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PHASE II R.A.P. REPORT FOR THE
CITY OF LAREDO INTERNATIONAL AIRPORT
FUEL FARM PROJECT

L.P.S.T. I.D. NO.: 95021

JBL GROUP

January 31, 1992

Mr. Jose Flores
City of Laredo International Airport
518 Flightline, Building #132
Laredo, Texas 78041

Re: Phase II R.A.P. Report for the City of Laredo
International Airport Fuel Farm
L.P.S.T. I.D. No.: 95021

Dear Mr. Flores:

We are pleased to submit the Phase II R.A.P. Report for the City of Laredo International Airport Fuel Farm on behalf of the City of Laredo, Webb County, Texas.

The report covers laboratory analysis for M.W. #1, #2, and #3 for BTEX and TPH compounds along with corresponding maps requested by the Texas Water Commission.

We appreciate the opportunity to assist you with the Fuel Farm Project and will continue to work with you.

Sincerely yours,

JBL GROUP

Jerilyn K. Rich
Environmental Specialist

Bill Rich

Bill Rich
Environmental Engineering Manager

P.O. Box 1870 • Laredo, Texas 78044-1870 • (512) 725-7410

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CITY OF LAREDO INTERNATIONAL AIRPORT
FUEL FARM PROJECT
L.P.S.T. I.D. NO.: 95021

Site Conditions

The site of the City of Laredo International Airport is located on the east side of the city on an old Army and Air Force Base. The site has had over thirty (30) underground storage tanks within the fuel farm area. Many of these tanks are believed to be removed, however, there are very few records indicating any action that was taken concerning the underground storage tanks.

The soils on the site are a sandy silty clay to a silty clay. The site drains by natural drainage to the south, southwest.

Project Description

The City of Laredo has been removing any and all free product on a daily basis at the subject site. Approximately 100 gallons have been removed from Recovery Well #5 and #6. The City of Laredo also has been collecting static water levels on a daily basis.

Free product levels have decreased to .015 feet in both Recovery Well #1 and Recovery Well #2. This is a substantial decrease in the depth of free product levels being in the past as much as 27.0 inches. Free product will continue to be removed until there is not any free product remaining in the wells.

JBL GROUP surveyed the well locations along with elevations to determine the exact groundwater flow path. (See Appendix C).

Groundwater Flow and Gradient

Groundwater level data have been collected from four (4) monitor wells along with data from the two (2) recovery wells. Data from these wells are shown in "Appendix C." The data were contoured and the results are shown on the groundwater contour sketch included in this report. As shown on the prints, the groundwater flow direction is to the southwest with a water table gradient of 15.04 feet per one thousand feet or 1.5 feet per one hundred feet.

Hydraulic Conductivity and Velocity

It is estimated that monitor wells #1, #2, #3, and #4 seem to demonstrate the same hydraulic conductivity estimated from the drawn down, elapsed time, while bailing the monitor wells. We estimate the hydraulic conductivity at approximately three (3) feet to five (5) feet per day. Actual calculations and additional field tests will need to be performed to present a detailed design for a remedial action center.

The groundwater flow velocity has been estimated from a hydraulic conductivity of five (5) feet per day and a water able gradient of 15.04 feet per one thousand feet. The Darcy Velocity is estimated at 6.5 feet per year while seepage velocity is estimated at twenty (20.0) feet per year.

These estimated, however, must be verified by an aquifer pump test as part of the detailed design.

Contaminant Distribution

Components of Aviation Gasoline and Jet Fuel are contained in the source areas and down gradient. "Source Area" are usually areas containing the highest amount of contamination of dissolved of free phase hydrocarbons. However, the source area has not been exactly determined. The distance downstream where the dissolved phase hydrocarbons are non-detect or with the Texas Water Commission allowable limits. This distance will need to be determined by establish a "clean" downstream monitor well. Upstream limits will also need to be determined. Monitor Well No. 4 could possible serve as the upstream well and would need to be resampled for BTEX and TPH compounds.

Source Area Groundwater

The "suspected" source area groundwater contains free product that is approximately .015' (feet) thick. The free product in Recovery Well #5 and #6 has been removed by the City of Laredo on a daily basis.

Groundwater

The analytical results in Monitor Well #1 indicated 4,176 ug/L BTEX compounds and 13.8 mg/L TPH compounds. Monitor Well #2 indicated 1,321 ug/L BTEX compounds and 214 mg/L TPH. Monitor Well #3 contains 90.5 ug/L BTEX compounds and 3.33 mg/L Benzene. TPH Monitor Well #1 contains 3,056 ug/L Benzene, Monitor Well #2 contains 329 ug/L Benzene and Monitor Well #3 contains 48.7 ug/LO Benzene. With a presence of high concentrations in Monitor Well #2, there seems to be a strong indication of the presence of Aviation Gasoline.

A water sample was taken from Monitor #4 to check the background characteristics of the groundwater. Total dissolved solids was 3,510 mg/L putting the groundwater in the 3,000 to 10,000 mg/L range set by the Texas Water commission. The conductivity was 2,800 umhos/cm.

Field Testing and Sampling

Water samples were taken with property QA/QC procedures to provide a representation of the water being tested. All sampling equipment was sufficiently cleaned and decontaminated between each sample. This was also done according to EPA approved methods. Samples were immediately cooled to 40 degrees F. +/- and brought to our laboratory to be tested.

Laboratory Testing

Laboratory testing for soil and water were done according to E.P.A. recommendations (GC/PID) Method 8020 with E.P.A. Method 5030 (Purge and Trap). Also for any water, E.P.A. Method 418.1 Method B (GC/FID) is used. Laboratory reports include the date of collection, date of extraction, date of analysis, report date, the extraction and analytical methods utilized with notes to any modifications to procedures that are a standard. Also the standard is utilized in the analysis along with the sample I.D. and depths.

Cause and Amount of Release

The cause or source of the release has not been exactly established. Tank and line integrity tests were done but did not give an indication of the source or cause. Abandonment of the existing lines and underground storage tanks would be a solution to eliminate the possible source or cause.

Since there are not records of product loss, the amount of the release of jet fuel and aviation gas is unknown.

SITE ASSESSMENT PROPOSAL

Drilling Activities

The migration of hydrocarbons, generated from both the jet fuel and aviation gas losses, to the groundwater has been in part defined. Additional sampling and monitor well installation are needed to define the total length of hydrocarbon migration.

As shown on the proposed Remediation System Plan, it is recommended that the investigation proceed with drilling of four (4) additional monitor wells and each monitor well sampled. In addition, two (2) soil samples will be obtained at each well location. Boreholes shall be converted to monitor wells at these locations.

Recommended sampling and drilling methods are outlined in the

QA/QC manual. Groundwater and soils will be tested for BTEX and TPH compounds.

REMEDIAL ACTION PROGRAM

Site Classification

The site has been classified under "Group 2" suing the Texas Water Commission (TWC) Guidelines. Targeted soil remediation cleanup levels are 30 mg.kg for total BTEX and 100 mg/kg for TPH. Targeted groundwater remediation levels are 500 ppb for total BTEX and 1 ppm TPH. The targeted Benzene residual concentration in groundwater after remediation is 50 ppb.

Remediation Intent

A conceptual remediation program has been developed to remove and treat groundwater contaminated with jet fuel and aviation gas. The remediation program and associated cost have been prepared based on the results of available data from Envirex Ltd. Changes to the remediation plan are subject to the collection of additional data.

The intent of the remediation design is to remove contaminated groundwater at a rate of maximum aquifer yield, mechanically adsorb and biologically treat the hydrocarbon, and reintroduce a portion of the treated water back into the source area in a "Closed Loop" fashion. It is proposed that reintroduced groundwater be supplemented with oxygen and nutrients (if needed) to stimulate biodegradation of the hydrocarbon.

Monitor and Purge Well Installation

Purge wells and monitor wells will be constructed of four (4) inch PVC casing and number ten (10) slot PVC well screens that are ten (10) feet in length. Well screens shall be set into place through hollow stem augers and gravel packed with 2NS sand. Development will be by three (3) inch bailer.

Step Drawdown Test

A step drawdown test will be performed on monitor wells and purge wells to determine the general yield characteristics of the aquifer. The yield test will be performed on each purge well. This data will be used to design the aquifer pump test.

Aquifer Pump Test

An aquifer pump test will be performed in Purge Well #2 and other "if needed". Purge Well #2 will be pumped while "time versus drawdown" data are obtained from Purge Well #1, Purge Well #2, Purge Well #3 and Monitor Well #2. This data will be used to calculate radius of plume capture for a set pumping rate.

Plume Capture Calculations

Preliminary plume capture calculations have been performed using the estimated hydraulic conductivity of five (5) feet per day and forty (40) feet per day. Results indicate that 0.2 to 0.5 gpm will provide a 25 foot capture radius. The actual radius of capture and maximum aquifer yield will be determined from the aquifer pump test data. *

Purge Pump Design

Purge wells will be pumped suing a pneumatically operated system. A pneumatically operated system was chosen due to the anticipated number of purge wells, low flow conditions, and pump cost saving.

Surface Treatment Design Options

Design options have been reviewed based on removal efficiency, cost of installation, operation, and maintenance. Selected surface treatment design options are:

1. Air Stripping Tower (AST) followed by Granular Activated Carbon (GAC) offgas treatment
2. Liquid phase GAC
3. A Microbial Activated Fluidized Granular Activated Carbon Bed

Design options were considered based on eleven (11) wells pumping at 2 gpm each, an influent TPH concentration of 80 mg/l, and an influent BTEX concentration of 1 mg/l. ?

As shown in the appendix, treatment cost per 1000 gallons have been generated by Envirex Ltd. using a five (5) year straight line depreciation of capital. It is shown here that a GAC fluid bed is a more economical treatment alternative than the other proposed technologies at a design flow rate of 100 gpm and 10 ppm BTEX. However, economics may favor one of the other treatment alternatives at a 10-20 gpm flow rate and 1 ppm BTEX. This cost analysis will be performed in the detailed system design, and the appropriate technology selected.

Cost analysis of each option above do not include the operation of the purge system responsible for moving water to the facility, or the ~~source area~~ injection system.

Proposed Treatment Method

It is proposed that groundwater treatment be performed using a microbially activated fluidized granular activated carbon bed. A schematic of the associated operations are detailed in the Mechanical Flow Diagram. As shown in the schematic, pumped water will be treated by a microbially activated fluidized granular-activated carbon bed.

Treated Effluent: Use and Discharge

Treated effluent will be discharged into source area injection wells and to the storm sewers if needed. Nutrients in an oxygen source will be added to effluent prior to entering the source area soils to enhance natural insitu biodegradation. The effectiveness of this process will be evaluated after additional site data have been collected.

Groundwater and Hydrocarbon Analysis

Prior to implementing the plan, background data will be obtained. The groundwater will be tested for dissolved oxygen, lead, and polynuclear aromatic hydrocarbons. Total dissolved solids, total suspended solids, and the biological oxygen demand will also be tested.

Microbe Analysis

Laboratory tests will be performed on soil samples to determine if hydrocarbon degrading microbes are present. Samples will be obtained during the drilling and installation of Purge Well #2 and Purge Well #3. Results of laboratory tests will be used to characterize the effectiveness of an insitu bioremediation program for this site.

CONCLUSION

Groundwater will be removed using closely spaced purge wells to capture the contaminant. Wells will be purged with the use of pneumatically operated double diaphragm pumps.

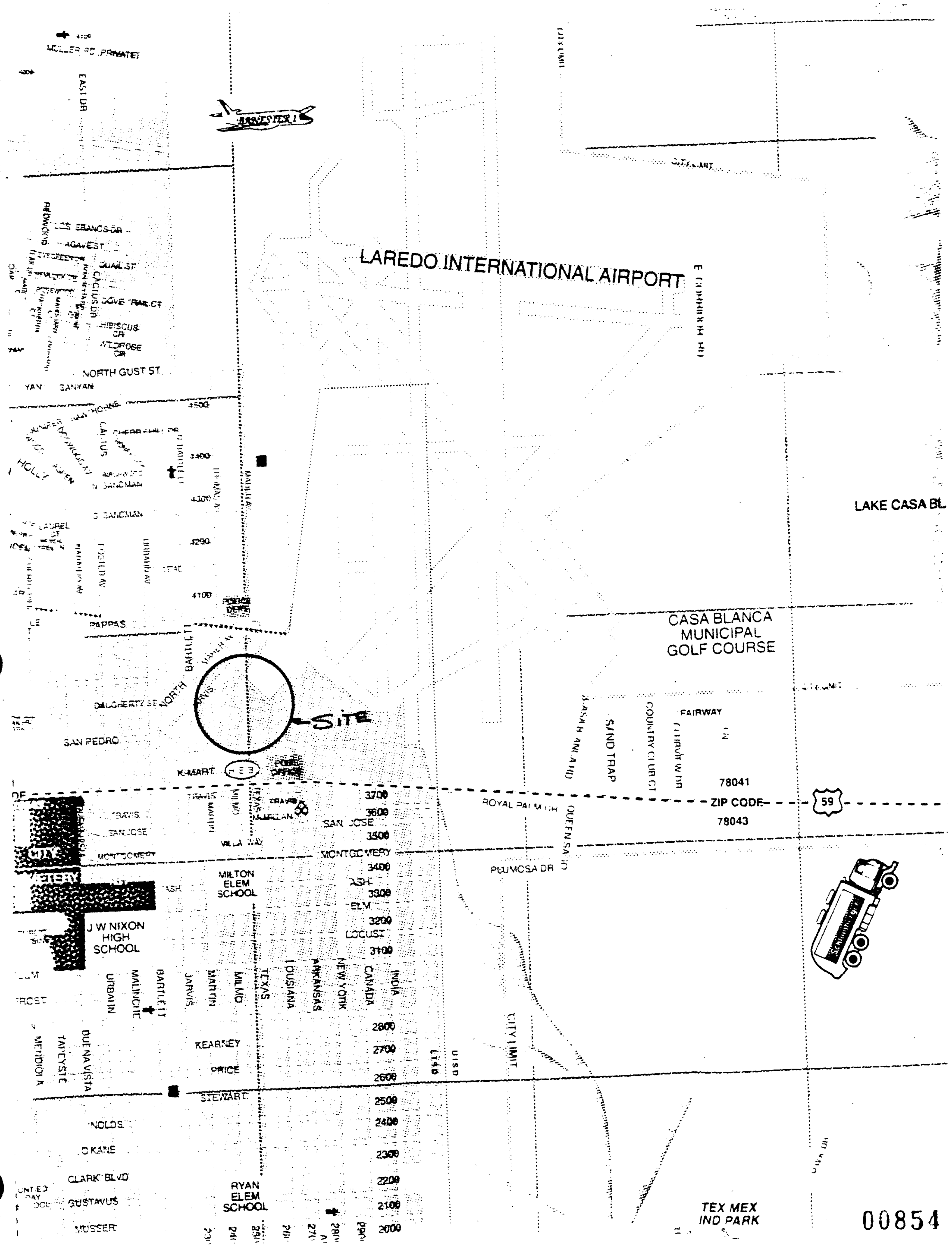
Groundwater contaminants will be adsorbed and biologically treated in a microbially activated fluidized granular activated carbon bed. Treated water will then recharge the source area by injection wells.

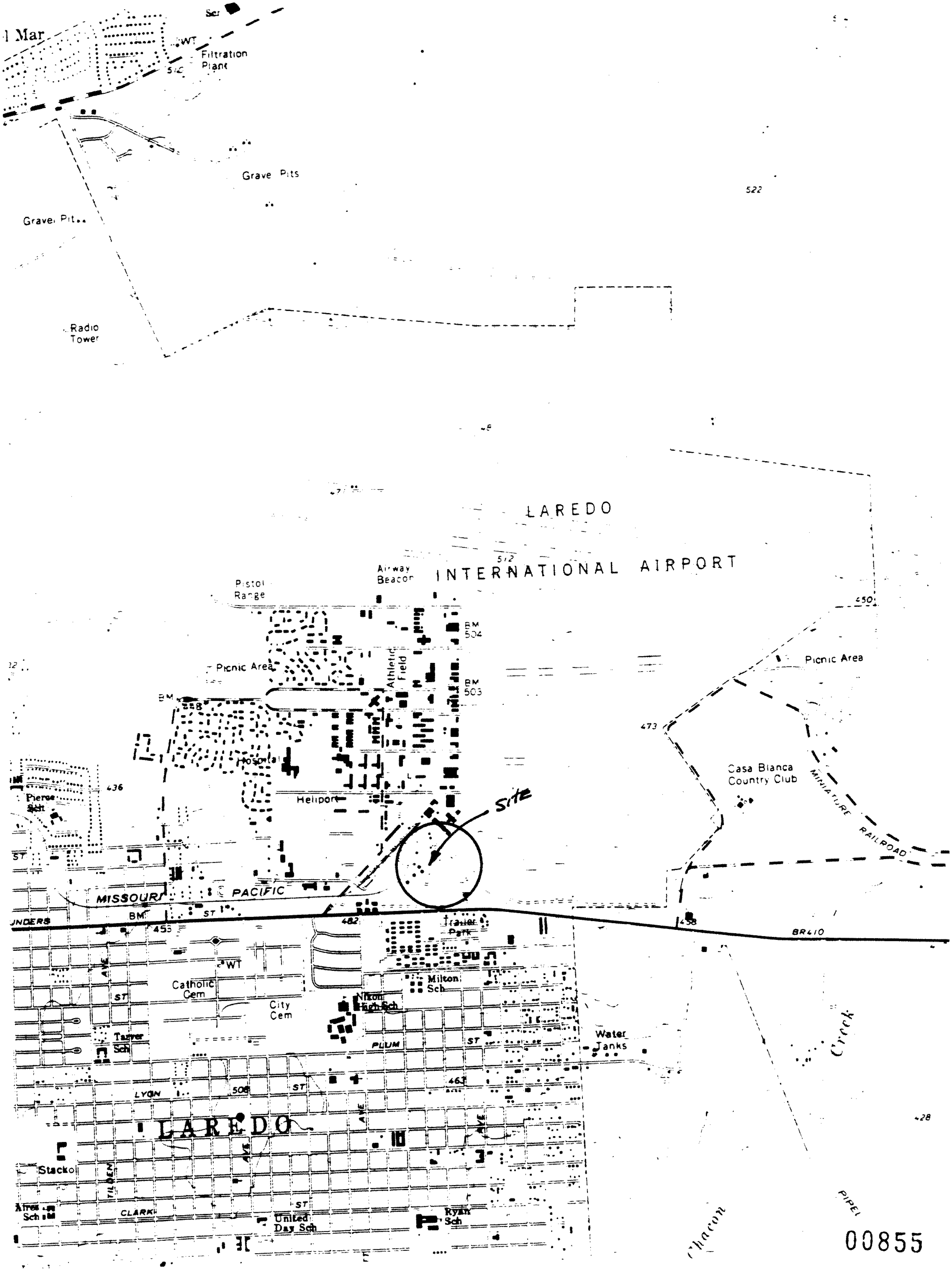
The source area discharge water will be supplied with nutrients and/or oxygen to stimulate insitu biodegradation. Insitu biodegradation will be used to enhance the breakdown of hydrocarbons adsorbed to soil grains.

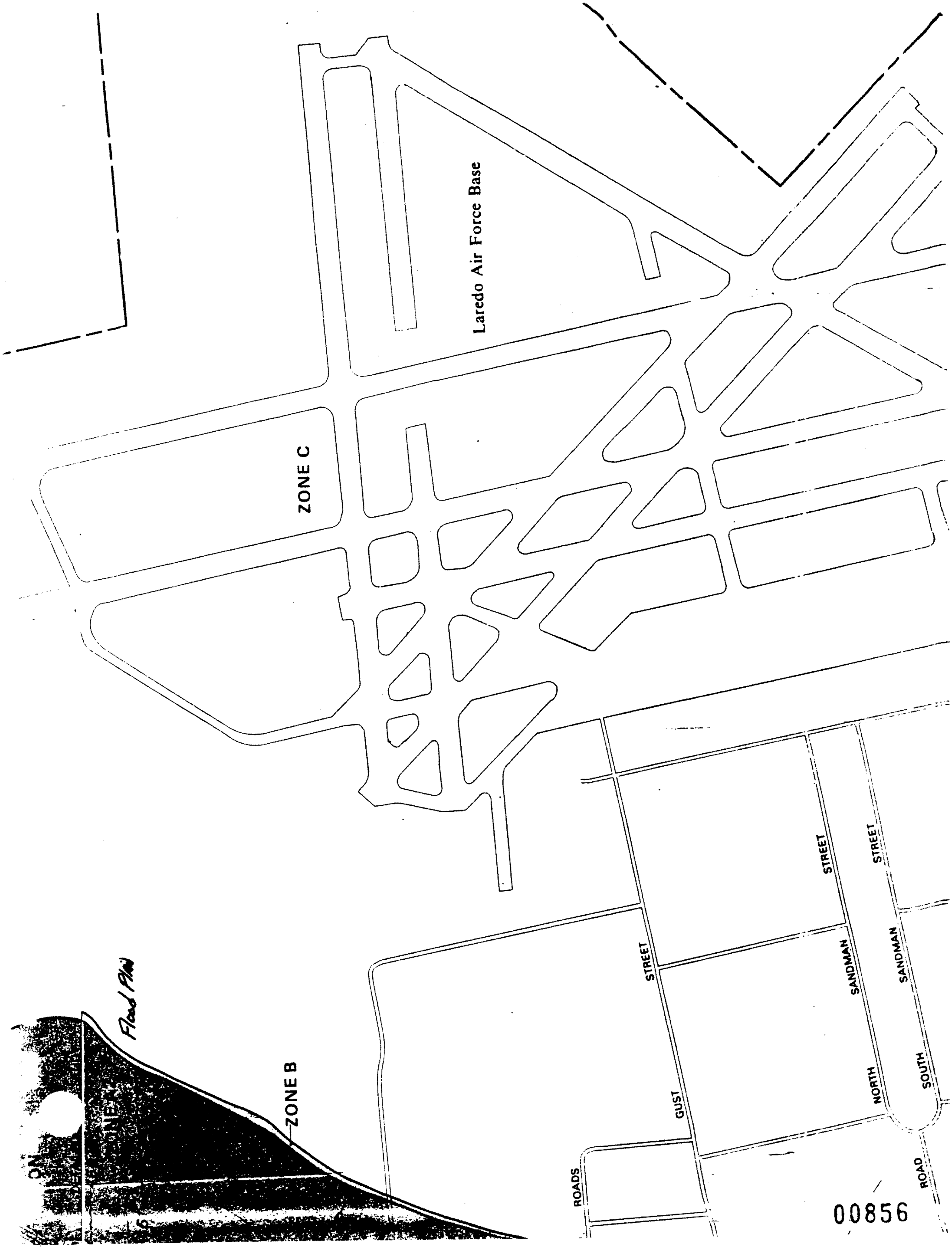
APPENDICES

APPENDIX A

MAPS


LAREDO INTERNATIONAL AIRPORT
LAKE CASA BL
CASA BLANCA MUNICIPAL GOLF COURSE
←SITE
K-MART
HEB
POST OFFICE
POLICE DEPT
ZIP CODE
78041
78043
59
ROYAL PALM
MONTGOMERY
SAN JOSE
TRAVIS
PLUMOSA DR
FAIRWAY
SAND TRAP
COUNTRY CLUB CT
QUEEN SABO
CITY LIMIT
MILTON ELEM SCHOOL
J W NIXON HIGH SCHOOL
RYAN ELEM SCHOOL
TEX MEX IND PARK
CITY CEMETERY
NORTH GUST ST
NORTH BARTLETT
DAUGHERTY ST
SAN PEDRO
PAPPAS
S SANDMAN
N SANDMAN
LOS EBANOS DR
AGAVE ST
QUAIL ST
DOVE TRAIL CT
HIBISCUS CIR
WILDROSE CIR
CACTUS DR
BANYAN
HOLLY
LAUREL
ASH
ELM
LOCUST
KEARNEY
PRICE
STEWART
REYNOLDS
O KANE
CLARK BLVD
GUSTAVUS
MUSSER
URBAHN
MALINCHE
BARTLETT
JARVIS
MARTIN
MILMO
TEXAS
LOUISIANA
ARKANSAS
NEW YORK
CANADA
INDIA
MENDIOLA
TATEYSTE
BUENA VISTA
FROST
UISD
MOLLER RD (PRIVATE)
EAST DR
BANVESTER I
3700
3600
3500
3400
3300
3200
3100
2800
2700
2600
2500
2400
2300
2200
2100
2000


Mar
Sch
WT
Filtration Plant
Grave Pits
Grave Pit
Radio Tower
522
LAREDO INTERNATIONAL AIRPORT
512
Airway Beacon
Pistol Range
BM 504
BM 503
Picnic Area
Athletic Field
BM 458
Hospital
Heliport
Pierce Sch
436
450
Picnic Area
473
Casa Blanca Country Club
MINIATURE RAILROAD
Site
MISSOURI PACIFIC
ST
UNDERS
BM 455
482
Trailer Park
458
BR410
WT
Catholic Cem
City Cem
Milton Sch
Nixon High Sch
Tarver Sch
PLUM ST
Water Tanks
Creek
LYON
508
ST
463
LAREDO
AVE
428
Stacko
TILDEN
Alres Sch
CLARK
ST
United Day Sch
Ryan Sch
Chacon
PIPEL


Laredo Air Force Base
ZONE C
Flood Plain
ZONE B
STREET
STREET
STREET
SANDMAN
SANDMAN
NORTH
SOUTH
GUST
STREET
ROADS
ROAD

APPENDIX B

LAB REPORTS

1/21/92

LAREDO AIRPORT

Sample I.D.	Sample Date	Matrix	Benzene	Toluene	Ethyl- benzene	P-Xylene	O-Xylene	M-Xylene	TTL Xylene	TTL BTEX	TPH	MTBE	Dissolved Solids	FREE PRODUCT	Units
MW-1	12/11/91	WATER	3,056	531	143	57	173	216	446	4,176	13,800	NA	NA	0	UG/L
MW-2	12/11/91	WATER	329	271	205	94	169	253	516	1,321	214,300	NA	NA	0	UG/L
MW-3	12/11/91	WATER	10	18	ND	ND	ND	13	13	42	3,330	49	35,100	0	UG/L
MW-4	NA	WATER	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0	UG/L
RW-5	NA	WATER	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0.015	UG/L
RW-6	NA	WATER	NA	NA	NA	NA	NA	NA	0	0	NA	NA	NA	0.015	UG/L

3,510 mg/l

pan american laboratories. inc.

Analytical and Consulting Chemists
5337 East 14th Street Brownsville, Texas 78521 (512) 831-4266 Fax. 831-4245

12/16/91

CERTIFICATE OF ANALYSIS

For : JBL GROUP
Address : P.O. BOX 1870
City, State, Zip : Laredo, Texas 78044
City of Laredo International Airport
Sample Marked : MW #1
Received : December 11, 1991 Lab # 106332

ANALYTE	CONCENTRATION (ug/l)
M.T.B.E.	<10
Benzene	3,056
Toluene	531
Ethyl Benzene	143
P-Xylene	57
O-Xylene	173
M-Xylene	216
	(mg/l)
Total Petroleum Hydrocarbons	13.8
Total Lead as Pb	
Total Dissolved Solids	
pH	

Analysis for M.B.T.E.X. by E.P.A. method 8020/5030
Paragraph 7.3.1
Analysis for TPH by E.P.A. method 418.1
Analysis for Total Lead by E.P.A. method 239.2
Analysis for TDS by USGS I 1752
Analysis for pH by E.P.A. method 150.1

RESPECTFULLY SUBMITTED,

PAN AMERICAN LABORATORIES INC.

pan american laboratories, inc.

Analytical and Consulting Chemists
5337 East 14th Street Brownsville, Texas 78521 (512) 831-4266 Fax. 831-4245

12/16/91

CERTIFICATE OF ANALYSIS

For : JBL GROUP
Address : P.O. BOX 1870
City, State, Zip : Laredo, Texas 78044
City of Laredo International Airport
Sample Marked : MW #2
Received : December 11, 1991 Lab # 106333

ANALYTE	CONCENTRATION (ug/1)
M.T.B.E.	<10
Benzene	329
Toluene	271
Ethyl Benzene	205
P-Xylene	94
O-Xylene	169
M-Xylene	253
	(mg/1)
Total Petroleum Hydrocarbons	214
Total Lead as Pb	
Total Dissolved Solids	
pH	

Analysis for M.B.T.E.X. by E.P.A. method 8020/5030
Paragraph 7.3.1
Analysis for TPH by E.P.A. method 418.1
Analysis for Total Lead by E.P.A. method 239.2
Analysis for TDS by USGS I 1752
Analysis for pH by E.P.A. method 150.1

RESPECTFULLY SUBMITTED,

PAN AMERICAN LABORATORIES INC.

pan american laboratories. inc.

Analytical and Consulting Chemists
5337 East 14th Street Brownsville, Texas 78521 (512) 831-4266 Fax. 831-4245

12/16/91

CERTIFICATE OF ANALYSIS

For : JBL GROUP
Address : P.O. BOX 1870
City, State, Zip : Laredo, Texas 78044
City of Laredo International Airport
Sample Marked : MW #3
Received : December 11, 1991 Lab # 106334

ANALYTE	CONCENTRATION (ug/l)
M.T.B.E.	48.7
Benzene	10.4
Toluene	18.2
Ethyl Benzene	<10
P-Xylene	<10
O-Xylene	<10
M-Xylene	13.2
	(mg/l)
Total Petroleum Hydrocarbons	3.33
Total Lead as Pb	
Total Dissolved Solids	
pH	

Analysis for M.B.T.E.X. by E.P.A. method 8020/5030
Paragraph 7.3.1
Analysis for TPH by E.P.A. method 418.1
Analysis for Total Lead by E.P.A. method 239.2
Analysis for TDS by USGS I 1752
Analysis for pH by E.P.A. method 150.1

RESPECTFULLY SUBMITTED,

PAN AMERICAN LABORATORIES INC.

pan american laboratories, inc.

Analytical and Consulting Chemists

5337 East 14th Street Brownsville, Texas 78521 (512) 831-4266 or 831-4245

December 13, 1991

CERTIFICATE OF ANALYSIS

For IBL GROUP

P.O. BOX 1870

Address Laredo, Texas 78044

Sample marked Water MW #4 City of Laredo International Airport

Received December 11, 1991 Lab. No. 106335

Analysis	Method	Analytical Results
Total Dissolved Solids	160.4	3,510 mg/l
Conductivity	120.1	2,800 umhos/cm

RESPECTFULLY SUBMITTED,

PAN AMERICAN LABORATORIES, INC

Unless otherwise stated, sample was submitted by Client

JOB #:

SITE NAME: Airport - City of Laredo /Ag[illegible]

PROJECT:

SAMPLED BY: Jenlyn Rice

JBL GROUP

P.O. Box 1870
Laredo, Texas 78044-1870

CHAIN OF CUSTODY NO: 2

PROJ. ENG. Jenlyn Rice

CONTACT:

SAMPLE NUMBER	DATE	TIME	SAMPLE LOCATION	MATRIX	COMPOSITE OR GRAB	NUMBER OF CONTAINERS	ANALYSIS REQUIRED BTEX	TPH	TDS					REMARKS RESERVATIONS ETC.
	12/13		Comp under 55 gal	Soil	C		X	X						

Relinquished By: (Signature)	Date/Time 12/18	Received By: (Signature)	Date Shipped: 12/18 Shipped By: Shipment Number:

Remarks:

Report To: Leak-Tec Corporation
Lab Number: 27581
Page #2

RESULTS: ppm - parts per million   ppb - parts per billion

QUALITY CONTROL DATA

	Value 1	Value 2	% Var.
TPH:	680	720	5.6
BENZENE:	98	97	1.0

CONCENTRATION UNITS: BTEX/ppb   TPH/ppm   MTBE/ppb

SAMPLE RESULTS

SAMPLE I.D.	BENZENE	TOLUENE	XYLENES	ETHYL BENZENE	TPH	MTBE
MW#1 599-15	4000	730	530	200	13	<10
MW#3 599-16	360	82	280	190	<10	<10
MW#4 599-17	<10	<10	<10	<10	<10	<10
Blank	<10	<10	<10	<10	<10	<10

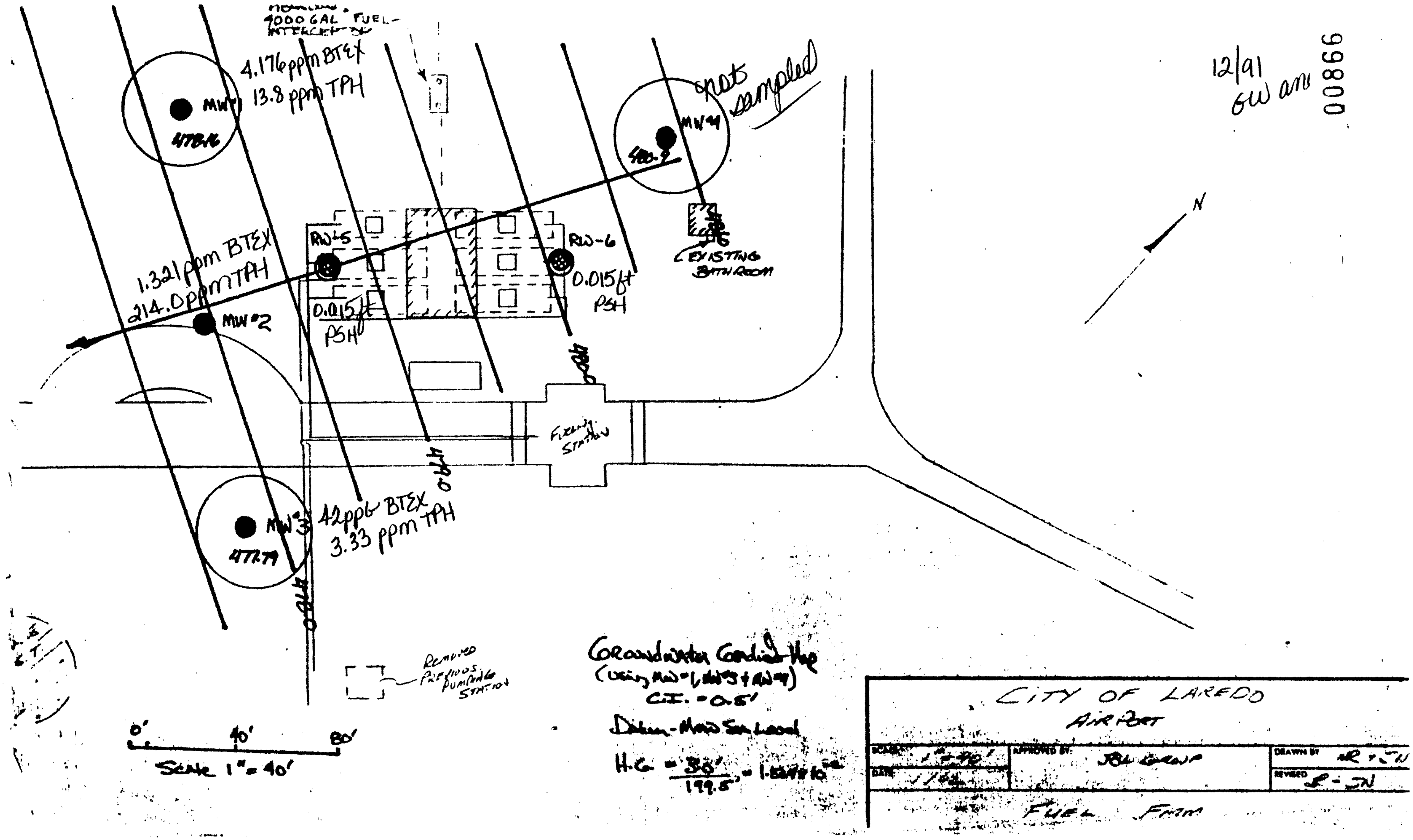
7/25/90

Attachment 8

APPENDIX C

GROUNDWATER ASSESSMENT

PHASE II R.A.P. REPORT FOR THE CITY
OF LAREDO INTERNATIONAL AIRPORT



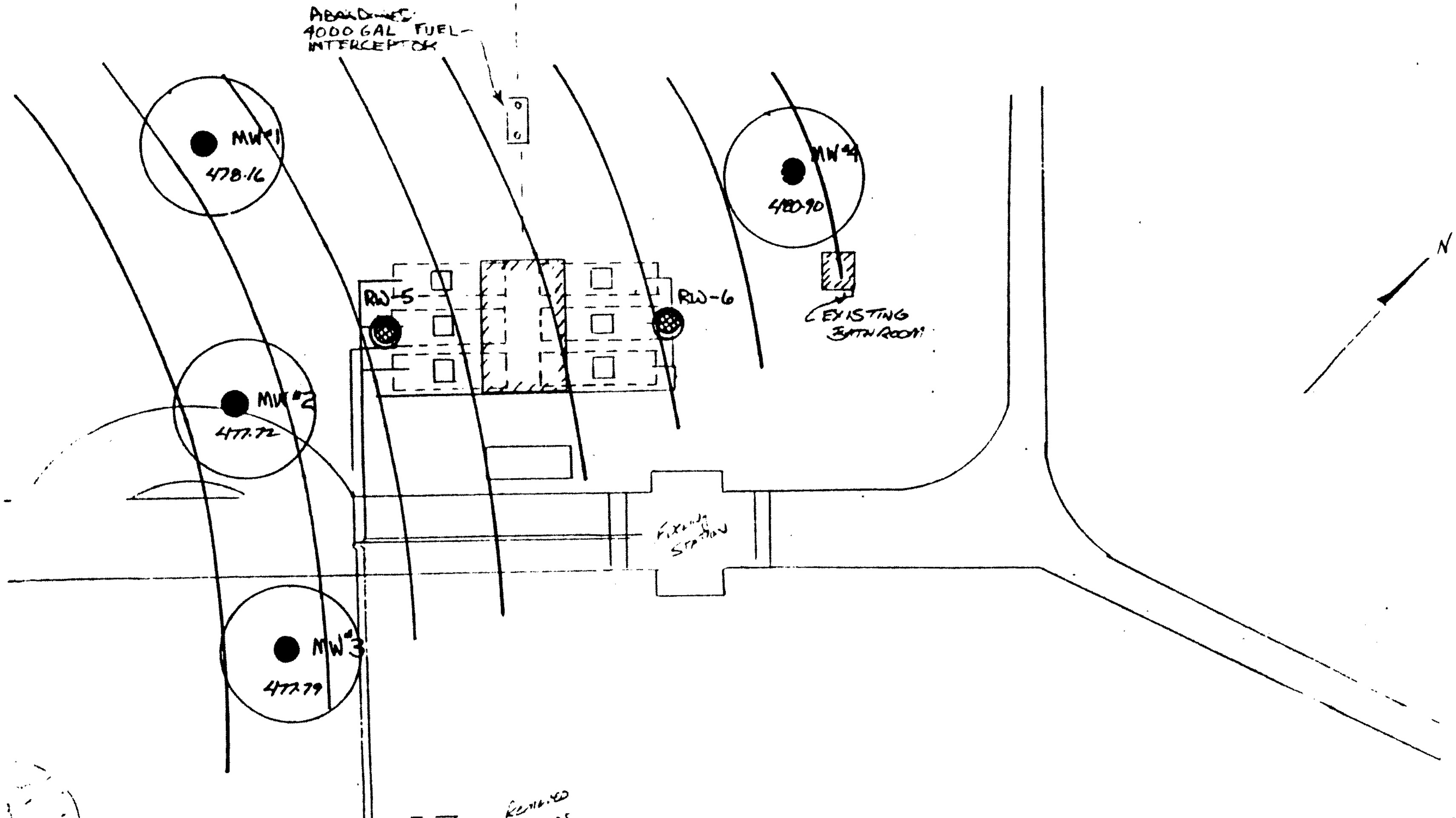
Groundwater Contour Map
(using MW-1, MW-3 & MW-4)
C.I. = 0.5'
Datum - Mean Sea Level
H.G. = 3.0' / 199.5' = 1.5 × 10⁻²

CITY OF LAREDO
AIRPORT

SCALE 1" = 40'	APPROVED BY: JBL Group	DRAWN BY:
DATE: 1/92		REVISED

FUEL FARM

12/91
GW an

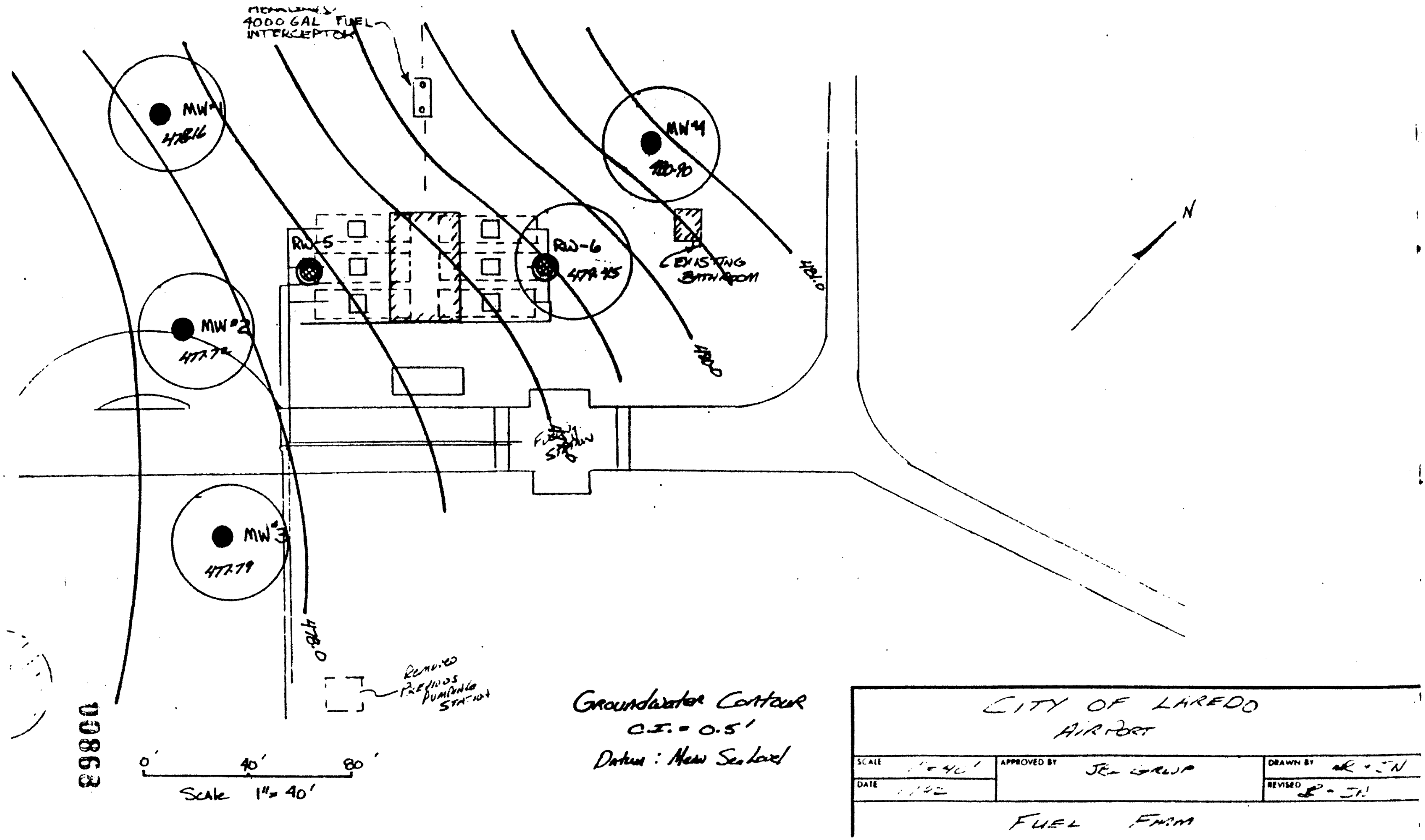


Groundwater Contour
C.I. = 0.5'
Datum : Mean Sea Level

CITY OF LAREDO
AIRPORT

SCALE: 1" = 40'
DATE: 1/92
APPROVED BY: JRL GROUP
DRAWN BY AR + JN
REVISED AR - JN

FUEL FARM

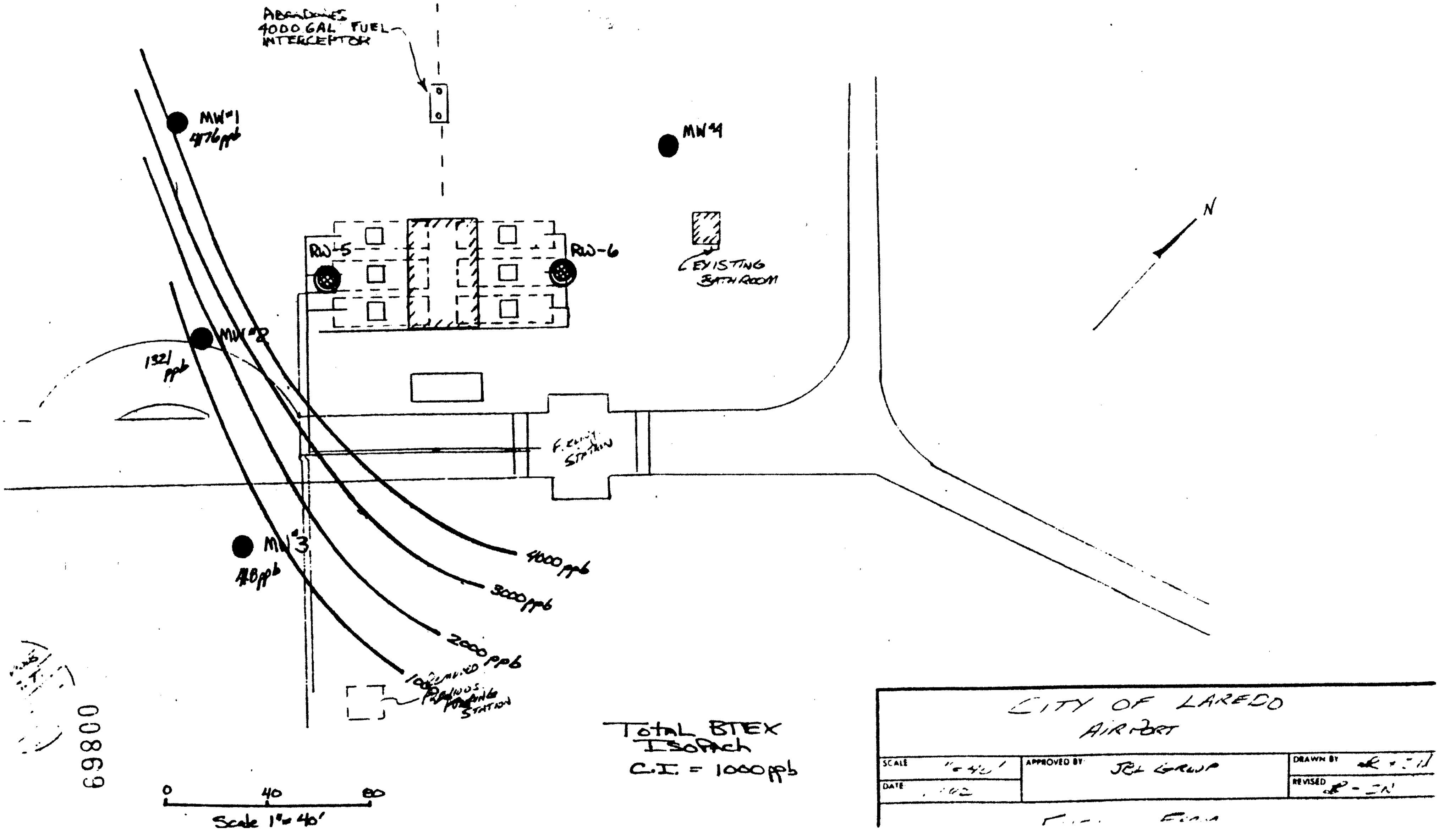


Groundwater Contour
C.I. = 0.5'
Datum: Mean Sea Level

CITY OF LAREDO
AIRPORT

SCALE 1" = 40'	APPROVED BY JEA GROUP	DRAWN BY [illegible]
DATE [illegible]		REVISED [illegible]

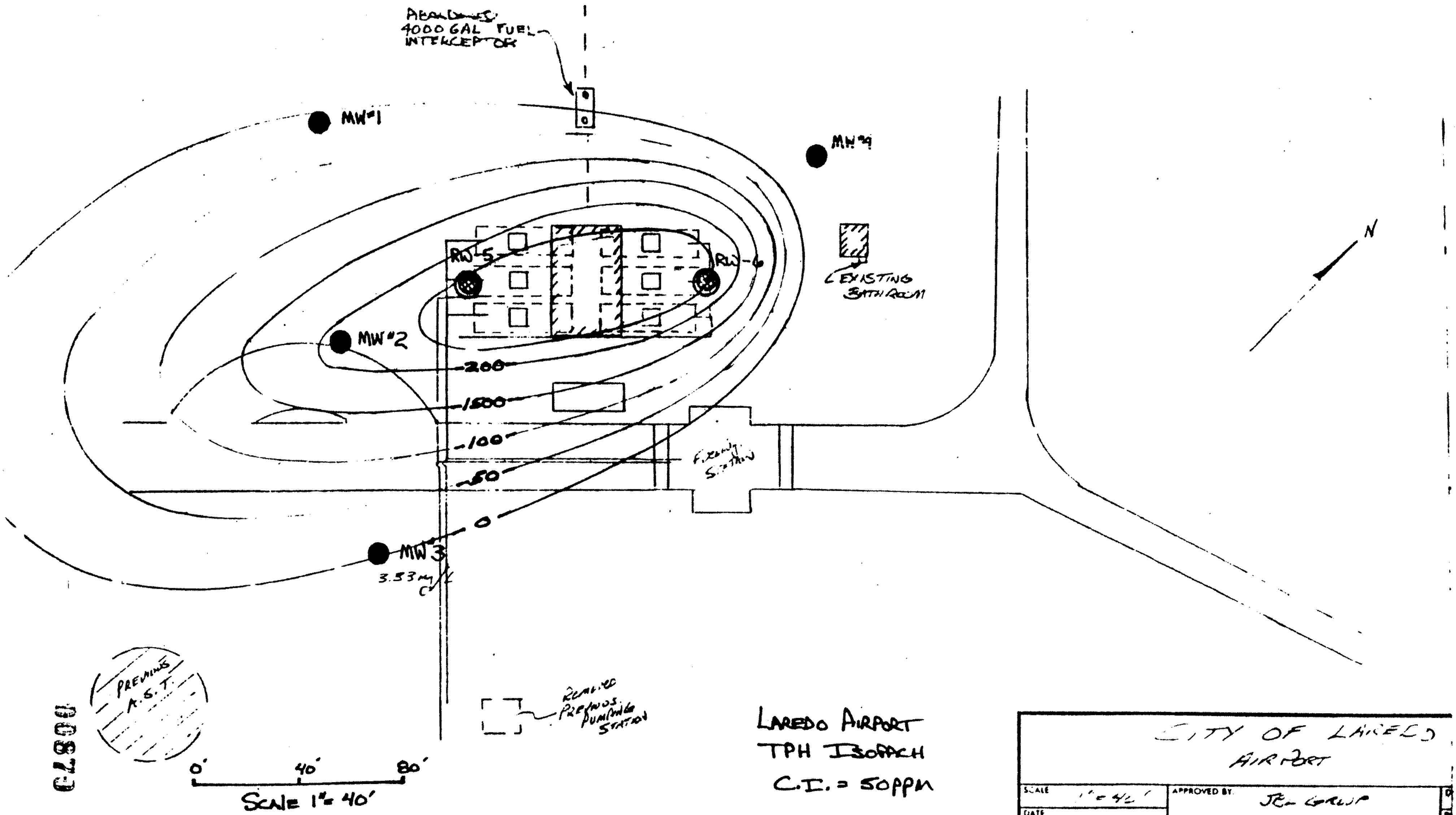
FUEL FARM



Total BTEX Isopach
C.I. = 1000 ppb

CITY OF LAREDO
AIRPORT

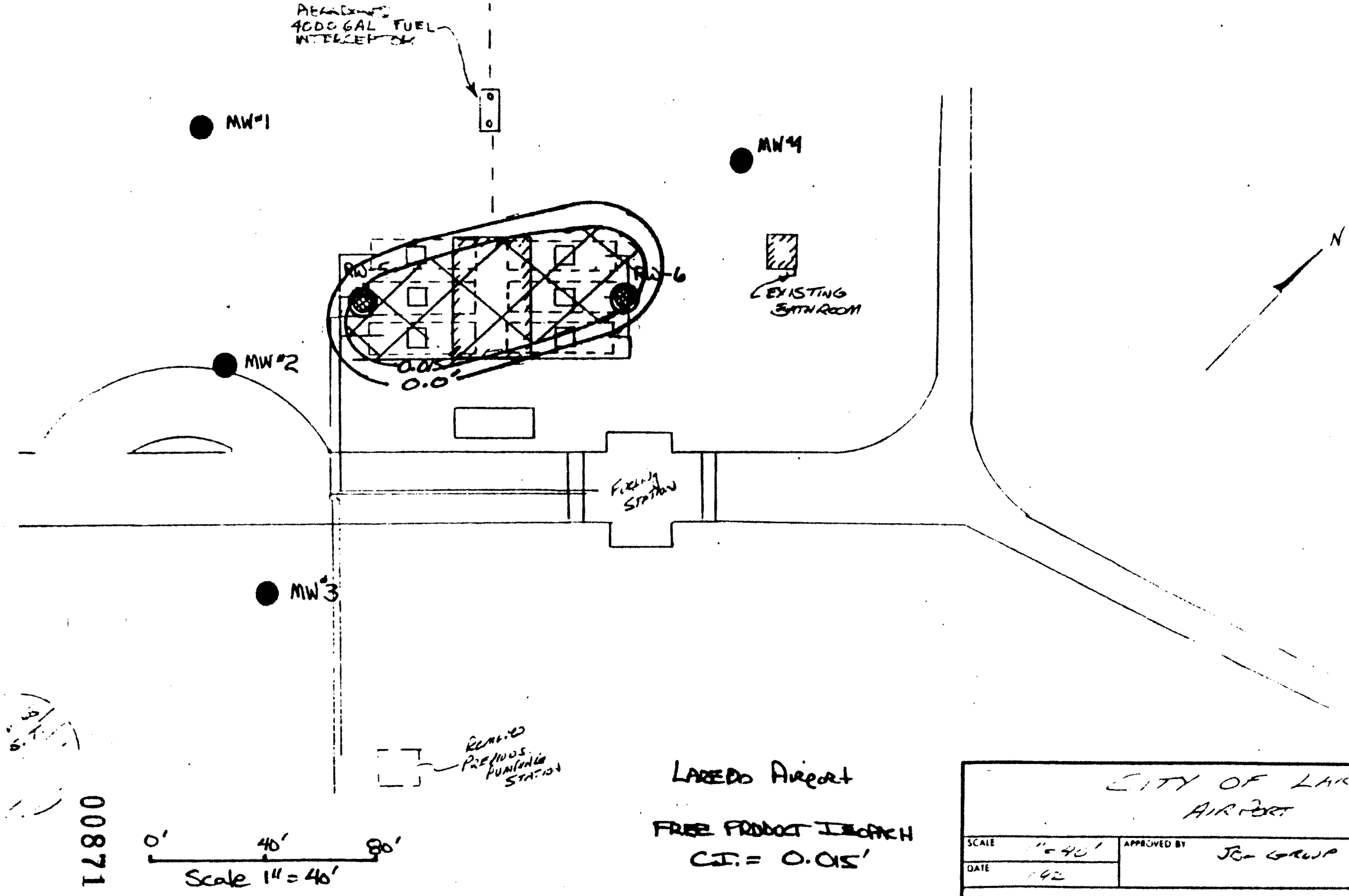
SCALE 1" = 40'
DATE [illegible]
APPROVED BY JRL GROUP
DRAWN BY [illegible]
REVISED [illegible]



Laredo Airport
TPH Isopach
C.I. = 50ppm

CITY OF LAREDO
AIRPORT

SCALE 1" = 40'
DATE [illegible]
APPROVED BY: JC GROUP



Laredo Airport

FREE PRODUCT ISOPACH

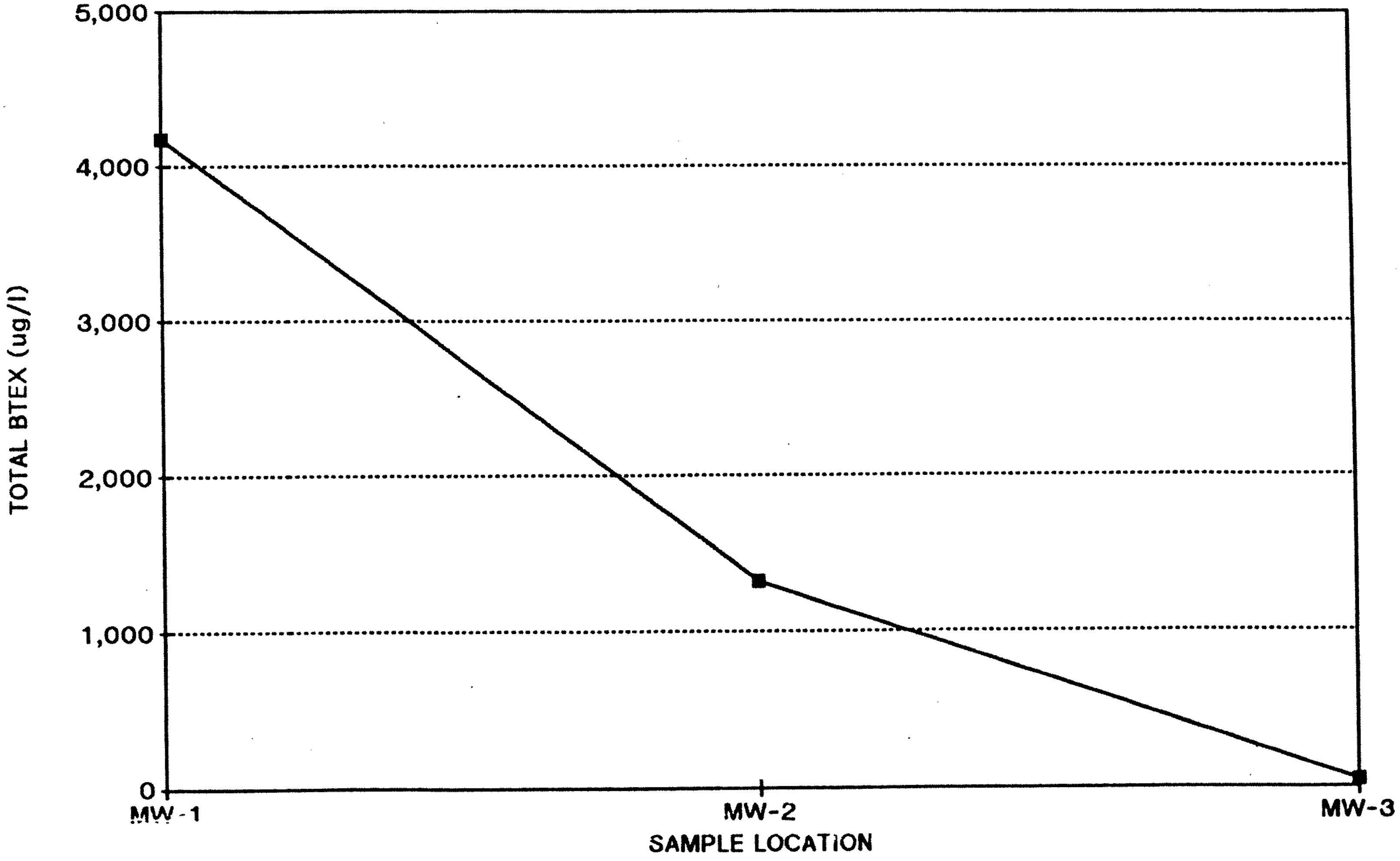
C.I. = 0.015'

CITY OF LAREDO
AIRPORT

SCALE 1" = 40'	APPROVED BY JCA GROUP	DRAWN BY
DATE 92		REVISED

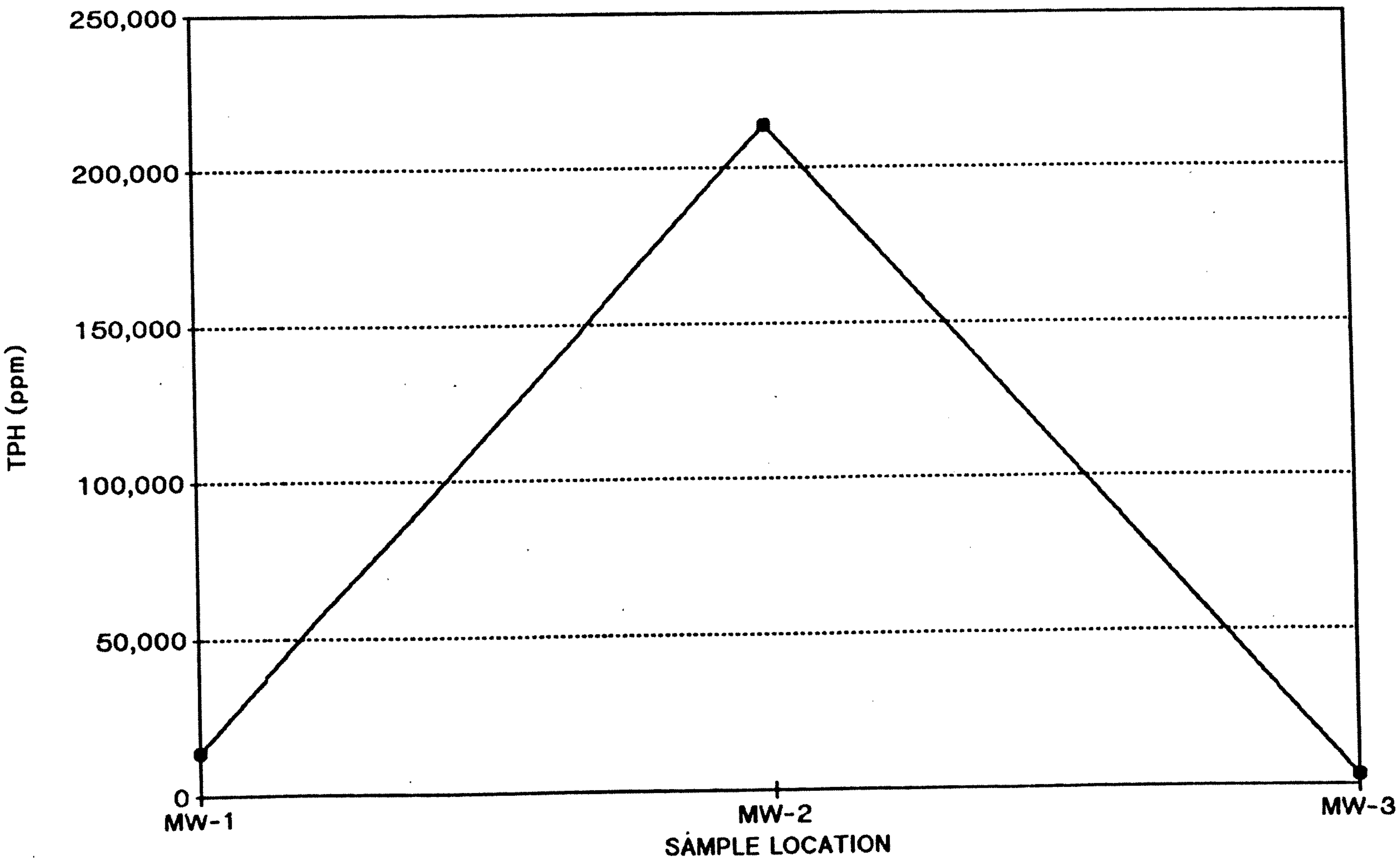
LAREDO AIRPORT

TOTAL BTEX CONCENTRATIONS (12/11/91)



LAREDO AIRPORT

TPH CONCENTRATIONS (12/11/91)



DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

RECOVERY WELL NO. 1 (NORTH)

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
10-1	8:05	112	113	1"		CHAVELY + JONES
10-2	8:15	112	112.5"	.5"		SANTOS + CHAVEZ
10-3	8:30	109.25	111.75	2.5		SANTOS + CHAVEZ
10-4	8:30	110	111	1"		SANTOS + CHAVEZ
10-7	8:25	113.5	116.25	2.75"		SANTOS + CHAVEZ
10-8	8:25	113.5	114.5	1"		SANTOS + CHAVEZ
10-9	9:10	112	114	2"		SANTOS + CHAVEZ

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

RECOVERY WELL NO. 2 (SOUTH)

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
10-1	8:15	130.5	132	1.5"		Chavez Torres
10-2	8:30	130	131	1.0"		SANTOS + CHAVEZ
10-3	8:45	128	128.5	.5"		SANTOS + CHAVEZ
10-4	8:45	128	127.5	-.5"		SANTOS + CHAVEZ
10-7	8:40	132.5	133	.5"		SANTOS + CHAVEZ
10-8	8:40	131.5	130.75	-.75"		SANTOS + CHAVEZ
10-9		130.5	130.75	-.25"		SANTOS + CHAVEZ

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

RECOVERY WELL NO. 3 (SOUTH EAST)

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
10-1	8:30	119.5	119	-5		CHAVEZY torres
10-2	8:45	119	119	-0-		SANTOS +CHAVEZ
10-3	9:00	117	117	-0-		SANTOS +CHAVEZ
10-4	9:00	116.5	116.25	-,25"		SANTOS +CHAVEZ
10-7	8:55	121	120.25	-.75		SANTOS +CHAVEZ
10-8	8:55	120	120	-0-		SANTOS +CHAVEZ

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

RECOVERY WELL NO. 4(SOUTH WEST)

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
10-1	8:45	108.	108	-0-		CHAVEZ TORRES
10-2	8:50	108	108	-0-		SANTOS +CHAVEZ
10-3	9:05	102	101	-1"		SANTOS &CHAVEZ
10-4	9:05	102	101	-1"		SANTOS &CHAVEZ
10-7	9:00	105	104.5	-.50"		SANTOS +CHAVEZ
10-8	9:00	104	102.5	-1.50"		SANTOS +CHAVEZ

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- RECOVERY WELL #6 -

	DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
91	11-1	8:30	117	118	1"		TORRES Y SANTOS
91	11-4	8:34	119	120	1"		Torres y CHAVEZ
9.	11-5	8:50	117	117	-0-		VAIDES Y CHAVEZ
91	11-6	8:30	116	116.5	.5"		CHAVEZ & SANTOS
91	11-7	8:20	114	114.5	5"		VAIDES Y CHAVEZ
91	11-8	8:15	119.5	120.25	75"		VAIDES Y CHAVEZ
91	11-12	8:30	116.	117.5	1.5		Torres y CHAVEZ
91	11-13	8:20	112	117.5	5.5"		CHAVEZ & SANTOS
91	11-14	8:40	114.5	114.75	.25"		Torres y CHAVEZ
91	11-15	8:25	114.75	115.25	.50"		SANTOS & CHAVEZ
91	11-18	8:25	111	115.50	4.5"		SANTOS & CHAVEZ
91	11-19	8:25	114.5	115	.50"		CHAVEZ Y SANTOS
91	11-20	8:30	119	121	2.0"		CHAVEZ & SANTOS
91	11-21	8:30	119	119.5	.50"		CHAVEZ & SANTOS
91	11-22	8:20	119	119	-0-		CHAVEZ & SANTOS
91	11-25	8:30	119	121	2"		CHAVEZ Y SANTOS
91	11-26	8:40	118	118.75	.75"		CHAVEZ & SANTOS

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- Recovery Well #5 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
91 11-1	8:45	134	134.5	.5"		Torres Santos
91 11-4	8:48	137	137.5	.5"		Torrey Chavez
91 11-5	9:00	134	134	-0-		Valdes y Chavez
91 11-6	8:45	133.5	133.5	-0-		CHAVEZ y SANTOS
91 11-7	8:30	132	132.	-0-		VALDES Y Chavez
91 11-8	8:28	138	138	-0-		Valdes/ [illegible]
91 11-12	8:40	135	135.25	.25"		Torres/ Chavez
91 11-13	8:50	135.5	135.5	-0-		CHAVEZ y SANTOS
91 11-14	8:47	132.	132	-0-		Torres y Chavez
91 11-15	8:40	133	133	-0-		CHAVEZ y SANTOS
91 11-18	8:40	132.5	132.5	-0-		CHAVEZ y SANTOS
91 11-19	8:40	132	132	-0-		CHAVEZ y SANTOS
91 11-20	8:45	132	132	-0-		CHAVEZ y SANTOS
91 11-21	8:45	137	137	-0-		CHAVEZ y SANTOS
91 11-22	8:35	136	136	-0-		CHAVEZ y SANTOS
91 11-25	8:45	138	138	-0-		CHAVEZ y SANTOS
91 11-26	8:55	136	136	-0-		CHAVEZ y SANTOS

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL #2 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
91 11-1	9:00	123	123	-0-		TORRES Y SANTOS
91 11-4	9:00	124	124	-0-		Torres y CHAVEZ
91 11-5	9:13	121.5	121.5	-0-		VAIDES Y CHAVEZ
91 11-6	9:00	121	121	-0-		CHAVEZ Y SANTOS
91 11-7	8:35	120	120	-0-		VAIDES Y CHAVEZ
91 11-8	8:34	126	126	-0-		VAIDES Y CHAVEZ
91 11-12	8:50	123	123	-0-		Torres Y CHAVEZ
91 11-13	9:05	123	123	-0-		SANTOS Y CHAVEZ
91 11-14	9:00	124	124	-0-		Torres Y CHAVEZ
91 11-15	8:55	124	124	-0-		CHAVEZ Y SANTOS
91 11-18	8:55	123	123	-0-		CHAVEZ Y SANTOS
91 11-19	8:55	123	123	-0-		CHAVEZ Y SANTOS
91 11-20	9:00	123	123	-0-		CHAVEZ Y SANTOS
91 11-21	9:00	125	125	-0-		CHAVEZ Y SANTOS
91 11-22	8:50	124	124	-0-		CHAVEZ Y SANTOS
91 11-25	9:00	126	126	-0-		CHAVEZ Y SANTOS
91 11-26	9:10	126	126	-0-		CHAVEZ Y SANTOS

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL #3 -

	DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
91	11-1	9:05	125	125	-0-		TORRES Y SANTOS
91	11-4	9:10	127	127	-0-		Torres Y CHAVEZ
91	11-5	9:18	124	124	-0-		VALDES Y CHAVEZ
91	11-6	9:05	123	123	-0-		CHAVEZ Y SANTOS
91	11-7	8:40	122.5	122.5	-0-		VALDES Y CHAVEZ
91	11-8	8:38	128	128	-0-		VALDES Y CHAVEZ
91	11-12	9:00	126	126	-0-		Torres Y CHAVEZ
91	11-13	9:10	126	126	-0-		CHAVEZ Y SANTOS
91	11-14	9:10	126	126	-0-		Torres Y CHAVEZ
91	11-15	9:00	126	126	-0-		CHAVEZ Y SANTOS
91	11-18	9:00	124.75	124.75	-0-		CHAVEZ Y SANTOS
91	11-19	9:00	124	124	-0-		CHAVEZ Y SANTOS
91	11-20	9:05	124	124	-0-		CHAVEZ Y SANTOS
91	11-21	9:05	127.5	127.5	-0-		CHAVEZ Y SANTOS
91	11-22	8:55	127	127	-0-		CHAVEZ Y SANTOS
91	11-25	9:05	128	128	-0-		CHAVEZ Y SANTOS
91	11-26	9:15	128	128	-0-		CHAVEZ Y SANTOS

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

MONITOR WELL #1

	DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
91	11-1	9:10	104	104	-0-		TORRES Y SANTOS
91	11-4	9:06	108	108	-0-		Torres Y CHAVEZ
91	11 5	9:25	105.5	105.5	-0-		VAIDES Y CHAVEZ
91	11-6	9:10	105.5	105.5	-0-		CHAVEZ Y SANTOS
91	11-7	8:45	104.	104.	-0-		VAIDES Y CHAVEZ
91	11-8	8:45	109	109	-0-		VAIDES Y CHAVEZ
91	11-12	9:00	106	106	-0-		Torres Y CHAVEZ
91	11-13	9:15	106	106	-0-		CHAVEZ Y SANTOS
91	11-14	9:15	108	108	-0-		Torres Y CHAVEZ
91	11-15	9:05	108	108	-0-		CHAVEZ Y SANTOS
91	11-18	9:05	106	106	-0-		CHAVEZ Y SANTOS
91	11-19	9:05	106	106	-0-		CHAVEZ Y SANTOS
91	11-20	9:10	106	106	-0-		CHAVEZ Y SANTOS
91	11-21	9:10	109	109	-0-		CHAVEZ Y SANTOS
91	11-22	9:00	108	108	-0-		CHAVEZ Y SANTOS
91	11-25	9:10	109	109	-0-		CHAVEZ Y SANTOS
91	11-26	9:20	109	109	-0-		CHAVEZ Y SANTOS

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- RECOVERY WELL #6 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-30-91	8:21	120	121.75	1.75		Forrest Chavez
12-31-91	8:20	120	121	1		Chavez Santos
1-2-92	8:15	120	121.5	.1.5"		MANDOY SANTOS
1-3-92	[illegible]	118	121.5	3.5"		VALDEZ Santos
1-6-92	9:10	118	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	119	[illegible]	.5"		[illegible] Chavez
[illegible]	[illegible]:20	[illegible]	[illegible]	.5"		[illegible]
1-9-92	8:18	121	122	1		Chavez Santos
1-10-92	8:18	122	[illegible]	[illegible]		[illegible]
1-13-92	[illegible]	[illegible]	[illegible]	1.[illegible]		Chavez Santos
1-14-92	8:15	118	[illegible]	1"		Chavez Santos
1-15-92	8:30	120.5	121.0	.50"		Forrest Chavez
[illegible]	8:30	124.0	125.0	1"		Forrest Chavez
[illegible]	[illegible]	0	0	-0-		[illegible]
	[illegible]	[illegible]	[illegible]	[illegible]		VALDEZ Chavez
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1-22-92	8:30	[illegible]	[illegible]	1"		VALDEZ Chavez
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1-[illegible]	[illegible]	108	108.5	.5"		[illegible]

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

RECOVERY WELL #5

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-30-91	8:30	141	141	-0-		TORRES + CHAVEZ
12-31-91	8:35	141	141	-0-		CHAVEZ + SANTOS
1-2-92	8:30	141	141	-0-		HANDOY SANTOS
1-3-92	8:26	141	141	-0-		VALDEZ SANTOS
1-6-92	[illegible]	141.5	[illegible]	-0-		CHAVEZ [illegible]
[illegible]	8:30	139.5	[illegible]	[illegible]		VALDEZ CHAVEZ
[illegible]	[illegible]	142.5	[illegible]	-0-		[illegible]
1-9-92	[illegible]	143	[illegible]	[illegible]		CHAVEZ SANTOS
[illegible]	8:35	145	145	-0-		[illegible]
1-13-92	[illegible]	[illegible]	[illegible]	[illegible]		CHAVEZ [illegible]
1-14-92	8:[illegible]	141.5	141.5	-0-		CHAVEZ SANTOS
1-15-92	[illegible]	144.0	144.0	-0-		[illegible]
1-16-92	8:35	148.0	148.0	-0-		Torres [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]		[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	8:35	[illegible]	[illegible]	-0-		VALDEZ CHAVEZ
[illegible]	[illegible]		[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL #2 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-3[illegible]	8:36	129	129	-0-		TORRES Y [illegible]AVEZ
12-31-91	8:50	129	129	-0-		CHAVEZ Y SANTOS
1-[illegible]-92	[illegible]	[illegible]	129	-0-		MANDO Y SANTOS
1-3-92	[illegible]	129	129	-0-		VALLE Y SA[illegible]
[illegible]	9:[illegible]	12[illegible]	[illegible]	-[illegible]-		[illegible]
		12[illegible]	12[illegible]	[illegible]		V[illegible]
[illegible]	[illegible]	[illegible]		-[illegible]-		[illegible]
1-9-92	[illegible]	130.5	130.5	-0-		[illegible] SAN[illegible]
	[illegible]	13[illegible]	[illegible]	-0-		V[illegible]
1-1[illegible]	[illegible]	[illegible]	[illegible]	- -		CHAVEZ Y [illegible]
1-1[illegible]	8:[illegible]	[illegible]	[illegible]	-0-		[illegible]
[illegible]	8:[illegible]	131.0	[illegible]	-[illegible]-		[illegible]
1-16-92	8:25	131.0	131.0	-0-		TORRES Y [illegible]
1-17-92	[illegible]	1[illegible]0	[illegible]	-0-		V[illegible]
[illegible]	[illegible]	13[illegible]	[illegible]	-[illegible]-		V[illegible]
1-2[illegible]	[illegible]	[illegible]		-[illegible]		VA[illegible]
1-2[illegible]	8:[illegible]	[illegible]	128.0	-[illegible]		V[illegible]
[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	13[illegible]	[illegible]			

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL # 3 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-30-91	8:45	132	132	—0—		TORRES Y CHAVEZ
12-31-91	8:55	132	132	—0—		CHAVEZ Y SANTOS
1-2-92	8:50	132	132	—0—		MALDO Y SANTOS
1-3-92	8:55	132	132	—0—		VALDEZ Y SANTOS
1-6-92	8:35	133	133	—0—		CHAVEZ Y SANTOS
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1-9-92	8:[illegible]	134.5	134.[illegible]	—0—		[illegible] SANTOS
1-10-92	8:50	[illegible]	[illegible]	—0—		VALDEZ Y [illegible]
[illegible]	8:[illegible]	[illegible]	[illegible]	[illegible]		CHAVEZ [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	—0—		[illegible] SANTOS
1-15-92	[illegible]	[illegible]	[illegible]	[illegible]		Torres [illegible]
1-16-92	8:44	134.0	13[illegible].0	—0—		Torres [illegible]
1-17-92	8:44	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	13[illegible]	[illegible]	[illegible]		VAL[illegible]
[illegible]	8:[illegible]	131	[illegible]	—0—		[illegible]
[illegible]	[illegible]	130.5	[illegible]	— —		[illegible]
[illegible]	8:35	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL #1 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-30-91	8:50	116.5	116.5	—0—		TORRES CHAVEZ
12-31-91	9:00	116.5	[illegible]	[illegible]		CHAVEZ [illegible]
1-2-92	8:55	116.5	116.5	—0—		MENDEZ [illegible]
[illegible]	8:46	114	114	—0—		[illegible]
1-6-92	9:23	[illegible]	[illegible]	—0—		CHAVEZ [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	8:4[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
1-9-92	8:48	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	110.5	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
1-14-92	8:45	110.5	110.5	[illegible]		[illegible]
[illegible]	[illegible]	111.0	111.0	[illegible]		Torres Chavez
1-16-92	8:46	111.0	111.0	-0-		Torres Chavez
1-17-92	[illegible]	110.5	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	105	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]					
[illegible]	[illegible]	104	[illegible]	—		

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- RECOVERY WELL # 6 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-2-91	a.m. 8:25	117.5	120	2.5		TORRES Y CHAVEZ
12-3-91	a.m. 8:10	119	120	1"		CHAVEZ MANDO
12-4-91	8:30	122	124	2"		CHAVEZ Y SANTOS
12-5-91	8:16	[illegible]	121	1"		VALDES CHAVEZ
12-6-91	[illegible]	[illegible]	119.5	.5		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	.5		VALDES Y [illegible]
12-10-91	8:05	119	119.5	.50		MANDO VALDEZ
12-11-91	8:14	119.5	119.[illegible]	[illegible]		VALDES [illegible]
[illegible]	8:30	[illegible]	[illegible]			VALDES [illegible]
12-13-91	8:30	[illegible]	[illegible]	.2		VALDES CHAVEZ
12-16-91	[illegible]	[illegible]	[illegible]	1.5		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	8:[illegible]	[illegible]	[illegible]	-0-		VALDEZ [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
		[illegible]	[illegible]	[illegible]		[illegible]
			[illegible]	1.[illegible]		[illegible]
	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	119	[illegible]	1.		[illegible]

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- RECOVERY WELL #5 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-2-91	8:44 a.m.	137	138	1"		TORRES y CHAVEZ
12-3-91	8:25 p.m.	137.5	137.5	-0-		CHAVEZ MANDO
12-4-91	8:45	137	137	-0-		CHAVEZ y SANTOS
12-5-91	8:25	137	139	-0-		VALDEZ y [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-0-		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		VALDEZ y [illegible]
12-10-91	8:20	138	138	-0-		MANDO y VALDEZ
12-11-91	8:25	[illegible]	[illegible]	-0-		VALDEZ y [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	-0-		VALDEZ y [illegible]
[illegible]	[illegible]	138.5	[illegible]	-0-		VALDES y [illegible]
12-1[illegible]-91	9:[illegible]	144	[illegible]	-0-		TORRES y SAN[illegible]
[illegible]	8:35	[illegible]	[illegible]	-0-		[illegible]
12-15-91	8:30	142	14[illegible]	-0-		VALDEZ y
[illegible]	3:[illegible]	[illegible]	[illegible]	-0-		[illegible]
[illegible]	[illegible]		[illegible]	-0-		[illegible]
[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]			

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL #2 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-2-91	8:54 a.m.	125.5	125.5	- 0 -		TORRES Y CHAVEZ
12-3-91	8:[illegible] a.m.	125.5	125.5	-0-		CHAVEZ DIMANDO
12-4-91	9:00	125.5	125.5	- 0 -		CHAVEZ SANTOS
12-5-91	8:30	12[illegible]	12[illegible]	[illegible]		VALDES Y CHAVEZ
[illegible]	8:45	12[illegible]	12[illegible]	[illegible]		VALDES [illegible]
[illegible]	8:[illegible]	12[illegible]	1[illegible]	-0-		VALDES Y CHAVEZ
12-10-91	8 35	126	126	- 0 -		MAR[illegible] VALDEZ
12-11-91	8:[illegible]	12[illegible]	126	-0-		V[illegible] [illegible]
[illegible]	[illegible]			[illegible]		[illegible]
12-13-91	8:45	12[illegible]	12[illegible]	-0-		V[illegible] [illegible]
12-1[illegible]-91	9:[illegible]	128	12[illegible]	-0-		[illegible]
12-1[illegible]-91	[illegible]	12[illegible]	[illegible]	[illegible]		V[illegible] [illegible]
12-18-91	8:45	127	12[illegible]	-0-		VALDEZ Y [illegible]
[illegible]	8:[illegible]	12[illegible]	[illegible]	[illegible]		CHAVEZ [illegible]
12-20-91	[illegible]	[illegible]				
[illegible]	[illegible]	12[illegible]	[illegible]	[illegible]		TORRES [illegible]
[illegible]	[illegible]	128	[illegible]	[illegible]		[illegible]
[illegible]						

DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL #3 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-2-91	9:00	128	128	- 0 -		Torres y Chavez
12-3-91	9:00	128	128	- 0 -		Chavez y Manzo
12-4-91	9:05	128	[illegible]	- 0 -		Chavez y Santos
12-5-91	8:55	130	130	- 0 -		Valdes y Chavez
[illegible]	8:50	[illegible]	[illegible]	- 0 -		Valdes y [illegible]
12-9-9[illegible]	[illegible]	129.5	[illegible]	- 0 -		Valdes y [illegible]
12-10-91	8:50	128.5	128.5	- 0 -		Manzo y Valdez
12-11-91	[illegible]	[illegible]	127.5	- 0 -		Valdes y [illegible]
[illegible]	[illegible]	[illegible]	[illegible]	- 0 -		[illegible]
[illegible]	[illegible]	130.0	[illegible]	[illegible]		[illegible]
12-16-91	9:5[illegible]	130	[illegible]	- 0 -		Torres y Santos
12-17-91	9:5[illegible]	130.0	[illegible]	[illegible]		[illegible]
12-18-91	8:50	132	13[illegible]	- 0 -		VALDEZ Y
12-19-91	8:[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	8:[illegible]	[illegible]	[illegible]	- 0 -		[illegible]
[illegible]	8:[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	8:[illegible]					

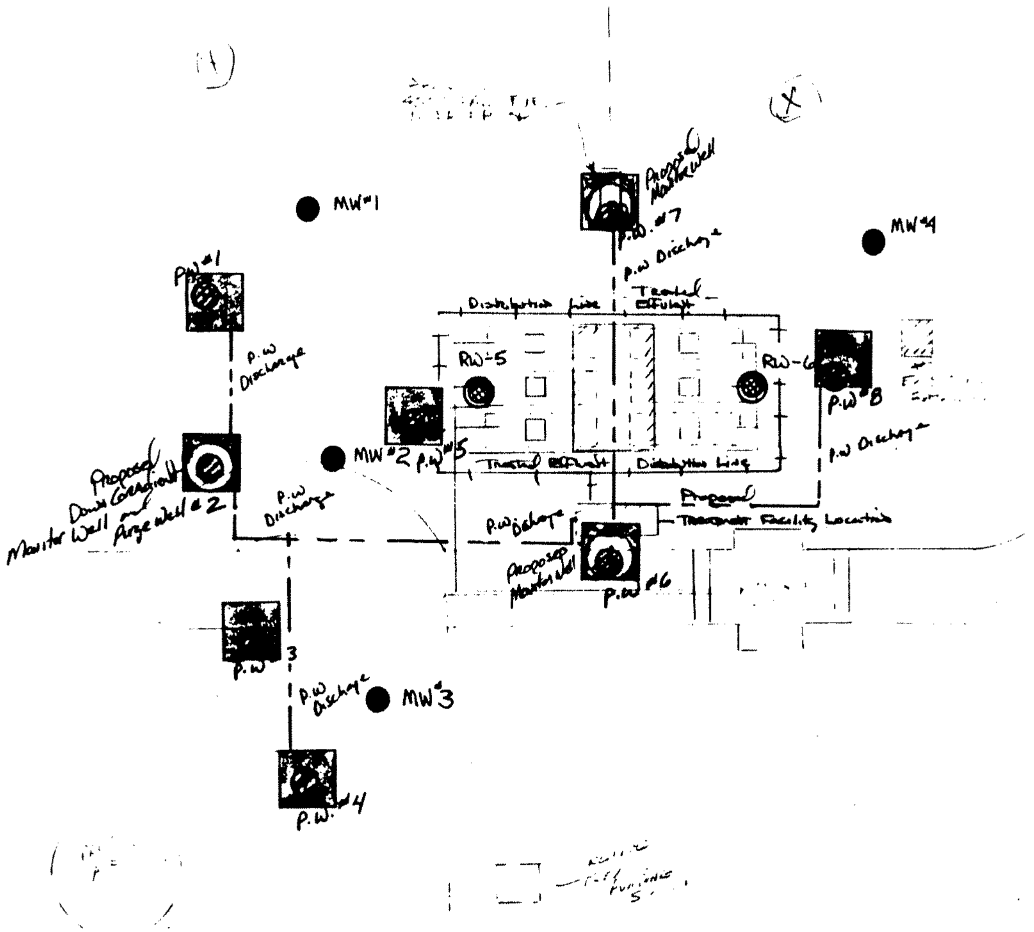
DAILY LOG
FUEL RECOVERY WELLS
LAREDO INTERNATIONAL AIRPORT

- MONITOR WELL # 1 -

DATE	TIME	(A) TOP OF LIQUID INCHES	(B) TOP OF WATER INCHES	(C) LAYER OF PETROLEUM (B) - (A) INCHES	(D) GALLONS RECOVERED	(E) OPERATOR
12-2-91	9:10 A.M.	108	108	-0-		TORREZ y CHAVEZ
12-3-91	9:00 A.M	108	108	-0-		CHAVEZ MANDO
12-4-91	9:10	108	108	-0-		CHAVEZ SANTOS
12-5-91	8:40	110	110	--		VALDEZ [illegible]
[illegible]	9:00	[illegible]	[illegible]	[illegible]		VALDEZ [illegible]
[illegible]	[illegible]	111.5	[illegible]	[illegible]		VALDEZ [illegible]
12-10-91	9:05	110	110	-0-		[illegible] [illegible]
[illegible]	[illegible]	112.5	112.5	-0-		VALDEZ [illegible]
[illegible]	8:50	[illegible]	[illegible]	[illegible]		VALDEZ [illegible]
[illegible]	8:50	110.5	110.5	-0-		VALDEZ [illegible]
12-16-91	9:40	111	111	-0-		TORREZ [illegible]
[illegible]	9:00	[illegible]	[illegible]	[illegible]		[illegible]
12-18-91	8:55	113	113	-0-		VALDEZ y
12-19-91	[illegible]	113	[illegible]	[illegible]		CHAVEZ SANTOS
		[illegible]	[illegible]	[illegible]		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		[illegible]
[illegible]						[illegible]

APPENDIX D

REMEDIATION ACTION PLAN

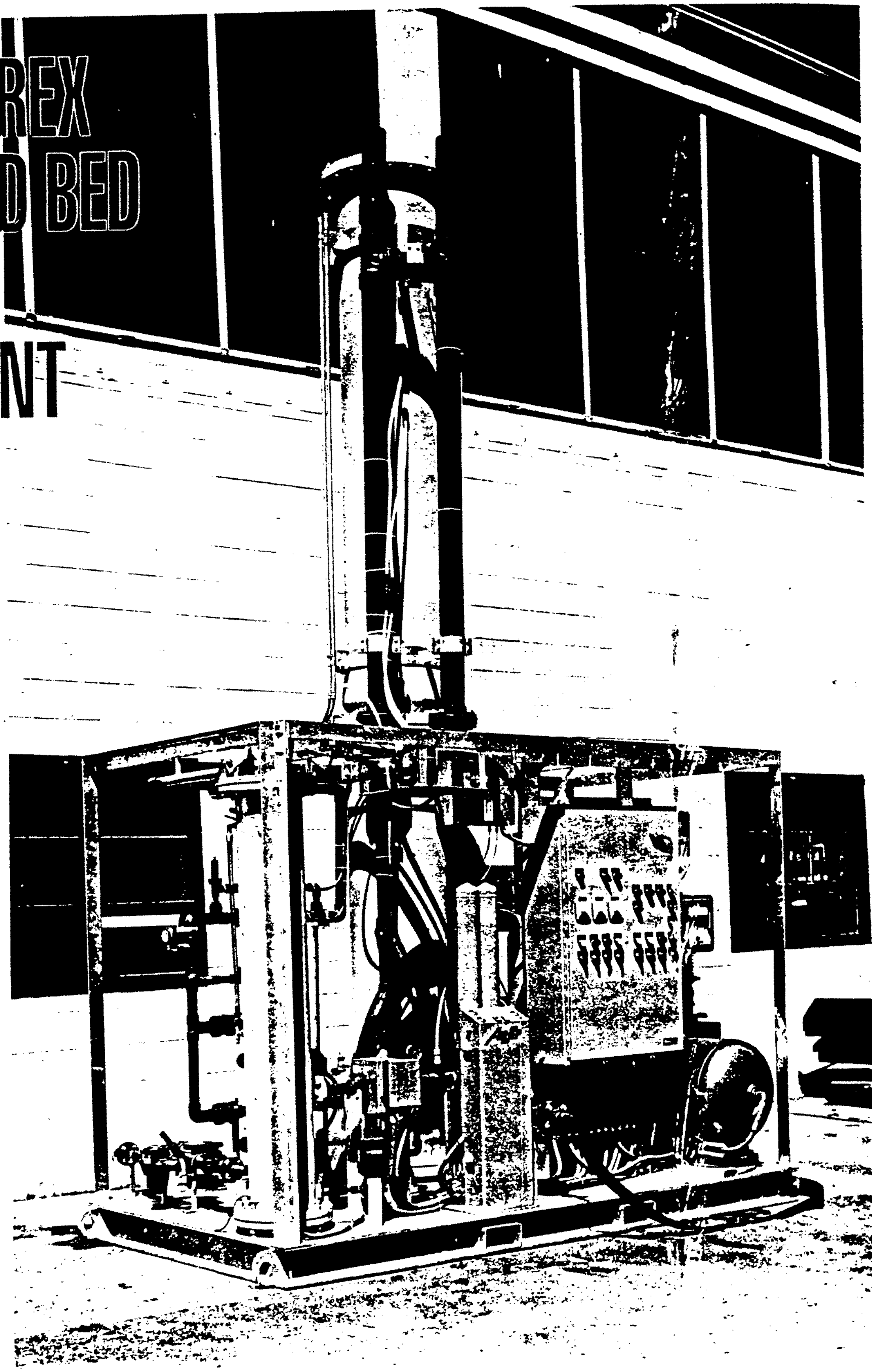


SCALE
DATE
APPROVED BY
DRAWN BY
REVISED

-Proposed Remedial Action Plan -

DRAWING NUMBER

THE ENVIREX GAC-FLUID BED BTEX TREATMENT SYSTEM

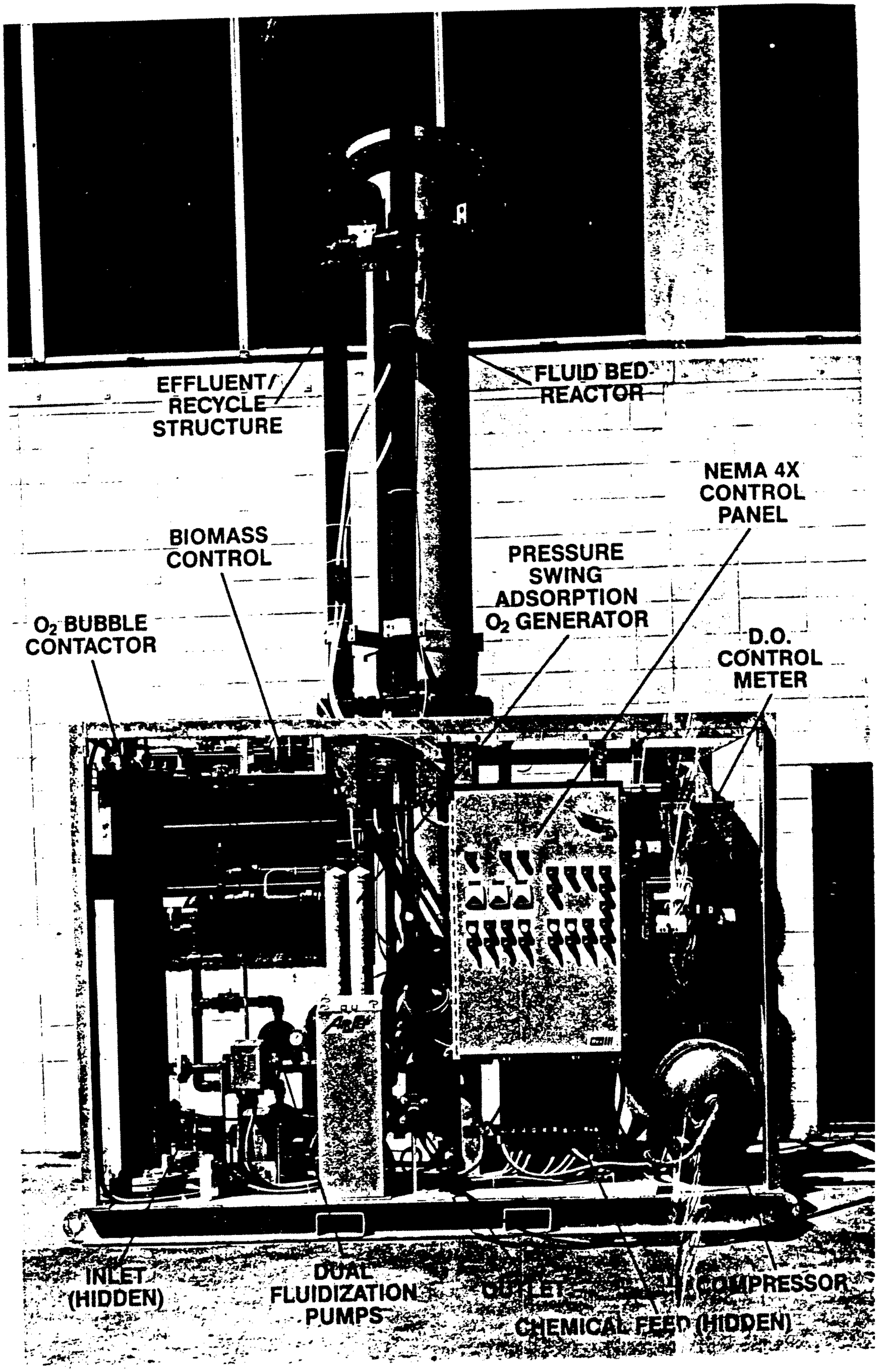


High rate process treats contaminated groundwater

- low ppb BTEX effluents
- no off gas
- surge buffering
- small, portable

From Envirex Ltd. Your single source for water and wastewater solutions.

1901 South Prairie Ave.,
Waukesha, WI 53186.
414/547-0141



THE ENVIREX GAC-FLUID BED
BTEX TREATMENT SYSTEM

BENEFITS OF THE GAC FLUID BED
FOR
BTEX CONTAMINATED GROUNDWATER

1. **BTX's Actually Destroyed** - The biological system actually breaks down the BTEX compounds (benzene, toluene, ethylbenzene and xylene) as opposed to merely transferring them from one phase to another.

2. **No Off Gas** - Due to utilization of predissolved pure oxygen, volatilization of organics due to aeration is eliminated. The need for air pollution permitting is eliminated.

3. **No Spent Carbon to Haul** - Biological regeneration of the carbon eliminates the need to thermally regenerate carbon or haul spent carbon (considered a hazardous waste when contaminated with benzene). Biologically refractive material may ultimately exhaust the carbon, but again, at much lower quantities than conventional systems.

4. **Ability to remain biologically viable at very low BTX concentrations** - Biological systems have difficulty meeting treatment objectives at extremely low organic concentrations because biomass attrition is greater than the rate of new biomass production. The GAC-Fluid Bed concept permits organics to be physically held on the carbon while micro-organisms growing on and in the carbon have time to break it down. At very low organic concentrations, mass transfer of organics to the micro-organisms becomes controlling. Carbon provides an additional driving force to get the contaminant onto the carbon and to the micro-organisms.

5. **Flexibility to operate as a conventional carbon column** - The GAC-Fluid Bed is essentially a carbon column operated at flux rates sufficient to fluidize the carbon. Should contaminant levels drop so low that good biological growth cannot be maintained, the reactor can be operated much like a conventional carbon column.

6. **Removal of Refractory Material** - Organics resistant or refractory to biological treatment can still be removed from the groundwater due to adsorption on the carbon.

7. **Portability** - The systems are skid mounted and self contained. At the completion of the remediation, the system can easily be moved to another site.

8. **In Situ Remediation** - Where soil conditions permit, the effluent, with small amounts of micro-organisms already acclimated to the BTEX's, nutrients, and rich in dissolved oxygen, can be reinjected into the ground to enhance the in-situ activity and shorten clean-up times.

9. **Iron Fouling** - Iron is oxidized by the disolution of pure oxygen prior to the reactor. Precipated iron accumulates on the biomass and is controlled via the biomass control system.

GAC FLUID BED
ADVANTAGES OVER OTHER
BIOLOGICAL REMEDIATION TECHNIQUES

1. **Size** - Due to the order of magnitude advantage in surface area over all other processes, the GAC Fluid Bed will always be significantly smaller than other processes. In many cases, the GAC Fluid Bed can be a truly portable system, able to be easily moved to another site at the completion of remediation whereas other processes would need to be permanent field erected systems.

2. **Off Gas** - Aerobic systems will provide the best results for BTX degradation. The Fluid Bed lends itself to the economical utilization of pure oxygen dissolved in the water prior to its entering the Fluid Bed reactor. This technique eliminates stripping of the BTX by the aeration technique and off gas associated with it.

3. **Stability** - Most BTX sites deal with relatively low organic concentrations. The use of truly immobilized cells is critical to the long term stability of a biosystem in this environment. The growth rate of new cells is slow and loss of biomass cannot be tolerated. The cells in an GAC Fluid Bed reside in the pores of the carbon structure resulting in stability from attrition of microorganisms due to sloughing, washout and settleability problems. Clarifiers and sludge return systems are not needed. Suspended growth systems including those using powdered carbon cannot maintain viable biomass populations at these low substrate concentrations.

4. **Carbon Regeneration** - The carbon carrier in an GAC Fluid Bed is bio logically regenerated within the Fluid Bed. Carbon replacement costs are minimal and due only to natural attrition of carbon and any re placement due to adsorption of refractory materials. Unlike powdered carbon systems, the carbon is **not** wasted with the sludge.

5. **Ability to meet ppb effluents** - The use of activated carbon as an immobilized cell carrier provides tremendous advantages in the treatment of low concentration organic wastes. First, the carbon provides an additional driving force in moving the organics from the liquid phase onto the carbon, and thereby into contact with the microorganisms residing on the carbon. The carbon also physically holds the organics in close proximity to the microorganisms allowing them the required contact time needed to degrade the material. Whereas other biological systems must rely on hydraulic detention time and mass transfer of the organics to the microorganisms to assure good removal rates, the GAC Fluid Bed merely has to adsorb the organics onto the carbon; a much faster reaction. The GAC Fluid Bed will also remove slow to degrade and refractory organics. Ultimately, only the truly non-biodegradable organics will use up carbon capacity which may necessitate the addition of fresh carbon. These organics will pass through other biosystems untouched.

USE OF THE GAC FLUID BED
FOR
OCPSF EFFLUENT POLISHING

The concept of using a Fluid Bed with activated carbon as a media was developed first for the treatment of BTEX contaminated groundwaters. Considerable research has been done over the past few years on the use of carbon to enhance the biological treatment of various wastewaters. The best known of these is the PACT process developed by DuPont.

The Fluid Bed with activated carbon provides all the benefits of the PACT process with the following additional advantages:

1. Growth of biomass on the GAC Fluid Bed is both on the surface of the carbon particles and within the pores. Since the carbon remains in the Fluid Bed (it is not separated in a clarifier), the process is a fixed film, immobilized cell technology. The Fluid Bed mechanics eliminate the plugging and sloughing problems other immobilized cell technologies have encountered.

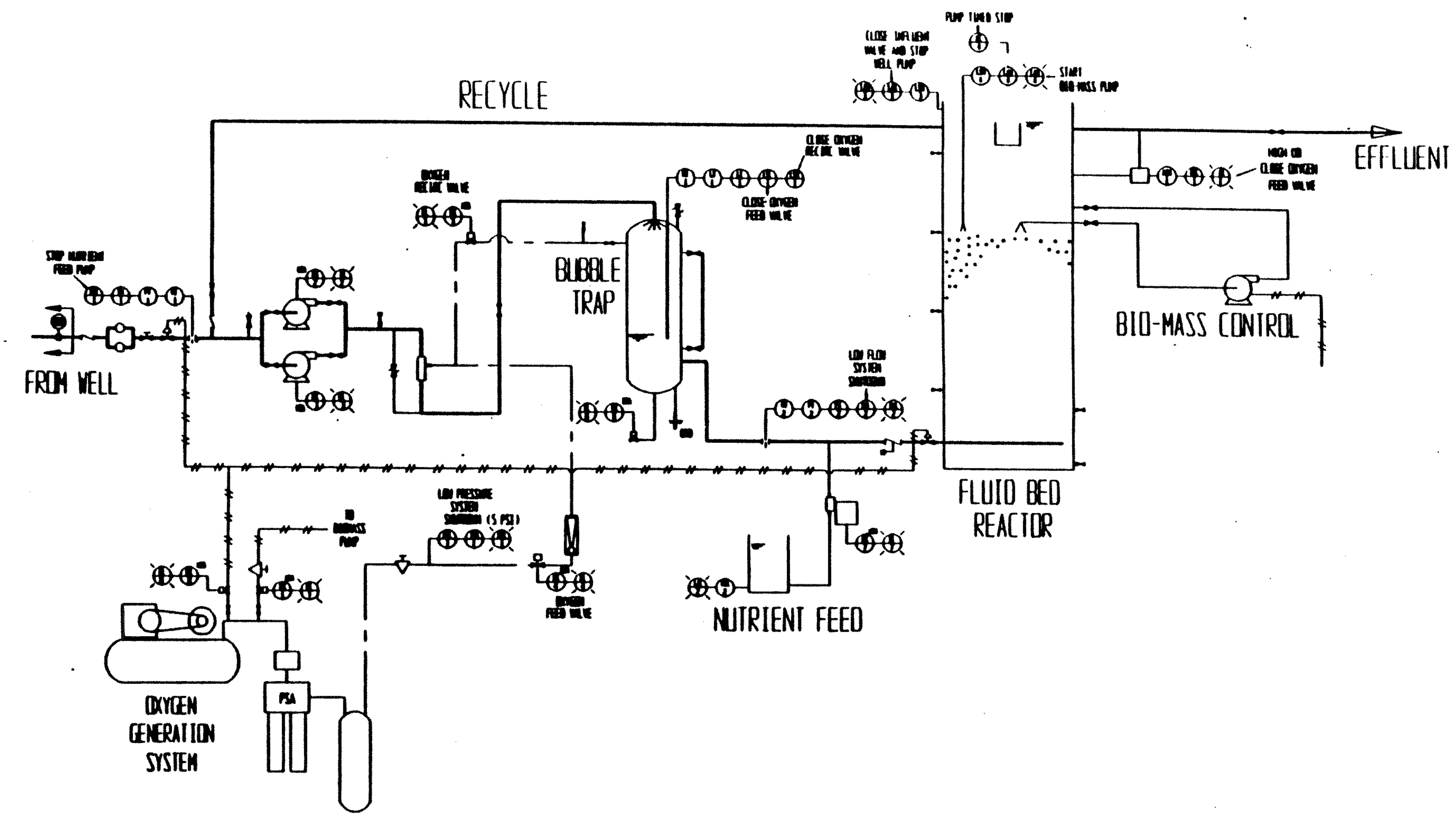
2. Biological regeneration of the carbon has been documented by a variety of sources. This factor alone substantially reduces the cost associated with carbon replacement in columns or the PACT process.

3. The Fluid Bed with its order of magnitude surface area advantage will be much smaller than other systems. It is an easy add on to an existing system.

4. The use of pure oxygen as the oxygen source eliminates any off-gas from the system. Stripping of volatile organics by bubbling air through the biological system is eliminated.

5. No license fees are charged with the Fluid Bed process. The Fluid Bed is a patented, proprietary process to Envirex Ltd. and is sold as a process equipment item typical of other wastewater treatment equipment.

The GAC Fluid Bed combines the benefits of plug flow and complete mix characteristics in one reactor. Utilizing recycle to maintain the fluidization flow, the incoming waste is diluted with recycle to maintain loadings in the range needed to reach the limits required by OCPSF.


STOP NUTRIENT FEED PUMP
FROM WELL
RECYCLE
OXYGEN RECYCLE VALVE
BUBBLE TRAP
CLOSE OXYGEN RECYCLE VALVE
CLOSE OXYGEN FEED VALVE
CLOSE INFLUENT VALVE AND STOP WELL PUMP
PUMP TIMED STOP
START BIO-MASS PUMP
HIGH DO CLOSE OXYGEN FEED VALVE
EFFLUENT
BIO-MASS CONTROL
LOW FLOW SYSTEM SHUTDOWN
FLUID BED REACTOR
TO BIOMASS PUMP
LOW PRESSURE SYSTEM SHUTDOWN (5 PSI)
OXYGEN FEED VALVE
NUTRIENT FEED
PSA
OXYGEN GENERATION SYSTEM

CASE 1

Influent	**Effluent**
100 gpm 10 ppm BTEX = 12#/day $.12/kw hour electrical cost 5 year project - straight line depreciation	<50 ppb total BTEX

1) **Carbon Only**

Capital - $125,000 Two (2) 7-1/2' dia. with 10' bed

Operating:

Pump = 3 HP = $6.44/day = $2,352/Year
Carbon - 2.4#/1000 gallons x 144 = 346#/day = $346/day = $126,290/ year

2) **Air strip with vapor phase recovery**

Note: Expected effluent 95% BTEX removal - probably won't meet 50 ppb limit.

Capital:

$25,000 Stripper 2-1/2 ft. diameter
$40,000 Vapor phase carbon adsorption
$ 5,000 Preheat/dehumdify
$70,000

Power: 5 HP pump and blower = $10.74/day = $3,919/year
Carbon: $67,475/year 130 mg/gm = 92.4#/day @ $2.00 lb.

3) **A/C Fluid Bed** - 4' dia. x 20' Ht.

Capital:

$145,000

Operating:

Fluidization Pump = 5 HP = $10.74/day = $3,919/year

Oxygen = 31#/Day x $0.06/# = $1.86/day = $679/year

Carbon Attrition = 200#/year = $200/year

Cost/1000 gallon - Based on straight 5 year depreciation of capital cost.

A. Carbon = $153,642/year = $2.92/Kgal.
B. Air Strip/vapor carbon = $ 85,196/year = $1.62/Kgal.
C. A/C Fluid Bed = $ 33,798/year = $ .64/Kgal.

CASE 2

Influent

100 gpm
25 ppm BTEX = 30#/day
$.12/KWhr. electrical
5 year project - Straight line depreciation

Effluent

< 50 ppb BTEX

1) **Carbon Only**

Capital	$125,000
Pump - 3 HP	$ 2,352/year
Carbon	$274,000/year - 40 mg/gm = 5.21#/Kgal = $750/day 15 days/charge cycle

2) **Air Strip/Carbon Vapor**

(* Probably will not reach 50 ppb without liquid phase carbon.)

Capital	$ 95,000 - Stripper and vapor phase carbon
Power	$ 5,487/year - 7 HP = $15.00/day
Carbon	$168,000/year - 1.6#/1000 gal = $230/day

3) **A/C Fluid Bed**

6' dia. reactor

Capital	$185,000
Power	$ 7,839/year - 10 HP = $21.00/day
O_2	$ 1,708/year - 78#/day @ $0.06/# = $4.68/day
Carbon Attrition	$ 600/year

Cost/1000 Gal. Treated

A. Carbon Only	$303,350/year = $5.73/Kgal.
B. Air Strip/Carbon	$192,500/year = $3.66/Kgal.
C. A/C Fluid Bed	$ 46,547/year = $ .89/Kgal.

CASE 3

Influent	**Effluent**
3 MGD (2083 GPM) 10 mg/l BTEX = 250#/day $.12/Kwhr. power 5 year project - straight line depreciation	<50 ppb BTEX

1) **Carbon Only**

5-12 ft. dia. columns (4 On-Off)

Capital	$ 600,000
Power	$ 23,516/year - 30 HP = $64.43/day
Carbon	$ 2,271,400/year - 35 mg/gm = 2.38#/Kgal = 7,150#/day = $6,222/day

2) **Air Strip/Vapor Carbon**

12 ft. diameter stripper.

Capital	$ 120,000/stripper $ 400,000/carbon $ 15,000/heater $ 535,000
Power	$ 27,433/year - pump 20 HP/blower 15 HP $75.17/day
Carbon	$1,406,000/year - 130 mg/gm = 1925#/day @ $2.00/# = $3,850/day

3) **A/C Fluid Bed**

One (1) 14 ft. diameter x 22' tall reactor

Capital	$540,000/Fluid Bed $ 45,000/800#/day PSA oxygen generator $585,000
Power	$ 31,355/year - pump 40 HP = $85.90/day
Oxygen	$ 14,244/year - PSA with 25 HP compressor 650#/day x $0.06/# = $39.02/day
Carbon Attrition	$ 5,000/year

Cost/1000 Gal. Treated - 5 year depreciation of capital

A) Carbon =	$2,414,926/year = $2.21/Kgal.
B) Air Strip =	$1,540,435/year = $1.41/Kgal.
C) A/C Fluid Bed =	$ 167,599/year = $ .15/Kgal.

COMBINED BIOLOGICAL FLUID BED - CARBON ADSORPTION SYSTEM FOR BTEX CONTAMINATED GROUNDWATER REMEDIATION

Robert F. Hickey[1], Daniel Wagner[1], and Gene Mazewski[2]

[1]Michigan Biotechnology Institute, Lansing, Michigan
[2]Envirex Ltd., Waukesha, WI

Paper prepared for presentation at the
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on Aquifer Restoration, Groundwater Monitoring
and Geophysical Methods
May 14-17, 1990
Las Vegas, Nevada
Sponsored by the
National Well Water Association

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[1]Michigan Biotechnology Institute, Lansing, Michigan
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ABSTRACT

Both Biological treatment and carbon adsorption have inherent advantages for remediation of groundwater contaminated with compounds such as benzene, toluene, ethylbenzene and xylenes (BTEX). Biological treatment destroys the contaminants and is extremely cost effective. Carbon adsorption is a positive removal mechanism that ensures a product water of high quality, but the process is relatively expensive and requires frequent carbon replacement and/or regeneration. Coupling the two processes realizes the inherent advantages of both approaches. An additional benefit of combining these removal mechanisms in a Biological Fluidized Bed Reactor (FBR) System is that no loss of BTEX due to volatilization occurs since predissolution of oxygen is used in place of conventional aeration for the fluidized bed process.

This paper summarizes preliminary performance data from a laboratory, pilot-scale Biological Fluidized Bed Reactor, using Granulated Activated Carbon (GAC) as the support media, operated at various BTEX concentrations and organic loading rates. Greater than 99 percent degradation of total BTEX was achieved at an organic loading rate of 3.0 kg COD/m^3-day or less and an empty bed hydraulic retention time of 5.0 minutes. System performance was extremely robust, easily handling a ten-fold step increase in loading due to the combined adsorptive capability of the biofilm coated GAC and ability to subsequently bioregenerate the GAC. Monitoring verified no off-gas was produced during treatment.

INTRODUCTION

In the U.S. there are over 2 million underground storage tanks (USTs) that are subject to governmental regulation. Of these (which constitute 60% of all USTs) it is estimated that between 20 and 25 percent may have suffered release and will require some soil and/or groundwater remediation.

The costs to execute a remedial program for UST's are staggering. The size of the remedial efforts can be generally characterized to fall into a bimodal distribution. Associated costs for the smaller site work range between $80-$100,000 per site, while the larger sites have an average remedial cost of $700-$800,0000.[7]

There are simply insufficient funds available to clean up the number of seriously contaminated sites. Due to this, there are only two courses of action available: either clean up fewer sites (or all sites to a lesser degree than is currently being required), or develop more economical technologies that significantly reduce the cost of clean-up.

The current state-of-the-art in remediation of groundwater contaminated with gasoline constituents (benzene, toluene, ethylbenzene and xylenes) is to either use granular activated carbon (GAC) to adsorb the pollutants in "pump and treat" type systems or to air strip these volatile compounds. Air stripping now requires that (VOCs) be captured on GAC in most locals. This has greatly increased the cost of this option. Although these physical-chemical approaches are effective in removal of BTEX, they suffer several drawbacks. As mentioned, they are costly processing options, and, in addition, the BTEX is simply transferred from the water to the GAC. This highly contaminated carbon must then be either thermally regenerated (possible air emissions problems) or landfilled in a Class I type landfill (high cost).

An alternative to these physical/chemical remedial techniques is biological treatment. The perceived problem associated with this treatment alternative is the greater amount of uncertainty associated with biological treatment. Regulatory personnel do not have the confidence that biological treatment can consistently meet the stringent treatment requirements being imposed. Because of this, most biological treatment systems installed to date have been required to us GAC for final effluent polishing as well as air emissions clean-up.[11]

In general, significantly greater cost savings can be achieved by integrating these two treatment technologies rather than simply piggy-backing them. Using GAC as a carrier to support biological growth is a method to achieve true integration and realize the advantages of both processing options, the economy of biological treatment and the positive removal and safety features of carbon adsorption.

During early work using granular activated carbon (GAC) systems for advanced municipal wastewater treatment, Weber et al. reported that both fixed- and expanded-bed adsorbers under study had unusually high capacities for the removal of total organic carbon.[11] This group subsequently suggested that bacterial activity was a significant mechanism in the removal of organics in GAC systems.[2] Concurrent pilot-scale work on the biological fluidized bed process revealed that this process configuration maximized surface area, mass transfer properties and therefore, volumetric throughput. The result was a reduction in required bioreactor size and capital expanse.[3,4]

In 1972, Weber introduced the concept of "biophysical-chemical" treatment, and showed that both adsorption and biological activity were operative in the GAC adsorbers.[12] It was demonstrated that aerobic, expanded-bed columns could operate relatively trouble-free and remove high levels of TOC, BOD and COD over periods of time which were far in excess of those predicted on the basis of adsorption alone. Although some effort has been directed towards understanding the important mechanisms and interactions between the various factors involved in Biological Activated Carbon (BAC) for municipal and industrial wastewater treatment systems, [1,5,6,8,9,13] little work has been completed towards using this concept for removal of BTEX or other volatile contaminants.

MATERIALS AND METHODS

Biological Fluidized Bed Reactor

A fluidized bed reactor (FBR) with a 5-liter working volume, constructed from 2 inch diameter clear PVC, was used for this study. The reactor had an 8 foot maximum bed height (working height) with a 3" diameter, 3 foot clear section above. The bed height was controlled at the desired level (8 ft.) by removal of media using a tubing pump (Watson Marlon Model 503 S/R) that served as an excess biomass shearing device. The GAC and sheared growth mixture was returned through a port approximately one foot above the withdrawal port. The GAC returned by gravity to the fluidized bed while the sheared biomass was carried away in the effluent stream. This allowed control of biofilm thickness and accurate determination of biomass production. The reactor was fed groundwater that was preoxygenated to the desired concentration using pure oxygen. BTEX was then added to this stream via a syring pump (Harvard Apparatus, Model 22) and dissolved using an in-line static mixer. Benzene, toluene, and xylenes were added at a 1:1:1 volumetric ration. Ethylbenzene was present as a contaminant in the xylenes at about 20 percent by volume. A schematic of the system is presented in Figure 1.

Two and one-half liters of 12 x 40 mesh GAC was added to the reactor as adsorbent/biomass carrier. This volume of media had a settled bed height of 48 inches. A flux rate of 12.1 gpm/ft^2 was maintained by the reactor by pumping 1.0 liter/min of the BTEX contaminated groundwater using a Masterflex tubing pump coupled to a variable speed drive. Influent and effluent sample ports were installed at points directly prior to where flow entered the FBR and in the clear zone above the fluidized bed, respectively.

BTEX Determination

Initial BTEX determinations were performed using a Perkin-Elmer Model HS 101 Total Headspace Analyzer coupled to a Perkin-Elmer Model 8700 gas chromatograph. The detection limits for each BTEX component was 20 ppb. Benzene, toluene, ethylbenzene, m,p-Xylene and o-Xylene were determined via EPA method 602 for subsequent experiments. The detection limits of this method was 1 ppb for each BTEX component. Samples were collected via glass/teflon syringes, acidified and stored in headspace free vials with teflon septa prior to analysis. Values reported in Tables 1-3 are the average concentrations based upon 9, 5 and 7 sample sets, respectively.

Dissolved Oxygen Analysis

Influent and effluent dissolved oxygen concentration were analyzed via a YSI (Yellow Springs, Inc.) polarographic electrode model 51B. The probe was air calibrated 15 minutes prior to use. In some cases influent dissolved oxygen concentrations exceeded the limit of the instrument (15 mg/L). In these cases, the sample was diluted to the measurable range using deaerated water prepared by purging with nitrogen gas. The D.O. of this mixture was then measured and the actual D.O. of the influent stream calculated. A YSI model 58 was used to obtain D.O. profiles through the FBR.

Solids Analysis

Influent and effluent total and volatile suspended solids were performed in accordance with Standard Methods[10] 2540. Fluidized bed solids were determined by withdrawing a measured volume of biofilm coated GAC, and determining total solids of these samples. These same samples were then placed in a 2 N NaOH solution to remove the biomass (8 hour contact time), rinsed, redried at 105°C and reweighed. Biomass solids were assumed to equal the difference between the initial dried weight and NaOH treated, washed and dried sample weight.

RESULTS

The FBR was initially seeded using an inocula with known capability to degrade BTEX. Nutrients were withheld to limit biological activity and allow breakthrough of the BTEX from the system. During this period a total influent BTEX concentration of approximately 17 mg/L (17,000 ppb) was added to influent. When a total effluent BTEX reached 7400 ppb (76% and 57% breakthrough of benzene and toluene, respectively) nitrogen (N) and phosphorous (P) addition, at a stoichiometric ratio of 100/5/1: COD/N/P was initiated. This approach ensured that biological activity and not adsorption would be responsible for any BTEX removal later observed. Over the course of the study, the influent water temperature varied from 14° to 18°C, averaging 16°C.

Subsequent to the initiation of nutrient addition, influent BTEX concentration was reduced to 7140 ppb. After nutrient addition, oxygen consumption immediately increased from approximately 5 to 20 mg/L, the maximum the oxygen transfer system, as originally constructed, could dissolve. Effluent BTEX concentration concurrently decreased to close to the detection limit (approximately 20 to 30 ppb) of the headspace technique initially used for BTEX analysis.

After three days, changes were made in the oxygen transfer system to permit a reasonable residual D.O. (4.0 mg/L). The system was then monitored for an 11 day period. Influent and effluent monitoring results for this period are summarized in Table 1. During this period a total influent BTEX concentration of 7080 ppb was reduced by at least 98 percent. Each BTEX compound was degraded to below the detection limits of the headspace technique. During this experimental run, the applied organic loading rate was 4.6 kg COD/m^3-d and the hydraulic residence time (HRT), based upon empty bed, was 7.2 minutes.

Because oxygen was predissolved in the influent, no off-gas was expected. To verify this, the top of the reactor was sealed and connected to a gas meter (based on liquid displacement) that allowed quantification of as little as 3 ml and detection of approximately one-third this amount. After 7 days of operation in this mode, no gas evolution was detected. A vacuum check of the gas lines revealed that the system was gas tight.

After this initial experimental run the flow rate was adjusted to 1.0 liter/min and maintained at this flow rate for all subsequent experimental runs reported herein. This resulted in a hydraulic flux rate of 12.1 gpm/SF and an HRT of 4.9 minutes.

The first applied loading studied at the higher flux condition was 4.9 kg COD/m^3-d (influent total BTEX of 5420 ppb). Under these conditions, the benzene concentration was reduced from an average value of 1780 ppb to less than 1 ppb (the detection limit of the analysis). Toluene was degraded down to an average concentration of 9.6 ppb. Total xylenes, particularly o-xylene, were observed to be the compounds least degraded (Table 2). Overall, BTEX removals at this loading rate were 98.8% (64 ppb total BTEX in the effluent).

Oxygen consumption during this period averaged 14.2 mg/L. A profile of D.O. concentrations taken on the last day of the experimental run (Figure 2) revealed that most of the uptake occurred in the lower half of the reactor.

A biological solids profile was concurrently taken with the D.O. profile. Bed solids averaged 4.17 g/L of fluidized bed volume. Effluent suspended solids averaged 1.9 mg/L, yielding a mean cell residence time of 7.5 days.

The next experimental run was conducted at a loading rate of 3.0 kg COD/m^3-d (influent BTEX = 3300 ppb). This drop in the organic loading resulted in a decrease in effluent BTEX to 7.1 ppb (Table 3). Both benzene and ethylbenzene were removed to less than 1 ppb. All constituents were removed to greater than 99%.

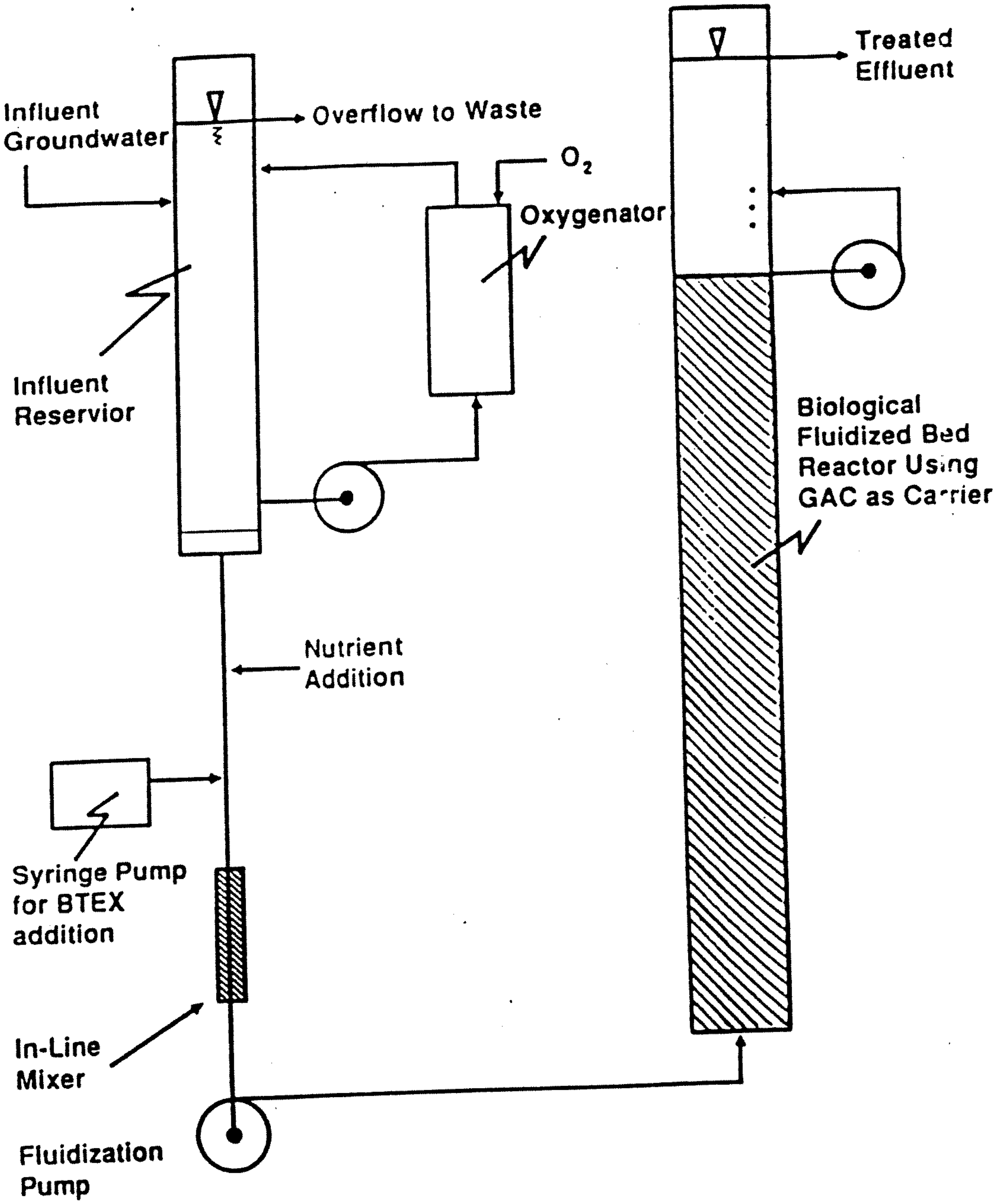

Figure 1. Schematic of Nominal 1500 liter per day Biological Fluidized Bed Laboratory Pilot Reactor System

TABLE 1. SUMMARY OF BIOLOGICAL FLUIDIZED BED LOADED AT 4.6 kg COD/m^3-d AND A 7.2 MINUTE HRT

COMPOUND	INFLUENT (ppb)	EFFLUENT (ppb)
BENZENE	2780 (±650)	<20
TOLUENE	2010 (±580)	<20
ETHYLBENZENE	410 (±65)	<20
p,m-XYLENE	1460 (±370)	<20
o-XYLENE	410 (±80)	<20
TOTAL	7080 (±1620)	<100

TABLE 2. SUMMARY OF BTEX REMOVAL IN A FLUIDIZED BED LOADED AT 4.9 kg COD/m^3-d AND A 5.0 MINUTE HYDRAULIC RETENTION TIME

COMPOUND	INFLUENT (ppb)	EFFLUENT (ppb)	%REMOVAL
BENZENE	1780 (±175)	<1 (-)	>99.9
TOLUENE	1482 (±142)	9.6 (±4.0)	99.4
ETHYLBENZENE	192 (± 17)	9.4 (±7.9)	95.1
p,m-XYLENE	1018 (± 93)	16.2 (±11.4)	98.4
o-XYLENE	948 (±332)	30.8 (±14.3)	96.8
TOTAL BTEX	5420 (±667)	64.0 (±16.6)	98.8

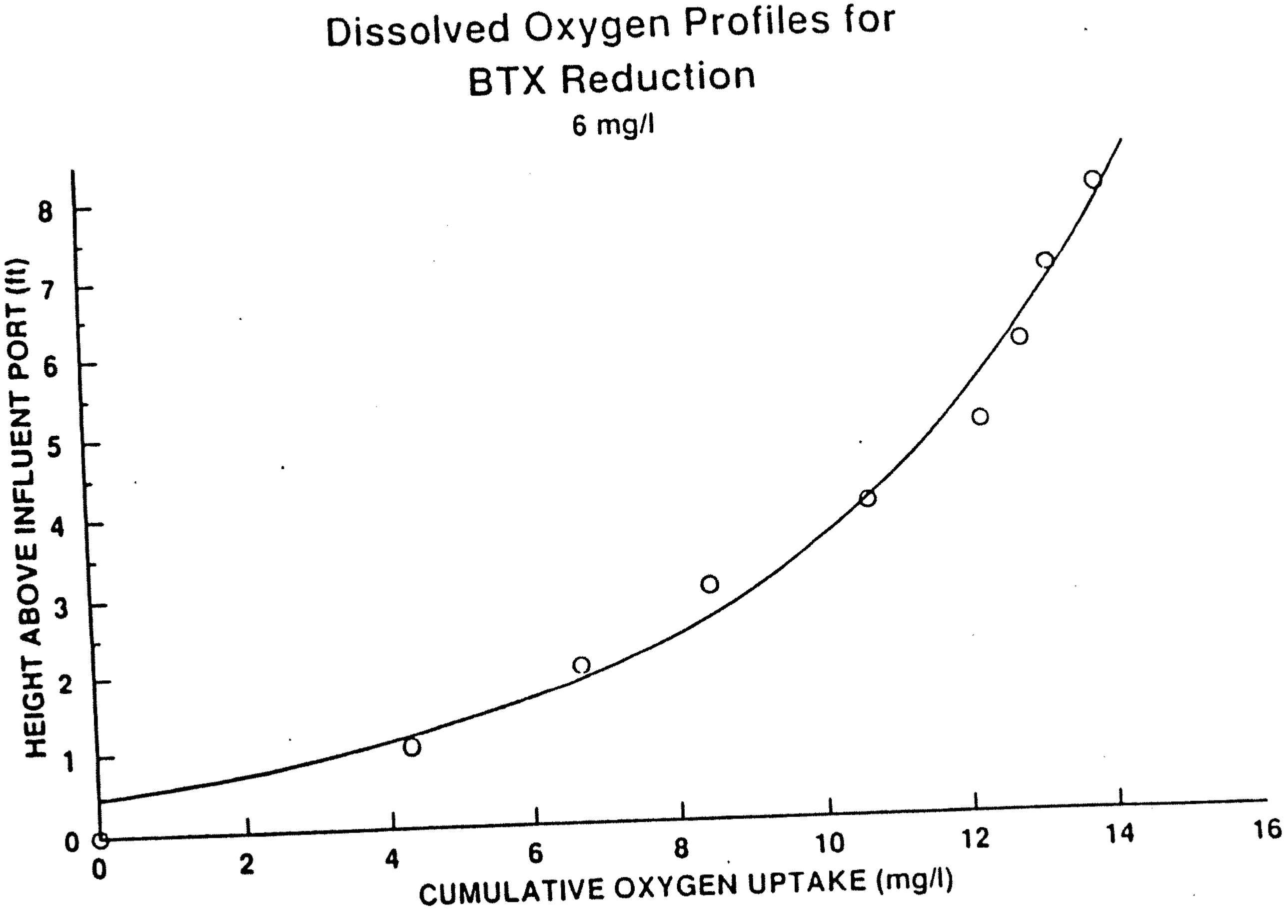

FIGURE 2. Oxygen Consumption Profile Through Fluidized Bed Reactor Receiving Nominal 6 mg/L (6000 ppb) Influent BTEX Concentration.

TABLE 3. SUMMARY OF BTEX REMOVAL IN A FLUIDIZED BED LOADED AT 3.0 kg COD/m^3-d AND A 5.0 MINUTE HYDRAULIC RETENTION TIME

COMPOUND	INFLUENT (ppb)	EFFLUENT (ppb)	% REMOVAL
BENZENE	1100 (± 183)	< 1 (-)	> 99.9
TOLUENE	1079 (± 169)	1.3 (± 1.3)	99.9
ETHYLBENZENE	137 (± 27)	< 1 (-)	> 99.9
p,m - XYLENE	751 (± 117)	5.1 (± 3.0)	99.3
o-XYLENE	234 (± 41)	0.7 (± 1.2)	99.7
TOTAL BTEX	3301 (± 535)	7.1 (± 5.0)	99.8

Oxygen consumption average 7.2 mg/L during the 7 day steady-state period. A profile for oxygen consumption through the bed was performed 2 days after the switch in the organic loading rate from 4.9 to 3.0 kg COD/m^3-d and again on the last day of data collection (Figure 3). Several observations can be made from this figure: 1) the total oxygen uptake for the final day was considerably reduced compared to that observed for the earlier profile, and 2) the uptake in the upper half of the bed was greatly reduced in the later sampling. This appears to indicate that BTEX previously adsorbed on the GAC and in equilibrium with the bulk liquid concentration was being consumed or bioregenerated in this portion of the bed. The eventual drop in oxygen uptake indicates all the BTEX adsorbed and available for consumption by desorption from the GAC had been removed.

A fourth experimental run at a nominal applied organic bed of 1.0 kg COD/m^3-d was conducted next. Under this loading condition, all constituents were degraded to less than 1 ppb. The average oxygen uptake was 3.0 mg/L for this run. Suspended solids production averaged 0.68 mg/L yield a mean cell residence time of 9.1 days. Bed solids average 1.81 g/L during this period.

It is important to note that even at this low influent BTEX concentration, that growth of the fluidized be occurred. This is not quite so surprising, when the mass loading of the system is considered. Even at this low influent BTEX (and COD) concentration, a F/M (food/mass) ratio of 0.56 mg COD/mg SS-d was maintained. The F/M ratios for the previous experimental runs were between 1.1 and 1.2 mg/mg-d.

Subsequent to this last steady-state experimental run, the effect of shock loading the system was examined. The BTEX concentration was step increased from 1,000 to 10,000 ppb. The effect of this load increase on oxygen consumption during the ensuing 110 hours is presented in Figure 4a. Benzene, toluene and combined p-m xylene are compared in Figure 4c. The data clearly show that although biological activity gradually increased, the primary BTEX removal mechanism was adsorption during the initial stages of the step load increase. After 30 hours, oxygen consumption rose to approximately 20 mg/L. At the 55 hour mark of this step load, the delivery of BTEX to the system was interrupted due to a malfunction. After approximately 17 hours the problem was discovered and corrected. Just prior to correcting this problem, oxygen consumption through the system was measured and found to be 12.0 mg/L. At a 5.0 minute HRT, this represents over 200 bed volumes with no substrate present in the influent stream. The only plausible explanation to the continued, relatively high oxygen consumption during this period, is utilization of BTEX that was adsorbed on the GAC. The result strongly supports the notion that bioregeneration of the GAC occurred during this time period.

DISCUSSION

The combination of biological fluidized bed technology with GAC (serving a dual role of adsorbent and biomass carrier) was extremely effective in reducing

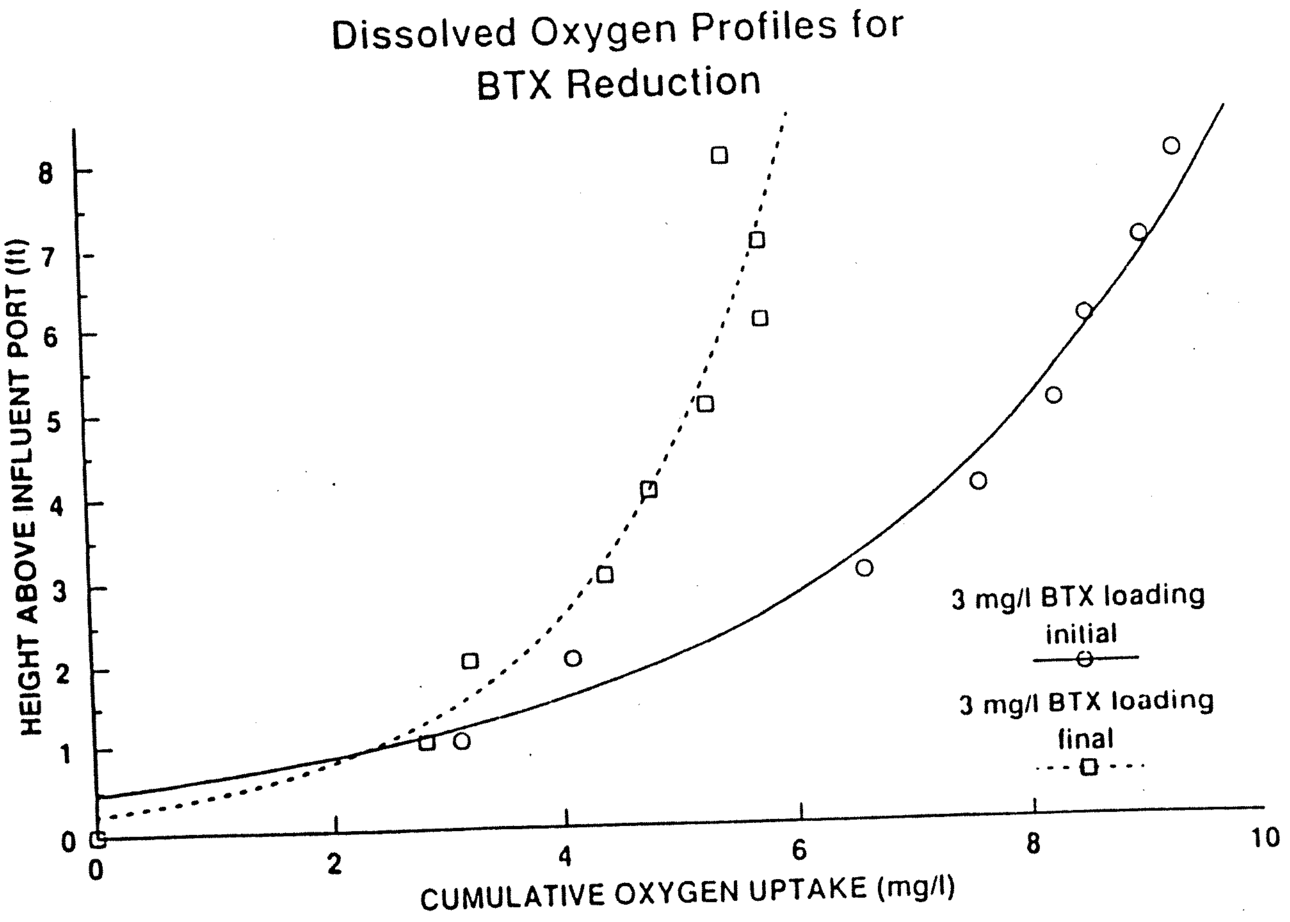

FIGURE 3. Oxygen Consumption Profile Through Fluidized Bed Reactor Two Days After Decreasing Organic Loading Rate from 4.9 to 3.0 kg COD/m^3-d and At Conclusion of Steady-State Operation At the Lower Loading Rate.

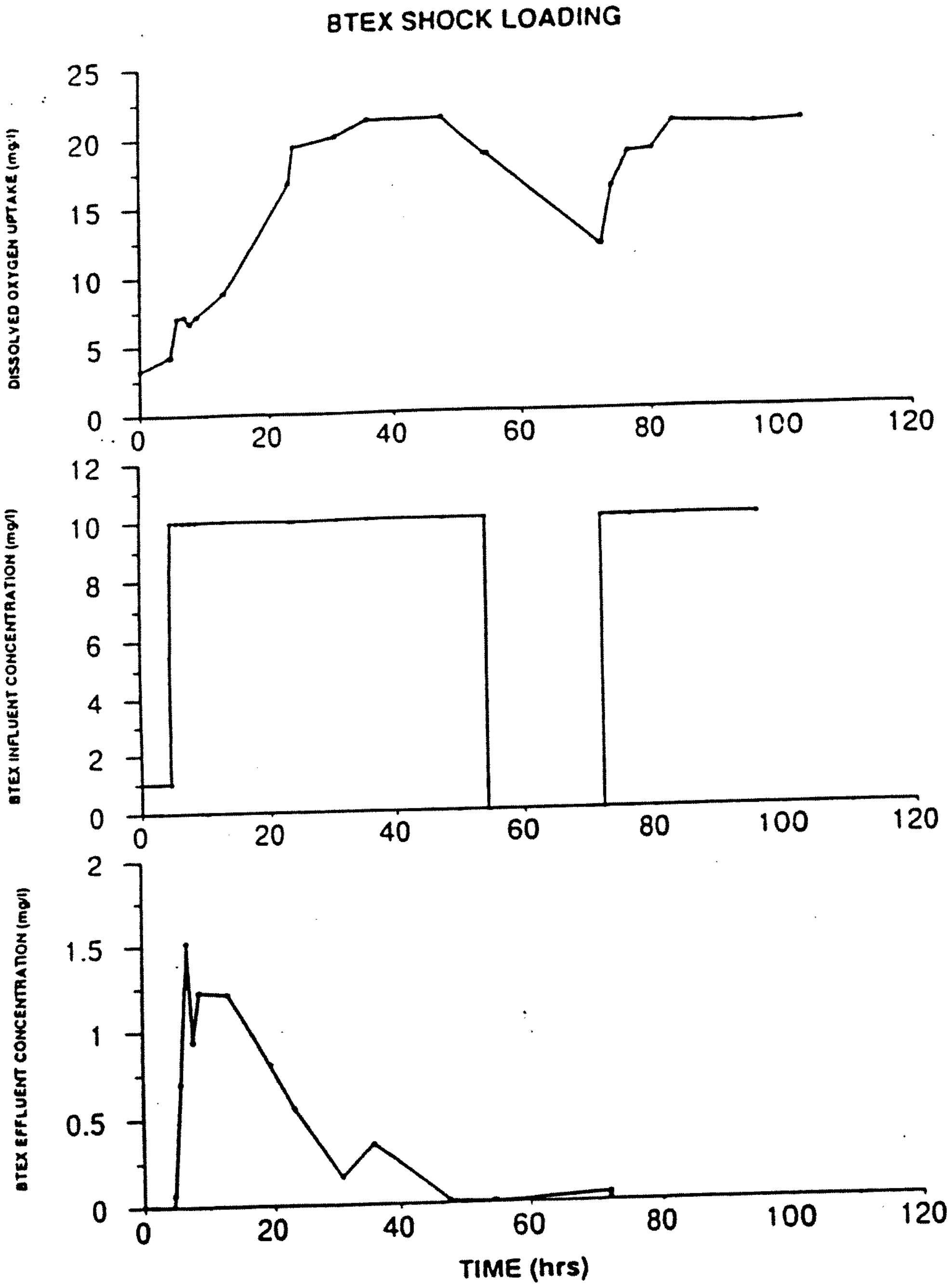

FIGURE 4. a) Oxygen Consumption, b) Influent BTEX and c) Effluent BTEX during a step increase in influent BTEX from 1 to 10 mg/L.

BTEX concentrations to extremely low levels. For experimental runs conducted at a hydraulic retention of 4.9 minutes and an organic loading rate of 4.9 kg COD/m^3-d or lower, benzene was removed to below detection limits (1 ppb). In general, the removal of the individual components followed the pattern of benzene > toluene > xylenes $\simeq$ ethylbenzene. At an applied organic loading rate of 3.0 kg COD/m^3-day, (3300 ppb BTEX with benzene, toluene, and xylene each present at approximately 1000 ppb) all BTEX constituents were reduced by greater than 99 percent to a total effluent BTEX of below 10 ppb.

In addition to the high rate and extent of BTEX degradation, monitoring verified that when preoxygenation with pure oxygen is used in conjunction with the FBR process, no gas evolution and therefore stripping of BTEX constituents occurred. This eliminates the need and associated cost required for vapor phase treatment via carbon adsorption or catalytic oxidation that is being required as post treatment for strictly biological and/or air stripping systems in many areas of the country.

Results also strongly support the contention that BTEX constituents adsorbed to GAC can and are biologically regenerated by the attached biofilm. This was evident in a number of instances during this study. This phenomenon is probably most clearly shown in the oxygen consumption profiles taken shortly after the organic loading rate was reduced from 4.9 to 3.0 kg COD/m^3-d and during the step load increase, when even after 17 hours without substrate addition to the FBR, an oxygen consumption of 12.0 mg/L was observed.

Even at low influent BTEX concentrations (influent COD as low as 3 mg/L) a highly active, fluidized bed that exhibited growth was observed. This is due in part to the short HRT's that allowed maintenance of a reasonable mass organic loading rate. It is also quite likely that this was also partially due to a concentrating effect that the GAC provided. More work is needed to determine if this is so.

These results, taken together, demonstrate that the coupled Biological Fluidized Bed system using GAC as an adsorbent carrier is extremely robust process that combines the advantages of both biological and adsorptive removal mechanisms.

ACKNOWLEDGEMENTS

They wish to express their thanks to Ms. Dianna Laverdiere for typing the manuscript. Thanks are also due to Ms. April Sunday for preparing the graphics. We also extend our thanks to Jennifer Reid, Xianda Zhao and Yanlyang Pan for performing various portions of the analytical work. Finally, a special thanks is due to Roger Owens for his many useful discussions and suggestions.

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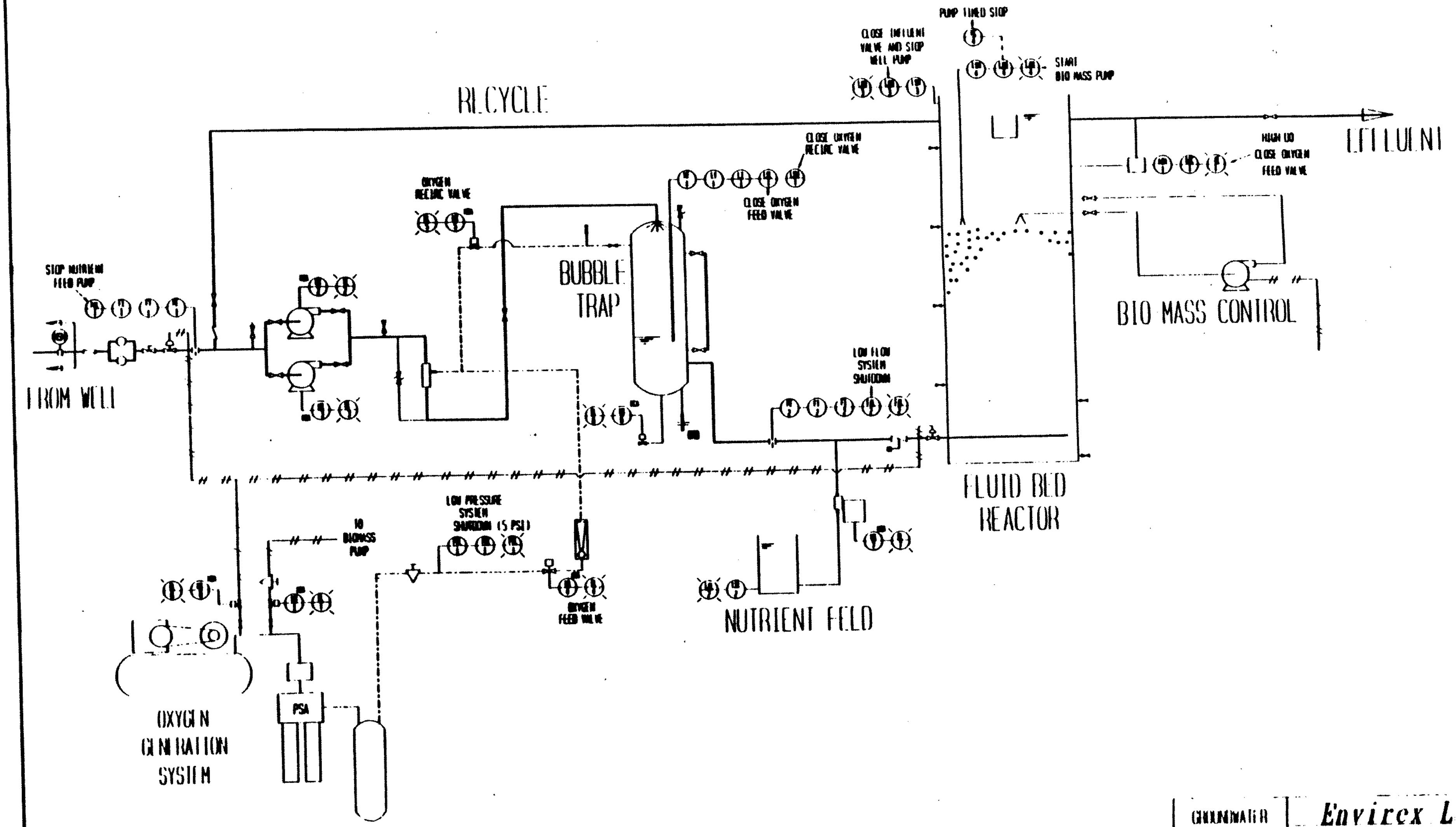
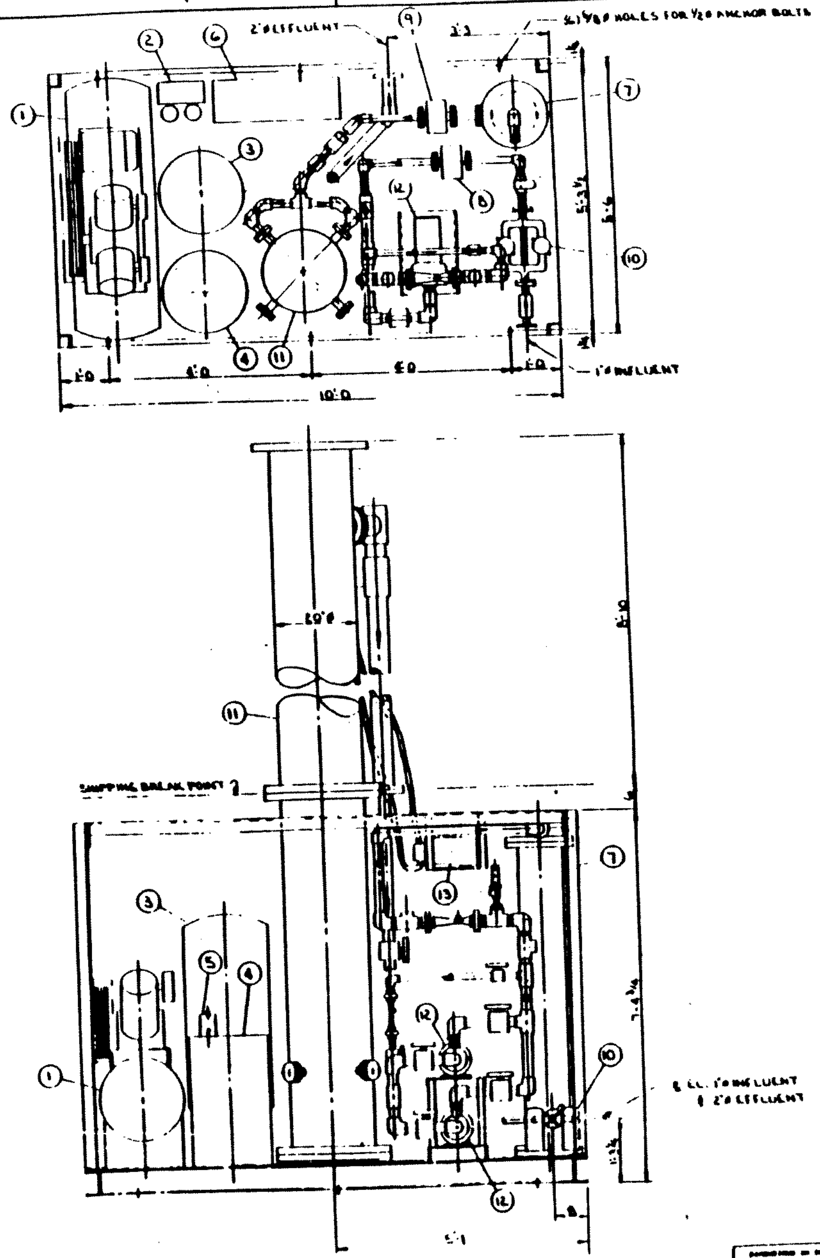
GAC-FLUID BED

30 GPM REACTOR



GROUNDWATER TREATMENT UNIT

Envirex Ltd.



CUSTOMER NOTE: 1) ALL MAIN PIPE, VALVES & FITTINGS WILL BE UV PROTECTED PVC.
2.) ALL FLANGE BOLT HOLE PATTERNS WILL MEET ANSI B16.1, 150 LB.
3.) STRUCTURAL STEEL SKID FRAME WORK, PIPE SUPPORTS, PUMP MOUNTING BASES & BUBBLE SEPARATION TANK WILL BE HOT [illegible]

LIST OF COMPONENTS

HB90001-101

1	1	SAYLOR-BEALL AIR COMPRESSOR, MODEL PC755-80 5HP, 230/460V, 3PH, 60HZ TEFC MOTOR WITH AIR DRYER. FACTORY MOUNTED ON 20"Ø, 80 GAL HORIZONTAL AIR RECEIVER.
2	1	AIRSEP MODEL AS-20 PSA OXYGEN GENERATOR.
3	1	20"Ø, 60 GAL. VERTICAL SURGE TANK.
4	1	18"Ø, 30 GAL NUTRIENT FEED TANK, POLYETHYLENE.
5	1	NUTRIENT FEED PUMP, PROMINENT, 115V, 60HZ.
6	1	42"H x 30"W x 10"DP NEMA 4X ELECTRICAL POWER PANEL, 460V, 3PH, 60HZ POWER SUPPLY.
7	1	10"Ø BUBBLE SEPARATION TANK WITH LIQUID LEVEL GAUGE GLASS AND RELIEF VALVE.
8	1	E+H MODEL FTE 1943 VARIOMAX MAGNETIC FLOWMETER, 1" SIZE, FULL SCALE: 30GPM, 115V, 60HZ.
9	1	E+H MODEL FTE 1943 VARIOMAX MAGNETIC FLOWMETER, 1½" SIZE, FULL SCALE: 30GPM, 115V, 60HZ.
10	1	PVC DUPLEX BASKET STRAINER, 1" SIZE.
11	1	28"Ø REACTOR VESSEL, PVC, WITH PVC FLOW DISTRIBUTION SYSTEM, EFFLUENT COLLECTION SYSTEM AND ACTIVATED CARBON MEDIA.
12	2	RECYCLE PUMP, GOULDS MODEL NPE, 1¼ x 1½-6, 2HP, 230V, 1PH, 60HZ TEFC.
13	1	BIO MASS PUMP ½HP, 115V, 60HZ

11082

1/4" = 1'-0

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Envirex
a Rexnord Division

GENERAL ARRANGEMENT- FLUID BED GROUNDWATER TREATMENT UNIT

HB90001-101

GAC-FLUID BED

3700 GPM REACTORS

REACTORS:

TWO (2)

DIAMETER: 14'-0"

HEIGHT: 22'-0"

OPERATING BED HEIGHT: 13'-0"

SINGLE PASS FLOW CAPACITY:

1850 GPM EACH

3700 GPM TOTAL

FLUIDIZATION PUMPS:

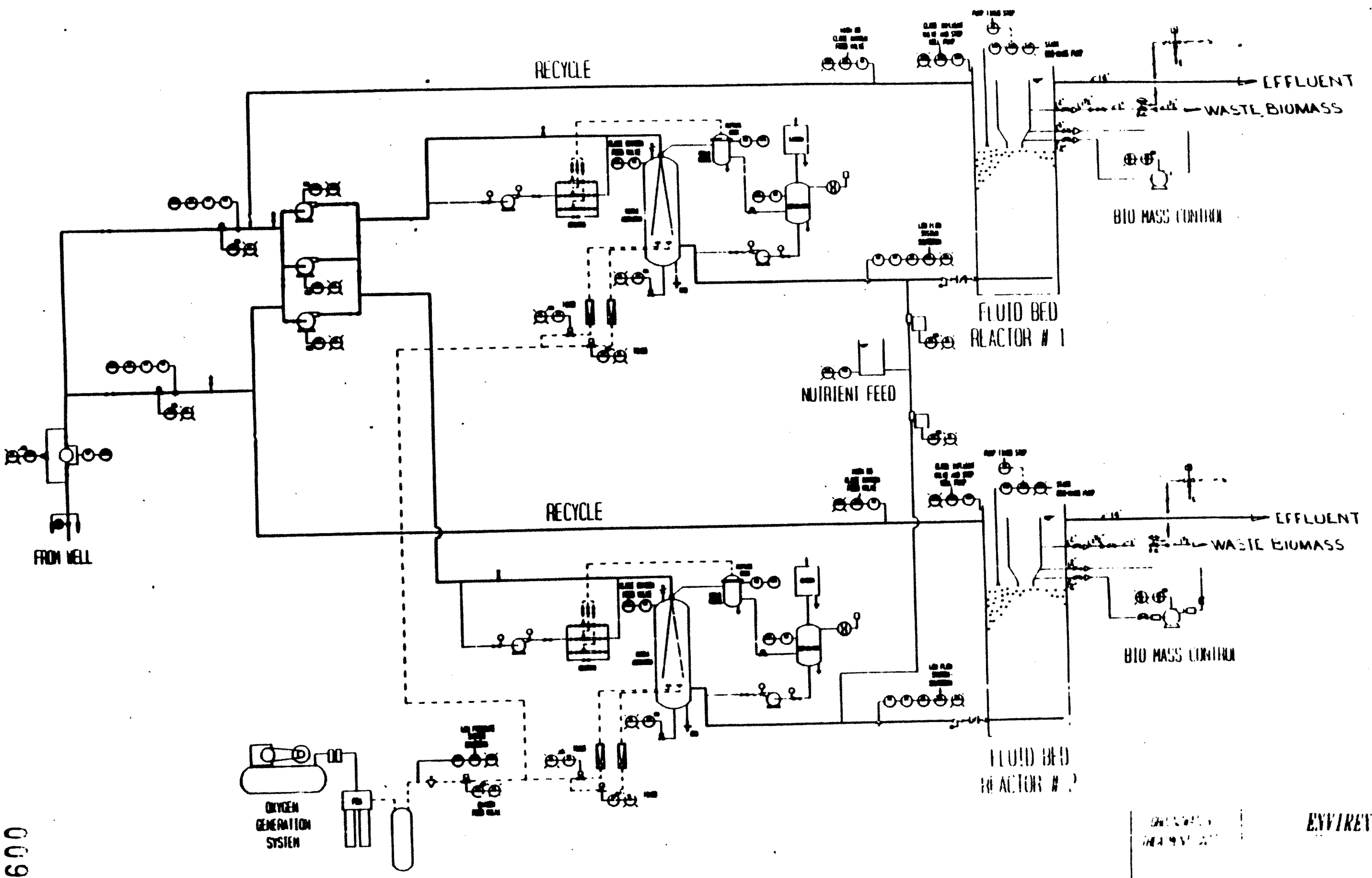
THREE (3) 40 HP (ONE STANDBY)

OXYGEN GENERATION SYSTEM:

25 HP (900 LBS./D O_2)

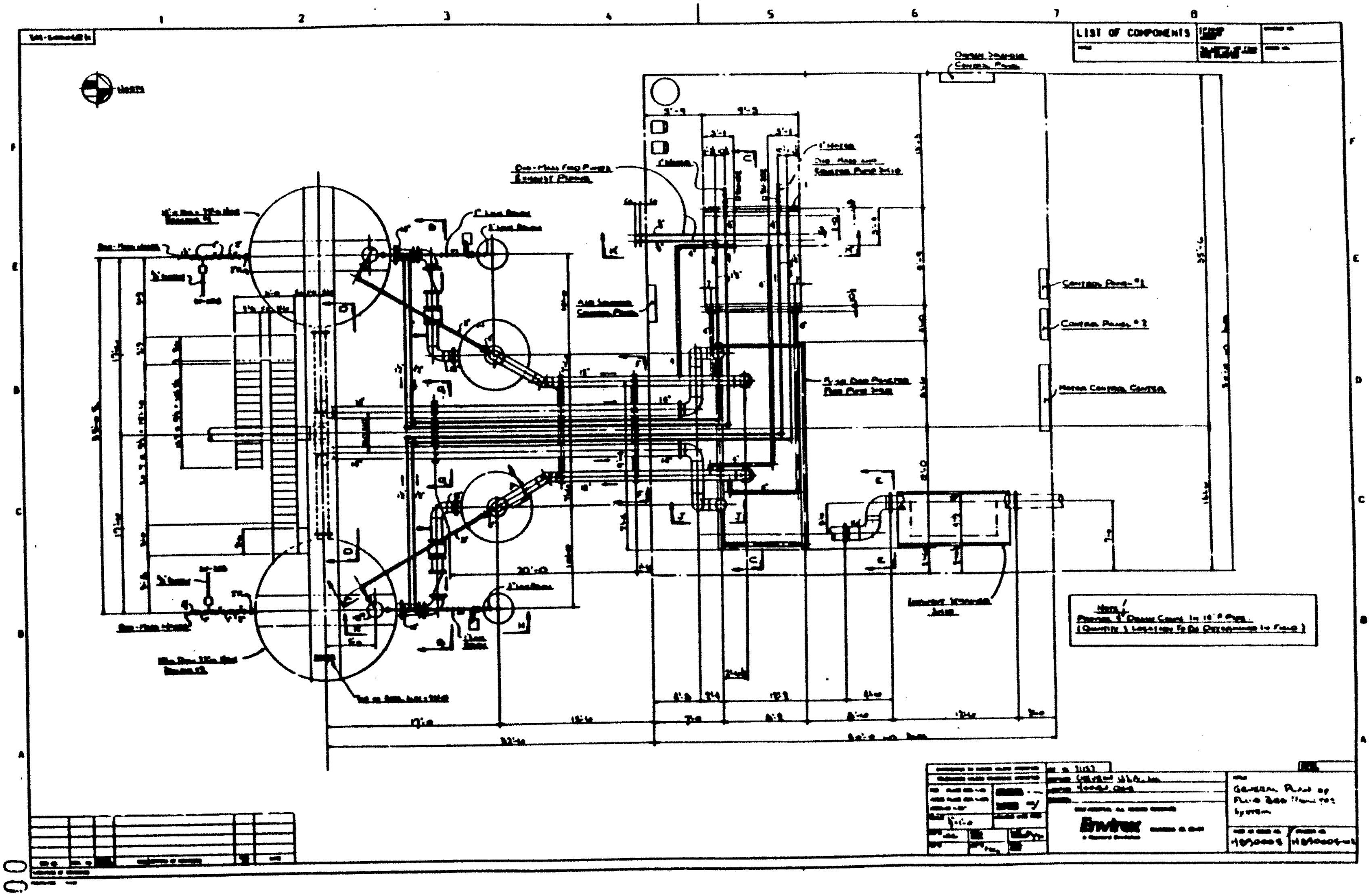
SHOP FABRICATION OF:

- REACTORS
- PUMP SKIDS
- OXYGENATORS
- INSTRUMENTATION AND CONTROLS


RECYCLE
EFFLUENT
WASTE BIOMASS
BIO MASS CONTROL
FLUID BED REACTOR # 1
NUTRIENT FEED
RECYCLE
EFFLUENT
WASTE BIOMASS
BIO MASS CONTROL
FLUID BED REACTOR # 2
FROM WELL
OXYGEN GENERATION SYSTEM

ENVIREX LTD.

[redacted]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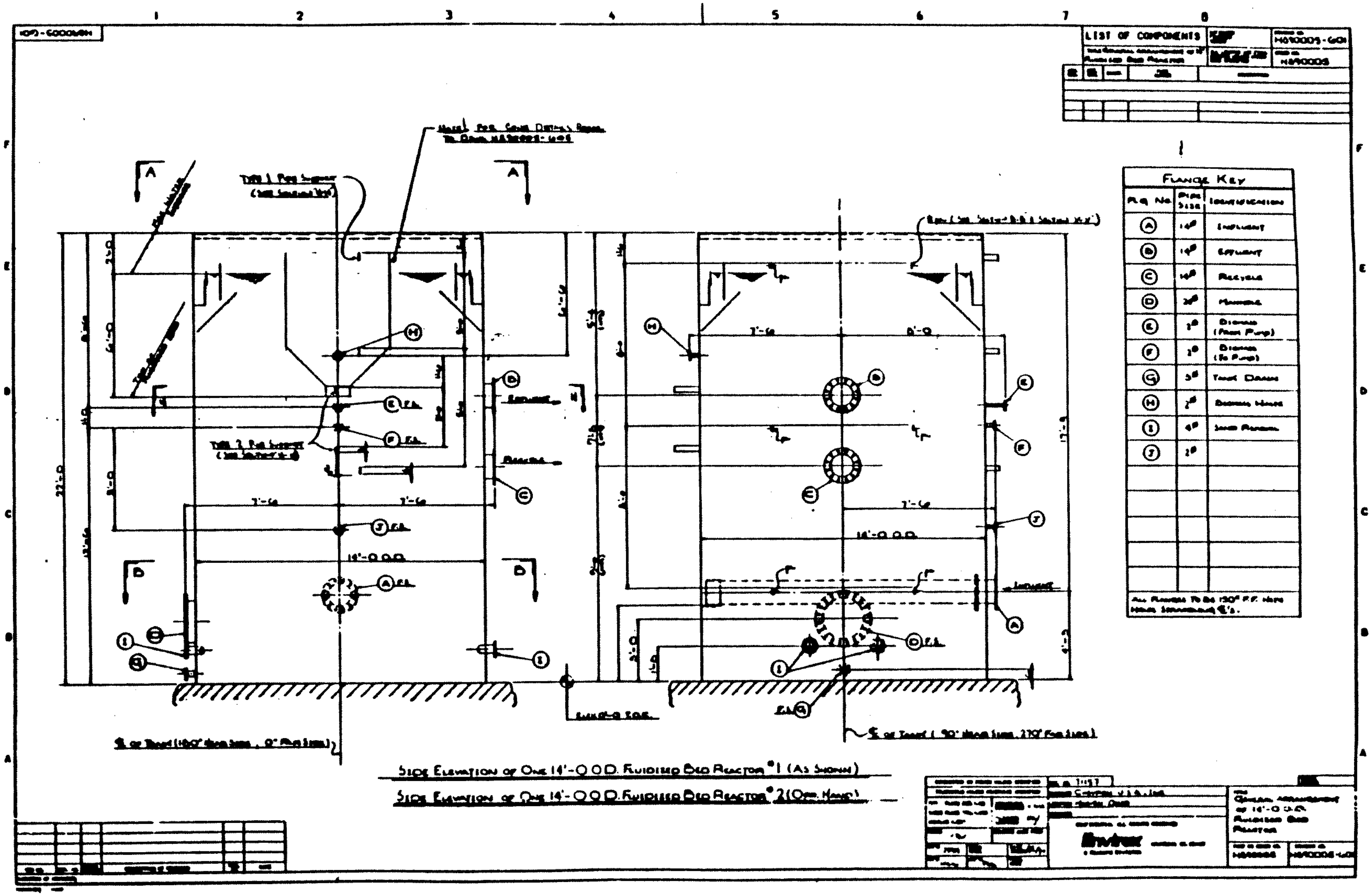
LIST OF COMPONENTS
North
9'-9
9'-5
20'-0
Control Panel #1
Control Panel #2
Motor Control Center
Note 1
General Plan of
Fluid Bed ... System
Envirex



Flange Key		
Fl.g No.	Pipe Size	Identification
Ⓐ	14"	Influent
Ⓑ	14"	Effluent
Ⓒ	14"	Recycle
Ⓓ	20"	Manhole
Ⓔ	2"	[illegible] (From Pump)
Ⓕ	2"	[illegible] (To Pump)
Ⓖ	3"	Tank Drain
Ⓗ	2"	[illegible]
Ⓘ	4"	Sand Removal
Ⓙ	2"	

All Flanges To Be 150# F.F. Holes Straddling ℄'s.

Side Elevation of One 14'-0 O.D. Fluidised Bed Reactor #1 (As Shown)

Side Elevation of One 14'-0 O.D. Fluidised Bed Reactor #2 (Opp. Hand)

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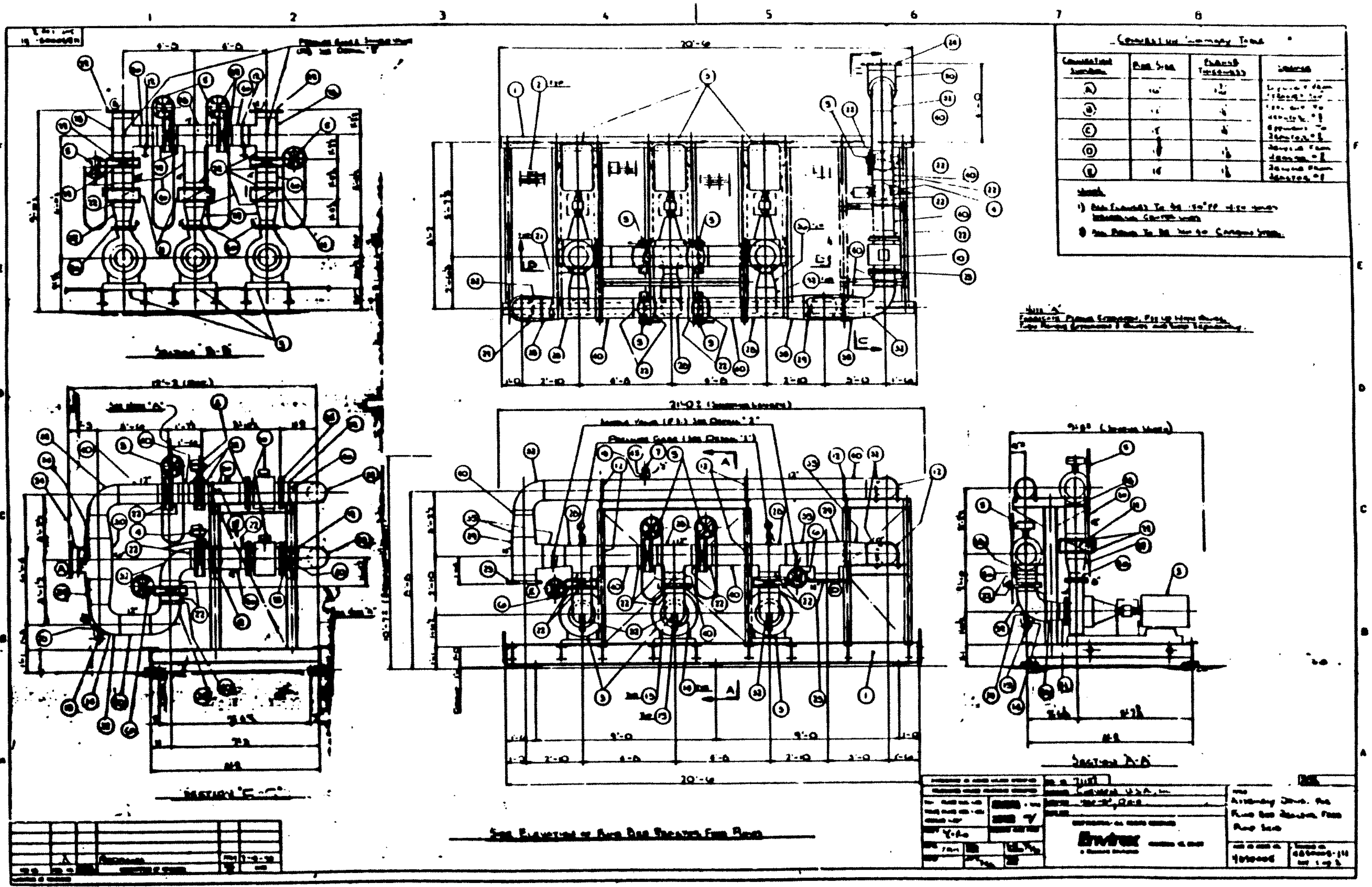

QA/QC PLAN FOR INVESTIGATION AND SAMPLING OF SOILS AND GROUNDWATER

INTRODUCTION

JBL GROUP is a professional consulting firm which provides hydrogeologic, engineering, microbiologic, and related testing services for comprehensive abatement and remediation of groundwater and environmental contamination.

This QA/QC Plan documents investigative procedures for accurate and consistent collection of groundwater and environmental data with an emphasis on environmental impacts resulting from inadvertent losses of petroleum products. The specific quality control procedures outlined are based upon the Groundwater Monitoring Technical Enforcement Guidance Document (EPA/530/SW-86/055), and Practical Guide to Groundwater Sampling (EPA/600/2-85/104).

SAMPLE SITE SELECTION

Selection of Monitor Well Locations

In general, many of the samples collected by JBL GROUP are from monitor wells. Various criteria is used to determine the selection of the sampling site. These include areas where losses are suspected to have occurred, or near structures that are subject to leaks or failure. Additional monitor wells will be installed in areas from the suspected contamination areas to delineate the contaminant plumes. This would include placement of monitor wells upgradient, downgradient, and outside the perimeter of the contaminant plumes.

Selection of Surface Water Sample Locations

Surface waters are usually sampled when groundwater is being discharged from a site into a nearby surface water body such as a pond, stream, or ditch. When surface waters are sampled, samples will be collected at or near the point of discharge into the surface water body. A determination then can be made whether the discharged water is contaminating the surface water body.

SAMPLING PROCEDURES

Drilling Method

Drilling Equipment Decontamination

Prior to commencing work, drilling equipment is cleaned to avoid introduction of foreign materials onto the site. The equipment subject to decontamination may include augers, drilling tools, sampling tools, and the rig itself. Material used to construct the wells, casing and screens are also decontaminated prior to installation. The methods used are site and parameter specific, and are outlined below:

Detergent Wash - using trisodiumphosphate or Alkonox type detergent with clean water

Solvent Wash - using water soluble solvent - Acetone or Methanol with clean water rinse

Water Rinse - a distilled water rinse is used to remove solvent or detergent residue. In the case of a contaminant which is water soluble, a clean water rinse may be sufficient without other methods.

Steam cleaning is used when contaminants are easily volatilized or persistent residues need to be removed. Steam cleaning is particularly useful when cleaning large or bulky equipment such as drilling rigs, augers, etc.

Decontamination and rinse water is generally disposed of on site Collection and disposal of decontaminated water is sometimes required. The water is containerized and stored on site while waste characterization and proper disposal is arranged.

Soil Borings

Soil borings are advanced with a rotary auger drilling rig using hollow stem or solid stem augers. The augers are turned into the soil in five foot sections. Continuous auger flights move soils cuttings from the drill bit to the surface. This procedure, using hollow augers, produces effectively a cased open hole to the end of the drill string, to facilitate sampling or others testing. When using sold augers, the auger must be removed to provide an open uncased hole for sampling, well installation, or other activities.

Other drilling methods which may be used include hand auguring and excavation with shovels, post hole diggers, or other manual methods. Hand boring methods are useful when soil types an die conditions permit easy penetration to the required depth. Hand methods normally are not used for soil borings below the water table.

Following completion of borings, the bore hole is plugged by various methods. Normally drill cuttings are placed in the hole and compacted to limit surface settlement. When conditions warrant, bore holes are plugged with soil bentonite mixtures, or bentonite and/or cement grout. When required, contaminated drill cuttings are containerized and stored on site. The materials are characterized and properly disposed.

Monitor Well Installation

Monitor wells are installed by auger drilling methods. Drilling equipment consists of B40 and B50 or other typical rotary auger rigs. The rig is used to drill a string of continuous flight augers into the ground to create a bore hole. The selected well casing is installed in the open hole by one of two methods. The first method is used with solid augers. The augers are drilled to total depth and withdrawn from the hole. The specified well casing and screen is placed in the bore hole and pushed or driven to the proper depth. The annular space between casing and the bore hole can be backfilled with native soil or a low permeability mixture of cement and/or bentonite.

The second method of well installation is used with hollow stem augers. The augers are again drilled to total depth providing a cased open hole. The well casing is placed inside the hollow auger to the required depth and the augers removed. As the augers are pulled, the well remains at the required depth and natural material can collapse around the screen. Gravel or sand pack, when required, is placed through the augers during removal. The rate of filter pack application is matched to the rate of auger withdrawal so that uniform filter zone is created. The filter pack is placed up to one to two feet above the screen to provide isolation from the well seal materials. The annular space is backfilled by approved methods which can include native soils or a low permeability grout. Grout, when required, can consist of various mixtures of cement, and/or bentonite. Grout is generally tremied through the augers during removal. Well sealing and grouting methods are designated based on the soil and groundwater conditions in the boring.

Well materials are selected based on the geologic conditions and groundwater sampling goals for each well. Casing types can consist of stainless or galvanized steel and PVC. Both threaded and coupled or flush threaded joints are used. Well screens consist of stainless steel continuous slot wire wound or PVC sawed slot construction. Stainless and galvanized steel materials are typically used when organic contaminants are expected, while PVC materials are used when the concern is for metals. Wells completed above grade are protected by a steel outer casing with a hinged lockable cover. The outer casing is set in concrete which is shaped to promote drainage away from the well. Wells which are finished flush with the existing grade are set in a sealable casting which is cemented to the existing surface. Inside the casing the well is sealed with an expandable locking plug.

Following installation, the wells are developed to remove fines from within the well and the aquifer material adjacent to the screen. This is done so that the produced water is sediment free and to provide good hydraulic connections with the aquifer. Well development methods include surging and swabbing, overpumping and bailing.

Vertical Sampling of Aquifers

Several methods are available for vertically sampling the aquifer. The choice of any given method is dictated by the specific conditions and objective of a particular investigation.

Two options are available using hollow stem augers. The first method utilized is a screened auger. In this method the augers penetrate to any required depth and a water sample is obtained, using a clean stainless steel bailer.

The second hollow stem method involved the use of a plugged lead auger. The auger string is inserted to total depth, which is determined on a site specific basis. A stainless steel screen (3 to 5 feet in length), and two (2) inch stainless steel casing are placed inside the augers to the top of the plug, which is removed, and the augers are withdrawn. As the augers are removed, the formation materials collapse about the well screen. The temporary well is then developed using any of the techniques described previously. This is called a piezometer.

The method using solid stem augers is similar to the second hollow stem method, except that the augers are removed from the boring and the screen and casing are driven to a total depth.

After completing sampling, the in-place well screen is pulled to the desired interval and redeveloped. Intervals are generally selected so that three (3) to five (5) feet of every nine (9) feet are sampled. The sampling interval an screen length can be varied to provided sampling of greater or lesser portion of the aquifer.

Preliminary Preparation For Sampling

All sampling events to be conducted will be scheduled with the analyzing laboratory to make sure the laboratory can accept the samples. The laboratory will be informed of the approximate number of samples to be collected and the tentative date and time of sample arrival.

Prior to the sampling trip any equipment which will be used shall be cleaned, calibrated, and in good working order. The sample bottle supply will also be verified to ensure containers are available.

Field sampling kits will be inspected to be sure that all items necessary are present. A standard sampling kit will contain the following items:

- a teflon squirt bottle with methanol or acetone
- alconox/TSP soap

- a sufficient supply of distilled water for rinsing
- disposable gloves
- paper towels
- a waterproof pen
- an appropriate amount of sample containers and labels
- the proper purging and sampling device
- nylon rope
- ice packs and cooler
- appropriate site and safety manuals

Sample Collection

Soil Sampling Procedures

Soil samples are taken during drilling with hollow stem augers by split barrel sampling methods. The split barrel sampler is a two (2) inch O.D. divided tube sampling device 18 to 24 inches in length. The sampler is driven into undisturbed soil in advance of the augers. The sampler is driven using a 140 hammer with a 30 inch free fall. The hammer blows are recorded for each of three 6 inch increments. The blows for the final two increments are summed and described at the standard penetration "N", which is a measure of the relative density of cohesionless soils. The sample is retrieved, opened and an intact sample of the soil strata is provided. The soils are classified and contained in glass jars for further review. If laboratory analysis is required on the soil, representative samples are placed in parameter specific containers. The containers are normally placed coolers and refrigerated through shipment to the designated laboratory.

Soil samples are also obtained by alternate methods. Grab samples are taken from solid augers, hand augers, or hand excavation tools. Solid augers are normally turned into the ground to a depth of ten (10) feet with as little soil disturbance as possible. The augers are removed and a relatively depth specific soil profile is present on the auger flights.

Samples can be taken directly from the augers. Soil samples are also taken during hand excavation as the desired depth is reached. Samples taken by these methods are also contained, preserved, and shipped as outlined previously.

Decontamination procedures are site and parameter specification are outlined in the decontamination section. Decontamination of sampling tools is done prior to the start and between each sampling event.

Sampling frequency is normally specified based on the objectives of each investigation. Typically for split barrel sampling the interval is at 2.5 feet to ten feet and at five foot intervals thereafter. On deeper borings where uniform soils are encountered, the interval may be extended as the depth increases. Grab samples are collected at preselected intervals or at locations as site conditions warrant.

Water Sampling Procedures

Prior to monitor well purging and sampling, the water level in each well will be measured. The electronic tape or wetted tape method will be used for measurement. Once static water levels are known, the volume of water in the wells will be determined for well purging.

Prior to the collection of a groundwater sample, the standing water in the well casing will be purged to ensure that a representative sample of the formation water is collected for analysis. Samples will not be collected before a minimum of three well volumes have been evacuated or before specific conductance has stabilized. To ensure that the groundwater sample is collected from the zone to be monitored, a maximum of five (5) well volumes will be purged. Wells that have a slow recovery period will be bailed dry and then sampled within 24 hours.

Once a well has been properly purged, samples will be collected in the following manner:

1. Rinse a clean teflon or stainless steel bailer at least five times with sample water.
2. Transfer the sample into the vial, filling the vial to overflowing, and avoiding turbulence and bubbling as much as possible. Water should stand above the top of the vial forming a convex meniscus. Carefully but quickly slip the cap onto the vial and tighten. Once the cap is tightly in place, invert the vial and gently tap against your hand to assure there are no bubbles inside. If bubbles are present, open the vial, and report the process.
3. Collect a replicate sample.
4. Label the sample vials. Labels will include the project number, sample identification number, preservatives, date and time of sample collection, type of analysis required, and the name of the sampler.
5. Fill out the chain-of-custody form, include preservation techniques in the remarks section.
6. Check to make sure the vial caps are tight, then place the labeled sample and duplicate on ice immediately.
7. Transport the sample set, on ice, back to the office for shipment to the analyzing laboratory, maintaining the

chain-of-custody.

If it is necessary to obtain samples for water quality analysis from wells with in-place plumbing (purge wells or domestic wells for example) samples will be collected from the most pump-proximal cold water tap available. The system will be allowed to flush until temperature or conductivity has stabilized. Flow will be reduced to approximately 500 ml/minute (a stream about the width of a pencil) or less for sample collection. The method for sample collection will follow those previously stated.

Surface water blank shall be collected in accordance with the above mentioned methodology. Care will be exercised to allow for minimum disturbance of bottom sediments.

One equipment blank will be collected for each sample set. The blank sample will be collected at a random time during the work period. The blank will be collected by filling the decontaminated sampling device with distilled or deionized water. Collect a sample of the water utilizing the already described methods.

Sample Preservation and Handling

Soil sample preservation will be provided by immediately placing the containerized samples on ice in a darkened environment to cool the sample to approximately four degrees Celsius.

Water samples to be analyzed for dissolved inorganic parameters will be filtered and preserved in the field. They will be preserved by acidifying the samples with the appropriate acid (either nitric or sulfuric) to lower sample pH to less than two (2), and cooling to four degrees Celsius. Water samples to be analyzed for volatile organics may be preserved in the field with hydrochloric acid, sodium azide, or mercuric chloride.

Acid preservation will be done in a well ventilated area. The tip of the acid bottle will not be allowed to come in contact with sample. If it does, the tip will be flushed five (5) times with distilled water and twice with acid before the next sample is acidified. Samples will remain on ice or be refrigerated at approximately four degrees Celsius until they are analyzed.

After samples have been collected, sample sets will be sent to the laboratory as quickly as possible in sealed coolers packed with fresh ice and chain-of-custody documentation.

Measures to Avoid Cross-Contamination of Samples

To avoid cross-contamination during soil sampling decontamination procedures discussed in the section under Drilling Equipment Decontamination will be followed between each sample interval.

To avoid cross-contamination during well water sampling the following guidelines will be followed. Upon arrival at a site the bailer to be used to collect water samples will be rinsed with methanol or acetone, then scrubbed with alconox soap and thoroughly rinsed with tap water, followed by a thorough rinse of distilled water. If water quality data are available for the site the least contaminated well will be sampled first, followed by the wells suspected to be most contaminated.

Between the collection of each sample, the bailer will be scrubbed with alconox soap, followed by a tap water and distilled water rinse. The nylon rope used on the bailer will be replaced. After completion of a round of sampling of a site the equipment will be decontaminated as previously described.

In case where teflon tubing is used, the tubing will be washed with a solution of tri-sodium phosphate (TSP) and tap water followed by a rinse with a minimum of one gallon of distilled water. The tubing will also be rinsed with at least three liters of sample water prior to sample collection.

METHODS FOR DETERMINING AQUIFER PARAMETERS

Hydraulic Gradient

The hydraulic gradient is calculated by dividing the difference in the static groundwater elevations by the horizontal distance between the same wells.

Horizontal Hydraulic Conductivity

The rising-head falling-head slug test developed by Bouwer and Rice (1976) is generally used to estimate the hydraulic conductivity of an aquifer with a single well. The wells can be partially penetrating and partially screened, perforated, or otherwise open. The test is initiated by causing an instantaneous change in the water level in a monitor well or piezometer through the introduction or removal of a solid cylinder of known volume. The change in water level is recorded utilizing a pressure transducer and displayed on a sensor display. The sensor display converts voltage output from the pressure transducer to the water level in feet above the transducer.

The method of interpreting the water level versus time data that arise from the test is based upon the Thiem equation which describes the relationship between the inflow into the bore hole and the drawdown. An automated numerical algorithm developed by Kemblowski and Klein is utilized to process the slug test data.

Transmissivity

Aquifer transmissivity and storativity are generally determined by performing a pump test. The general set-up procedure is to install a production well five (50 feet from a permanent monitor well and the second temporary observation well fifty feet from the production well.

The production well is pumped at a constant discharge rate, while drawdowns are recorded in the pumping well and adjacent wells with digital electronic water level sensing devices at specified time intervals. Discharge from the pumping well is direct so as to avoid aquifer recharge to the test area. The test is allowed to run for a minimum of four hours at constant discharge rate. Upon completion of the pumping period, recovery in the observation wells in monitored for a minimum of thirty minutes or until recover to static water level is reached.

The method of interpreting the drawdown data versus time and/or distance is based on techniques developed by Theis, or those modified for. The Theis method,such as Cooper and Jacob (1946), Hantush (1964), Neuman (1974), or Kahn (1982).

SAFETY PLAN

All employees adhere to O.S.H.A. safety rules according to CFR20 and CFR 40 rules and regulations.

Benzene levels are monitored so employee (TWA) levels are below 10 ppm for an eight hour period.

Site Location and the Public

Site locations requiring UST excavation are fenced with a cyclone fence to protect the public from danger of either falling in or over exposure to volatile aromatics as Benzene.

Employees are:

- Required to wear hard hats when working on site.
- Required to wear plastic gloves while sampling or working with contaminated soil.
- Required to wear respirators where volatile aromatics are at high concentrations.

Underground Storage Tanks

Underground Storage Tanks are vented and dry ice is placed in underground storage tanks according to their volume. All tanks are vented below 20% LEL.

JBL GROUP

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FEB 13 1992
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February 4, 1992

Ms. Anne Miller
Texas Water Commission
Responsible Party Remediation Section
Petroleum Storage Tank Division
P.O. Box 13087, Capitol Station
Austin, Texas 78711-3087

Subject: Phase II R.A.P. Report for the City of Laredo
International Airport Fuel Farm
L.P.S.T. I.D. NO.: 95021

Dear Ms. Miller:

We at JBL GROUP have completed the Environmental Assessment which includes the quarterly report and a Remedial Action Plan for the City of Laredo's International Airport Fuel Farm. Also included are the corresponding drawings, calculations and analysis which are presented in this report.

Any questions that you may have or if you need further information please call us at anytime at our office at (512)725-7410 or contact Mr. Jose Flores, the Airport Director for the City of Laredo. Thank you.

Sincerely yours,

JBL GROUP

Jerilyn K Rich

Jerilyn K. Rich
Corrective Action Specialist

Bill Rich

Bill Rich
Environmental Engineering Manager

CC: Mr. Bill Morris, District 11 Field Office

Mr. Jose Flores, City of Laredo International Airport

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