

**BIO-AUGMENTATION
WORKPLAN
MARCH 17, 1998**

**TONY'S EXPRESS AUTO SERVICE
3609 EAST 14TH STREET
OAKLAND, CALIFORNIA**

FOR

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1 INTRODUCTION

The following is a workplan to augment the ongoing natural bioremediation at Tony's Express Auto Services, 3609 East 14th Street, Oakland, California. The property is primarily used as a service station.

1.1 BIOREMEDIATION

Bacteria native to the soil at hydrocarbon contamination sites normally degrade hydrocarbons. The most effective hydrocarbon degraders (eaters) are the aerobic (oxygen using) bacteria. The amount of available dissolved oxygen is usually the factor controlling the rate that these bacteria degrade the gasoline.

A much slower degradation process starts when the dissolved oxygen is depleted. The plume begins to become anaerobic and the bacterium commences to reduce nitrate, ferric iron, and sulfate to further degrade the hydrocarbons. Eventually, as these compounds and the oxygen are used, the bacteria begin methogenesis, in which the hydrocarbons are converted to methane.

The results of prior bioremediation sampling indicate that natural attenuation/bioremediation is active at this site. In a number of the wells the biodegradation has proceeded to the point that nearly all of the electron acceptors and the nutrients that bacteria require to degrade gasoline have been consumed while a significant amount of hydrocarbons remain. This makes it necessary to augment the electron acceptors and nutrients.

All of the wells show the impact of active biodegradation. It is not therefore possible to determine a background level of the compounds. The closest approximation for background levels at this site is the highest concentrations of electron acceptors and the lowest levels of by-products.

Compound	Function	Concentration	Well
Dissolved Oxygen (O ₂)	Electron Acceptor	2.5 mg/l	MW08
Nitrate	Electron Acceptor	4.5 mg/l	MW04
Sulfate	Electron Acceptor	42 mg/l	MW04
Ferrous Iron	By-product	0.23 mg/l	MW07
Methane	By-product	0.0113 mg/l	MW05
Carbon Dioxide	By-product	62.7 mg/l	MW05

All of the tested wells have reduced levels of dissolved oxygen. Six of the nine wells have less than 0.1 mg/l of dissolved oxygen.

Both Nitrate and Sulfate have been reduced from the levels found in MW04, with Nitrate being reduced to non-detectable levels in three wells and Sulfate in four wells, see table 3.

The presence of Ferrous iron in the wells indicates that biodegradation has progressed to the point that the system is oxygen deficient and the bacteria have started to reduce the iron to provide oxygen for the degradation.

Biodegradation in MW02, which is in the heart of the plume, has consumed all of the available electron acceptors.

The carbon dioxide (CO₂) levels in the groundwater indicate that a portion of the hydrocarbons have been degraded. CO₂ and water are the final byproducts of the biodegradation of hydrocarbons. The carbon in CO₂ results from the oxidation of the hydrocarbon radical CH₂ and as such 1 mg of CO₂ = 0.41 mg of CH₂ (CH₂ (12+1+1 = 14) / (CO₂ (12+16+16=34)). The amount of CO₂ in MW08, 153 mg/l, indicates that at least 62.73 mg/l of hydrocarbons have been oxidized. ← not true

The presence of methane (CH₄) indicates that a number of the wells have progressed into methogenesis.

The levels of electron acceptors present and the presence of the reaction products, carbon dioxide, methane and ferrous iron indicate that the bacteria in the soil and the compounds in the groundwater have the capability to consume a significant amount of hydrocarbons.

Introducing ambient air (O₂) into the system during vapor vacuum extraction and/or sparging will increase this bioactivity.

Comparison of the hydrocarbon degrader counts (amount of bacteria) to the TPHg concentration, electron acceptors, byproducts, and nutrients, indicate that the orthophosphate concentration and ammonia concentration can have a significant effect on the bio-activity. As shown in Table 3, just a small change in the orthophosphate level from 0.1 mg/l in MW01 to 0.4 mg/l in MW02 increased the hydrocarbon degraders count from 60 to 220 cfu/ml. This indicates that the addition of a small amount of phosphate to the system should increase the biodegradation rate.

A RBCA Tier Two risk assessment was performed for the site in order to develop a further understanding of the risk to be expected from this site. The biodegradation capacity of the groundwater was also determined as part of the risk assessment. The water was found to have the capacity to consume 15.53 mg of hydrocarbons per liter of water. Four of the wells contain greater than 20 mg/l of TPHg. This indicates that it would be beneficial to increase the biodegradation capacity of the aquifer. The most cost beneficial way to do this is by adding dissolved oxygen.

2 BIO -AUGMENTATION

2.1 Air Sparging

The air sparging shall be performed by pumping, filtered, oil free compressed, air into MW2 and MW3. The air will be delivered by a 3/8-inch polyethylene tube to an air-defusing filter set at a depth of 20 feet in the wells. The top of the wells will be sealed. The top of slots is currently below the top of groundwater in MW2 and MW3 and the sparging is expected to pressure the

casing until air escapes into the formation, see Figure 5. Ideally this will cause the water near the well to become saturated with oxygen.

MW2 and MW3 shall be used because they are at the center of the plume and that laterals have already been run to these wells. Currently these laterals are stubbed off out side of the well traffic boxes. This will necessitate the replacement of the traffic boxes with larger boxes to expose the end of the lateral.

The pump will be placed in the traffic box where the soil vapor extraction laterals and the MW2 and MW3 laterals now terminate.

2.2 NUTRIENT ADDITION

As found during the December 30, 1997 sampling round the phosphate and ammonia levels are reduced to levels that negatively effects the biodegradation rate. Sodium hexametaphosphate and ammonium sulfate will be added to the wells in order to augment the levels of these compounds.

2.2.1 Phosphate

Research of the current literature indicates that the direct addition of orthophosphate may cause the precipitation of insoluble phosphate salts, thus plugging the infiltration wells and the surrounding aquifer, see appendix C.

In sodium hexametaphosphate (SHMP), the phosphate is in the form of polyphosphate which ~~and~~ forms complex ions with the calcium and iron ions and does not precipitate out of solution. Additional sodium SHMP has a neutral pH of 7 and may be used in the treatment of potable water.

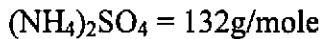
The current groundwater plume covers an area of approximately 100 by 200 feet or 20,000 square feet. The affected water bearing strata is 17 feet thick and extends from 8 to 25 feet below the surface. The plume volume is 340,000 cubic feet. Assuming a porosity of 0.3, the plume contains 102,000 cubic feet, 762,960 gallons or 2,888,318 liters of water.

We hope to raise the initial phosphate concentration in the contaminated aquifer to 1 mg/l. To do this 2888 grams ($1\text{mg/l} \times 2,888,318 \text{ l} \times 1\text{g}/1000\text{mg}$) or 6.37 pounds ($2888 \text{ g} \times 1\text{lb}/453.6 \text{ g}$) of phosphate has to added to the formation. Sodium hexametaphosphate has a phosphate content of 66.5 percent; therefore, $6.37/.665=9.58$ pounds of SHMP has to be added to the formation. Ten pounds of SHMP will be mixed with 1000 pounds or 120 gallons of water; 12 gallons of the resulting one percent solution shall be decanted into each of the monitor wells.

2.2.2 Ammonium Sulfate

In addition to the SHMP, 10 pounds of ammonium sulfate as an ammonia source shall be mixed into the water mixture. In addition to ammonia, this will also supply some sulfate, an important electron acceptor to the system.

Ten pounds of ammonium sulfate should raise the concentration of ammonia and sulfate to the following:



$$\text{N}=14, \text{H}=1, (\text{NH}_4)_2 = 36\text{g/mole} = 36\text{g/mole}/132\text{g/mole} = 0.273$$

$$\text{S}=32, \text{O} = 16, \text{SO}_4 = 96\text{g/mole} = 96\text{g/mole}/132\text{g/mole} = 0.727$$

$$\text{NH}_4 = 10 \times 0.273 = 2.73 \text{ pounds}$$

$$\text{SO}_4 = 10 \times 0.727 = 7.27 \text{ pounds}$$

From phosphate addition calculations above, 6.37 pounds of a substance is equivalent to 1 mg/l in the contaminated aquifer.

$$\text{NH}_4 \ 2.73/6.37 = 0.4 \text{ mg/l in the formation.}$$

$$\text{SO}_4 \ 7.27/6.37 = 1.14 \text{ mg/l in the formation.}$$

3 HYDROCARBON CONTAMINATION

The primary mass of hydrocarbon contamination at this site was found in the soil (1126 pounds) with significant amounts to be found in the groundwater (81.4 pounds). The soil contamination is present in three phases; absorbed onto the soil, vapor and free phase. The free phase product has been found either coating the sand grains or as a floating product layer. Presently there is no significant floating product plume at this site.

The amount bound to the soil (1126 pounds) was found by contouring the results of the soil samples taken during test borings to find the resulting areas and volumes, see table 4.

The mass in groundwater (81.4 pounds) was found by contouring the December 1997 ground water results and calculating the volume of contaminated water, as shown in table 4.

Past experience has shown that significant levels of soil hydrocarbons can be removed through vapor extraction. Examination of the maps of soil contamination and the placement of the soil vapor extraction points indicate they have been placed to remove the highest levels of contamination. Cost estimate comparisons for the removal of the soil will be developed after the soil vapor extraction pilot test.

4 VAPOR EXTRACTION PILOT TEST

In order to determine the effectiveness of vapor extraction at this site, we propose to perform a five-day vapor extraction pilot test. A test of this length is needed in order to determine the actual lateral influence of the vapor extraction and to give some idea of the rate of decline in the concentration of soil vapor.

A number of parameters are important when considering the effectiveness of vapor extraction:

Radius of influence of vapor extraction.

Expected flow rates.

Vacuums needed to produce the above flow rates.

Concentration of hydrocarbon vapors in extracted air.

Removal rates of the hydrocarbon through vaporizing of the gasoline.

Removal rates of hydrocarbon by chemical or biological oxidation of the hydrocarbon and its extraction as carbon dioxide.

Extent of oxygen and carbon dioxide exchange across the top of groundwater.

Reduction of hydrocarbon concentrations in or product thickness on groundwater.

Results obtained for these parameters will guide in the determination of the feasibility of vapor extraction as an effective remediation process at this site. If vapor extraction is continued these results will be used to design the system.

4.1 AIR EFFLUENT TREATMENT

Four 110 carbon canisters, connected in series, will be used to treat the extracted soil vapor.

4.2 VACUUM EXTRACTION PILOT TEST DETAILS

The pilot test will be performed by using a Roton 404, air pump to extract and carbon to treat the vapors from the existing vapor extraction wells, see Figures 4 and 5 for laterals and locations. The test will be performed for a period of five days or until the PID readings indicate that breakthrough has occurred between the third and fourth carbon canister.

During the initial start-up, the flow rate will be varied. A series of vacuum readings, at increasing flow rates, will be recorded for each of the vapor extraction laterals.

The pilot test will last for a period of 5 days. The following samples will be collected:

Prior to the test, vapor samples will be collected from all of the monitor wells and analyzed for TPHg and BTEX.

Start up, samples of the influent and effluent of the system. To be taken after the system has operated for one hour.

First day, sample of influent taken after the system has operated for 6 hours.

Day two, influent taken after system has operated for 24 hours.

Day three, influent after the system has operated for 48 hours.

Day four, influent after the system has operated for 72 hours.

Day five, samples of the influent and the effluent taken after system has operated 96 hours. After these samples have been collected the system will be shut down.

4.2.1 SAMPLING DETAIL

Prior to sampling, the system will be adjusted and allowed to run with steady parameters for one hour. Then the values for the following parameters will be recorded:

Well influent vapor temperature.

Well vacuum.

Differential pressure, across flow meter, total influent.

Stack Temperature, exit.

Stack Pressure, 1 foot below exit.

Hydrocarbon concentration of the influent as determined by an PID Hydrocarbon Vapor meter.

Hydrocarbon concentration of between each carbon and the effluent as determined by an PID Hydrocarbon Vapor meter.

Lower Explosion Limit (LEL) and Oxygen level with LEL/O₂ meter.

After the parameter values are recorded, the system samples will be collected.

4.2.2 INFLUENT SAMPLE

The influent sample will be obtained from a sample port located in the piping connecting the blower to the carbon canisters. The flow pressure from the exhaust is great enough to fill a 1-liter tedlar bag, fitted with a special septum "valve" and tubing bib bag. Sterile poly tubing is fitted to the sample port and the tedlar bag. Then the sample valve of the tedlar bag is opened and the bag is filled with the sample. Once the tedlar bag is full, the valve is closed and locked, the sample port closed, and the appropriate label is placed on the bag.

4.2.3 EFFLUENT

A sample port for the effluent is located in the exhaust stack.

The labels for both the influent and effluent tedlar bag samples show the date, time, sample ID# and analyses to be run.

The samples will be Chain-Of-Custody delivered to a certified laboratory, where the samples will be analyzed for TPHg and MBTEX.

4.2.4 BREAKTHROUGH

Effluent vapors between each carbon canister will be monitored with a PID meter. The system will be shut down when contaminated effluent reaches the last carbon.

4.2.5 CALCULATIONS

To calculate the pounds (lb) per day the concentration is multiplied by the volume of air produced in one day.

The lab reports the Concentrations (C) of the air sampling in g/liter. The first step is to convert this value to lbs/cf (pounds per cubic foot). $1 \text{ ug/l} \times 0.000001 \text{ g/ug} \times 0.002205 \text{ lb/g} \times 28.32 \text{ l/cf} = 0.0000000621 \text{ lb/cf}$

The volume of air produced in one day, equals the flow rate (Q) x the time of flow. $V = Q \times T = \text{cf/day} = \text{cf/min} \times 1440 \text{ min/day}$

The volume must be corrected to standard temperature and pressure (STP).

P = Pressure = 29.92 in Hg @ STP $\approx 1 \text{ atm}$.

V = Volume cf

T = Temperature in degrees above absolute Zero = 491.58°R @ STP. 273°K

Using the Ideal Gas Law $P_1 V_1 / T_1 = P_2 V_2 / T_2$

Solving for $V_2 = P_1 V_1 T_2 / P_2 T_1$

$V_1 = Q \text{ cfm} \times 1440 \text{ min/day}$

$T_2 = 491.58^\circ \text{R}$, $T_1 = 459.58 + T^\circ \text{F Air}$

$P_2 = 29.92$, $P_1 = \text{Air Pressure} - \text{System Vacuum}$

$V_2 = Q \text{ cfm} \times 1440 \text{ min/day} \times 491.58^\circ \text{R} / (459.58^\circ + T^\circ \text{F}) \times P_1 / P_2$

$X \text{ lb/day} = C \text{ ug/l} \times 0.0000000621 \text{ lb l/ug cf} \times Q \text{ cf/min} \times 1440 \text{ min/day} \times 491.58^\circ \text{R} / (459.58^\circ + T^\circ \text{F})$

Q for the Influent sample = The well flow rate. This will be calculated from the readings from the orifice plate flowmeter.

Q for the Effluent = The well flow

4.2.6 FLOW RATES

The flow rates, for the well will be measured by the use of an orifice plate. An orifice plate restricts the flow of air across it. This restriction causes a pressure drop across the orifice. By measuring the resulting pressure change across the orifice it is possible to calculate the air flow rate. The pressure drop (millimeters (mm) water) is used to calculate the flow rate across a square edge orifice plate.

$$V_e = CK \text{ sqr}(P) \quad Q = A V_e$$

Where:

V_e = velocity in feet per minute (fpm)

C = Orifice Coefficient = 0.65 (for orifice used)

K = Constant = 794.6 mm water

P = Pressure differential across the orifice

Q = Flow rate in cubic feet per minute (CFM)

A = Area orifice in square feet. 1" = 0.00545 ft²

$Q = A \times 0.65 \times 794.6 \times \text{Square Root } (P)$

4.2.7 EXPECTED SYSTEM FLOW RATES

Experience with Roton blowers on sites with lithology similar to this site indicates an expected flow rate of 40 to 50 cfm.

4.3 RESULTS PILOT TEST

The sample results from the pilot test will be used to determine:

The expected poundage

The most beneficial vapor treatment system type.

The probable effective parameters and run time of this type of treatment system.

Effect of vapor extraction on groundwater bioremediation.

Expected cost to remove soil contamination using vapor extraction.

A graph of the influent concentration versus time will be constructed and a probable decline curve developed.

Currently, the date of the pilot test has not been decided. We will give your office five working days notice by telephone before we start the test.

If you have, any questions involving this test do not hesitate to contact Roy Butler at (530) 668-5300.

5 SAMPLING PLAN

During the groundwater monitoring rounds the following information and samples will be gathered:

1. Depth to water
2. Groundwater samples for TPHg and BTEX, certified analysis.
3. In order to determine the effectiveness bio-augmentation, the wells will be tested in the field for the following electron acceptors or reaction byproducts:

- Dissolved Oxygen, O₂
 - Nitrate, NO₃⁻
 - Sulfate, SO₄⁻
 - Ferrous iron, Fe⁺⁺. The actual electron acceptor is Ferric iron Fe⁺⁺⁺ but it is insoluble, so the reaction product Fe⁺⁺ was measured.
4. To further define the effectiveness bio-augmentation, water samples will be taken from five of the on-site wells, MW01, MW02, MW05, MW08, and MW11, and will be analyzed for the following.
- Methane, end product of methogenesis.
 - Carbon Dioxide, end product for all biodegradation of hydrocarbons.
 - Hydrocarbon degraders, the bacteria that consume gasoline.
 - Ammonia nitrogen, a nutrient used by bacteria.
 - phosphate, another nutrient used by bacteria.

6 INTERESTED PARTIES

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7 LIMITATIONS

This report is based upon the following:

- The observations of field personnel.
- The results of laboratory analyses performed by a state certified laboratory.
- Referenced documents.
- Our understanding of the regulations of the State of California and Alameda County, Hazardous Materials Section and/or City of Oakland, California.


Changes in groundwater conditions can occur due to variations in rainfall, temperature, local and regional water usage and local construction practices. In addition, variations in the soil and groundwater conditions could exist beyond the points explored in this investigation.

State certified analytical results are included in this report. This laboratory follows EPA and State of California approved procedures; however, WEGE is not responsible for errors in these laboratory results.

The services performed by Western Geo-Engineers, a corporation, under California Registered Geologist #3037 and/or Contractors License #513857, have been conducted in a manner consistent with the level of care and skill ordinarily exercised by members of our profession currently practicing under similar conditions in the State of California and the Woodland area. Our work and/or supervision of remediation and/or abatement operations, active or preliminary, at this site is in no way meant to imply that we are owners or operators of this site. Please note that known contamination of soil and/or groundwater must be reported to the appropriate agencies in a timely manner. No other warranty, expressed or implied, is made.

If you have any questions concerning this report or if we can be of further assistance, please don't hesitate to contact us at (530) 668-5300.

Respectfully,


Roy Butler
Project Geologist



Jack E. Napper
Registered Geologist #3037



Table 1, Tony's Express, Groundwater Elevations					
	DEPTH TO TOP SLOTS	DEPTH TO WATER			
DATE		12/30/97			
MW01	10	9.3			
MW02	10	9.05			
MW03	10	9.74			
MW04	7	9.43			
MW05	6	9.15			
MW06	6	9.3			
MW07	6	8.65			
MW08	7	8.95			
MW09	8	DESTROYED			
MW10	8	8.78			
MW11	8	10.2			
	CASING ELEVATION	GROUND- WATER ELEVATION			
MW01	97.99	88.69			
MW02	98.58	89.53			
MW03	97.78	88.04			
MW04	97.85	88.42			
MW05	99.04	89.89			
MW06	98.77	89.47			
MW07	97.83	89.18			
MW08	97.25	88.3			
MW09	95.94				
MW10	94.54	85.76			
MW11	95.94	85.74			

Table 2, ug/l, Gasoline Range Hydrocarbons in Groundwater								
DATE	10/5/94	12/2/94	3/6/95	6/5/95	10/2/95	1/3/96	4/3/96	9/12/96
MW01, TPHg	320000	80000	32000	21000	5900	30000	31000	
MW01, Benzene	24000	3800	190	950	140	71	98	
MW01, Toluene	21000	6600	150	650	130	73	120	
MW01, Ethylbenzene	2600	2300	150	570	140	50	63	
MW01, Xylene	15000	11000	490	1500	390	120	170	
MW02, TPHg	260000	42000	490	8000	46000	3400	27000	19000
MW02, Benzene	17000	1700	3.2	220	160	7.6	100	210
MW02, Toluene	19000	2200	2.6	330	130	13	92	220
MW02, Ethylbenzene	570	1200	1.6	350	93	7.4	44	110
MW02, Xylene	15000	3600	5.9	660	240	26	130	400
MW03, TPHg	3000000	250000	21000	350000	15000	19000	70000	66000
MW03, Benzene	190000	19000	80	20000	510	290	310	430
MW03, Toluene	740000	22000	73	42000	410	270	260	420
MW03, Ethylbenzene	310000	4400	35	5800	210	97	89	210
MW03, Xylene	13000	28000	130	36000	650	890	280	510
MW04, TPHg					9300	1100	1900	2100
MW04, Benzene					23	4	12	46
MW04, Toluene					11	1.3	7.5	24
MW04, Ethylbenzene					9.9	0.9	5.2	31
MW04, Xylene					29	3.3	14	73
MW05, TPHg					1500	830	780	
MW05, Benzene					1.1	<0.5	1.3	
MW05, Toluene					1.3	<0.5	1	
MW05, Ethylbenzene					3.9	1.3	4.8	
MW05, Xylene					5.3	2.2	3.8	
MW06, TPHg					12000	68000	48000	23000
MW06, Benzene					350	60	140	150
MW06, Toluene					310	61	110	160
MW06, Ethylbenzene					200	27	62	110
MW06, Xylene					610	180	170	310
MW07, TPHg					3300	1500	1900	
MW07, Benzene					8.9	1.5	2.1	
MW07, Toluene					12	0.9	2.6	
MW07, Ethylbenzene					17	3	5.1	
MW07, Xylene					45	4.1	6.9	
MW08, TPHg					94000	23000	58000	46000
MW08, Benzene					310	19	250	210
MW08, Toluene					250	12	170	150
MW08, Ethylbenzene					180	8.8	140	160
MW08, Xylene					480	47	330	360
MW10, TPHg								26000
MW10, Benzene								98
MW10, Toluene								37
MW10, Ethylbenzene								63
MW10, Xylene								99
MW11, TPHg								2300
MW11, Benzene								7
MW11, Toluene								7.2
MW11, Ethylbenzene								12
MW11, Xylene								31

Table 2, ug/l, Gasoline Range Hydrocarbons in Groundwater			
DATE	12/9/96	4/10/97	12/30/97
MW01, TPHg			27000
MW01, Benzene			2300
MW01, Toluene			2100
MW01, Ethylbenzene			1400
MW01, Xylene			5100
MW02, TPHg	6200	53000	35000
MW02, Benzene	110	150	4900
MW02, Toluene	6.6	110	4900
MW02, Ethylbenzene	2.1	37	1600
MW02, Xylene	14	1120	7000
MW03, TPHg	54000	54000	
MW03, Benzene	320	130	
MW03, Toluene	280	120	
MW03, Ethylbenzene	90	38	
MW03, Xylene	250	120	
MW04, TPHg	4000	<50	2300
MW04, Benzene	14	<0.5	410
MW04, Toluene	6.3	<0.5	270
MW04, Ethylbenzene	4.2	<0.5	100
MW04, Xylene	12	<0.5	1500
MW05, TPHg			790
MW05, Benzene			82
MW05, Toluene			66
MW05, Ethylbenzene			59
MW05, Xylene			160
MW06, TPHg	57000	29000	36000
MW06, Benzene	480	60	660
MW06, Toluene	450	70	7600
MW06, Ethylbenzene	160	24	1500
MW06, Xylene	460	71	7700
MW07, TPHg			1400
MW07, Benzene			130
MW07, Toluene			98
MW07, Ethylbenzene			75
MW07, Xylene			200
MW08, TPHg	27000	24000	28000
MW08, Benzene	88	86	6000
MW08, Toluene	43	55	1600
MW08, Ethylbenzene	44	50	2100
MW08, Xylene	80	100	4700
MW10, TPHg	3000	1000	10000
MW10, Benzene	8.1	21	5300
MW10, Toluene	2.2	9.3	76
MW10, Ethylbenzene	1.5	3.3	1100
MW10, Xylene	5.1	33	780
MW11, TPHg	650	<50	710
MW11, Benzene	1.8	<0.5	66
MW11, Toluene	0.5	<0.5	97
MW11, Ethylbenzene	0.8	<0.5	59
MW11, Xylene	0.42	<0.5	190

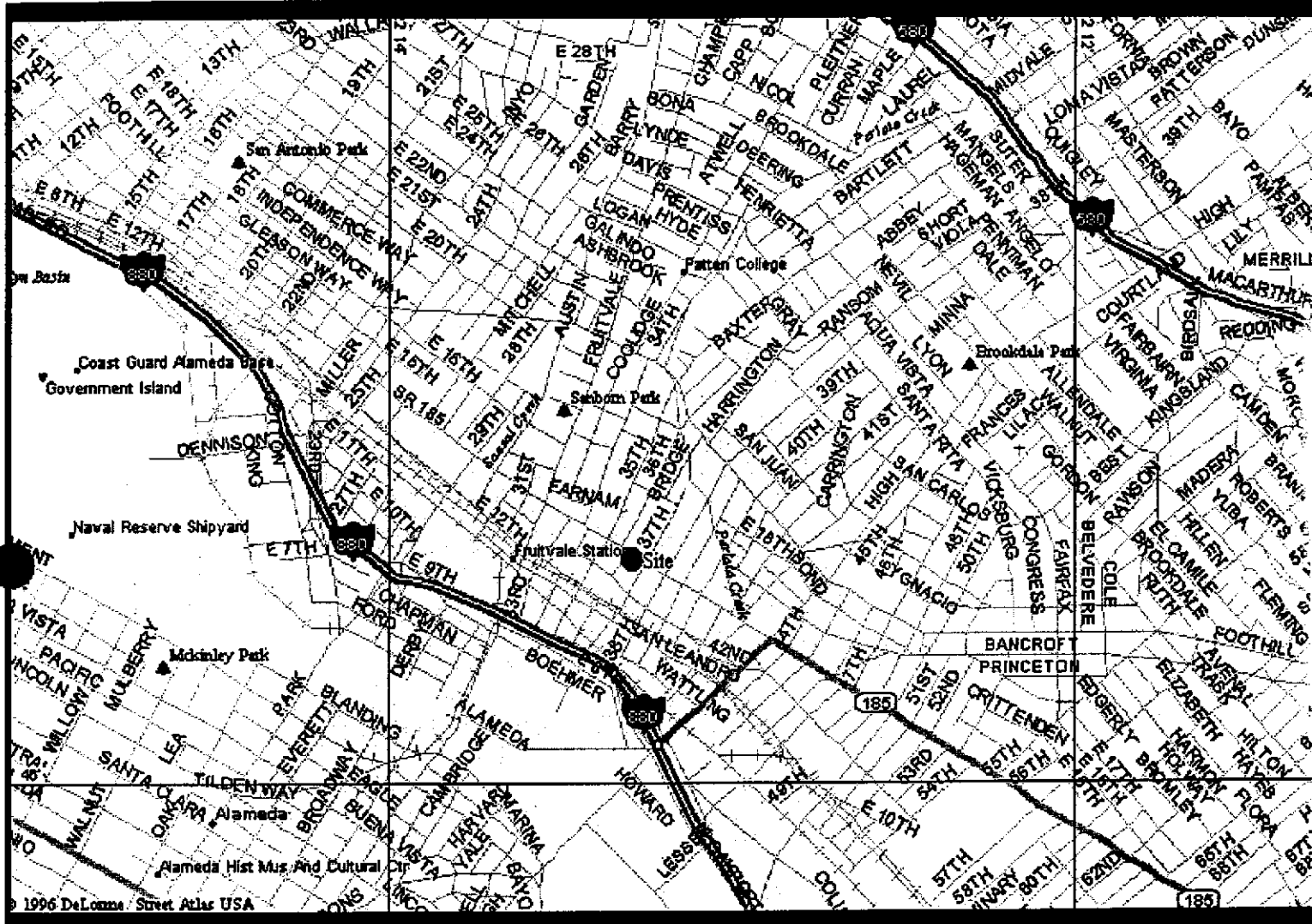
Table 3. Bioremediation Sampling

WELL	TPHg	Dissolved Oxygen	Nitrate as Nitrogen	Ferrous Iron	Sulfate	Methane	Carbon Dioxide	Ammonia Nitrogen	Ortho-Phosphate	Hydro-carbon degraders	ORP	K
UNITS	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	cfu/ml		feet/day
MW01	27	0.5	<0.1	3.04	<1	3.2	99.1	1.3	0.1	60	-110	0.4
MW02	35	<0.1	<0.1	>3.30	<1	1.24	117	1.3	0.4	220	-81	0.47
MW03	FLOATING PRODUCT NOT SAMPLED											
MW04	2.3	<0.1	4.5	0.39	42						72	2.01
MW05	0.79	<0.1	0.3	0.94	18	0.0113	62.7	0.8	0.4	160	46	2.01
MW06	36	<0.1	<0.1	0.30	5						14	10.42
MW07	1.4	1.2	0.2	0.23	32	0.449	64.2	0.2	0.2	60	-82	3.86
MW08	28	2.5	0.1	>3.30	0	3.54	153	0.8	0.3	300	1	1.16
MW09	WELL DESTROYED											
MW10	10	<0.1	0.3	2.21	<1						4	9.66
MW11	0.71	<0.1	3.5	0.32	35						66	2.54

Table 4 Pounds TPHg in soil and in groundwater.								
Pounds TPHg in Soil								
		soil density=	1.9					
Square Feet	Thickness	Cubic feet	Upper mg/kg	Lower mg/kg	Average con mg/kg	kg Soil	mg TPHg	pounds TPHg
117	5	585	1300	1000	1150	31474.35	36195497	79.8
1178	5	5890	1000	1	500.5	316895.5	1.59E+08	349.7
855	5	4275	460	1	230.5	230004.8	53016114	116.9
408	5	2040	120	100	110	109756.7	12073236	26.6
143	5	715	1000	100	550	38468.64	21157754	46.6
300	5	1500	220	100	160	80703.45	12912552	28.5
1494	5	7470	100	1	50.5	401903.2	20296111	44.7
180	5	900	630	100	365	48422.07	17674056	39.0
285	5	1425	1800	200	1000	76668.28	76668278	169.0
123	5	615	500	100	300	33088.41	9926524	21.9
1283	5	6415	200	100	150	345141.8	51771263	114.1
2986	5	14930	100	1	50.5	803268.3	40565051	89.4
Total pounds TPHg in Soil								1126.3

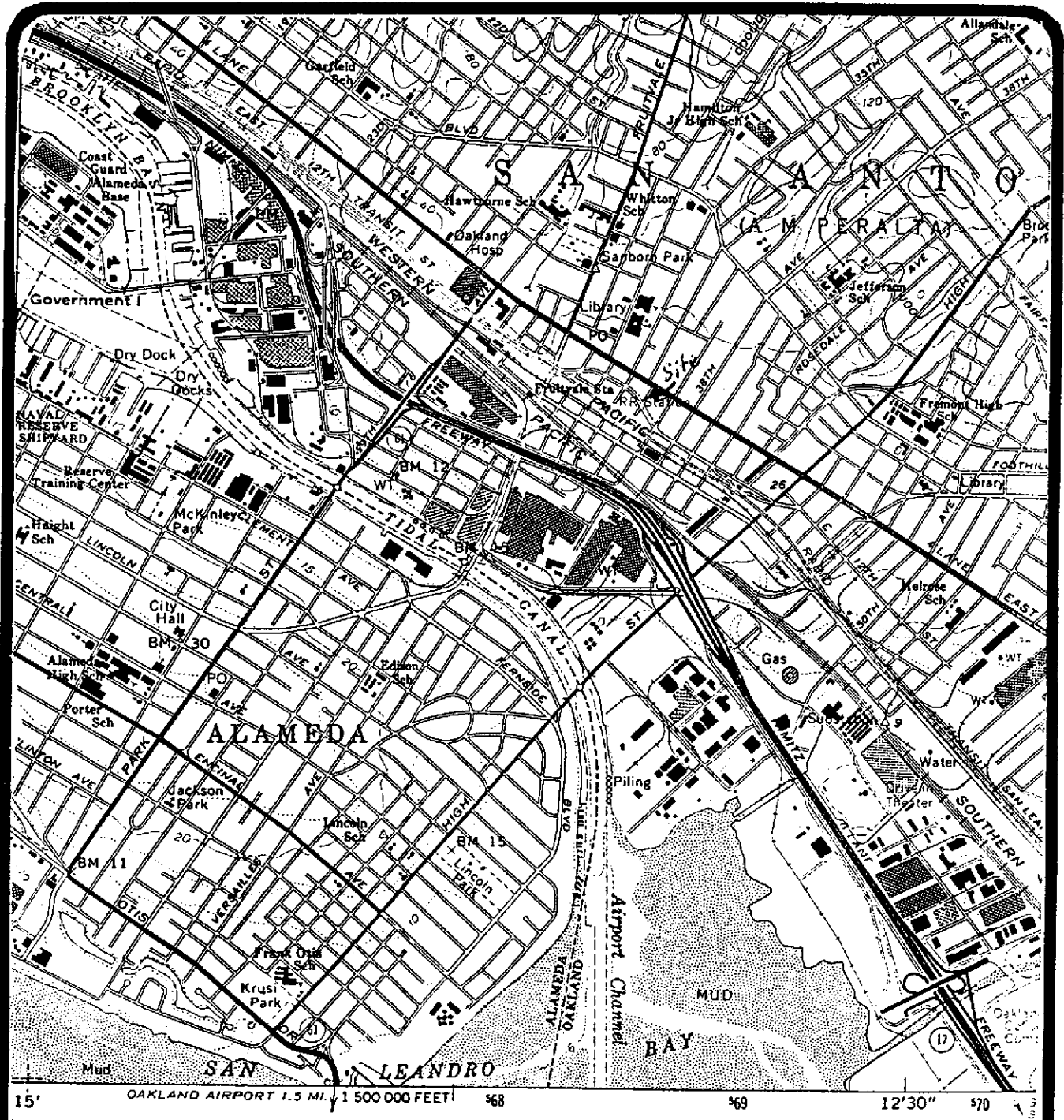
MASS GROUNDWATER CONTAMINATION								
6.25		PORES	0.3					
Square Feet	Thickness	Cubic feet	Upper mg/l	Lower mg/l	Average con mg/l	LITERS water	mg TPHg	pounds TPHg
8326	17	141542	36	10	23	1202413	27655509	60.970
11674	17	198458	10	1	5.5	1685921	9272563	20.443
Total Calculated Mass TPHg in Groundwater								81.413

Figure 1, Location Map





ESTERN
GEO-ENGINEERS



Map compiled, edited, and published by the Geological Survey

under the control by USGS and NOS/NOAA, and Alameda County

Elevation topography from aerial photographs by photogrammetric methods
and by planetable surveys 1947. Revised from aerial photographs
taken 1958. Field checked 1959

Hydrography compiled from NOS Chart 5535 (1958)

Projection: Polyconic projection

Grid: 10,000-foot grid based on California coordinate system, zone 3

Scale: 1000-meter Universal Transverse Mercator grid ticks,
zone 10, shown in blue. 1927 North American Datum

Reference: 1927 North American Datum 1927

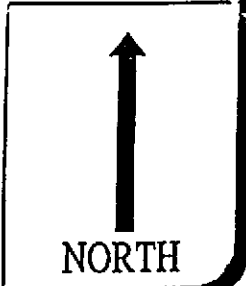
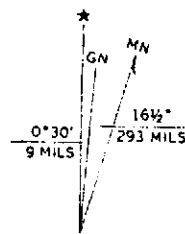


FIGURE 2, USGS TOPOGRAPHIC MAP

E. 14th Street

36th Avenue

MW05

MW02

MW03

MW06

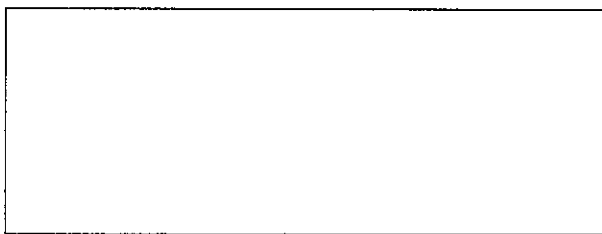
MW7

MW01

TONY'S
EXPRESS
AUTO
SERVICES

MW08

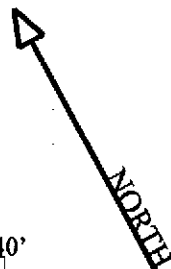
MW04



MW 10

MW11

0 40'

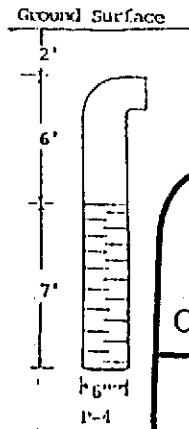
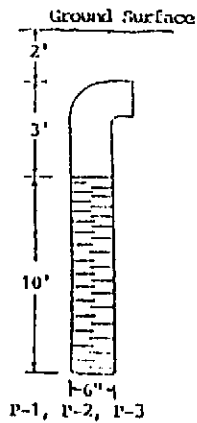
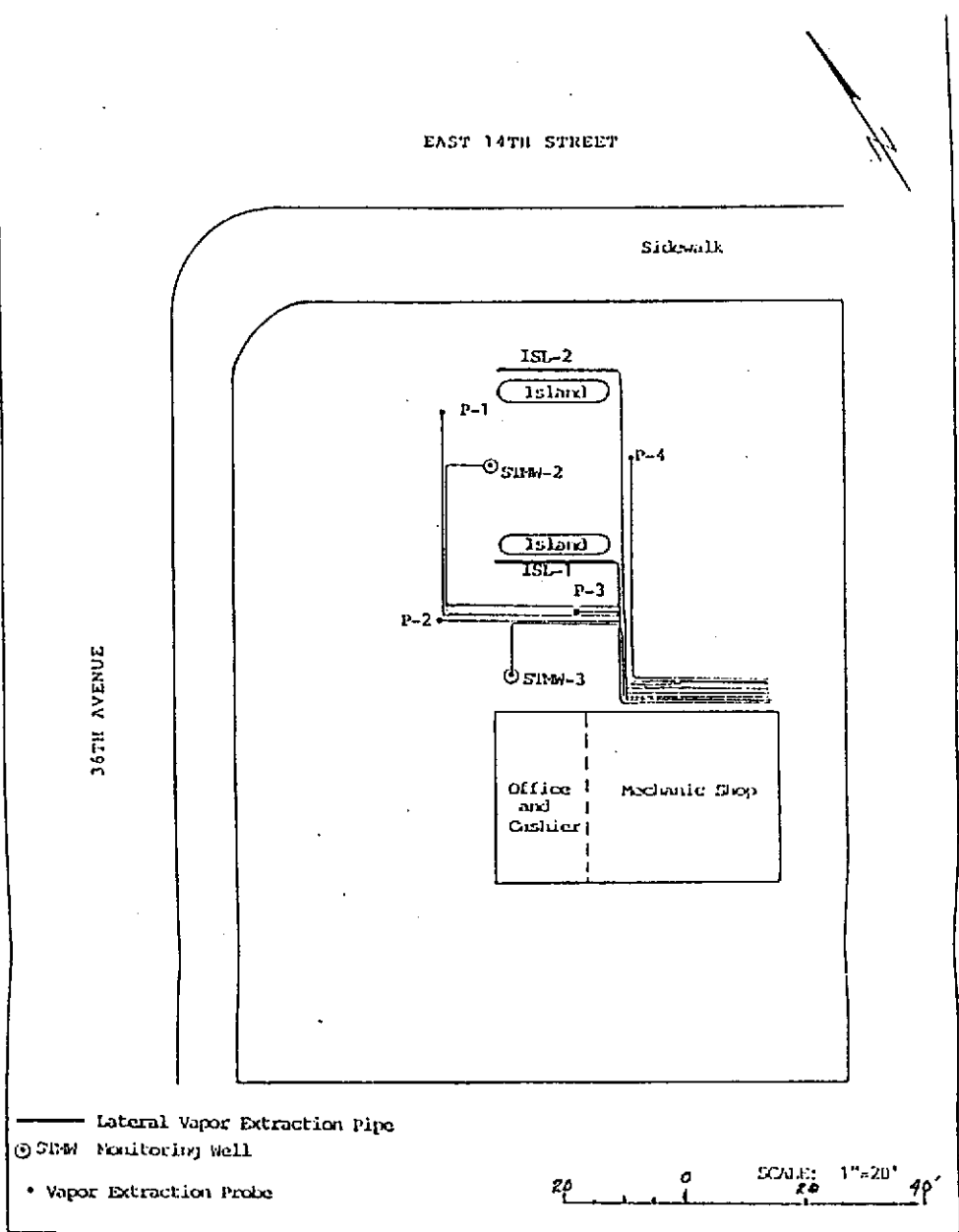


● Monitor Well

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3609 E. 14TH STREET
OAKLAND, CALIFORNIA

FIGURE 3
SITE BASE MAP

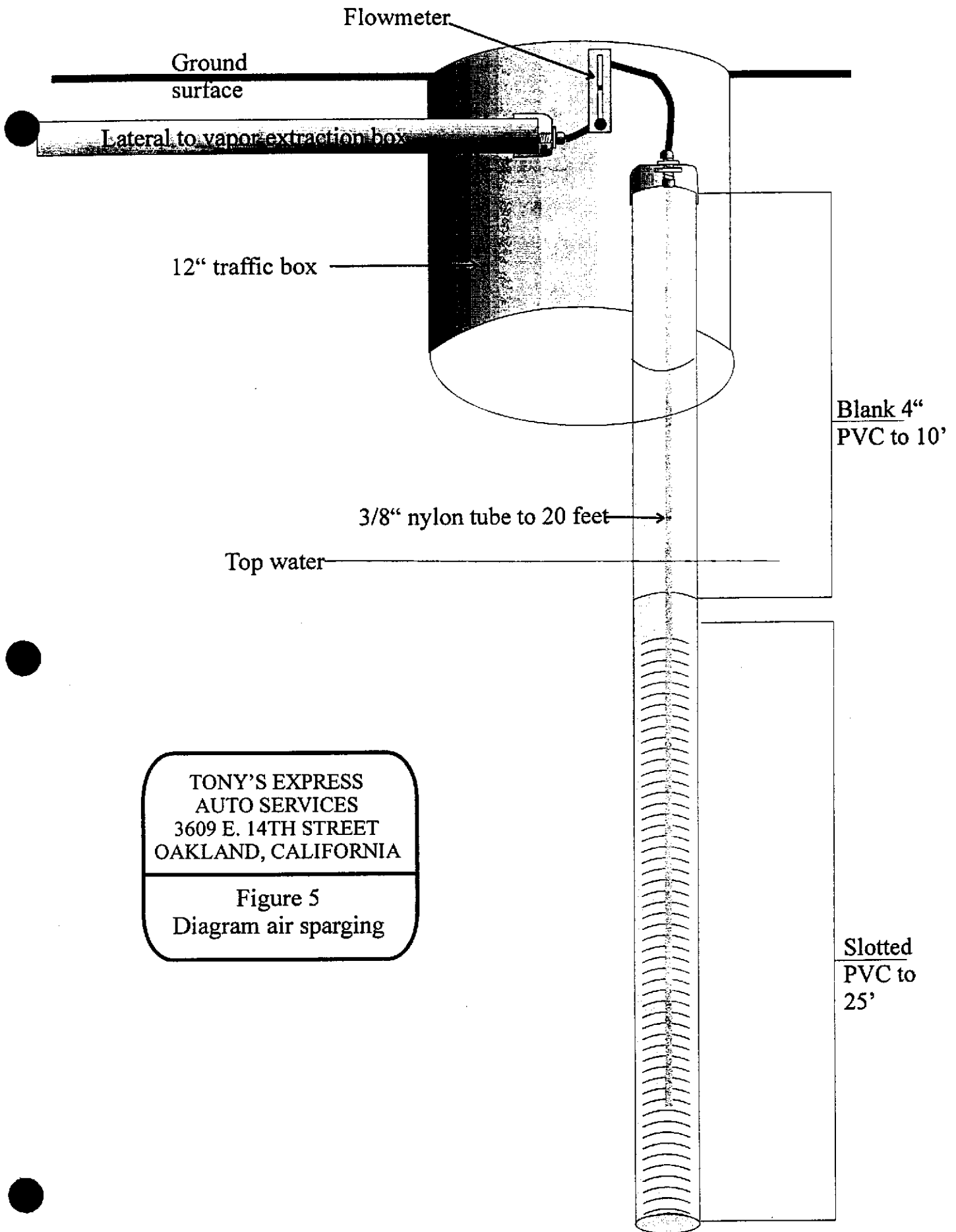
EAST 14TH STREET



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 OAKLAND, CALIFORNIA

Figure 4
 Vapor Extraction and
 air sparging laterals

Profile of Vapor Extraction Probes



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 OAKLAND, CALIFORNIA

Figure 5
 Diagram air sparging

E. 14th Street

36th Avenue

MW05
0.79

MW02
35

MW03
p

MW06
36

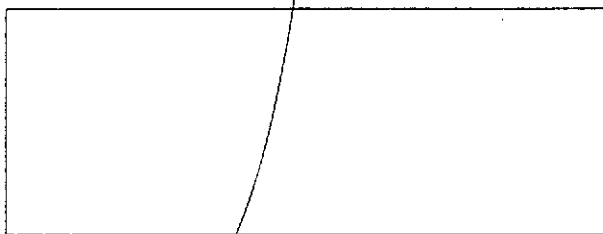
1.4
MW07

27
MW01

28
MW08

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SERVICES

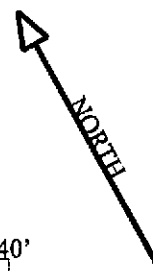
2.3
MW04



10
MW 10

0.71
MW11

1ppm



0 40'

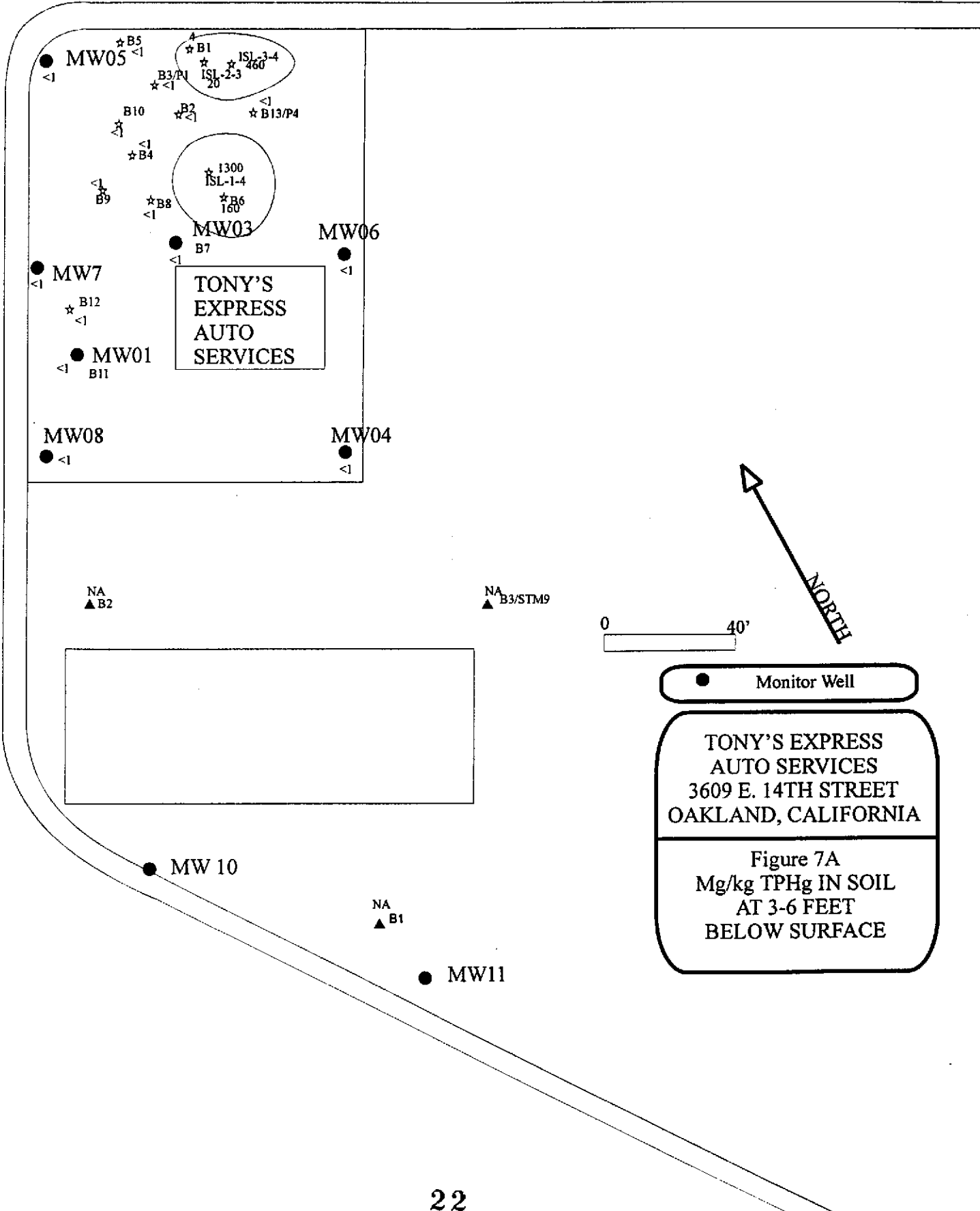
● Monitor Well

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OAKLAND, CALIFORNIA

FIGURE 6
ppm TPHg in
Groundwater

E. 14th Street

36th Avenue



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AUTO
SERVICES

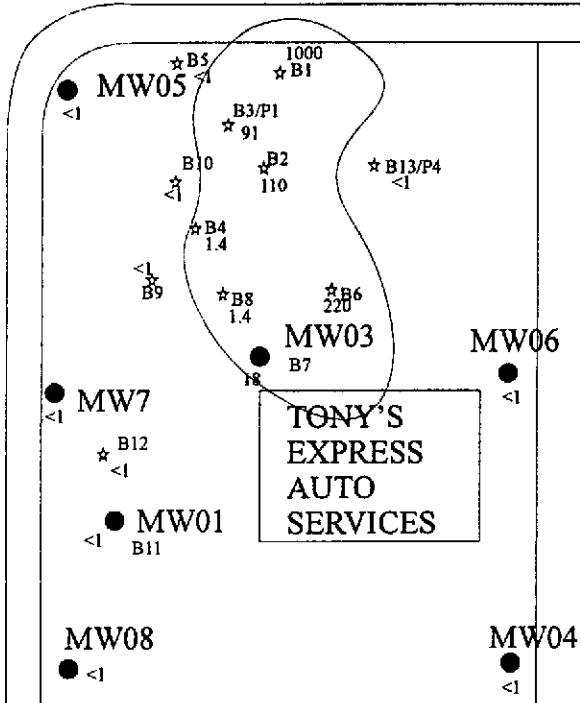
● Monitor Well

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OAKLAND, CALIFORNIA

Figure 7A
Mg/kg TPHg IN SOIL
AT 3-6 FEET
BELOW SURFACE

E. 14th Street

36th Avenue



MW05

1000

B3/P1

B10

B4

B8

MW03

TONY'S EXPRESS AUTO SERVICES

MW7

MW01

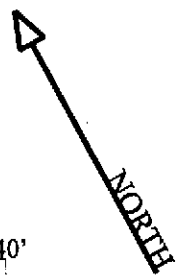
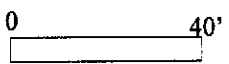
MW08

MW06

MW04

240
▲ B2

▲ B3/STM9
<1



● Monitor Well

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3609 E. 14TH STREET
OAKLAND, CALIFORNIA

Figure 7B
Mg/kg TPHg IN SOIL
AT 10 FEET
BELOW SURFACE

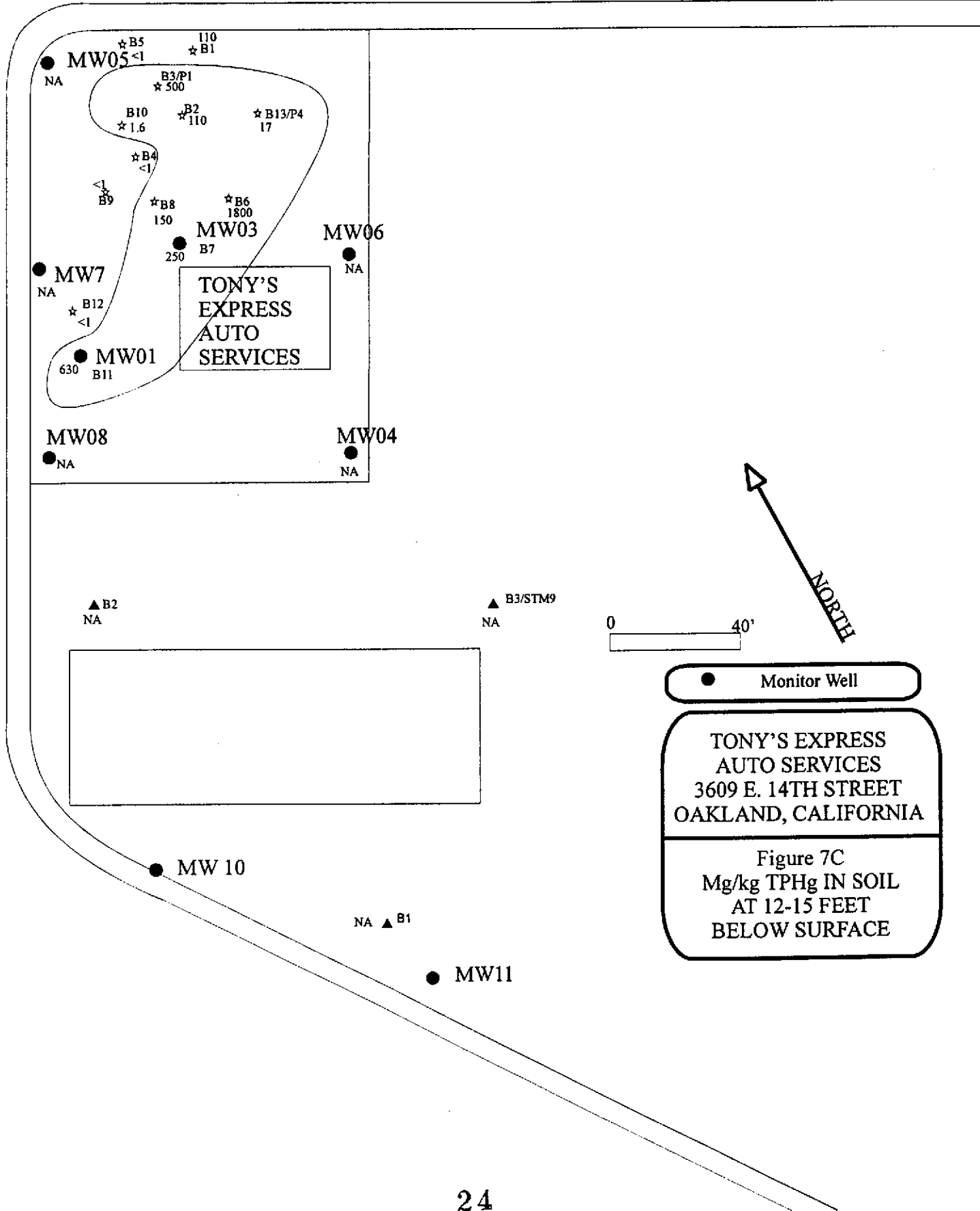
MW 10

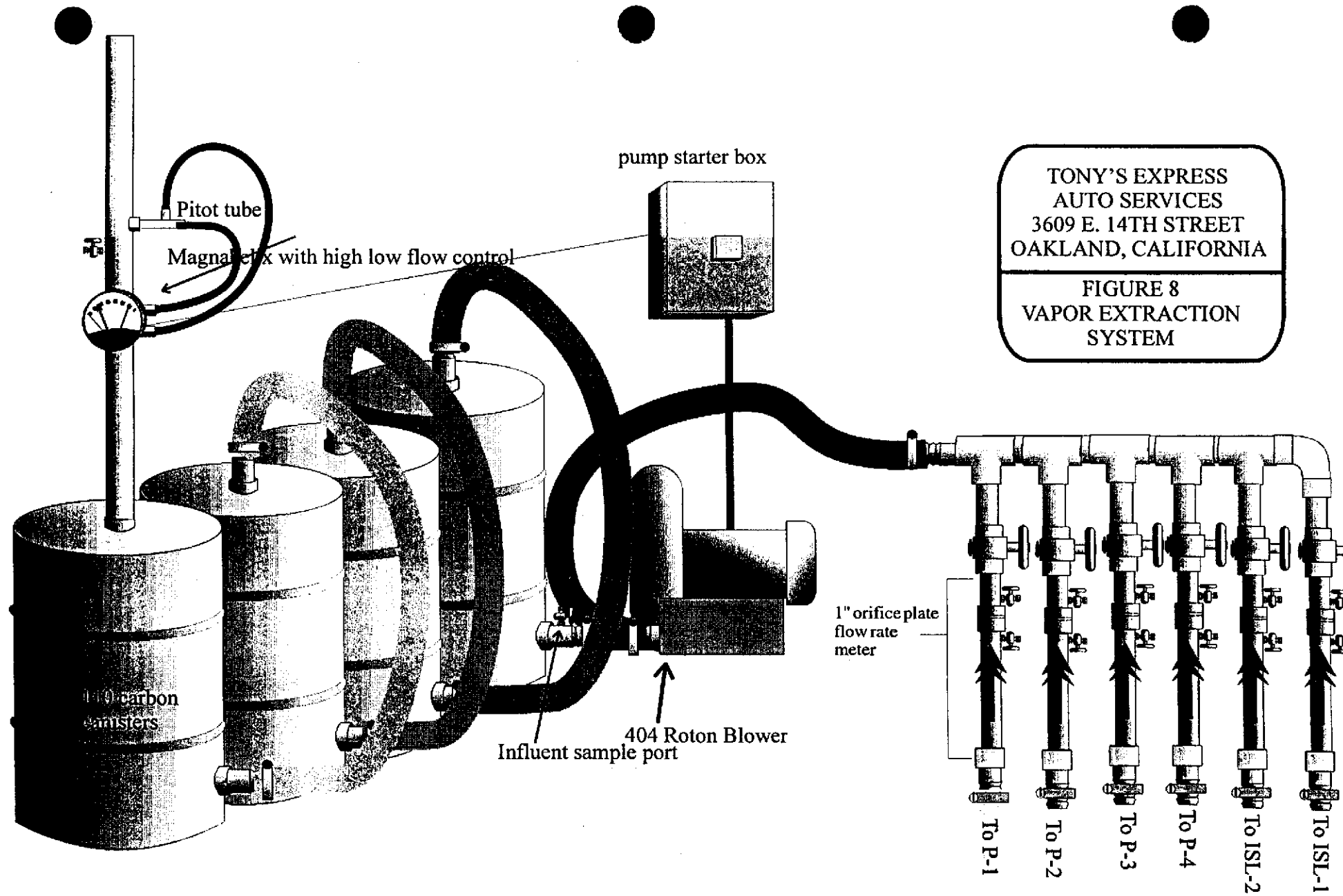
<1
▲ B1

MW11

E. 14th Street

36th Avenue





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OAKLAND, CALIFORNIA

FIGURE 8
VAPOR EXTRACTION
SYSTEM

APPENDIX A

METHODS
AND
PROCEDURES
QA/QC

APPENDIX A.

METHODS AND PROCEDURES, QA/QC

This Appendix documents the specific methods, procedures, and materials used to collect and analyze ground water samples and monitoring the vapor recovery system.

Gauging and Measuring Monitor Wells.

Prior to sampling a well, WEGE personnel obtain three measurements: the depth to ground water (DTW) and the product thickness using a battery powered depth to water-product interface probe and or by using a specially designed bailer. And the vacuum influence at the well head, using a water manometer that is attached to a sample port in the well head. The DTW probe is lowered into the well casing until the instrument signals that the top of water has been reached. The distance from the top of water to the top of casing is read from the tape that is attached to the probe. The tape is calibrated in 0.01 foot intervals for accuracy to 0.01 foot. The measured distance is subtracted from the established elevation at the top of casing to determine the elevation of ground water with respect to mean sea level. The probe is washed with TSP (Tri Sodium Phosphate) and rinsed in distilled water before each measurement. WEGE has designed and built bailers that will collect a sample of the contents of a well to show the exact thickness of any floating product. Some of the abbreviations used in water sampling and or measuring or monitoring are: DTW, Depth to Water (from surface reference ie usually TOC); TOC, Top of Casing; MSL, Mean Sea Level; AMSL and BMSL, Above and Below MSL; BS, Below Surface; TOW, Top of Water; TSP, Tri Sodium Phosphate.

Purging Standing Water from Monitor Wells

If no product is present, WEGE personnel purge the well. This is accomplished by removing ground water from the well until the water quality parameters (temperature, pH, and conductivity) stabilize, or until the well is emptied of water. Periodic measurements of ground water temperature, pH, and conductivity were taken with a Hydac Monitor or other meter and recorded along with the volume of ground water removed from the well. Purging is done by one or more methods singularly or in combination. Bailers, pneumatic or electric sample pumps, or vacuum pump tanks or trucks may be used. The usual amount of water removed is three well volumes. The water collected during purging is either safely stored onsite for later disposition, transported to an approved onsite or offsite sewer discharge system, or an approved onsite or offsite treatment system.

Collection of Water Sample for Analysis

The well is allowed to recover after purging and a ground water sample is collected. A fresh bailer is used to collect enough water for the requirements of the laboratory for the analyses needed or required. The water samples are decanted from the bailer into the appropriate number and size containers. These containers are furnished pre-cleaned to exact EPA protocols, with and without preservatives added, by the analytical laboratory or a chemical supply company. The bottles are filled, with no headspace, and then capped with plastic caps with teflon liners.

The vials or bottles containing the ground water samples are labeled with site name, station, date, time, sampler, and analyses to be performed, and documented on a chain of custody form. They were placed in ziplock bags and stored in a chest cooled to 4°C with ice. The preserved samples are chain of custody delivered to the chosen laboratory.

Analytical Results

TPH is the abbreviations used for Total Petroleum Hydrocarbons used by the laboratories for water and soil analyses. The letter following TPH indicates a particular distinction or grouping for the results. The letters "g", "d", "k", or "o" indicate gasoline, diesel, kerosene, or oil, respectively, ie TPH-d for diesel range TPH.

MBTEX acronym or abbreviation used for Methyl Tertiary Butyl Ether (MTBE), Benzene, Toluene, Ethylbenzene and all of the Xylenes.

The less than symbol, <, used with a "parts per value" indicates the lower detection limit for a given analytical result and the level, if present, of that particular analyte is below or less than that lower detection limit.

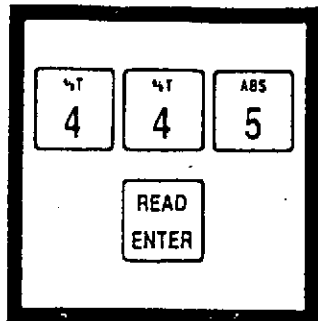
Other abbreviations commonly used are ppm, ppb, mg/Kg, ug/Kg, ml/l and ul/l are parts per million, parts per billion, milligrams per kilogram, micrograms per kilogram, milliliters per liter, microliters per liter, respectively.

Chain of Custody Documentation

All water samples that are collected by WEGE and transported to a certified analytical laboratory are accompanied by chain-of-custody (COC) documentation. This documentation is used to record the movement and custody of a sample from collection in the field to final analysis and storage. Samples to be analyzed at the certified laboratory were logged on the COC sheet provided by the laboratory. The same information provided on the sample labels (site name, sample location, date, time, and analysis to be performed) are also noted on the COC form. Each person relinquishing custody of the sample set signs the COC form indicating the date and time of the transfer to the recipient. A copy of the COC follows the samples or their extracts throughout the laboratory to aid the analyst in identifying the samples and to assure analysis within holding times.

Copies of the COC documentation are included with the laboratory results in Appendix B of this report.

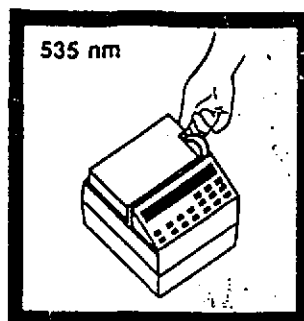
HRDO Method



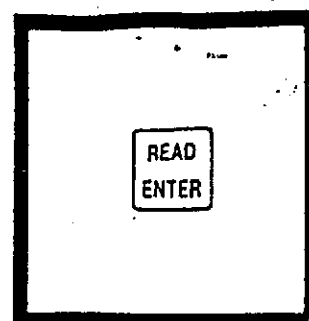
1. Enter the stored program number for dissolved oxygen.
Press: 4 4 5 READ/ENTER
The display will show:
DIAL nm TO 535

Note: Or, use the up and down arrows to scroll the display to: 445 mg/l O₂ HRDO and press: READ/ENTER

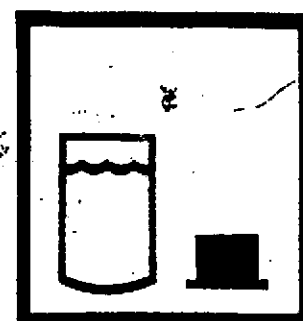
Note: Samples must be analyzed on site and cannot be stored; see Sampling and Storage below.



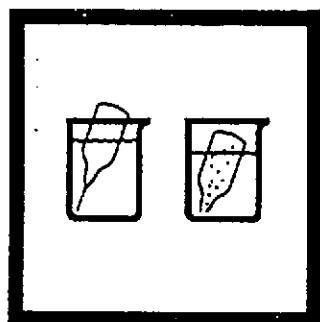
2. Rotate the wavelength dial until the small display shows:
535 nm



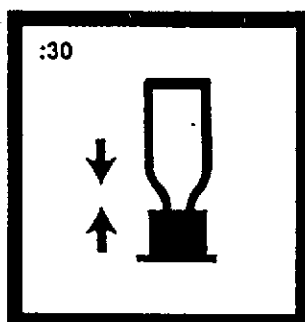
3. Press: READ/ENTER
The display will show:
mg/l O₂ HRDO



4. Fill a zeroing vial (the blank) with at least 10 mL of sample. Fill a blue ampul cap with sample.



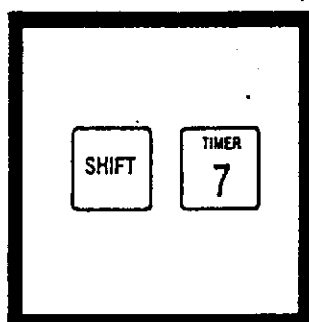
5. Fill a High Range Dissolved Oxygen AccuVac Ampul with sample.
Note: Keep the tip immersed while the ampul fills completely.



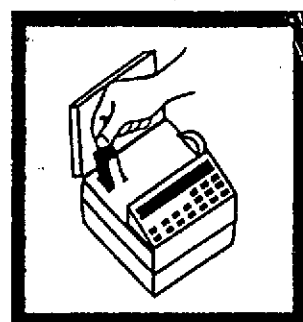
6. Without inverting the ampul, immediately place the ampul cap that has been filled with sample securely over the tip of the ampul. Shake the ampul for approximately 30 seconds.

Note: A small amount of the undissolved HRDO Reagent does not affect results.

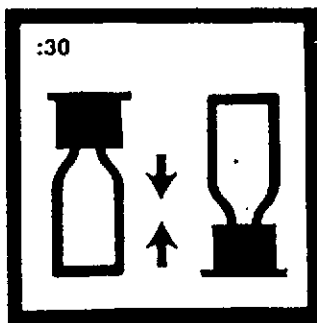
Note: The cap prevents contamination with atmospheric oxygen.



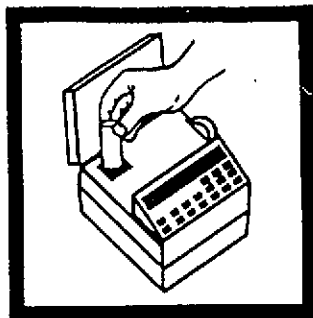
7. Press: SHIFT TIMER
A two-minute reaction period enables oxygen, which was degassed during aspiration, to redissolve and react.



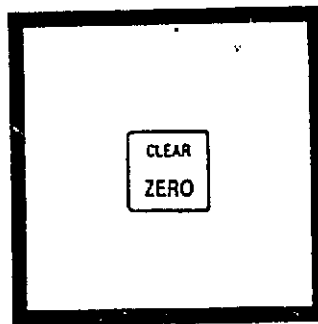
8. Place the AccuVac Vial Adapter into the cell holder.
Note: Place the grip tab at the rear of the cell holder.



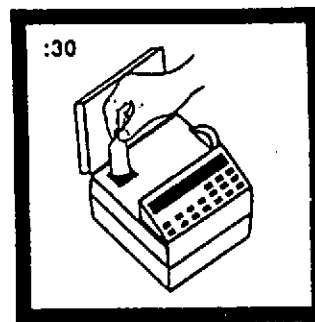
9. When the timer beeps, the display will show:
 mg/l O₂ HRDO
 Shake the ampul for 30 seconds.



10. Place the blank into the cell holder. Close the light shield.



11. Press: ZERO
 The display will show:
 WAIT
 then:
 0.0 mg/l O₂ HRDO



12. Place the AccuVac ampul into the cell holder. Close the light shield. Wait approximately 30 seconds for the air bubbles to disperse from the light path.

Press: READ/ENTER

The display will show:
 WAIT
 then the result in mg/L dissolved oxygen will be displayed.

Note: In the constant-on mode, pressing READ/ENTER is not required. WAIT will not appear. When the display stabilizes, read the result.

SAMPLING AND STORAGE

The foremost consideration in sampling with the High Range Dissolved Oxygen AccuVac Ampul is to prevent the sample from becoming contaminated with atmospheric oxygen. This is accomplished by capping the ampul with an ampul cap in the interval between breaking open the ampul and reading the absorbance. If the ampul is securely capped, the ampul should be safe from contamination for several hours. The absorbance will decrease by approximately 3% during the first hour and will not change significantly afterwards.

Sampling and sample handling are important considerations in obtaining meaningful results. The dissolved oxygen content of the water being tested can be expected to change with depth, turbulence, temperature, sludge deposits, light, microbial action, mixing, travel time and other factors. A single dissolved oxygen test rarely reflects the accurate over-all condition of a body of water. Several samples taken at different times, locations and depths are recommended for most reliable results. Samples must be tested immediately upon collection although only a small error results if the absorbance reading is taken several hours later.

ACCURACY CHECK

The results of this procedure may be compared with the results of a titrimetric procedure or dissolved oxygen meter.

PRECISION

In a single laboratory, using a standard solution of 7.22 mg/L O₂ determined by the Winkler method and two representative lots of reagent with the DR/2000, a single operator obtained a standard deviation of ± 0.20 mg/L O₂.

INTERFERENCES

The following do not interfere at a level of 10 mg/L which is in excess of naturally occurring levels of Cr³⁺, Mn²⁺, Fe²⁺, Ni²⁺, Cu²⁺ and NO₂⁻

APPENDIX B

MSDS
OF COMPOUNDS
TO BE ADDED

✕

Coatings Performance Materials Data Sheet

Sodium Hexametaphosphate (SHMP)

PRODUCT: Sodium Hexametaphosphate (SHMP)
Plates
NSF® Certified to ANSI / NSF Std. 60

GRADE: Technical

CODE NO.: 7890-310

GENERAL DESCRIPTION: Clean, clear glass plates of amorphous sodium polyphosphate

FORMULA: $\text{Na}_{(n+2)}\text{P}_n\text{O}_{(3n+1)}$; n = 9-15

MOLECULAR WEIGHT: 978-1592

CAS NO.: 68915-31-1

DATE EFFECTIVE: June 21, 1996

CHARACTERISTICS**SPECIFICATION LIMITS**

P_2O_5 , %	66.5 Minimum
pH, 1% Solution	6.8 - 7.2
Plate Size:	
Thickness, inches	± 1/16
Width, inches	1.5 Maximum

Solutia Sodium Hexametaphosphate is a glassy, amorphous sodium polyphosphate with a $\text{Na}_2\text{O}/\text{P}_2\text{O}_5$ molar ratio of approximately 1.1.

NOTE: Specification Limits are subject to change from time to time.

Production Location: Trenton, MI

Packaging: 50 lb. multiwall bags

Labeling Requirements: Product label

Shipping: Sodium Phosphate

Classification:

Handling Precautions: No precautionary statement required on label.

Handle in accordance with good industrial hygiene and safety practices. These include avoiding unnecessary exposure and removal of material from eyes, skin, and clothing.

Key Properties:

- Sequestration
- Neutral Salt
- Buffer Capacity
- Infinite Solubility in Water

Applications:

- Deflocculation
- Consumer Products: The unique combination of SHMP's ability to sequester water hardness and its infinite solubility in water makes it a product of choice in applications such as laundry boosters, water conditioners and in bath beads.
- Industrial Water Treatment: SHMP can be used in continuously recycled industrial water as a softener and to control scale formation in condensers, heat exchangers, pipelines and boilers. SHMP has two particular advantages over the pyro- and tripolyphosphates in industrial water treatment. First, it maintains polyphosphate properties longer in high temperature systems at mildly alkaline pH's. Second, its infinite solubility in water allows very concentrated stock solutions to be prepared.
- Potable Water Treatment: Due to the sequestration and threshold properties of SHMP, it is commonly added to potable water to aid in corrosion control and antiscaling of distribution equipment and lines. Solutia sodium hexametaphosphate conforms to the requirements of ANSI / NSF Standard 60, Maximum Use Level 11.9 mg/L, and meets or exceeds ANSI / AWWA Standard B502-88.
- Industrial Cleaning: In the textile industry, SHMP is used to chelate calcium and iron, hence keeping their salts from being redeposited on the surface of the fabric. It also provides good dispersion in pigmenting and dyeing operations.
- Film Development: The excellent sequestering properties of SHMP improve the efficiency of the photographic film developing process by chelating foreign metal ions.
- Oil Well Drilling Muds: Deflocculants are required in oil well drilling muds to maintain high specific gravity at the low viscosity necessary for easy pumping. SHMP is an excellent deflocculant and offers superior cost-performance in wells with depths down to 5,000 feet.
- Kaolin Clay Processing: SHMP is effective as a deflocculant in the preparation of high solids slurries with sufficient fluidity to allow rapid settling of coarse impurities. Another advantage occurs in the final bleaching of the clay with sulfuric acid. With SHMP's neutral pH, a minimal amount of sulfuric acid is required to lower the pH to 3.5, which is required for effective bleaching.

FOR MORE COMPLETE INFORMATION ON PROPERTIES AND SAFE HANDLING OF THIS MATERIAL, SEE THE Solutia MATERIAL SAFETY DATA SHEET (MSDS).

NOTICE: Although the information and recommendations set forth herein (hereinafter "Information") are presented in good faith and believed to be correct as of the date hereof, Solutia Inc. makes no representations or warranties as to the completeness or accuracy thereof. Information is supplied upon the condition that the persons receiving same will make their own determination as to its suitability for their purposes prior to use. In no event will Solutia Inc. be responsible for damages of any nature whatsoever resulting from the use of or reliance upon Information or the product to which Information refers. Nothing contained herein is to be construed as a recommendation to use any product, process, equipment or formulation in conflict with any patent, and Solutia Inc. makes no representation or warranty, express or implied, that the use thereof will not infringe any patent. The data set forth herein are based on samples tested and are not guaranteed for all samples or applications. Such data are intended as guides and do not reflect product specifications for any particular product. NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESS OR IMPLIED, OR MERCHANTABILITY, FITNESS FOR A PARTICULAR

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For Customer Order assistance, call toll-free 800-325-4330 or FAX 314-674-2490.
Additional information follows.

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MONSANTO -- SODIUM HEXAMETAPHOSPHATE - SODIUM HEXAMETAPHOSPHATE, TECHNICAL
MATERIAL SAFETY DATA SHEET
NSN: 6810008238109
Manufacturer's CAGE: 76541
Part No. Indicator: A
Part Number/Trade Name: SODIUM HEXAMETAPHOSPHATE

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General Information
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Item Name: SODIUM HEXAMETAPHOSPHATE, TECHNICAL
Company's Name: MONSANTO COMPANY
Company's Street: 800 N LINDBERGH BLVD
Company's City: ST LOUIS
Company's State: MO
Company's Country: US
Company's Zip Code: 63167
Company's Emerg Ph #: 314-694-1000, 800-424-9300 (CHEMTREC)
Company's Info Ph #: 314-694-1000
Distributor/Vendor # 1: WALTRON LTD (201-534-5100)
Distributor/Vendor # 1 Cage: 71229
Record No. For Safety Entry: 007
Tot Safety Entries This Stk#: 009
Status: SE
Date MSDS Prepared: 03FEB92
Safety Data Review Date: 04APR95
Supply Item Manager: CX
MSDS Preparer's Name: NONE
MSDS Serial Number: BWSTG
Hazard Characteristic Code: N1
Unit Of Issue: DR
Unit Of Issue Container Qty: 100 POUNDS
Type Of Container: DRUM
Net Unit Weight: 100 LBS

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Ingredients/Identity Information
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Proprietary: NO
Ingredient: SODIUM HEXAMETAPHOSPHATE
Ingredient Sequence Number: 01
Percent: UNKNOWN
NIOSH (RTECS) Number: TR4950250
CAS Number: 68915-31-1
OSHA PEL: 15 MG/M3 TOTAL DUST
ACGIH TLV: 10 MG/M3 TDUST 9394
Other Recommended Limit: NONE RECOMMENDED

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Physical/Chemical Characteristics
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Appearance And Odor: WHITE POWDER, GRANULES, OR GLASS PLATES. ODORLESS.
Boiling Point: NOT GIVEN
Melting Point: 1162F, 628C
Vapor Pressure (MM Hg/70 F): NOT GIVEN
Vapor Density (Air=1): NOT GIVEN
Specific Gravity: 81 LBS/FT3 PWD
Decomposition Temperature: UNKNOWN
Evaporation Rate And Ref: NOT APPLICABLE
Solubility In Water: INFINITE
pH: 7.0
Corrosion Rate (IPY): UNKNOWN

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Fire and Explosion Hazard Data
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Flash Point: NOT APPLICABLE

Lower Explosive Limit: NOT GIVEN
 Upper Explosive Limit: NOT GIVEN
 Extinguishing Media: NONFLAMMABLE. USE EXTINGUISHING MEDIA SUITABLE FOR SURROUNDING FIRE.
 Special Fire Fighting Proc: NONFLAMMABLE. USE STANDARD FIREFIGHTING PROCEDURES FOR SURROUNDING MATERIALS IN THE FIRE.
 Unusual Fire And Expl Hazrds: MATERIAL IS NOT COMBUSTIBLE.

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 Reactivity Data
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Cond To Avoid (Stability): NONE SPECIFIED BY MANUFACTURER.
 Materials To Avoid: NONE SPECIFIED BY MANUFACTURER.
 Hazardous Decomp Products: NONE SPECIFIED BY MANUFACTURER.
 Hazardous Poly Occur: NO
 Conditions To Avoid (Poly): DOES NOT OCCUR.

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 Health Hazard Data
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LD50-LC50 Mixture: LD50 RAT ORAL 6600 MG/KG.
 Route Of Entry - Inhalation: YES
 Route Of Entry - Skin: YES
 Route Of Entry - Ingestion: NO
 Health Haz Acute And Chronic: PRODUCT REPORTED NOT TO CAUSE SIGNIFICANT EYES: SLIGHTLY IRRITATING. SKIN: NON-IRRITATING. INGESTION: PRACTICALLY NON-TOXIC. CHRONIC: NONE SPECIFIED.
 Carcinogenicity - NTP: NO
 Carcinogenicity - IARC: NO
 Carcinogenicity - OSHA: NO
 Explanation Carcinogenicity: THIS COMPOUND CONTAINS NO INGREDIENTS AT CONCENTRATIONS OF 0.1% OR GREATER THAT ARE CARCINOGENS OR SUSPECT CARCINOGENS.
 Signs/Symptoms Of Overexp: EYES: SLIGHT IRRITATION. SKIN: NON- IRRITATING. INGESTION: NON-TOXIC.
 Med Cond Aggravated By Exp: NONE SPECIFIED BY MANUFACTURER.
 Emergency/First Aid Proc: NONE SPECIFIED BY MANUFACTURER.

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 Precautions for Safe Handling and Use
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Steps If Matl Released/Spill: SWEEP UP AND PLACE BULK MATERIAL IN CONTAINER. FLUSH SMALL SPILLS TO SEWER WITH PLENTY OF WATER. FLUSH SPILL AREA WITH WATER.
 Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
 Waste Disposal Method: DISPOSE OF WASTE IN A LANDFILL IN ACCORDANCE WITH LOCAL, STATE AND FEDERAL REGULATIONS.
 Precautions-Handling/Storing: PRODUCT IS VERY HYGROSCOPIC AND SHOULD BE STORED IN A DRY AREA IN POLY OR VAPOR BARRIER BAGS TO PREVENT MOISTURE PICKUP AND CAKING.
 Other Precautions: HANDLE IN ACCORDANCE WITH GOOD INDUSTRIAL HYGIENE AND SAFETY PRACTICES, INCLUDING AVOIDING UNNECESSARY EXPOSURE AND REMOVAL OF MATERIAL FROM EYES, SKIN AND CLOTHING. AVOID EYE CONTACT. MINIMIZE SKIN CONTAMINATION. AVOID BREATHING DUST.

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 Control Measures
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Respiratory Protection: USE NIOSH APPROVED EQUIPMENT WHEN AIRBORNE EXPOSURE IS EXCESSIVE.
 Ventilation: PROVIDE VENTILATION TO MINIMIZE EXPOSURE. USE LOCAL EXHAUST AT SOURCES OF AIR CONTAMINATION.
 Protective Gloves: NONE NORMALLY REQUIRED.
 Eye Protection: NONE NORMALLY REQUIRED.
 Other Protective Equipment: NONE SPECIFIED BY MANUFACTURER.
 Work Hygienic Practices: WASH AFTER HANDLING AND BEFORE EATING, DRINKING, OR SMOKING. LAUNDRY CONTAMINATED CLOTHING BEFORE REUSE.
 Suppl. Safety & Health Data: NONE SPECIFIED BY MANUFACTURER.

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Transportation Data
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Trans Data Review Date: 95094
DOT PSN Code: ZZZ
DOT Proper Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
IMO PSN Code: ZZZ
IMO Proper Shipping Name: NOT REGULATED FOR THIS MODE OF TRANSPORTATION
IATA PSN Code: ZZZ
IATA Proper Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
AFI PSN Code: ZZZ
AFI Prop. Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
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Disposal Data
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Label Data
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Label Required: YES
Technical Review Date: 04APR95
Label Status: F
Common Name: SODIUM HEXAMETAPHOSPHATE
Chronic Hazard: NO
Signal Word: CAUTION!
Acute Health Hazard-Slight: X
Contact Hazard-Slight: X
Fire Hazard-None: X
Reactivity Hazard-None: X
Special Hazard Precautions: PRODUCT REPORTED NOT TO CAUSE SIGNIFICANT
EYES: SLIGHTLY IRRITATING. SKIN: NON-IRRITATING. INGESTION: PRACTICALLY
NON-TOXIC. CHRONIC: NONE SPECIFIED. PRODUCT IS VERY HYGROSCOPIC AND SHOULD
BE STORED IN A DRY AREA IN POLY OR VAPOR BARRIER BAGS TO PREVENT MOISTURE
PICKUP AND CAKING. FIRST AID: NONE SPECIFIED BY MANUFACTURER. TARGET
ORGANS; UNKNOWN.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: MONSANTO COMPANY
Label Street: 800 N LINDBERGH BLVD
Label City: ST LOUIS
Label State: MO
Label Zip Code: 63167
Label Country: US
Label Emergency Number: 314-694-1000,800-424-9300 (CHEMTREC)
Year Procured: 1995
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delete information in this archive please sent updates to dan@siri.org.

FISHER SCIENTIFIC -- AMMONIUM SULFATE - AMMONIUM SULFATE,ACS
MATERIAL SAFETY DATA SHEET
NSN: 6810002646546
Manufacturer's CAGE: 22527
Part No. Indicator: B
Part Number/Trade Name: AMMONIUM SULFATE

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General Information
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Item Name: AMMONIUM SULFATE,ACS
Company's Name: FISHER SCIENTIFIC CO
Company's Street: 585 ALPHA DR
Company's City: PITTSBURGH
Company's State: PA
Company's Country: US
Company's Zip Code: 15238-2911
Company's Emerg Ph #: 412-526-8300 201-796-7100
Company's Info Ph #: 412-526-8300 201-796-7100
Record No. For Safety Entry: 003
Tot Safety Entries This Stk#: 007
Status: SE
Date MSDS Prepared: 10JUN92
Safety Data Review Date: 10JUL95
Supply Item Manager: CX
Preparer's Company: FISHER SCIENTIFIC CHEMICAL DIV
Preparer's St Or P. O. Box: 1 REAGENT LN
Preparer's City: FAIR LAWN
Preparer's State: NJ
Preparer's Zip Code: 07410-5000
MSDS Serial Number: BXFQH
Specification Number: O-C-265
Hazard Characteristic Code: C3
Unit Of Issue: BT
Unit Of Issue Container Qty: 500 GRAM
Type Of Container: BOTTLE
Net Unit Weight: UNKNOWN

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Ingredients/Identity Information
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Proprietary: NO
Ingredient: AMMONIUM SULFATE (2:1), DIAMMONIUM SULFATE; SULFURIC ACID,
DIAMMONIUM SALT
Ingredient Sequence Number: 01
Percent: 100
NIOSH (RTECS) Number: BS4500000
CAS Number: 7783-20-2
OSHA PEL: NOT ESTABLISHED
ACGIH TLV: NOT ESTABLISHED
Other Recommended Limit: NOT ESTABLISHED

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Physical/Chemical Characteristics
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Appearance And Odor: ODORLESS, COLORLESS RHOMBIC CRYSTALS/WHITE GRANULES
Melting Point: 455F,235C
Specific Gravity: 1.769
Solubility In Water: 76.7%
pH: 5.5

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Fire and Explosion Hazard Data
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Extinguishing Media: DRY CHEMICAL, CARBON DIOXIDE, WATER SPRAY, OR REGULAR
FOAM. FOR LARGE FIRES, USE WATER SPRAY, FOG OR REGULAR FOAM.
Special Fire Fighting Proc: NO ACUTE HAZARD. MOVE CONTAINER FROM AREA IF

POSSIBLE. AVOID BREATHING VAPORS/DUSTS. KEEP UPWIND.
Unusual Fire And Expl Hazrds: NEGLIGIBLE FIRE HAZARD WHEN EXPOSED TO HEAT/
FLAME.

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Reactivity Data
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Stability: YES
Cond To Avoid (Stability): STABLE UNDER ABNORMAL TEMPERATURES &
PRESSURES.
Materials To Avoid: AMMONIUM NITRATE & POTASSIUM/SODIUM-POTASSIUM ALLOY,
BASES, CHLORATES, CHLORINE, CONCRETE, COPPER & ALLOYS (SEE SUPP)
Hazardous Decomp Products: GASEOUS AMMONIA, OXIDES OF SULFUR, TOXIC OXIDES
OF NITROGEN, NITROGEN TRICHLORIDE
Hazardous Poly Occur: NO
Conditions To Avoid (Poly): HAZARDOUS POLYMERIZATION HAS NOT BEEN REPORTED
TO OCCUR UNDER NORMAL TEMPERATURES AND PRESSURES.

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Health Hazard Data
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LD50-LC50 Mixture: ORAL LD50 (RAT): 2840 MG/KG
Route Of Entry - Inhalation: YES
Route Of Entry - Skin: NO
Route Of Entry - Ingestion: NO
Health Haz Acute And Chronic: INHALATION: MILD RESPIRATORY SYSTEM
IRRITATION, ASTHMATIC ATTACK. SKIN: IRRITATION, CHRONIC CONTACT MAY CAUSE
DERMATITIS. EYES: IRRITATION, CHRONIC CONTACT MAY CAUSE CONJUNCTIVITIS.
INGESTION: IRRITATION OF THE MOUTH, ESOPHAGUS & STOMACH.
Carcinogenicity - NTP: NO
Carcinogenicity - IARC: NO
Carcinogenicity - OSHA: NO
Explanation Carcinogenicity: NONE
Signs/Symptoms Of Overexp: IRRITATION, SORE THROAT, COUGH, SHORTNESS OF
BREATH, SYMPTOMS OF PULMONARY EDEMA, REDNESS, EYE PAIN, ABDOMINAL PAIN,
NAUSEA, VOMITING, DIARRHEA.
Med Cond Aggravated By Exp: PERSONS WITH ASTHMA.
Emergency/First Aid Proc: INHALATION: REMOVE TO FRESH AIR. IF BREATHING
HAS STOPPED, PERFORM CPR. KEEP PERSON WARM & AT REST. SKIN: WASH
W/SOAP/MILD DETERGENT & LARGE AMOUNT OF WATER 15-20 MINS. EYES: WASH
ASPIRATION HAZARD. OBTAIN MEDICAL ATTENTION IN ALL CASES. NOTE TO
PHYSICIAN: NO SPECIFIC ANTIDOTE. TREAT SYMPTOMATICALLY & SUPPORTIVELY.

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Precautions for Safe Handling and Use
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Steps If Matl Released/Spill: SWEEP UP & PLACE IN SUITABLE CLEAN, DRY
CONTAINERS FOR RECLAMATION/LATER DISPOSAL. DON'T FLUSH INTO SEWER. KEEP
UNNECESSARY PEOPLE AWAY.
Neutralizing Agent: NONE SPECIFIED BY MANUFACTURER.
Waste Disposal Method: DISPOSE OF IN ACCORDANCE WITH FEDERAL, STATE &
LOCAL REGULATIONS. NFPA HAZARDOUS CHEMICAL 49.
Precautions-Handling/Storing: OBSERVE ALL FEDERAL, STATE & LOCAL
REGULATIONS WHEN STORING. PROTECT CONTAINERS FROM PHYSICAL DAMAGE.
Other Precautions: SEPARATE FROM STRONG OXIDIZERS SUCH AS CHLORATES,
NITRATES, NITRITES & ALL OTHER INCOMPATIBLE SUBSTANCES. PREVENT EYE & SKIN
CONTACT W/MATERIAL.

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Control Measures
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Respiratory Protection: NIOSH/MSHA APPROVED RESPIRATOR SELECTED BASED ON
CONTAMINATION LEVELS IN THE WORK PLACE, THE SPECIFIC OPERATION & THE
WORKING LIMITS OF THE RESPIRATOR.
Ventilation: LOCAL EXHAUST VENTILATION SYSTEM
Protective Gloves: REQUIRED
Eye Protection: SPLASH-PROOF/DUST-RESISTANT GOGGLES
Other Protective Equipment: EYE WASH, IMPERVIOUS CLOTHING & EQUIPMENT

Work Hygienic Practices: REMOVE & LAUNDER CONTAMINATED CLOTHING BEFORE REUSE.

Suppl. Safety & Health Data: MATERIALS TO AVOID: NITRATES, STRONG OXIDIZERS, POTASSIUM CHLORATE, POTASSIUM NITRATE, POTASSIUM NITRITE, SODIUM HYPOCHLORITE, ZINC

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Transportation Data
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Trans Data Review Date: 95191
DOT PSN Code: ZZZ
DOT Proper Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
IMO PSN Code: ZZZ
IMO Proper Shipping Name: NOT REGULATED FOR THIS MODE OF TRANSPORTATION
IATA PSN Code: ZZZ
IATA Proper Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
AFI PSN Code: ZZZ
AFI Prop. Shipping Name: NOT REGULATED BY THIS MODE OF TRANSPORTATION
MMAC Code: NR

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Disposal Data
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Label Data
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Label Required: YES
Technical Review Date: 10JUL95
Label Status: F
Common Name: AMMONIUM SULFATE
Chronic Hazard: YES
Signal Word: CAUTION!
Acute Health Hazard-Slight: X
Contact Hazard-Slight: X
Fire Hazard-None: X
Reactivity Hazard-None: X
Special Hazard Precautions: INHALATION: MILD RESPIRATORY SYSTEM IRRITATION, ASTHMATIC ATTACK. SKIN: IRRITATION, CHRONIC CONTACT MAY CAUSE DERMATITIS. EYES: IRRITATION, CHRONIC CONTACT MAY CAUSE CONJUNCTIVITIS. INGESTION: IRRITATION OF THE MOUTH, ESOPHAGUS & STOMACH. IRRITATION, SORE THROAT, COUGH, SHORTNESS OF BREATH, SYMPTOMS OF PULMONARY EDEMA, REDNESS, EYE PAIN, ABDOMINAL PAIN, NAUSEA, VOMITING, DIARRHEA.
Protect Eye: Y
Protect Skin: Y
Protect Respiratory: Y
Label Name: FISHER SCIENTIFIC CO
Label Street: 585 ALPHA DR
Label City: PITTSBURGH
Label State: PA
Label Zip Code: 15238-2911
Label Country: US
Label Emergency Number: 412-526-8300 201-796-7100

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APPENDIX C

SCOPE NEWS LETTER

SCOPE NEWSLETTER

Year : 1996 - Country : GERMANY

Bioremediation of an old fuel oil-contaminated site using hexametaphosphate

Groundwater is often found to be contaminated with various organic chemicals whereby heterotrophic bacteria dominate. Phosphate is a required electron acceptor, an essential nutrient, and an important limiting factor of hydrocarbon degradation in bioremediation.

This case concerns contamination, 40-50 years ago, by a leaking pipeline, of 15 000-17 000 L. Most of the oil floating on the groundwater was removed in the 70's ; the pollution now lies 4-9m below ground level.

The in situ remediation design consists of 2 infiltration wells, production wells, plus a groundwater processing plant. Before infiltration, hydrogen peroxide and nitrate were added to the reinfiltreated water to meet the electron acceptor demand, plus phosphate to meet nutrient demand.

Initial results suggested that phosphorus was the limiting factor for heterotrophic bacterial activity. It is probable that the phosphate stopped the limitation and oxygen was used in and next to the infiltration wells. However, during the use of diphosphate, problems occurred with the precipitation of insoluble phosphate salts and thus plugging of the infiltration wells and the surrounding aquifer occurred.

After 2 months the phosphorus source was stopped, the wells regenerated with H₂O₂ and acid, then 6 weeks later was replaced by sodium hexametaphosphate. This eliminated problems of precipitation and plugging in the infiltration wells. For the first time a phosphorus supply for the whole contaminated area was observed.

Although all the work to date on polyphosphates in bioremediation has concentrated on tripolyphosphates, this study showed the superiority of polyphosphate over orthophosphate on a field scale. It was also found that sodium hexametaphosphate is superior over commonly used phosphates in transporting phosphorus over long aquifer distances.

Martin Steioff/Wolfgang Dott. Applied Bioremediation of Petroleum Hydrocarbons (301-309)

