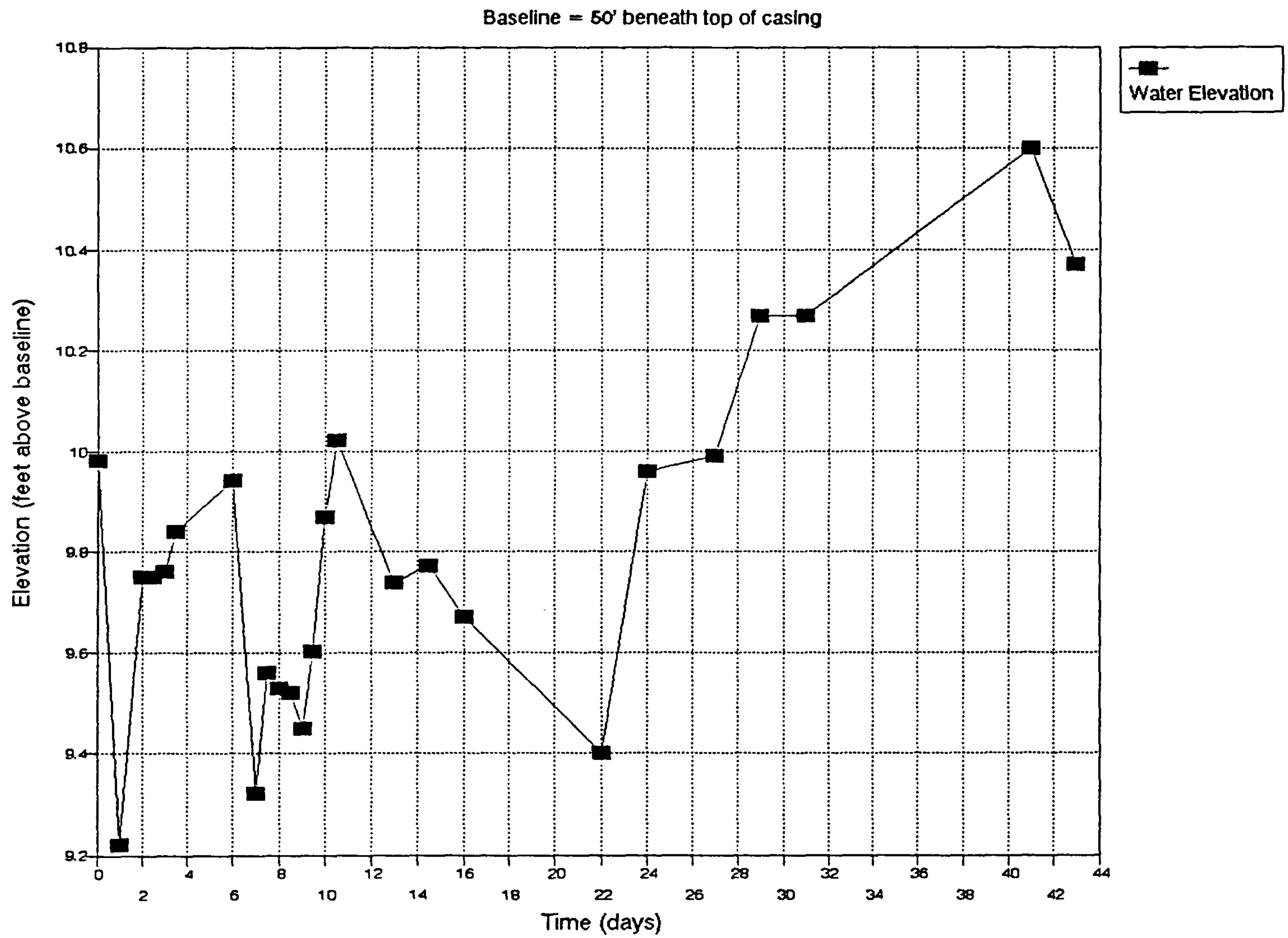


Figure 5

GBR-7 Hydraulic Response vs. Time

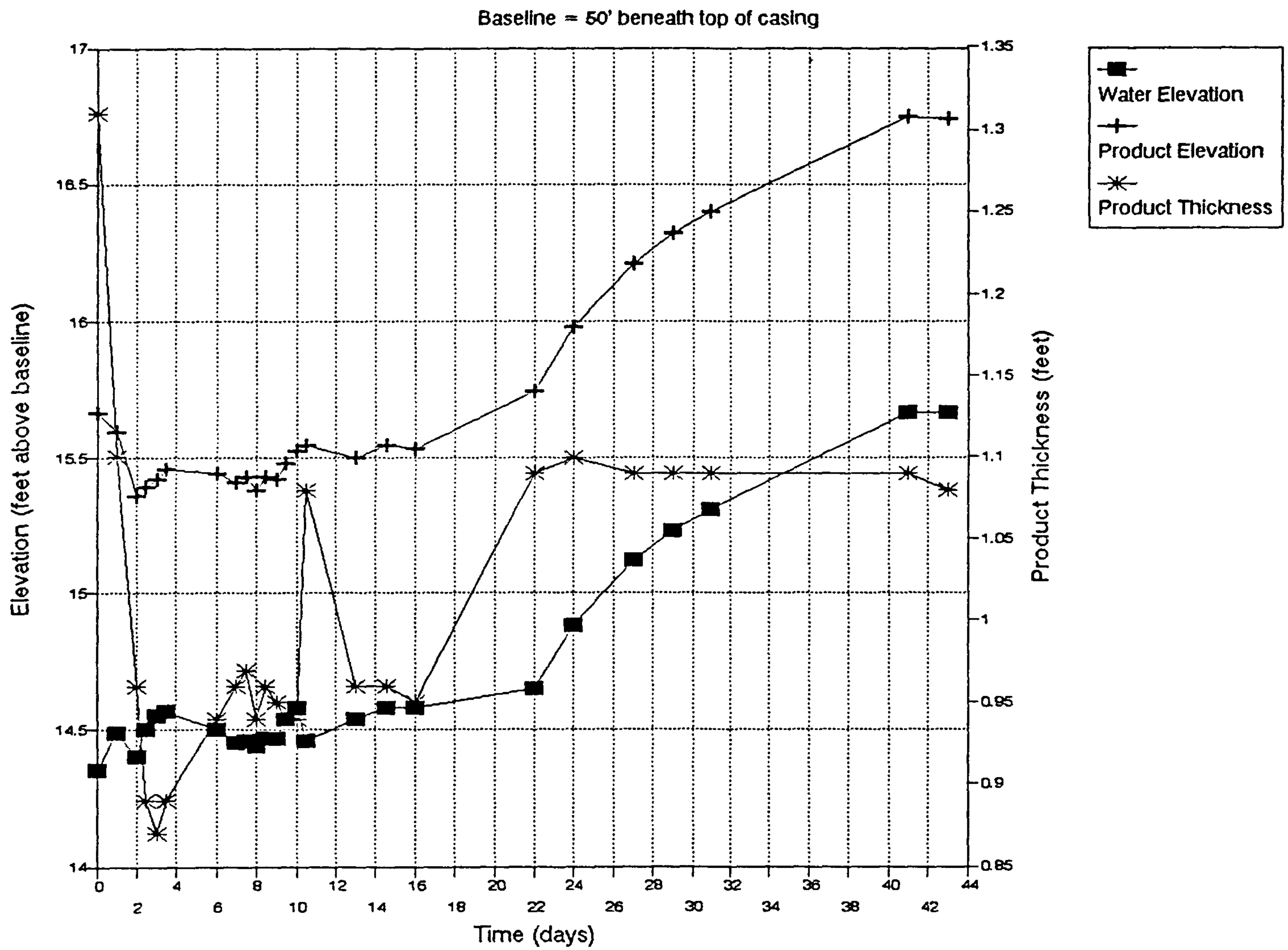


Figure 6

GBR-13 Hydraulic Response vs. Time

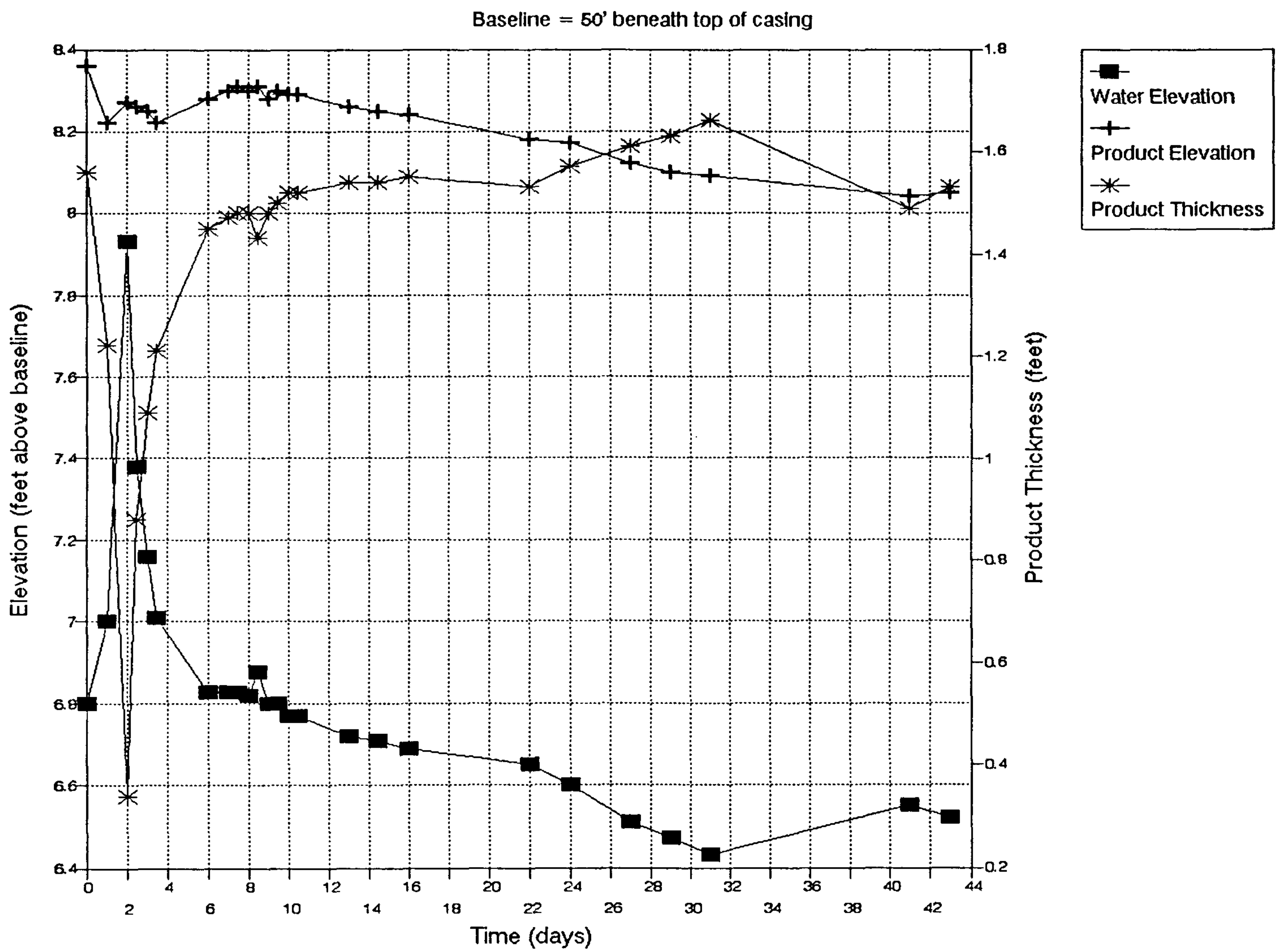


Figure 7

GBR-8 Hydraulic Response vs. Time

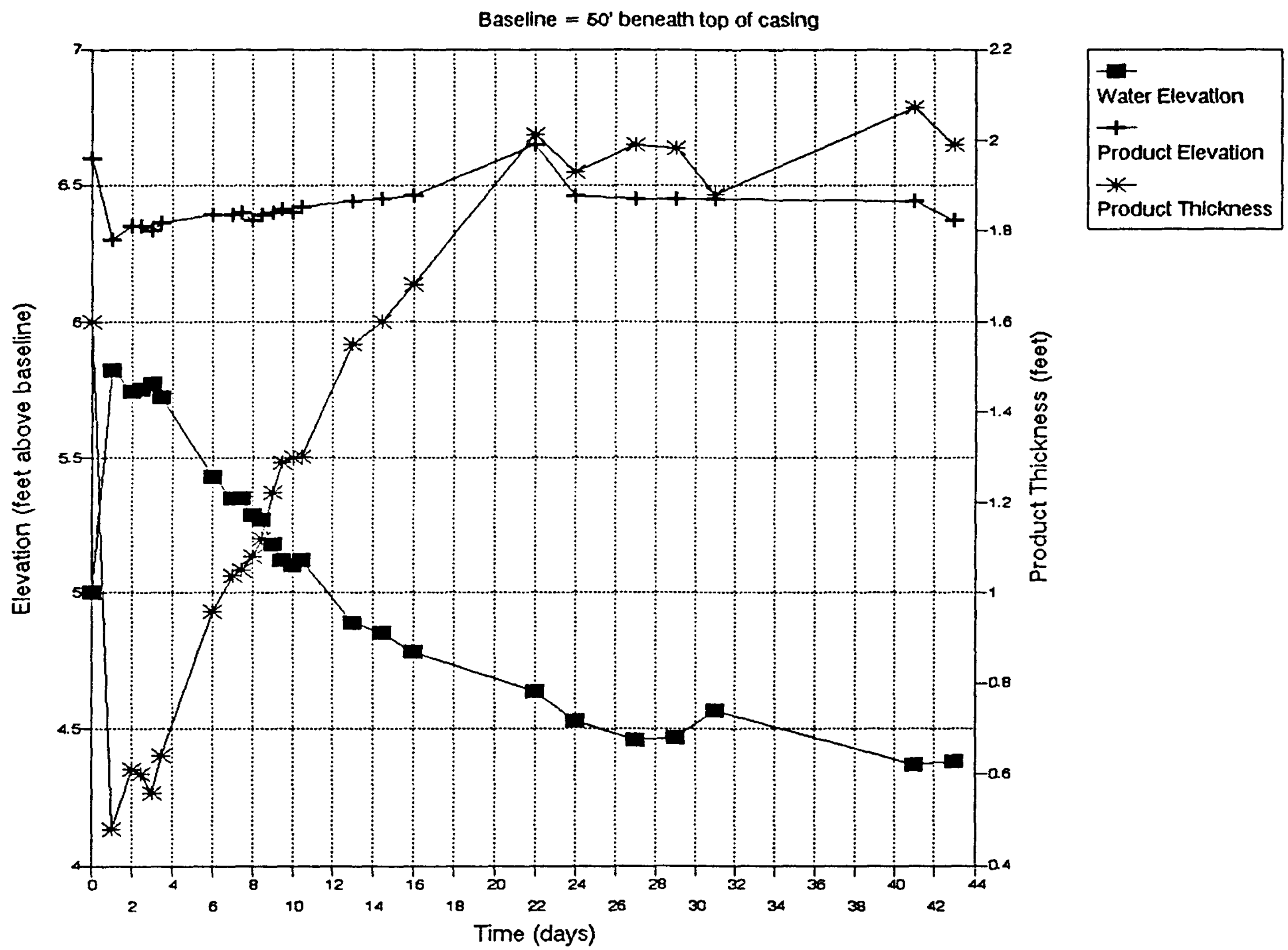


Figure 8

GBR-20 Hydraulic Response vs. Time

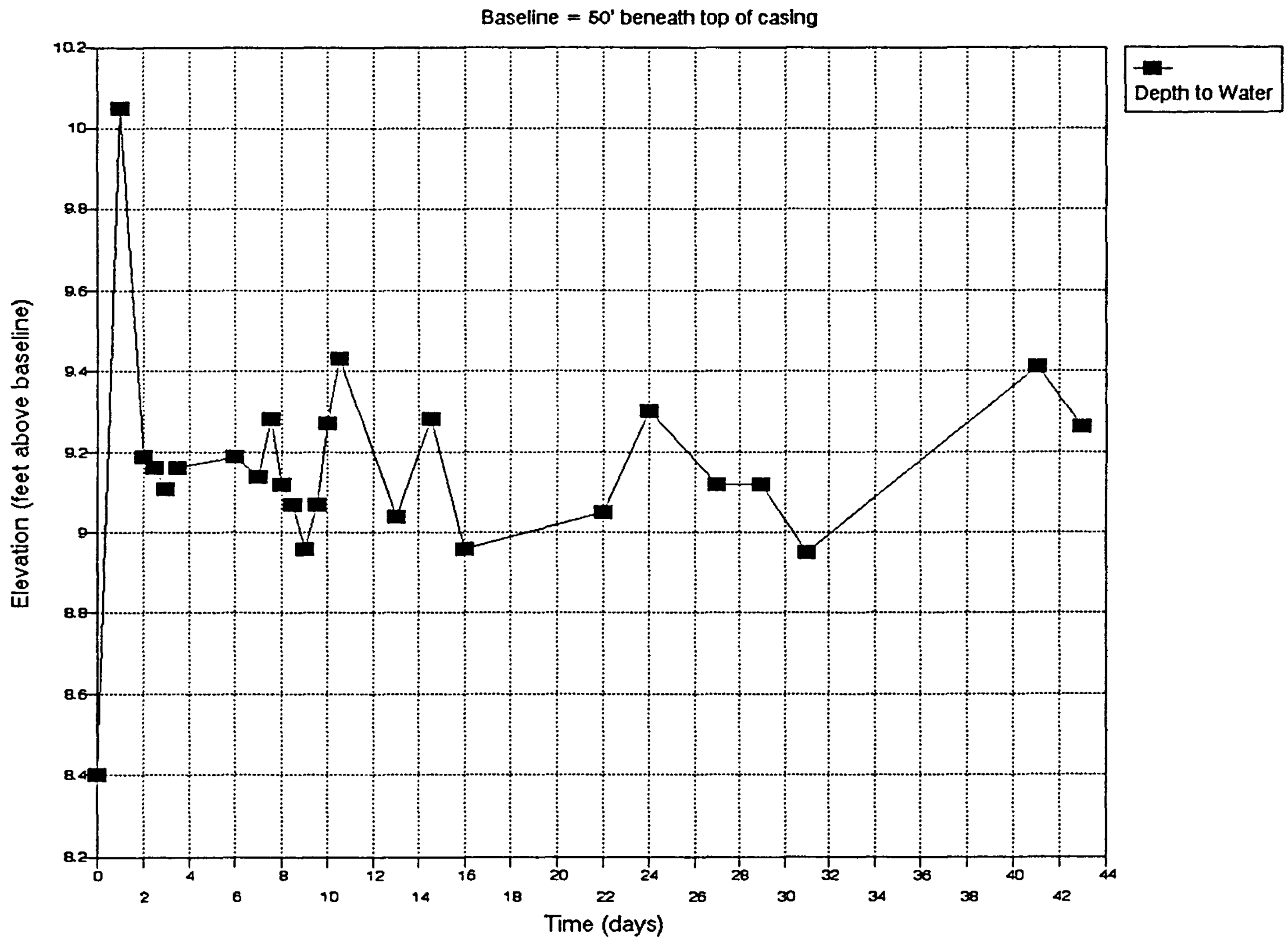


Table 4

Controlled Water Application Hydrogeologic Response Summary

Monitor Well Number	Distance From Cell Boundary (feet)	Hydraulic Response	Lag Time (days)	Free Product Response	Lag Time (days)
GBR-41	10	Yes	2	NA	NA
GBR-5	105	Yes	ND	Yes	3
GBR-7	110	Yes	2	Yes	3
GBR-6	117	Yes	2	NA	NA
GBR-20	108	Yes	**	No	NA
GBR-13	163	No	NA	No	NA
GBR-8	308	No	NA	Yes	*
GRW-3	300	NM	NM	NM	NM

*May be related to product recovery activities in this area, and not to the controlled water application

**Hydraulic response was inferred based on increasing TDS with time and not on hydrographs

NM = Not Measured

dissipation is attributed to the relatively low hydraulic conductivity of subsurface materials beneath the site. The hydraulic response observed in monitor well GBR-41 is a clear indicator that the hydrogeologic environment was affected by the controlled water application activities. Changes in TDS concentration were also observed in GBR-41; the significance of these changes is discussed in section 5.2.

Monitor wells GBR-5, GBR-6, and GBR-7 are situated approximately 12 feet from one another. This well cluster is approximately 110 feet south of the north cell. Hydrographs of ground-water and free product thickness versus time are shown on figures 3, 4, and 5 for wells GBR-5, GBR-6, and GBR-7, respectively. Prior to the initiation of controlled water application, both GBR-5 and GBR-7 had measurable free product thicknesses of 3.30 and 1.31 feet, respectively. It should be noted that GBR-6 was purged of three casing volumes of water and sampled for pH, specific conductance, TDS, acidity, alkalinity, sodium adsorption ratio, and major ions (see appendix A) on October 9, 1990. The effects of controlled water application on free product thickness were most apparent in monitor wells GBR-5 and GBR-7 (see figures 3 and 5).

GBR-5 showed the most dramatic increases in free product thickness, with an increase from 3.3 feet to a maximum thickness of 9.89 feet of free product seven days after the water applications ceased (see figure 3). However, this maximum free product thickness could not be sustained without the hydraulic driving forces of the controlled water application, and the weight of the free hydrocarbon column redistributed itself after 22 days to a free product thickness in the well at day 42 of 2.35 feet. It is believed that continued hydraulic water application would have sustained the 9.89-foot hydrocarbon column over a longer time period.

Monitor well GBR-7 had an initial free product thickness of 1.31 feet (see figure 5); however, following purging activities associated with water quality sampling in GBR-6, the free product thickness decreased to 0.87 feet by October 12, 1990 (day 3 on figure 7). However, incremental thicknesses increased steadily in GBR-7, with a lag time of about three days from the start of each stage of water application. A total post-purge increase in free product thickness of 0.23 feet was achieved in well GBR-7. The maximum free product thickness of about 1.10 feet was sustained over a three-week period following the cessation of water applications. Thus, it appears that if the hydrocarbon thickness is of a sub-critical height, the free product thickness will remain stable with time.

The effects of the controlled water application on ground-water elevation are also apparent in monitor well GBR-6 (see figure 4). In addition to ground-water elevation monitoring, samples for water quality analyses were also obtained on the following dates: October 9, 1990, October 15, 1990, and October 29, 1990. The hydrographs clearly show the decreases in water level resulting from purging activities and the relatively quick rate of hydraulic recovery. It should also be noted that ground-water elevations increase progressively with time despite the withdrawal of water for purging and sampling. A net increase in ground-water elevation of about 0.62 feet was observed over the test duration. The effects of the controlled water application peaked almost 26 days after the last water application stage was completed. The increasing distance from the water applicationed area appears to result in slightly longer ground-water mound propagation/dissipation times and a longer peak ground-water elevation response time.

The effects of the controlled water application on ground-water elevation and free product thickness in monitor well GBR-13 were not readily apparent (see figure 6). The cause of the increase in ground-water elevation and associated decrease in free product thickness on October 11, 1990, is not known, but may be attributed to ground-water recovery activities in the vicinity of this well. Free product thicknesses were slow to recover from the decrease (eleven-day recovery period). Following this recovery period, a net increase in free product thickness was observed over the next eighteen days. It is not apparent that this increase in free product thickness was directly related to the controlled water application, but it may instead be the result of free phase hydrocarbon redistribution as a result of increasing hydrocarbon thicknesses in areas closer to the controlled water application cell.

Monitoring well GBR-8 also showed an apparent increase in free product thickness, despite the lack of an apparent response in ground-water elevation (see figure 7). In the case of free product thickness, accumulations in this well increased from a pre-purge thickness of 1.60 feet to a maximum thickness of 2.07 feet. Monitor well GBR-8 is approximately 308 feet southwest of the north cell. The free product increase attained its peak approximately 7 days after the end of water application; this accumulation was sustained for another three-week period. Because of the distance between monitor well GBR-8 and the water application cell, it is believed that the hydraulic response in GBR-8 is not directly related to the controlled water application.

Monitor well GBR-20 did not show any readily discernible hydraulic effects of the controlled water application (see figure 8). Ground-water elevations fluctuated from ± 0.20 feet, although an unexplained peak in ground-water elevation occurred on October 10, 1990. This peak may be related to the unusual hydraulic response observed in well GBR-13 around October 11, 1990.

In summary, based on the observed increases in free product thickness, controlled water application appears to be an effective means of remediating contaminated soil and enhancing free product recovery.

5.2 Controlled Water Application Impacts on Ground-Water Quality

Monitoring for specific conductance was performed on four monitor wells throughout the duration of the controlled water application applications. The results of these measurements are provided in table 3. As listed in table 3, specific conductance varied from 3120 to 6840 umhos/cm. Wells at a distance greater than 120 feet from the water applicationed cell did not show appreciable changes in specific conductance (as compared with GRW-3, a well outside the influence of the controlled water application). However, monitor well GBR-41, located 10 feet northeast of the water applicationed cell, showed a 40% increase in specific conductance five days after the cessation of water applications. A 48% increase was the maximum increase in specific conductance observed eight days after water application. Following specific conductance measurements on October 29, 1990, which indicated a greater than 20% increase in specific conductance had occurred, a ground-water sample was obtained on November 2, 1990, and analyzed for major ions. The results of these analyses are provided in table 5; laboratory data sheets are included in appendix A.

As summarized in table 5, changes in water quality were observed in ground-water samples obtained from GBR-41 before and after the controlled water application. After the initiation of controlled water application, the concentrations of major cations and anions increased, thereby resulting in increased TDS and specific conductance. Chloride and sulfate concentrations increased at the expense of bicarbonate, thereby decreasing the alkalinity of the water while increasing its hardness. Among the cations, net increases were observed for all constituents, except potassium.

When major cation and anion concentrations are plotted in terms of milliequivalents per liter (meq/l) on a tri-linear diagram (see figure 9), the changes in water quality resulting from controlled water application become more apparent. It should be noted that while total concentrations for most cations increased, their proportions relative to one another did not change appreciably. On the other hand, the anion balance for GBR-41 was enriched with respect to chloride and sulfate. This shift in water quality is shown in the combined ion diagram on figure 9.

Increases in TDS, chloride, sulfate, and cations as the result of applying water to unleached soils is a documented effect of irrigation practices, especially in arid environments. Arid regions are especially susceptible to increasing TDS as surplus alkali solutes accumulate in the near surface due to high evapotranspiration rates. Irrigation, or water application, accelerates the natural leaching process for these solutes. Gypsiferous and calcareous soils are common in this area and contribute calcium, sulfate, and chloride ions to the ground water (Hem, 1970). Thus, controlled water application, like irrigation, merely accelerates the natural leaching process. With successive cycling of water beneath the site, an overall increase in TDS and select ions may be observed over time.

Figure 9
Pre-and Post-Flood Water Quality
Trilinear Diagram of Major Cations and Anions

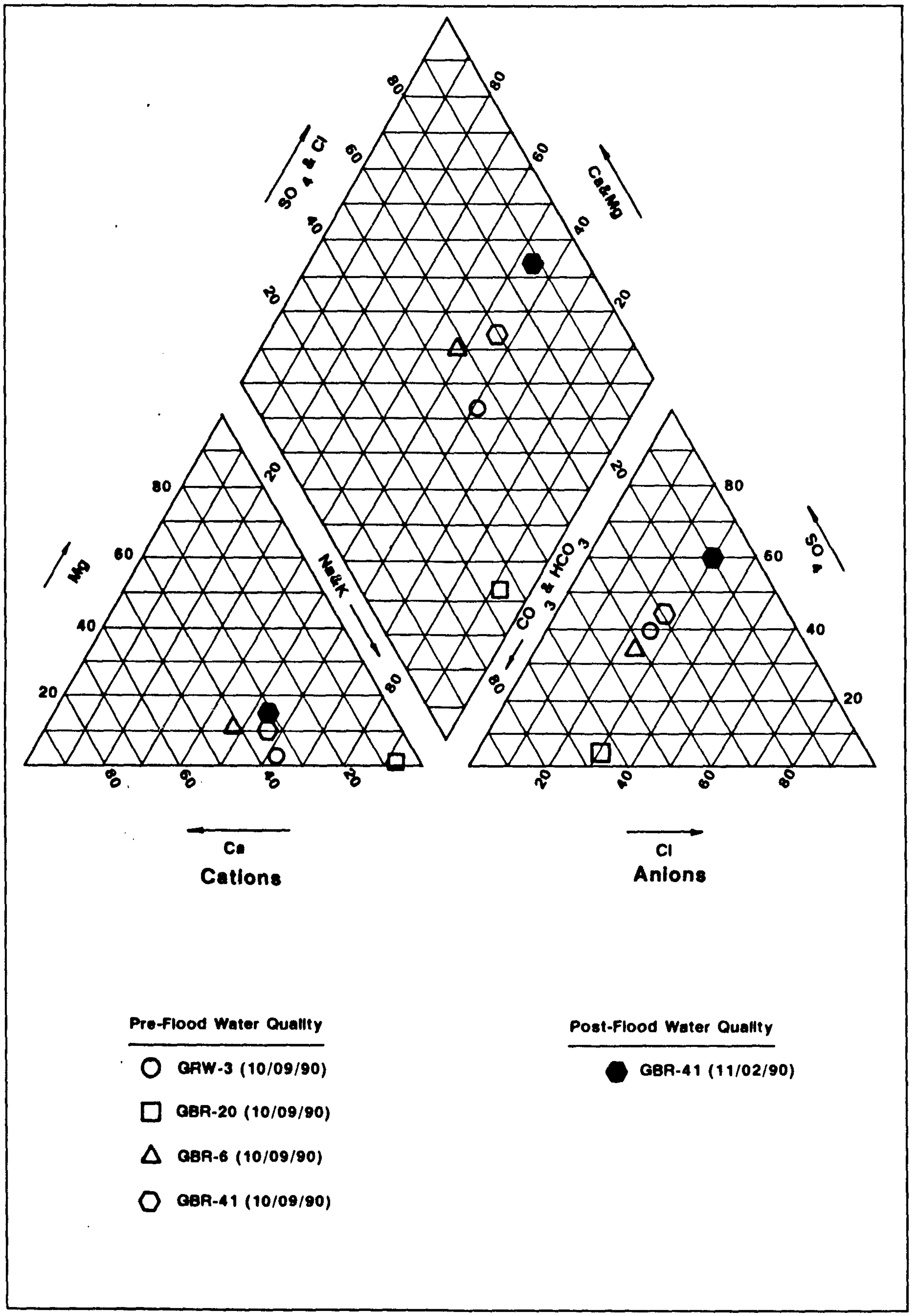


Table 5

Monitor Well GBR-41: Water Quality Analyses

Parameter	Units	SAMPLE Pre-Water Application 10/09/90	Post-Water Application 11/02/90	% change
pH	s.u.	7.80	6.97	-12
Conductivity	μmhos/cm	4620.	6840.	+48
Resistivity	ohm–m	2.16	1.46	-68
TDS (180°)	mg/l	3240.	5050.	+56
TDS (calculated)	mg/l	3130.	4830.	+54
Total alkalinity, as $CaCO_3$	mg/l	770.	428.	-56
Total acidity, as $CaCO_3$	mg/l	0.	0.	0
Total hardness, as $CaCO_3$	mg/l	1200.	1730.	+44
Sodium adsorption ratio		8.4	10.1	+20

	Pre mg/1	Pre eg/l	Post mg/l	Post eg/l	% change
Bicarbonate, as HCO_3	939.	15.4	522.	8.55	-56
Carbonate, as CO_3	0.	0.0	0.	0.	0.00
Chloride	467.	13.2	812.	22.9	+74
Sulfate	1090.	22.8	21.80	45.4	+50
Calcium	365.	18.2	482.	24.	+32
Magnesium	71.3	5.86	128.	10.5	+80
Potassium	4.56	0.12	2.3	0.06	-50
Sodium	670.	29.2	966.	42.	+44
Major cations		53.4		76.6	NA
Major anions		51.4		76.9	NA
Cation/anion difference		1.91%		0.18%	NA

0348/CFARPT.TBL

5.3 Controlled Water Application Impacts on Hydraulic Containment

Despite the addition of water to the north cell and the hydraulic response observed in adjacent wells, ground-water levels in the area of the recovery network (see figure 1) remained stable, or decreased. Ground-water elevations in well GBR-8 actually decreased by over one foot during the monitoring period. This decrease is attributed to draw-down created by the operating recovery wells near GBR-8.

Ground-water capture near the product recovery well network was not affected by the ground water mound created near the water applicationed cell. Therefore, controlled water application does not compromise the hydraulic containment provided by the existing recovery well network.

6.0 Recommendations

Based on the ease of field monitoring and the limited area of ground-water elevation and quality impacts, we recommend that additional controlled water application be implemented. A monitoring and application proposal will be submitted for each area considered for surface water application.

7.0 Conclusions

Based on the sources of information and references cited herein, we offer the following conclusions.

- Controlled water application is a viable means of enhancing free product recovery of hydrocarbons from subsurface soils in a variety of areas at the refinery.

- The controlled water application may be easily implemented at low cost by on-site personnel using available equipment, treated ground water, and existing monitor and/or recovery wells.

- A measurable hydraulic response was apparent within a 120-foot radius of the water applicationed cell. However, hydraulic containment by the existing recovery well network was not affected.

- The amount of recoverable hydrocarbons was enhanced by controlled water application. Free product thicknesses in wells remained stable for several weeks following cessation of water application, except when the free product accumulation was so great that, in the absence of sustained capillary pressure increases induced by water application, the hydrocarbons redistributed themselves along the top of the water table.

- Monitoring results suggest that TDS concentrations in areas immediately adjacent to and beneath the water application cells may increase as a result of controlled water application.

8.0 References

Giant Refining Company, 1989, Controlled Application of Water to Remediate Hydrocarbon in Soil at the Giant Bloomfield Refinery, submitted to the New Mexico Oil Conservation Division, October 1989.

Giant Refining Company, October 12, 1990, Letter to Mr. David Boyer, New Mexico Oil Conservation Division, r.e. Request for Sampling Modifications to the Controlled Application of Water. . .

Geoscience Consultants, Limited, 1987, Soil and Groundwater Investigation and Remedial Action Plan, Albuquerque, NM, 102 pages.

Geoscience Consultants, Limited, 1986, Preliminary Report on Groundwater Investigation for Giant Industries, Inc., Albuquerque, NM, 42 pages.

Hager, Dorsey, 1951, Practical Oil Geology, 6th Edition, McGraw Hill Book Company, New York, 589 pages.

Hem, John D., 1970, Study and Interpretation of the Chemical Characteristics of Natural Waters, 2nd Edition, USGS, Water-Supply Paper 1473, 363 pages.

Levorsen, A. I., 1967, Geology of Petroleum, 2nd Edition, W. H. Freeman and Company, San Francisco, 724 pages.

New Mexico Oil Conservation Division, October 17, 1990, certified letter from William C. Olson, Hydrogeologist to Timothy A. Kinney, Giant Refining Company, r.e. Approval of Sampling Modifications to the Controlled Application of Water. . .

APPENDIX A

Analytical Laboratory Data Sheets

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT: Giant Refinery
ID: 9010041028
SITE: RW-3
LAB NO: F6140

DATE REPORTED: 10/23/90
DATE RECEIVED: 10/04/90
DATE COLLECTED: 10/04/90

Lab pH (s.u.)	7.91
Lab conductivity, umhos/cm	3970
Lab resistivity, ohm-m	2.52
Total dissolved solids (180), mg/l	2950
Total dissolved solids (calc), mg/l	2940
Total alkalinity as CaCO3, mg/l	829
Total acidity as CaCO3, mg/l	0
Total hardness as CaCO3, mg/l	944
Sodium absorption ratio	9.8

	mg/l	meq/l
Bicarbonate as HCO3	1010	16.6
Carbonate as CO3	0	0
Chloride	435	12.3
Sulfate	944	19.7
Calcium	349	17.4
Magnesium	17.5	1.44
Potassium	2.28	0.06
Sodium	692	30.1
Major cations		49.1
Major anions		48.5
Cation/anion difference		0.54 %

C. Neal Schaeffer
Lab Director

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT: GBR
ID: N/A
SITE: GBR-6
LAB NO: F5235

DATE REPORTED: 10/23/90

DATE RECEIVED: 10/09/90
DATE COLLECTED: 10/09/90

Lab pH (s.u.)	7.95
Lab conductivity, umhos/cm	4030
Lab resistivity, ohm-m	2.48
Total dissolved solids (180), mg/l	2700
Total dissolved solids (calc), mg/l	2640
Total alkalinity as CaCO3, mg/l	958
Total acidity as CaCO3, mg/l	0
Total hardness as CaCO3, mg/l	1180
Sodium absorption ratio	6.43

	mg/l	meq/l
Bicarbonate as HCO3	1170	19.2
Carbonate as CO3	0	0
Chloride	387	10.9
Sulfate	728	15.2
Calcium	373	18.6
Magnesium	61.5	5.06
Potassium	3.21	0.08
Sodium	509	22.1
Major cations		45.9
Major anions		45.2
Cation/anion difference		0.75 %

C. Neal Schaeffer
Lab Director

iml
Inter-Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT: GBR
ID: N/A
SITE: GBR-20
LAB NO: F5237

DATE REPORTED: 10/23/90
DATE RECEIVED: 10/09/90
DATE COLLECTED: 10/09/90

Lab pH (s.u.)	8.43
Lab conductivity, umhos/cm	3120
Lab resistivity, ohm-m	3.21
Total dissolved solids (180), mg/l	1820
Total dissolved solids (calc), mg/l	1760
Total alkalinity as CaCO3, mg/l	1000
Total acidity as CaCO3, mg/l	0
Total hardness as CaCO3, mg/l	106
Sodium absorption ratio	29.4

	mg/l	meq/l
Bicarbonate as HCO3	1070	17.6
Carbonate as CO3	71.7	2.39
Chloride	352	9.94
Sulfate	67.5	1.41
Calcium	36.1	1.8
Magnesium	3.95	0.32
Potassium	2.8	0.07
Sodium	698	30.3
Major cations		32.5
Major anions		31.4
Cation/anion difference		1.86 %

C. Neal Schaeffer
C. Neal Schaeffer
Lab Director

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT: GBR
ID: N/A
SITE: GBR-41
LAB NO: F5236

DATE REPORTED: 10/23/90
DATE RECEIVED: 10/09/90
DATE COLLECTED: 10/09/90

Lab pH (s.u.)	7.80
Lab conductivity, umhos/cm	4620
Lab resistivity, ohm-m	2.16
Total dissolved solids (180), mg/l	3240
Total dissolved solids (calc), mg/l	3130
Total alkalinity as CaCO3, mg/l	770
Total acidity as CaCO3, mg/l	0
Total hardness as CaCO3, mg/l	1200
Sodium absorption ratio	8.4

	mg/l	meq/l
Bicarbonate as HCO3	939	15.4
Carbonate as CO3	0	0
Chloride	467	13.2
Sulfate	1090	22.8
Calcium	365	18.2
Magnesium	71.3	5.86
Potassium	4.56	0.12
Sodium	670	29.2
Major cations		53.4
Major anions		51.4
Cation/anion difference		1.91 %

O. Neal Schaeffer
Lab Director

iml
Inter·Mountain
Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

Client: Giant Refinery

Date reported: 10/30/90
Date received: 10/29/90
Date collected: 10/29/90

Analysis requested: electrical conductivity, umhos/cm.

Lab #:	Sample site:	Sample ID:	Result:
F5362	GBR #6	N/A	4066 umhos/cm
F5363	GBR #20	N/A	3281 umhos/cm
F5364	GBR #41	N/A	6280 umhos/cm
F5365	GRW-3	N/A	4218 umhos/cm

C. Neal Schaeffer
Senior Chemist

Inter-Mountain Laboratories, Inc.

2506 West Main Street
Farmington, New Mexico 87401
Tel. (505) 326-4737

CLIENT:	GBR	DATE REPORTED:	11/14/90
ID:	1405		
SITE:	GB4-41	DATE RECEIVED:	11/05/90
LAB NO:	F5398	DATE COLLECTED:	11/02/90

Lab pH (s.u.)	6.97
Lab conductivity, umhos/cm	6840
Lab resistivity, ohm-m	1.46
Total dissolved solids (180), mg/l	5050
Total dissolved solids (calc), mg/l	4830
Total alkalinity as CaCO3, mg/l	428
Total acidity as CaCO3, mg/l	0
Total hardness as CaCO3, mg/l	1730
Sodium absorption ratio	10.1

	mg/l	meq/l
Bicarbonate as HCO3	522	8.55
Carbonate as CO3	0	0
Chloride	812	22.9
Sulfate	2180	45.4
Calcium	482	24
Magnesium	128	10.5
Potassium	2.3	0.06
Sodium	966	42
Major cations		76.6
Major anions		76.9
Cation/anion difference		0.18 %

C. Neal Schaeffer
Lab Director

CONTROLLED FLOODING APPLICATION OF WATER TO REMEDIATE HYDROCARBON IN SOIL AT THE GIANT BLOOMFIELD REFINERY

October 9, 1989

Prepared by:

GEOSCIENCE CONSULTANTS, LTD

HEADQUARTERS
500 Copper Avenue, NW
Suite 200
Albuquerque, New Mexico 87102
(505) 842-0001
FAX (505) 842-0595

WEST COAST REGIONAL OFFICE
1400 Quail Street
Suite 140
Newport Beach, CA 92660
(714) 724-0536
FAX (714) 724-0538

EASTERN REGIONAL OFFICE
1109 Spring Street
Suite 706
Silver Spring, MD 20910
(301) 587-2088
FAX (301) 587-3625

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

1.0 INTRODUCTION

A plan for the controlled flooding application (CFA) of water to remediate hydrocarbon existence in soils was submitted to the New Mexico Oil Conservation Division (NMOCD) as part of Giant Industries' discharge plan. Giant's discharge permit does not include the CFA at this time. Geoscience Consultants Limited has prepared this additional plan for submission to NMOCD, to remediate an area of high hydrocarbon concentration in the soil at the Giant Bloomfield Refinery (GBR).

2.0 BACKGROUND

In December, 1986 Giant Industries prepared and submitted a preliminary report to NMOCD titled Preliminary Report on Groundwater Investigation for Giant Industries, Inc. In June, 1987, Giant Industries prepared and submitted to NMOCD a report titled Soil and Groundwater Investigation and Remedial Action Plan.

Giant Industries applied for a discharge permit in March of 1988 by filing a discharge plan with the NMOCD. Giant's discharge plan included a proposal to remediate a small area of soil containing hydrocarbons. The objective of this application is to saturate the underlying soil and flush the hydrocarbon product toward the existing recovery wells.

NMOCD approved Giant's discharge plan in December of 1989. NMOCD, however, did not include the CFA as part of the discharge permit due to uncertainty in the proposed plans implementation. Giant Industries believe that this remediation is necessary and is submitting this detailed plan for the CFA of water to remediate soil containing hydrocarbon in the southern portion of Giants Bloomfield Refinery.

3.0 METHODOLOGY

The application site will consist of two bermed cells in the Southern Refinery Area, each 95 feet by 110 feet for a total surface area of 20,900 square feet. During frost-free periods, treated ground water will be applied to the site to flush the underlying contaminated soil (Figure 3-1). The site will be disked to facilitate infiltration of applied water and graded to be level. A 12 to 18-inch high berm will be constructed around the site to prevent any runoff from the CFA area. Water will be applied only during working hours when Giant personnel can monitor the application.

Tests previously conducted on this soil demonstrated that the unsaturated zone (upper 30 feet) exhibits an average moisture content of 11.5% by volume and an open pore space of 23%. If enough water is supplied to saturate the upper 30 feet of soil, a significant volume of soil hydrocarbon should be flushed out of the soil as a wetted front of water and entrained hydrocarbons should be driven to the existing ground water interface, and be captured by the recovery pumps.

Because the transport of hydrocarbon in the vadose zone cannot always be predicted with theoretical models, it is imperative that the recovery wells collect any hydrocarbon that may be dislodged by the flushing action of the water. A series of ground water and product recovery wells are in place and operational in the southern refinery area down gradient from the application area and will prevent any contamination from migrating off the site. Over one year of ground-water level data has been obtained to demonstrate that the pumping network will capture any flushed hydrocarbons.

The CFA will require approximately 7.25 feet of water to saturate the vadose zone (Appendix A). Giant proposes to approach this upper limit of saturation through a series of staged applications. After a period of two weeks during which total precipitation is less than 0.1 inch, twenty two (22) inches of reclaimed ground water (about 25% of the maximum calculated open pore space) will be applied to Area I at a rate that does not result in excessive ponding on the surface. The first application will be stage 1 and each subsequent application will be considered the next stage.

The response of the aquifer will be monitored according to the schedule proposed in Section 4.0. The application rate will be adjusted after evaluation of the response. It is anticipated that 14 days will be required to apply 22 inches of reclaimed water and realize a response at the monitor wells. There will be as many stages of application as necessary until the 7.25 feet of water has been applied to the area being treated.

During water application, the recovery wells in the southern refinery area will be pumped continuously and the effects of the application of water will be monitored by evaluation of the thickness of floating hydrocarbons in observation wells GBR-5, GBR-7, GBR-13, GBR-20 and GRW-3.

Initiation of subsequent stages will depend on the close scrutiny of monitoring data. Application rates for subsequent stages will be increased or decreased, as required, until floating product in the observation wells reaches a maximum thickness. Monitoring of these applications will determine the optimum application rate to be used for the duration of the controlled flooding program.

4.0 MONITORING

The source water for the controlled flooding will be sampled prior to initiation of the CFA. It is expected that the water to be used for the CFA will come from storage tanks 27, 32, 34 and 37 which will have been previously filled with ground water and will be air stripped prior to application.

Prior to the start and at the end of the CFA the air stripper effluent will be sampled. The analytes for the air stripper samples will be halogenated volatile organic compounds (EPA 601), aromatic volatile organic compounds (EPA 602), total dissolved solids (TDS), major ions and specific conductance (corrected for temperature).

Before initiation of the CFA wells GBR - 41, GBR - 20, GBR - 6 and GRW - 3 will be sampled for TDS, major ions and specific conductance to determine background concentrations. The background values for specific conductance will also be determined for GBR - 5, GBR - 7, GBR - 8, and GBR - 13.

Hydraulic response will be monitored daily with an oil/water-level probe in wells GBR - 41, GBR - 20, GBR - 5, GBR - 6, 7, 8, and 13. The specific conductance will be monitored based on hydraulic response to the CFA. If the analytical results of specific conductance sampling show an increase or decrease of 20% with respect to background, the well from which the sample was taken will be sampled for TDS and major ions. If the concentrations of TDS or major ions show a 20% increase the CFA will be stopped. If the CFA is stopped due to increased concentrations of TDS or ions the monitoring will be continued until a trend toward background conditions is documented.

5.0 SCHEDULE

The CFA of water at the GBR will begin in October 1989, if weather conditions permit. The time to initiate and complete each stage will depend on the hydraulic response at the observation wells. It is felt that each area (I&II) will require four stages of water application at approximately two weeks per stage. The CFA will be considered complete when hydraulic response at the monitor wells has stabilized. Monitoring will continue for a period of two weeks following the last stage of water application. All results will be reported to the OCD in a timely fashion upon completion of the exercise.

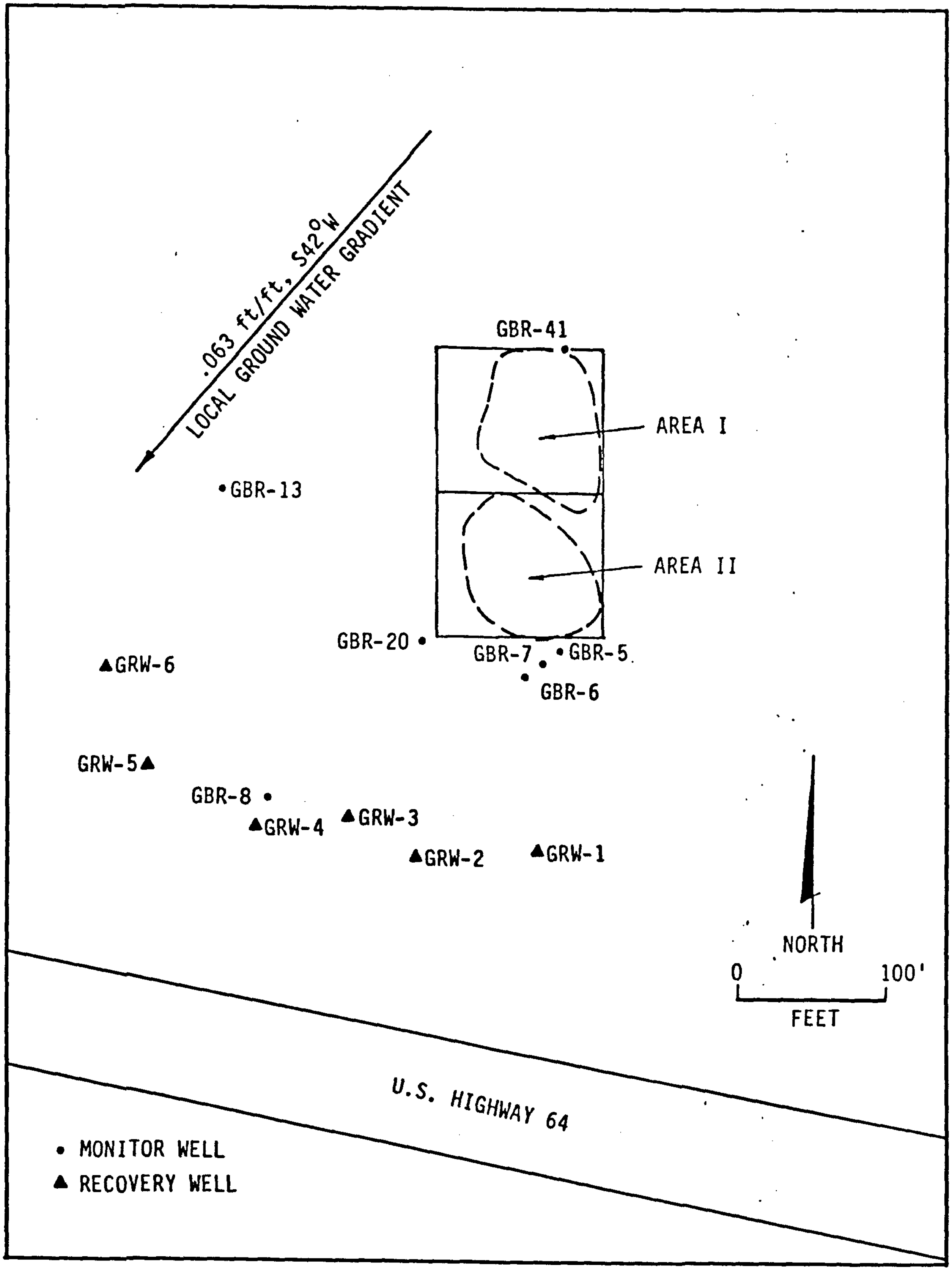


FIGURE 3-1
CONTROLLED FLOODING APPLICATION AREA
AND WELL LOCATION MAP

GCL

APPENDIX A

CONTROLLED FLOODING APPLICATION CALCULATIONS

Geoscience
Consultants, Ltd.

ENGINEERING CALCULATION

Date: 4/10/?
By: ARJN
File:

Consumptive Use Calculations
Controlled flooding at Giants Bloomfield Refinery
Index

1 cm² = 0.1550 in²
1 in² = 6.452 cm²
1 m² = 10.764 ft²
1 ft² = 929.0 cm²

1 acre = 43,560 ft²
= 4049 m²

1 hectare = 10,000 m²
= 2.471 acres

1 mi² = 2.590 km²
= 640 acres

Volume

1 m³ = 1000 liters
= 35.314 ft³
= 264 gal (U.S.)

1 ft³ = 28.320 liters
= 7.481 gal (U.S.)

1 gal = 3.785 liters

1 acre foot = 43,560 ft³
= 3.259 × 10⁵ gal
= 1234 m³

Discharge

1 ft³/min = 0.472 liters/sec
1 acre foot/day
= 3.259 × 10⁵ gal/day
1 ft³/sec = 448.8 gal/min
= 724 acre feet/year

Density

Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air

8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure

1 bar = 0.9869 atmosphere
= 10⁶ dynes/cm²
= 14.50 lb/in²

pressure developed from static liquid
1 cm mercury
= 0.01316 atmosphere
1 ft water
= 0.02950 atmosphere
33.90 ft water
= 1.00 atmosphere

Consumptive use calculation
Controlled flooding
Giant Bloomfield Refinery
Objective

1 cm² = 0.1550 in²
1 in² = 6.452 cm²
1 m² = 10.764 ft²
1 ft² = 929.0 cm²

1 acre = 43,560 ft²
= 4049 m²

1 hectare = 10,000 m²
= 2.471 acres

1 mi² = 2.590 km²
= 640 acres

Volume

1 m³ = 1000 liters
= 35.314 ft³
= 264 gal (U.S.)

1 ft³ = 28.320 liters
= 7.481 gal (U.S.)

1 gal = 3.785 liters

1 acre foot = 43,560 ft³
= 3.259 × 10⁵ gal
= 1234 m³

Discharge

1 ft³/min = 0.472 liters/sec
1 acre foot/day
= 3.259 × 10⁵ gal/day
1 ft³/sec = 448.8 gal/min
= 724 acre feet/year

Density

Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air

8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure

1 bar = 0.9869 atmosphere
= 10⁶ dynes/cm²
= 14.50 lb/in²

pressure developed from static liquid
1 cm mercury
= 0.01316 atmosphere
1 ft water
= 0.02950 atmosphere
33.90 ft water
= 1.00 atmosphere

Objective

Determine amount of water to be used in the implementation of controlled flooding as per the Giant Bloomfield Refinery's Discharge Plan

1 cm² — 0.1550 in²
1 in² — 6.452 cm²
1 m² — 10.764 ft²
1 ft² — 929.0 cm²
1 acre — 43,560 ft² — 4049 m²
1 hectare — 10,000 m² — 2.471 acres
1 mi² — 2.590 km² — 640 acres

Volume
1 m³ — 1000 liters — 35.314 ft³ — 264 gal (U.S.)
1 ft³ — 28.320 liters — 7.481 gal (U.S.)
1 gal — 3.785 liters
1 acre foot — 43,560 ft³ — 3.259 × 10⁵ gal — 1234 m³

Discharge
1 ft³/min — 0.472 liters/sec
1 acre foot/day — 3.259 × 10⁵ gal/day
1 ft³/sec — 448.8 gal/min — 724 acre feet/year

Density
Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air
8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure
1 bar — 0.9869 atmosphere — 10⁶ dynes/cm² — 14.50 lb/in²
pressure developed from static liquid
1 cm mercury — 0.01316 atmosphere
1 ft water — 0.02950 atmosphere
33.90 ft water — 1.00 atmosphere

Methodology

Methodology

Controlled flooding requires saturation of the soil from the ground surface to the groundwater potentiometric surface.

The mean depth to water for 1988 is calculated for wells GBR-41 (North of controlled flooding) and GBR-5 (South of controlled flooding). The average depth to water at these two wells, multiplied by the area to be flooded, is used to calculate the Volume of soil to be saturated.

The void space of this type of deposit is 35% (Freeze & Cherry, 1979). Antecedent moisture content is 11.2 % by volume at Giants Bloomfield refinery (Stephens 1986). This leaves 23.8 % volume to be saturated. Potential Evapotranspiration for station Farmington 4 NE @ 36°45' lat and 108°10' long. for June-Aug using 61 yrs of record is 7.21 inches/Month (Gabin and Lesperance, 1977).

The calculated consumptive use is the Potential Evapotranspiration for this area plus the Volume of void space.

Geoscience Consultants, Ltd.

ENGINEERING CALCULATION

Date: 1/10/89
By: NEE
File:

Average depth to water at GBR-5

1 cm²—0.1550 in²
1 in²—6.452 cm²
1 m²—10.764 ft²
1 ft²—929.0 cm²

1 acre—43,560 ft²
—4049 m²

1 hectare—10,000 m²
—2.471 acres

1 mi²—2.590 km²
—640 acres

Volume

1 m³—1000 liters
—35.314 ft³
—264 gal (U.S.)

1 ft³—28.320 liters
—7.481 gal (U.S.)

1 gal—3.785 liters

1 acre foot—43,560 ft³
—3.259 × 10⁵ gal
—1234 m³

Discharge

1 ft³/min—0.472 liters/sec
1 acre foot/day
—3.259 × 10⁵ gal/day
1 ft³/sec—448.8 gal/min
—724 acre feet/year

Density

Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air

8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure

1 bar—0.9869 atmosphere
—10⁶ dynes/cm²
—14.50 lb/in²

pressure developed from static liquid
1 cm mercury
—0.01316 atmosphere
1 ft water
—0.02950 atmosphere
33.90 ft water
—1.00 atmosphere

Date	Water Elevation
1-19-88	5362.73
2-26-88	5362.26
3-11-88	5362.59
5-17-88	5362.59
6-9-88	5362.37
7-8-88	5362.26
8-11-88	5362.14
9-14-88	5362.03
10-6-88	5362.09
11-9-88	5361.90

$\bar{X}$ = 5362.30

Ground Elevation at GBR-5 = 5392.82

Average depth to water in 1988 = 30.52'

Consultants, Ltd. ENGINEERING CALCULATION

By: NEL

File:

1 cm² = 0.1550 in²
1 in² = 6.452 cm²
1 m² = 10.764 ft²
1 ft² = 929.0 cm²

1 acre = 43,560 ft²
= 4049 m²

1 hectare = 10,000 m²
= 2.471 acres

1 mi² = 2.590 km²
= 640 acres

Volume

1 m³ = 1000 liters
= 35.314 ft³
= 264 gal (U.S.)

1 ft³ = 28.320 liters
= 7.481 gal (U.S.)

1 gal = 3.785 liters

1 acre foot = 43,560 ft³
= 3.259 × 10⁵ gal
= 1234 m³

Discharge

1 ft³/min = 0.472 liters/sec
1 acre foot/day
= 3.259 × 10⁵ gal/day
1 ft³/sec = 446.8 gal/min
= 724 acre feet/year

Density

Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air

8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure

1 bar = 0.9869 atmosphere
= 10⁶ dynes/cm²
= 14.50 lb/in²

pressure developed from static liquid
1 cm mercury
= 0.01316 atmosphere
1 ft water
= 0.02950 atmosphere
33.90 ft water
= 1.00 atmosphere

Average depth to water at GBR-41

Date	Water Elevation
2-26-88	5367.85
3-11-88	5368.90
5-17-88	5367.69
7-8-88	5367.50
8-11-88	5367.48
9-14-88	5365.52
10-6-88	5367.64

$\bar{x} = 5367.80$

Ground Elevation at GBR-41 = 5396.15

Average depth to water in 1988 = 28.35'

∴ Average depth to water across controlled flooding

$(28.35 + 30.52) \div 2 = 29.43'$

Volume calculations

Area to be flooded

→ 110' × 190' = 20,900 ft^2

Volume of soil to be saturated

→ 20,900 ft^2 × 29.43 ft = 615,087 ft^3

Volume of water required to saturate soil

35% (void space) − 11.2% (Antecedent moisture)

= 23.8% total volume soil

→ 615,087 ft^3 × .238 = 146,390 ft^3 water

Volume lost to evapotranspiration

→ 20,900 ft^2 × .02 ft/day × 14 days

= 5852 ft^3

Consultants, Ltd.

ENGINEERING CALCULATION

Date: [illegible]
By: Nee
File:

Total consumptive use

1 cm² — 0.1550 in²
1 in² — 6.452 cm²
1 m² — 10.764 ft²
1 ft² — 929.0 cm²

1 acre — 43,560 ft²
— 4049 m²

1 hectare — 10,000 m²
— 2.471 acres

1 mi² — 2.590 km²
— 640 acres

Volume

1 m³ — 1000 liters
— 35.314 ft³
— 264 gal (U.S.)

1 ft³ — 28.320 liters
— 7.481 gal (U.S.)

1 gal — 3.785 liters

1 acre foot — 43,560 ft³
— 3.259 × 10⁵ gal
— 1234 m³

Discharge

1 ft³/min — 0.472 liters/sec
1 acre foot/day
— 3.259 × 10⁵ gal/day
1 ft³/sec — 448.8 gal/min
— 724 acre feet/year

Density

Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air

8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure

1 bar — 0.9869 atmosphere
— 10⁶ dynes/cm²
— 14.50 lb/in²

pressure developed from static liquid
1 cm mercury
— 0.01316 atmosphere
1 ft water
— 0.02950 atmosphere
33.90 ft water
— 1.00 atmosphere

Total consumptive use

Volume to saturate soil +

Volume lost to Potential Evapotranspiration.

$146,390\ ft^3 + 5852\ ft^3$

→ $152,242\ ft^3$

= 1.14 million gallons

= 3.5 acre-feet

Geoscience Consultants, Ltd.

ENGINEERING CALCULATION

Date: 1/10/01
By: NEIE
File:

1 cm² = 0.1550 in²
1 in² = 6.452 cm²
1 m² = 10.764 ft²
1 ft² = 929.0 cm²

1 acre = 43,560 ft²
= 4049 m²

1 hectare = 10,000 m²
= 2.471 acres

1 mi² = 2.590 km²
= 640 acres

Volume

1 m³ = 1000 liters
= 35.314 ft³
= 264 gal (U.S.)

1 ft³ = 28.320 liters
= 7.481 gal (U.S.)

1 gal = 3.785 liters

1 acre foot = 43,560 ft³
= 3.259 × 10⁵ gal
= 1234 m³

Discharge

1 ft³/min = 0.472 liters/sec
1 acre foot/day
= 3.259 × 10⁵ gal/day
1 ft³/sec = 448.8 gal/min
= 724 acre feet/year

Density

Water 1.000 g/cm³ at 4°C
0.998 g/cm³ at 20°C
Sea water 1.025 g/cm³ at 15°C
Mercury 13.55 g/cm³ at 20°C
Air 1.29 × 10⁻³ g/cm³ at 20°C and atmospheric pressure

Specific weight water in air

8.335 lb/gal at 0°C
8.328 lb/gal at 60° F
8.322 lb/gal at 20° C
62.18 lb/ft³ at 60° F

Pressure

1 bar = 0.9869 atmosphere
= 10⁶ dynes/cm²
= 14.50 lb/in²

pressure developed from static liquid
1 cm mercury
= 0.01316 atmosphere
1 ft water
= 0.02950 atmosphere
33.90 ft water
= 1.00 atmosphere

References

1 Freeze, R.A. and Cherry, J.A. 1979. Groundwater, Prentice Hall, NJ p 37

2 Gabin, V. and Lesperance, L. 1977. New Mexico Climatological Data, W.K. Summers & Assoc Socorro NM. p 294

3 Stephens, Daniel B., 1986, Final Data Report on Laboratory Analysis of Soil Hydraulic Properties prepared for Geoscience Consultants, LTD. Albuq. NM. Daniel B. Stephens and Associates inc Socorro, NM p 19