GROUNDWATER TECHNOLOGY
A DIVISION OF OIL RECOVERY SYSTEMS, INC
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REPORT

SUBSURFACE HYDROCARBON INVESTIGATION
BAY CENTER PROJECT
EMERYVILLE, CALIFORNIA

MARCH 17, 1987

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20-8200

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REPORT
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INTRODUCTION

This report presents the results of the additional Phase I work performed by Groundwater Technology, Inc. at the Bay Center Project located in Emeryville, California (See Figure 1, Site Location Map). The additional work was performed in preparation for the installation of a hydrocarbon recovery system, and included the installation of one new monitoring well, the collection and analysis of water samples from both the new and existing wells, and the approximation of the aquifer characteristics.

WORK STEPS

MONITORING WELL INSTALLATION

The purpose of the boring was to explore the site for the presence of subsurface contamination, and to obtain an approximation of the aquifer characteristics. Groundwater Technology located the boring (MW-E) in the assumed down gradient direction from the excavated tank pit, in the vicinity of the proposed recovery well (See Figure 2 - Site Plan).

The boring for the monitoring well was drilled with a truck mounted drill rig using 7.5 inch O.D. (outside diameter) hollow stem augers. The drilling was performed under the direction of

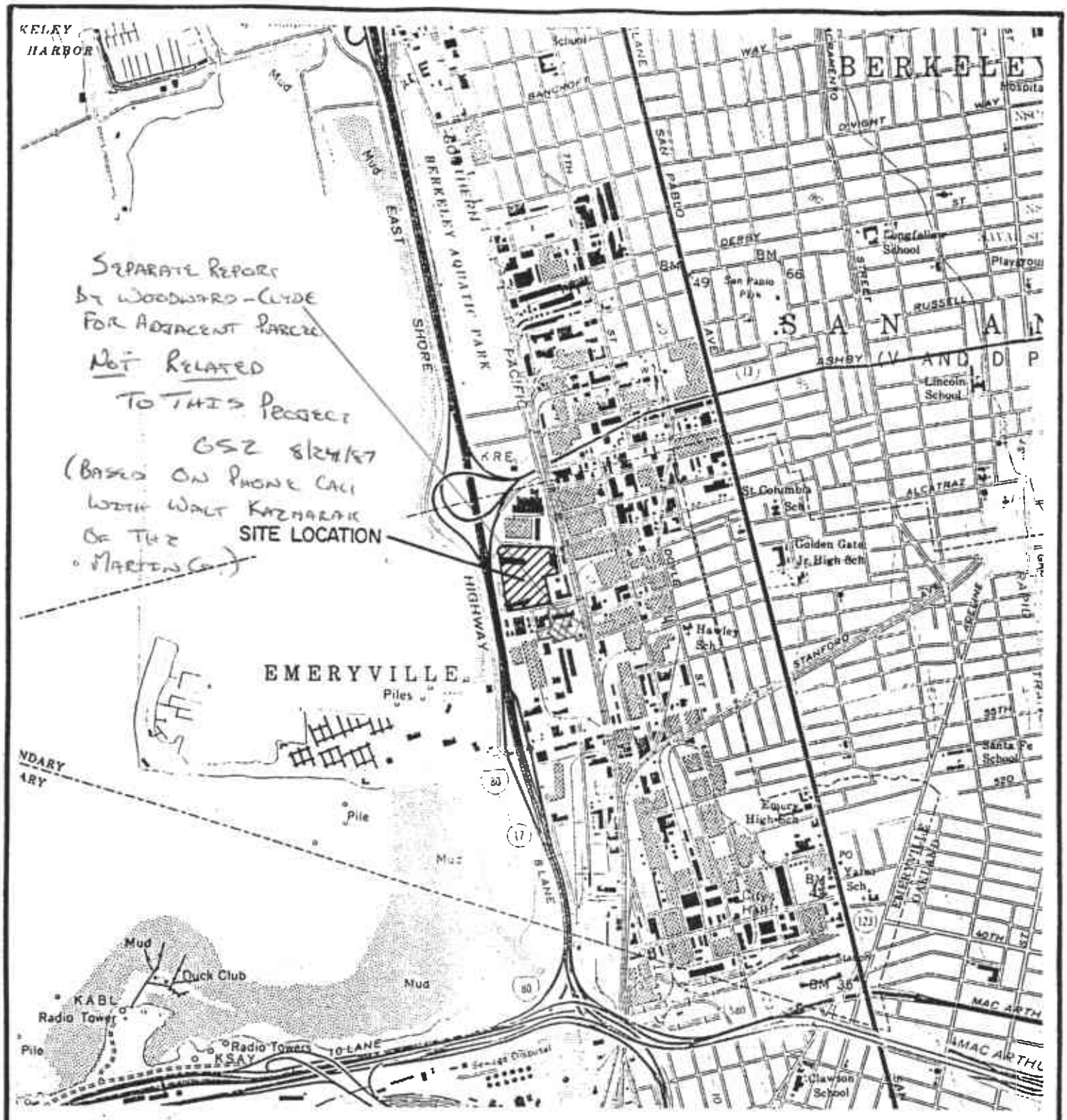

FIGURE 1

SITE LOCATION MAP

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GROUNDWATER TECHNOLOGY

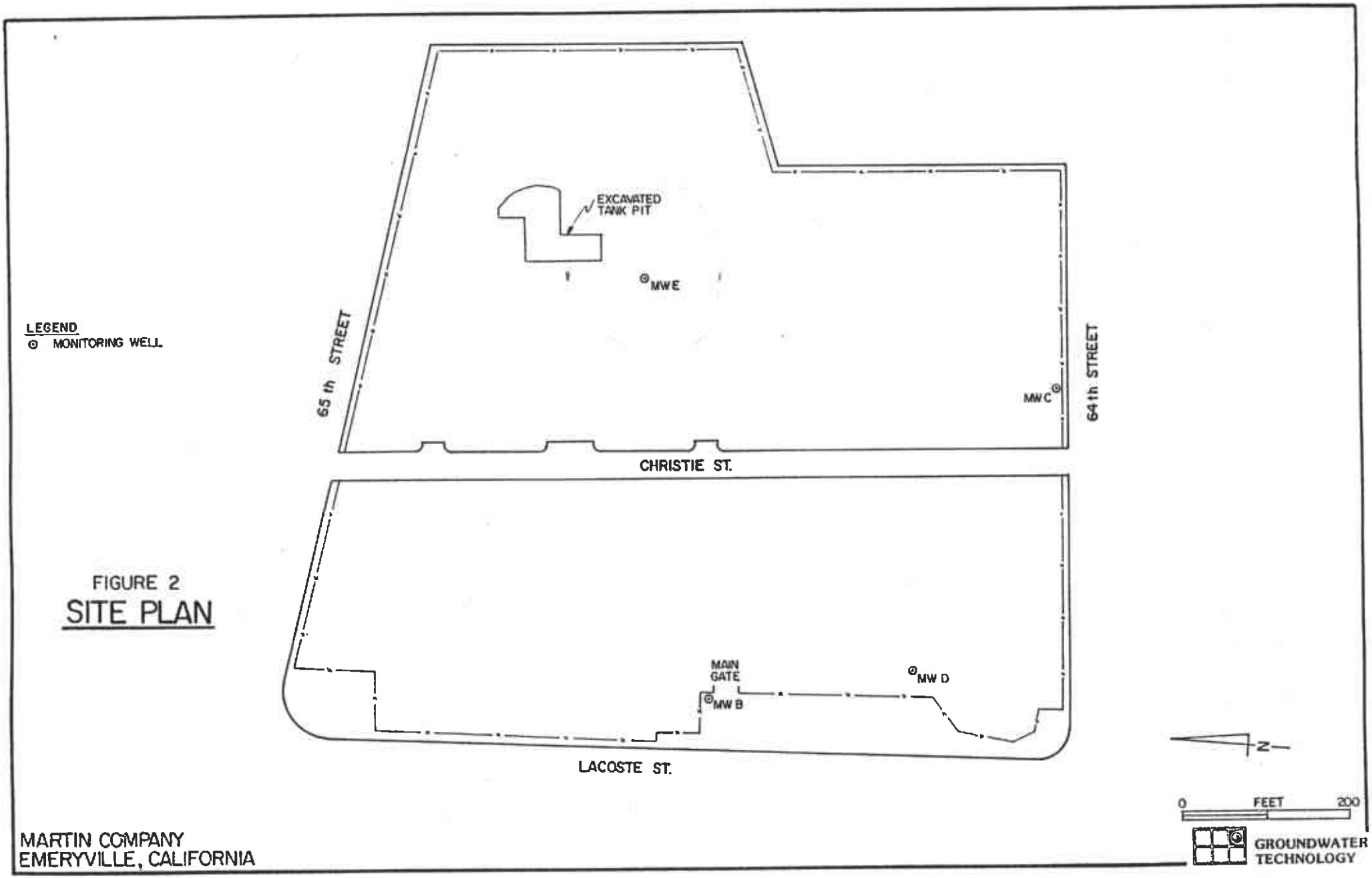

FIGURE 2

SITE PLAN

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EMERYVILLE, CALIFORNIA

the project geologist who also maintained a continuous log of the materials encountered in accordance with the Unified Soil Classification System. (See Appendix I - Drill Log).

The monitoring well was constructed with two-inch diameter PVC schedule 40 pipe and well screen. The 0.020 inch slotted well screen was installed from the bottom of the boring to 7 feet below ground surface. Blank casing was then installed to the surface. A well pack consisting of #2 Monterey sand was placed in the annulus (the space between the borehole and well casing) from the bottom of the boring to approximately 6 feet below ground surface. The well was completed with a bentonite seal and grouted with cement to the surface where a traffic rated street box was installed to provide access to the well (See Appendix I for Well Construction Details).

SOIL SAMPLING

Soil samples were obtained during drilling using a 2.5 inch O.D. split spoon sampler lined with three, 2 x 6 inch brass sample tubes. The sampler was driven eighteen inches at each sampling point. Samples were collected at 5 foot intervals beginning at 13.5 feet below ground surface to the bottom of the boring. The collected samples were sealed and capped for subsequent delivery to the laboratory for sieve analyses. Each sample was labeled with the boring number, sample designation number, and depth. All samples remained in the possession of the project geologist until delivery to the laboratory.

Sieve analyses were performed at the Johnson Division laboratory on three of the collected soil samples for grain size determination to be used in the design of the recovery well (See Appendix II - Sieve Analysis).

WATER SAMPLING

Monitoring wells B through E were developed by hand bailing and sampled with an EPA approved Teflon sampler. Access was not available to monitoring well A due to the presence of construction generated soil piles. The groundwater samples were collected in glass vials with Teflon caps in a manner such that no air was trapped inside and then labeled immediately with the job I.D., sample number, date, time and type of analysis requested. The samples were then stored on ice in a thermally insulated cooler until delivery to the laboratory. Analyses for organochlorine pesticides, PCB's, volatile organics and base/ neutral acids were conducted by EPA Methods 608, 624 and 625.

AQUIFER TEST

A modified slug test/bail down test was performed on the new monitoring well. In brief, this consisted of measuring the static water level in the well, removing a known volume of water and recording the water level versus time until the static level was reattained. Analysis of the data obtained was conducted

using two methods; Bower and Rice, (1976)[1], and Cooper, et.al., (1967)[2] to determine approximate values for the aquifer characteristics near the proposed recovery well.

SITE CONDITIONS

HYDROGEOLOGY

The local groundwater gradient was determined after surveying the elevations at the top of the monitoring well casings and subtracting the measured depth to groundwater levels to obtain water elevations (See Table I). The measurements indicate that the gradient is fairly flat (<1%) under the site, and appears to be flowing to the southwest toward San Francisco Bay. All of the monitoring information obtained from monitoring well B shows a decrease in the groundwater elevation which appears as a groundwater depression.

1. Bower H. and Rice, R.C., 1976, "A slug test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells" Water Resources Research, Vol. 12, No. 3 p. 423-428.

2. Cooper, H.H. Jr., Bredehoeft J.D., Papadopulos, I.S., 1967, "Response of a Finite Diameter Well to an Instantaneous Charge of Water" Water Resources Research, 3 p. 263-269.

TABLE I

GROUNDWATER MONITORING

	Elevation at Top of Casing (ft.)	Depth to Water (ft.)	Water Elevation (ft.)
December 30, 1986			
MW-B	23.30	8.44	14.86
MW-C	25.20	9.55	15.65
MW-D	24.90	9.63	15.27
MW-E	25.00	9.19	15.81
January 5, 1987			
MW-B	23.30	8.12	15.18
MW-C	25.20	8.40	16.80
MW-D	24.90	9.56	15.34
MW-E	25.00	8.05	16.95
January 21, 1987			
MW-B	23.30	8.30	15.00
MW-C	25.20	9.49	15.71
MW-D	24.90	8.61	16.29
MW-E	25.00	8.24	16.76

AQUIFER CHARACTERISTICS

As previously discussed, two methods were used to approximate the hydrogeologic characteristics of the aquifer underlying the site. The Bower and Rice, (1976), method was developed for use in unconfined aquifers with partially penetrating wells such as the Emeryville site conditions. Cooper et. al., (1967), method was designed for fully penetrating wells in confined aquifers of rather low transmissivity. This last method was used only to verify that the approximate values obtained by Bower and Rice were consistent with aquifers of low transmissivity. The following table presents the results of the aquifer characteristic calculations from both methods performed on the data obtained from the December 30, 1986 bail down test of monitoring well E (See Appendix III - Calculations). The calculated values obtained as a result of the bail down test are typical for silty sands and clays similar to the subsurface materials encountered beneath the site.

AQUIFER CHARACTERISTICS

	HYDRAULIC CONDUCTIVITY (gpd/ft^2)	TRANSMISSIVITY (gpd/ft)	PUMPING RATE (gpm)
MW-E Bouwer Method	0.98	38.22	0.81
MW-E Cooper Method	1.20	46.75	1.22

Five gallons of groundwater was removed from the well which created a drawdown of 1.14 feet. The water level was then measured for the next 7.5 hours until the measurements became constant, although the original static level was not reattained within this time frame.

Because capture zone calculations for silty sands and clays are not representative of actual areas of influence, they were omitted and the radius of influence, where the pumping well draw-down equals 0.25 feet, was assumed to be a more realistic value in determining the zone down gradient which should be affected by pumping and groundwater treatment activity (See Appendix III, Calculations). This approach yielded approximate down gradient capture distances of 60 to 70 feet.

GROUNDWATER CONTAMINATION

The results of laboratory analyses performed on groundwater samples from the site indicate that although hydrocarbon contamination and some acid extractable organics and base/neutral organics are present in the wells sampled, the levels are significantly lower, if detectable, than previously reported in the report prepared by Aqua Science Engineering titled, "Phase II - Extent of Groundwater Contamination Investigation, Bay Center". (See Tables III and IV and Appendix IV - Water Analysis).

TABLE III
LATEST WATER ANALYSIS
PRIORITY POLLUTANTS
(ppb)

	MW-B	MW-C	MW-D	MW-E
(EPA 624- VOLATILE ORGANIC COMPOUNDS)				
BENZENE	ND	61	ND	4400
ETHYLBENZENE	ND	89	ND	1700
TOLUENE	ND	85	ND	6600
(EPA 625 - ACID EXTRACT ORGANICS)				
PHENOL	ND	ND	17	ND
(EPA 625 - BASE/NEUTRAL EXTRACT ORGANICS)				
NAPTHALENE	ND	22	ND	150
2 - CHLORONAPTHALENE	ND	12	ND	ND
PYRENE	ND	ND	ND	1.3
(EPA 608 - PESTICIDES & PCB COMPOUNDS)				
ALL RESULTS	ND	ND	ND	ND

TABLE IV

PREVIOUSLY REPORTED PRIORITY POLLUTANTS

GROUNDWATER ANALYSIS

(ppb)

Monitored Well	MW-A	MW-B	W-9
Closest Resampled Well	(MW-E)	(MW-B)	(MW-C)
(EPA 624 - Volatile Organic Compounds)			
Benzene	41,000,000	ND	9,000
Ethylbenzene	4,200,000	ND	ND
Toluene	22,000,000	ND	ND
(EPA 625 - Base/Neutral Extract Organics)			
Benzo-A-Anthracene	63,000	ND	10,000
Benzyl-Butyl-Phthalate	80,000	ND	ND
BI-3, 2-Ethyl-Hexyl-Phthalate	ND	ND	34,000
Fluoranthene	6,000	ND	ND
Fluorene	33,000	ND	ND
Napthalene	1,100,000	ND	12,000
Phenanthrene	83,000	ND	22,000
Pyrene	8,000	13,000	28,000
Benzo-A-Pyrene	ND	ND	15,000
Benzo-B-Fluoranthene	ND	ND	10,000
Benzo-K-Fluoranthene	ND	ND	10,000
Chrysene	ND	ND	14,000
Indeno - 1, 2, 3 - CD- Pyrene	ND	ND	15,000

(EPA 608 - Pesticides & PCB Compounds)

α - BHC	4,400	4,600	190
β - BHC	-	120	ND
γ - BHC	270	48	ND
δ - BHC	-	250	ND
DDE	290	310	750
DDD	330	510	420
DDT	480	150	410
PCB - 1206	7,200	ND	ND

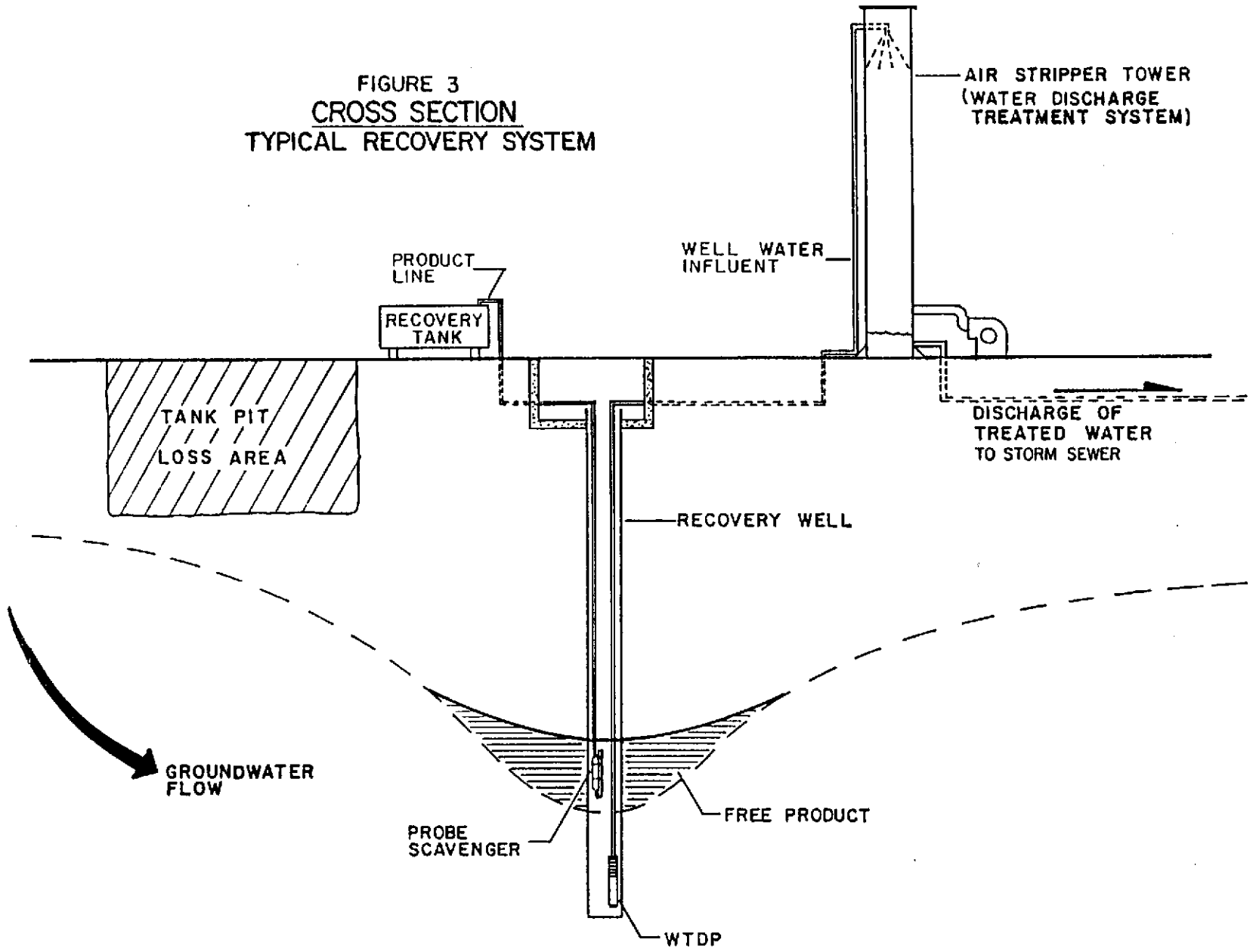
NOTE: Units were originally reported in ppm but were changed to ppb for comparison purposes.

CONCLUSIONS & RECOMMENDATIONS

Because the latest groundwater analysis data indicates that the contaminants present are volatile organics, Groundwater Technology believes that groundwater extraction combined with air stripping treatment is the best recovery approach for this site. The latest laboratory analyses indicate that additional treatment for pesticides, PCB's and most acid and base/neutral organic compounds will not be necessary. Therefore, the groundwater extraction system would include a pumping well, PW-1, equipped with a 1/2 hp water table depression pump with Teflon seals and one probe scavenger (See Figure 3, Typical Recovery System). The recovery well would likely be located near monitoring well E

FIGURE 3

CROSS SECTION
TYPICAL RECOVERY SYSTEM



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NO SCALE

GROUNDWATER
TECHNOLOGY

and the excavated tank pit. Well construction would consist of 10-inch diameter stainless steel 0.030 slotted well screen and blank casing placed within a 24 inch borehole. The well would be packed in the same manner as the monitoring wells with sand placed in the annulus from the bottom of the boring to 2 feet above the top of the screen and sealed with 1 foot of bentonite and concrete. A traffic rated vault box would be installed such that the recovery well and the associated pump control panels are located below grade.

Groundwater withdrawn from the pumping well would be transported to the treatment compound through a below grade piping system. A water treatment system would be installed to remove the dissolved petroleum hydrocarbons. The following three treatment steps must be evaluated in the preliminary design of the treatment system:

1. Microbiological treatment
2. Inorganic treatment
3. Removal of the dissolved organics

The purpose of and technologies potentially employed in each of these treatment steps are detailed in Appendix V. After obtaining the results of background water quality sampling, Groundwater Technology engineers would perform a thorough evaluation of the results and determine final design specifications for an effective scale prevention system.

The location of the treatment complex will be determined by the Martin Company, Groundwater Technology, and other involved parties based on technical considerations, environmental concerns, aesthetics, and to facilitate the development of the site.

Air stripping is proposed as the preferred treatment system for removal of the dissolved organics. Air stripping achieves high removal efficiencies and is more cost effective than liquid-phase activated carbon. The Bay Area Air Quality Management District may place limitations of up to 15 pounds per day or 200 ppm total hydrocarbons (THC) on air emissions and may limit other air stream constituents such as benzene. These limitations may require the use of an additional vapor phase carbon or catalytic conversion system for treatment of air emissions.

Because we are anticipating the presence of free floating hydrocarbons on the water table, Groundwater Technology will be installing a double-pump system within the recovery well. One pump will depress the water table, forming a "cone of depression". The second pump will recover any free floating product which collects within the recovery well. Recovered product will be stored on-site in a 630 gallon cylindrical polypropylene tank. The product recovery pump will operate automatically whenever free product is present in the recovery well. It is impossible to predict recovery rates prior to

operation; therefore, Groundwater Technology will install a tank full sensor which would automatically shut-off the product pump to prevent overfilling. A totalizer would also be installed to quantify recovery rates.

The water table depression pump and the air stripping system will operate continuously. It is anticipated that the recovery well can sustain pumping rates of 1 to 3 gpm. The contaminated groundwater will be treated using a one foot diameter by 27.5 foot tall air stripping tower. Effluent from the treatment system will be discharged into the storm sewer after obtaining a NPDES permit. The system will initially be operated without discharging the effluent while obtaining effluent analyses to verify compliance with permit requirements.

During operation of the treatment system, air emissions will be calculated using the results of laboratory analyses performed on influent and effluent water samples. Based upon the enclosed analytical laboratory data (See Appendix IV) Groundwater Technology anticipates influent concentrations of 13 ppm total volatile organic compounds to the air stripping system. With this defining parameter, worse case mass emissions to the atmosphere are estimated at 0.78 lbs/day total volatile hydrocarbons (mass emission calculations are included as Appendix VI).

Influent and effluent water samples will be obtained bi-weekly for the first month. After the first month, liquid influent will be monitored on a monthly basis until air emissions have stabilized.

Based upon field inspection, laboratory analyses and preliminary calculations, Groundwater Technology believes one operating recovery well, pumping between 1 and 3 gpm, has the ability to draw the contaminated water from around the old tank pit, capture the water up to 70 feet down gradient and have some influence on groundwater movement as far away as the corner of LaCoste and 64th Street. Therefore, it is Groundwater Technology's opinion that the Martin Company should proceed with the recovery system operating with one pumping well, as presented in the proposal titled, "Bay Center Project Emeryville, California, dated October 1986 and as described within this report.

CLOSURE

Groundwater Technology would like to thank the Martin Company for the opportunity to conduct this subsurface hydrocarbon investigation. Should you have any questions or require additional information with respect to this site, please contact us.

MAJOR DIVISIONS		SYMBOLS	TYPICAL NAMES
COARSE GRAINED SOILS (More than ½ of soil > no. 200 sieve size)	GRAVELS (More than ½ of coarse fraction > no. 4 sieve size)	GW	Well graded gravels or gravel-sand mixtures, little or no fines
		GP	Poorly graded gravels or gravel-sand mixtures, little or no fines
		GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
	SANDS (More than ½ of coarse fraction < no. 4 sieve size)	SW	Well graded sands or gravelly sands, little or no fines
		SP	Poorly graded sands or gravelly sands, little or no fines
		SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (More than ½ of soil < no. 200 sieve size)	SILTS & CLAYS LL < 50	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
	SILTS & CLAYS LL > 50	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silty clays, organic silts
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils

CLASSIFICATION CHART
(Unified Soil Classification System)

CLASSIFICATION	RANGE OF GRAIN SIZES	
	U.S. Standard Sieve Size	Grain Size In Millimeters
BOULDERS	Above 12"	Above 305
COBBLES	12" to 3"	305 to 76.2
GRAVEL	3" to No. 4	76.2 to 4.76
coarse	3" to ¾"	76.2 to 19.1
fine	¾" to No. 4	19.1 to 4.76
SAND	No. 4 to No. 200	4.76 to 0.074
coarse	No. 4 to No. 10	4.76 to 2.00
medium	No. 10 to No. 40	2.00 to 0.420
fine	No. 40 to No. 200	0.420 to 0.074
SILT & CLAY	Below No. 200	Below 0.074

GRAIN SIZE CHART

SANDS AND GRAVELS	BLOWS/FOOT†
VERY LOOSE	0 - 4
LOOSE	4 - 10
MEDIUM DENSE	10 - 30
DENSE	30 - 50
VERY DENSE	OVER 50

RELATIVE DENSITY

SILTS AND CLAYS	BLOWS/FOOT†
VERY SOFT	0 - 2
SOFT	2 - 4
MEDIUM STIFF	4 - 8
STIFF	8 - 16
VERY STIFF	16 - 32
HARD	OVER 32

CONSISTENCY

METHOD OF SOIL CLASSIFICATION

†NUMBER OF BLOWS OF 140 POUND HAMMER FALLING 30 INCHES TO DRIVE A 2 INCH O.D. (1-3/8 INCH I.D.) SPLIT SPOON (ASTM D-1586).

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OIL RECOVERY SYSTEMS

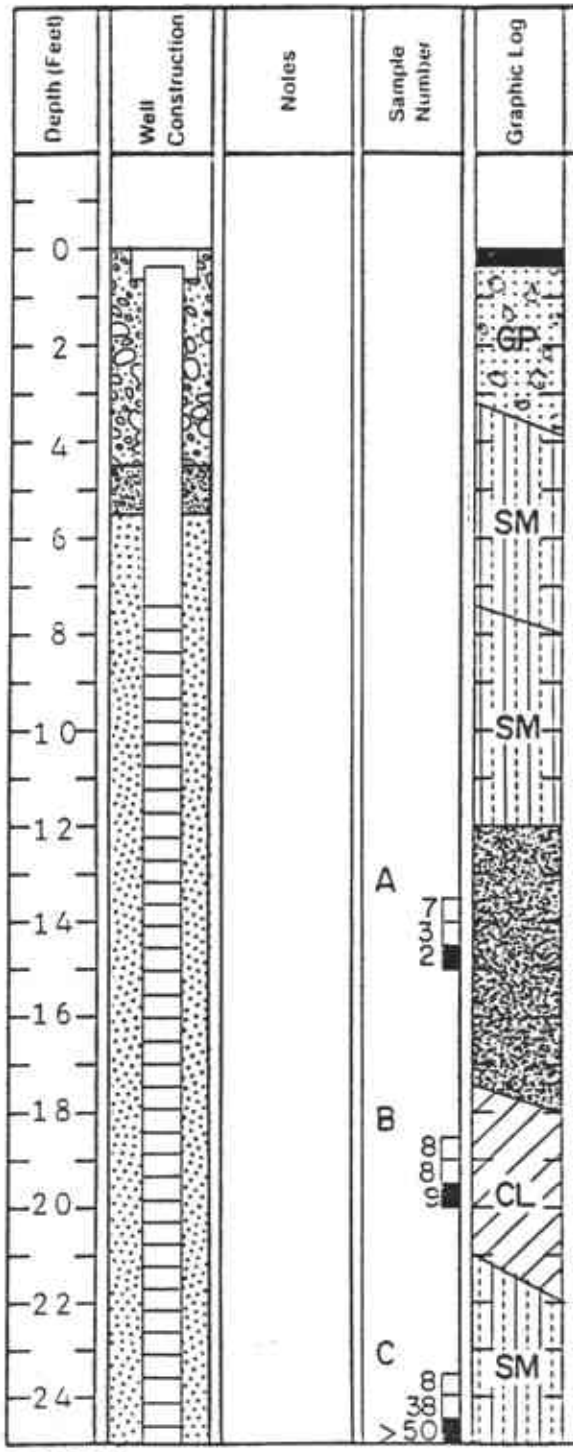
Monitoring Well E

Drilling Log

Project: Bay Center — Owner: Martin Company
Location: Emeryville — Project Number: 20-8200
Date Drilled: 12/8/86 — Total Depth of Hole: 50ft. — Diameter: 7.5 in.
Surface Elevation: — Water Level, Initial: 8.5 ft — 24-hrs.:
Screen: Dia. 2 in. — Length: 40.0 ft. — Slot Size: .02 in.
Casing: Dia. 2 in. — Length: 7.0 ft. — Type: PVC
Drilling Company: Sierra Pacific — Drilling Method: H.S. Auger
Driller: L. Pera — Log by: J. Miley

Sketch Map

Notes



Description/Soil Classification

4" Asphalt

Brown sandy gravel (loose, dry)

Dark brown silty sand (medium dense, moist)

▼ Encountered water 12/8/86 (1400 hrs)

Brown silty sand with gravel (loose, wet)

Black organic ooze (very soft, wet)

Tan-orange silty clay with gravel (stiff, moist)

Tan silty sand (very dense, wet)

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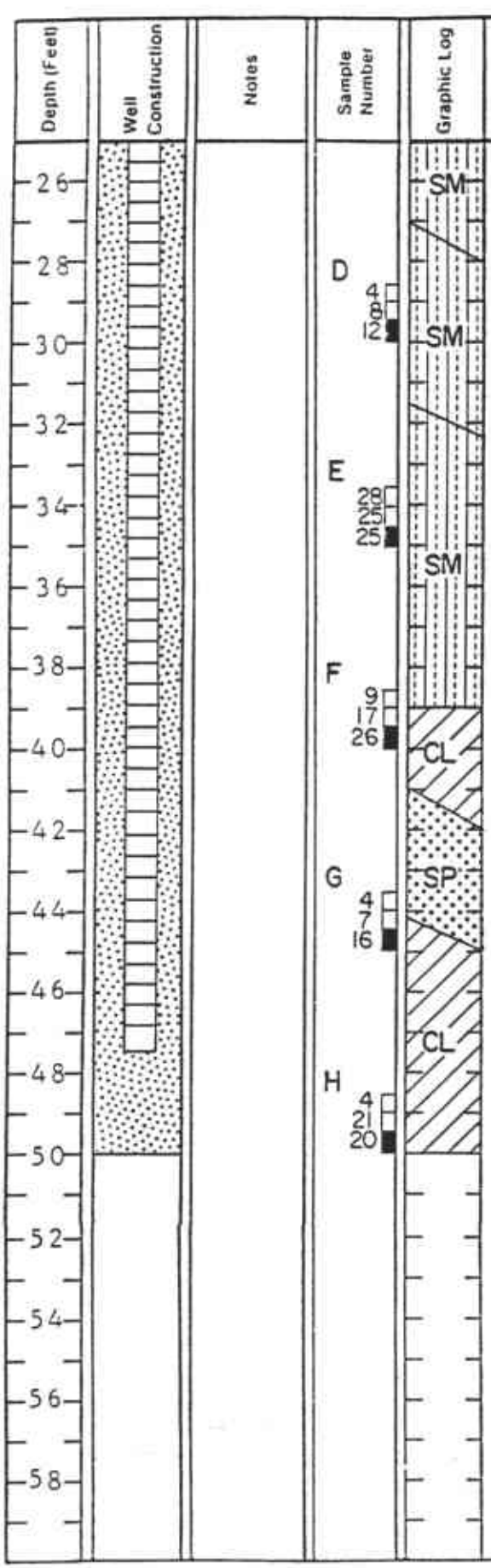
Monitoring Well E

Drilling Log



Description/Soil Classification (Color, Texture, Structures)
Tan silty sands (cont.)
Tan interbedded silty sands and silty clays (medium dense, wet)
Brown silty sand (very dense, wet)
Brown silty clay (hard, pliable, wet)
Tan medium grained sand (loose, wet)
Grey silty clay with some sand & gravel (hard, wet)
(increasing gravels)
End of boring, Installed Monitoring Well

SAND ANALYSIS REPORT

DRILLER

ENGINEER GROUNDWATER TECHNOLOGY, INC.
CONCORD, CA. 94520

ANALYSIS BY ALBERT J. SMITH
DATE 7 JANUARY, 1987

JOB NAME

LOCATION

JOHNSON I.D. NUMBER B70008
SAMPLE SENT IN BY GROUNDWATER TECHNOLOGY, INC.

Johnson Division
P.O. Box 64118 St. Paul, Minn. 55164
Tel. 612-636-3900
800-328-9110
Telex 297451

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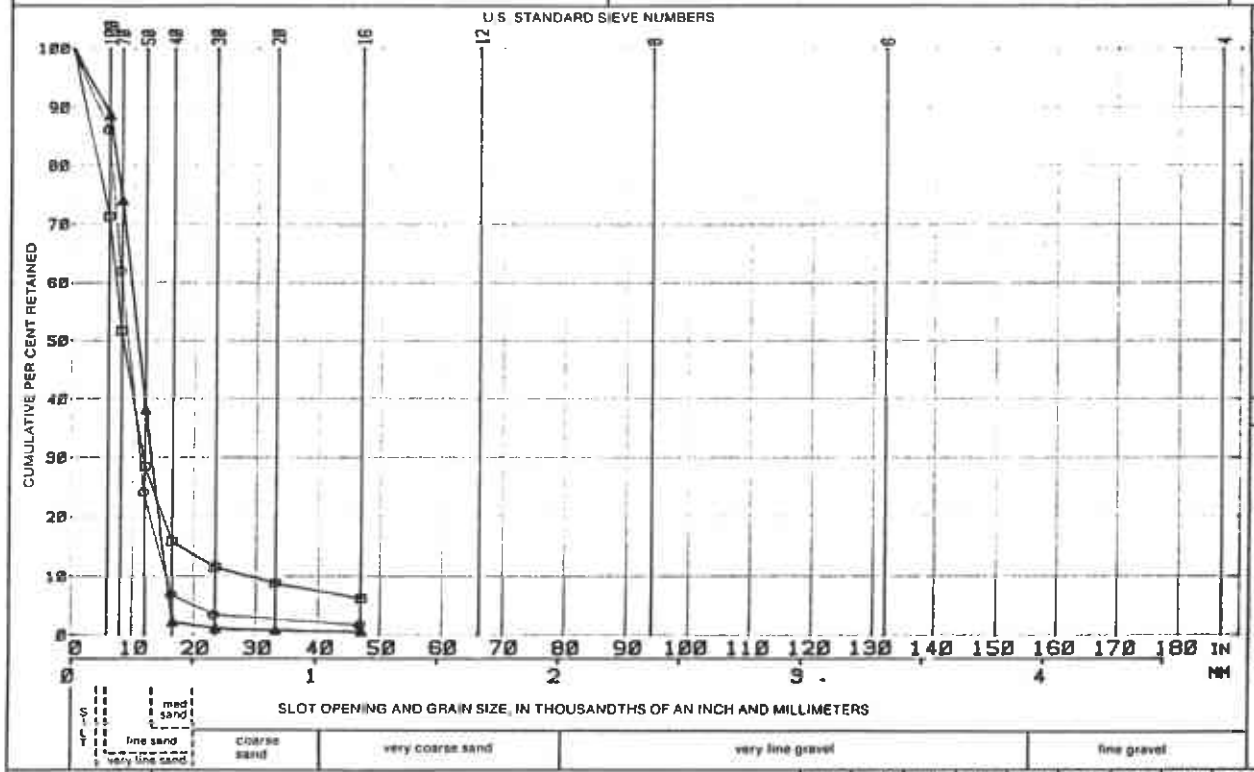

TEST HOLE DATA

DIAMETER

DEPTH

DRILLING METHOD

DRILLING FLUID

GEOPHYSICAL LOGS

STATIC WATER LEVEL

WELL DATA

CASING DIAMETER

DESIRED YIELD

WELL APPLICATION
MONITORING WELL

DESIGN RECOMMENDATIONS

We suggest use of Monterey Sand 12 X 20 Sand Pack to stabilize the formation.

COMMENTS

Samples were wet sieved with a #200 sieved. Material less than #200 sieved (0.003-inch) is not included in sieve analysis. This material is clay & silts. Per cent material removed:

29.5 feet	82%
34>5 feet	77%
39.5 feet	22%

COMBINED SAMPLE DEPTHS	PHYSICAL SAMPLE DESCRIPTION		mm	4.76	3.36	2.38	1.68	1.19	.840	.590	.420	.297	.210	.149	.074	.053	TOTAL WT.
			Inches	.187	.123	.094	.066	.047	.033	.023	.016	.012	.008	.006	.003	.002	
			U.S. Sieve#	4	6	8	12	16	20	30	40	50	70	100	200	270	
29.5 FT.	○ FINE SAND	CUMULATIVE % RETAINED						1.7		3.4	8.9	24.1	62.1	88.2			58.8
34.5 FT.	□ FINE SAND							6.3	8.9	11.6	18.1	28.6	51.8	71.4			112.8
39.5 FT.	△ FINE SAND							0.6	0.8	1.1	2.2	36.2	74.2	88.8			358.8

SCREEN RECOMMENDATIONS

DIAMETER 10 PS

SLOT	LENGTH	SETTING
30		

SO MANY CONSIDERATIONS ENTER INTO THE MAKING OF A GOOD WELL THAT, WHILE WE BELIEVE SLOT SIZES FURNISHED OR RECOMMENDED FROM SAND SAMPLES ARE CORRECT WE ASSUME NO RESPONSIBILITY FOR THE SUCCESSFUL OPERATION OF JOHNSON WELL SCREENS.

AQUIFER CHARACTERISTIC CALCULATIONS

BOUWER AND RICE

Aquifer characteristic calculations were performed following the methods outlined in the water resource paper written by Bouwer and Rice, (1976). A semilogarithmic plot of the head loss (y) verses time (t) was prepared for the data obtained. The value of the term $(1/t)\ \ln y_o/y_t$ is obtained from the best-fitting straight line from the plotted data choosing an arbitrary time and it's equivilant head loss.

The value of $\ln R_e/r_w$ can be evaluated from the electrical resistance analog results and the following equation:

$$\ln R_e/r_w = \left[\frac{1.1}{\ln(H/r_w)} + \frac{A + B \ln [(D-H)/r_w]}{L/r_w}\right]^{-1}$$

where: A and B are dimensionless coefficients that are functions of L/r_w and are obtained from Figure 3 from the Bouwer and Rice paper. If the aquifer thickness, D, is significantly greater than the saturated screen thickness, H, then a value of 6 can be used for $\ln[(D-H)/r_w]$.

The hydraulic conductivity, K, is then determined from:

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln y_o/y_t$$

After determining the hydraulic conductivity, the pumping rate (Q) can be calculated to determine the potential discharge which can be expected to be obtained from the recovery well.

$$Q = 2\pi KL \frac{y}{\ln (R_e/r_w)}$$

Aquifer transmissivity can be determined from:

$$T = KH$$

where: H equals the saturated thickness of the well screen interval.

[1] Bouwer, H. and Rice, R.C., 1976, "A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells" Water Resources Research, Vol. 12, No. 3 p. 423-428.

Bail/Slug Test Analysis
Method: Bouwer and Rice, 1976
Project: Martin Company
Well No.: MW-E
Date: December 30, 1986

r_w = boring radius
r_c = well casing radius if the water level is above screen
or
r_c = cross sectional area of well that relates Q to dy/dt if the water level is within perforation section of screen
y = head loss
H = saturated screen thickness
L = perforated screen thickness
D = total aquifer thickness
K = hydraulic conductivity
Q = pumping rate
T = transmissivity
t = time in days

Given:

r_w = 3.75 inch = 0.3125 ft.

r_c = 1.00 inch = 0.083 ft. (water level above screen interval)

r_c = 2.20 inch = 0.183 ft. (water level within perforations)

from

$$r_c = [(r_c)^2 + \eta (r_w^2 - r_c^2)]^{1/2}$$

η = porosity of sand pack = 30%

H = 39 ft.

L = 40 ft.

D = ∞

$(1/t) \ln y_o/y_t$ at t = 80 sec y_t = 0.45 ft. = 0.015 sec.

H/r_w = 125

L/r_w = 128

A = 5

B = 83

$\ln[(D-H)/r_w]$ = 6

Then:

$$\ln R_e/r_w = \left[\frac{1.1}{\ln(H/r_w)} + \frac{A + B \ln [(D-H)/r_w]}{L/r_w} \right]^{-1}$$

$$\ln R_e/r_w = \left[\frac{1.1}{\ln(125)} + \frac{5 + 83 \ln [6]}{128} \right]^{-1}$$

$$\ln R_e/r_w = 0.241$$

$$K = \frac{r_c^2 \ln (R_e/r_w)}{2L} \frac{1}{t} \ln y_o/y_t$$

$$K = \frac{(.183 \text{ ft.})^2 (.241)}{2 (40 \text{ ft})} (0.015 \text{ sec})$$

$$K = 1.5 \times 10^{-6} \text{ ft./sec}$$

$$K = 0.131 \text{ ft/day}$$

$$K = 0.980 \text{ gpd/ft}^2$$

$$Q = 2\pi KL \frac{y}{\ln(R_e/r_w)}$$

$$Q = 2\pi (0.131 \text{ ft./day})(40 \text{ ft}) \frac{(1.14 \text{ ft})}{(.240)}$$

$$Q = 156.4 \text{ ft}^3/\text{day}$$

$$Q = 1170 \text{ gpd}$$

$$Q = 0.81 \text{ gpm}$$

$$T = KH$$

$$T = (0.980 \text{ gpd/ft}^2)(39 \text{ ft})$$

$$T = 38.22 \text{ gpd/ft.}$$

Where will s = 0.25 ft.

$$W(u) = \frac{s\ T}{114.6\ Q}$$

$$W(u) = \frac{(0.25)(38.22)}{114.6\ (0.81)}$$

$$W(u) = 0.1029$$

$$(u) = 1.5$$

$$r = \left(\frac{(u\ T\ t)}{1.87\ s}\right)^{1/2}$$

$$r = \left(\frac{(1.5)(38.1)(30)}{1.87\ (0.25)}\right)^{1/2}$$

$$r = 60 \text{ ft.}$$

COOPER, BREDEHOEFT AND PAPADOLPULOUS METHOD

Aquifer characteristic calculations were performed following the methods outlined, and using the "type curves" presented in the water resource paper written by Cooper, et.al. (1967). A semilogarithmic plot of the ratio of the measured head to the head after groundwater removal (H/H_o) versus time (t) was prepared for the data obtained. The semilogarithmic plot from well E was superimposed over the "type curve" of a well of finite diameter until a best fit was obtained. The value of t was determined at the match point such that $Tt/r_c^2 = 1.0$. The transmissivity is found by the following formula:

$$T = \frac{1.0 r_c^2}{t}$$

The value of storativity can be found from the value of the u-curve generated from the field data and computed using the following formula:

$$S = (r_c^2 u)/r_s^2$$

The coefficient of permeability or hydraulic conductivity can be calculated from:

$$K = T/b$$

After determining the transmissivity, storativity and hydraulic conductivity the pumping rate (Q), can be calculated to determine the potential discharge which can be expected to be

obtained from the recovery well. To determine the pumping rate the "well function of u" W(u) must be known. This can be determined from the following Theis Nonequilibrium Equations and a chart displaying values of W(u) corresponding to values of u.

$$u = \frac{1.87\ r^2 s}{Tt}$$

$$W(u) = \text{corresponding chart value of } u$$

$$Q = \frac{Ts}{114.6\ W(u)}$$

REFERENCED CITED

Cooper, H.H., Jr., Bredehoeft J.D., Papadopulous, I.S., 1967, Response of a Finite Diameter Well to an Instantaneous Charge of Water." Water Resources Research, 3 p. 263-269.

Bail/Slug Test Analysis
Method: Cooper, Bredehoeft and Papadolpulous, 1967
Project: Martin Company
Well No.: MW-E
Date: 12/30/86

r = boring radius
r_c = well casing radius
r_s = well screen radius
H_o = water level difference after baildown
H = difference in water levels between t and t_o
b = well screened interval below the water table
s = saturated aquifer thickness minus water column thickness necessary to operate pump
T = transmissivity
K = hydraulic conductivity
S = storativity
t = time in days
t_1 = time at curve match point

Given:

r	=	3.75 inch	=	0.3125 ft.
r_c	=	1 inch	=	0.083 ft.
r_s	=	1 inch	=	0.083 ft.
b	=	39 feet		
s	=	32 feet		
t_1	=	1.6 min.		
u	=	10^{-1}		

Then:

$$T = \frac{(1.0)(r_c)^2}{(t_1)}$$

$$T = \frac{(1.0)(0.083)^2}{(1.6)}$$

$$T = 0.00434 \text{ ft.}^2/\text{min}$$

$$T = 6.25 \text{ ft.}^2/\text{day}$$

$$T = 46.75 \text{ gpd/ft.}$$

$$K = \frac{(T)}{(b)}$$

$$K = \frac{(46.75)}{(39)}$$

$$K = 1.20 \text{ gpd/ft.}^2$$

$$S = \frac{(r_c^2\ u)}{r_s^2}$$

$$S = \frac{(0.083)^2(10^{-1})}{(0.083)^2}$$

$$S = 10^{-1}$$

$$u = \frac{1.87\ r^2\ S}{Tt}$$

$$u = \frac{(1.87)(0.3125)^2(.1)}{(46.75)(30)}$$

$$u = 1.3 \times 10^{-5}$$

$$W(u) = 10.6734$$

$$Q = \frac{T\ s}{114.6}\ W(u)$$

$$Q = \frac{(46.75)(32)}{(114.6)(10.6734)}$$

$$Q = 1.22 \text{ gpm}$$

Where will s = 0.25 ft.

$$W(u) = \frac{s\ T}{114.6}\ Q$$

$$W(u) = \frac{(0.25)(46.75)}{(114.6)(1.22)}$$

$$W(u) = 0.08359$$

$$u = 1.6$$

$$u = \frac{(1.87)(r)^2\ s}{Tt}$$

$$r = \left(\frac{u\ T\ t}{1.87\ s}\right)^{1/2}$$

$$r = \left(\frac{(1.6)(46.75)(30)}{(1.87)(0.25)}\right)^{1/2}$$

$$r = 70 \text{ feet}$$

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Date Sampled: 12/30/86
Date Received: 12/31/86
Date Extracted: 12/31/86
Date Reported: 01/20/87
Project #20-8200

Sample Number

6122036

Sample Description

Martin Company (Bay Center) -
Emeryville, MW-B, Water Sample

PRIORITY POLLUTANTS

VOLATILE ORGANIC COMPOUNDS
results in ppb

Acrolein	<100	trans-1,2-Dichloroethene	< 0.5
Acrylonitrile	<100	1,2-Dichloropropane	< 0.5
Benzene	< 0.5	1,3-Dichloropropene	< 0.5
Bromomethane	< 0.5	Ethylbenzene	< 0.5
Bromodichloromethane	< 0.5	Methylene chloride	< 0.5
Bromoform	< 0.5	1,1,2,2-Tetrachloroethane	< 0.5
Carbon tetrachloride	< 0.5	Tetrachloroethene	< 0.5
Chlorobenzene	< 0.5	1,1,1-Trichloroethane	< 0.5
Chloroethane	< 0.5	1,1,2-Trichloroethane	< 0.5
2-Chloroethylvinyl ether	< 0.5	Trichloroethene	< 0.5
Chloroform	< 0.5	Toluene	< 0.5
Chloromethane	< 0.5	Vinyl chloride	< 0.5
Dibromochloromethane	< 0.5	1,2-Dichlorobenzene	< 0.5
1,1-Dichloroethane	< 0.5	1,3-Dichlorobenzene	< 0.5
1,2-Dichloroethane	< 0.5	1,4-Dichlorobenzene	< 0.5
1,1-Dichloroethene	< 0.2		

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Arthur G. Burton
Laboratory Director

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Date Reported: 01/20/87
Project #20-8200

Sample Number	Sample Description
6122036	Martin Company (Bay Center) - Emeryville, MW-B, Water Sample

PRIORITY POLLUTANTS

ACID EXTRACT ORGANICS
results in ppb

4-Chloro-3-methylphenol	< 1
2-Chlorophenol	< 1
2,4-Dichlorophenol	< 1
2,4-Dimethylphenol	< 1
2,4-Dinitrophenol	< 1
2-Methyl-4,6-dinitrophenol	< 1
2-Nitrophenol	< 1
4-Nitrophenol	< 1
Pentachlorophenol	< 1
Phenol	< 1
2,4,6-Trichlorophenol	< 1

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Project #20-8200

Sample Number
6122036

Sample Description
Martin Company (Bay Center) - Emeryville, MW-B, Water Sample

PRIORITY POLLUTANTS

BASE/NEUTRAL EXTRACT ORGANICS

results in ppb

Acenaphthene	< 1	Diethylphthalate	< 10
Acenaphthylene	< 1	Dimethylphthalate	< 1
Anthracene	< 1	Di-n-octylphthalate	< 1
Benzo (a) anthracene	< 1	Dibutylphthalate	< 1
Benzo (b) fluoranthene	< 1	Isophorone	< 1
Benzo (k) fluoranthene	< 1	Benzidine	< 10
Benzo (a) pyrene	< 1	2,4-Dinitrotoluene	< 1
Benzo (g,h,i) perylene	< 1	2,6-Dinitrotoluene	< 1
Chrysene	< 1	1,2-Diphenylhydrazine	< 1
Dibenzo (a,h) anthracene	< 1	Nitrobenzene	< 1
Fluoranthene	< 1	N-Nitrosodimethylamine	< 1
Fluorene	< 1	N-Nitrosodi-n-Propylamine	< 1
Indeno (1,2,3-c,d) pyrene	< 1	N-Nitrosodiphenylamine	< 1
Naphthalene	< 1	2-Chloronaphthalene	< 1
Phenanthrene	< 1	1,3-Dichlorobenzene	< 1
Pyrene	< 1	1,4-Dichlorobenzene	< 1
Bis (2-chloroethyl) ether	< 1	1,2-Dichlorobenzene	< 1
Bis (2-chloroethoxy) methane	< 1	3,3-Dichlorobenzidine	< 10
Bis (2-ethylhexyl) phthalate	< 1	Hexachlorobenzene	< 1
Bis (2-chloroisopropyl) ether	< 1	Hexachlorobutadiene	< 1
4-Bromophenyl phenyl ether	< 1	Hexachloroethane	< 1
Butyl benzyl phthalate	< 1	Hexachlorocyclopentadiene	< 1
4-Chlorophenyl phenyl ether	< 1	2,3,7,8-Tetrachlorodibenzo-p-dioxin	< 1
		1,2,4-Trichlorobenzene	< 1

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Project #20-8200

Sample Number

6122036

Sample Description

Martin Company (Bay Center) - Emeryville, MW-B, Water Sample

PRIORITY POLLUTANTS

PESTICIDE AND PCB COMPOUNDS
results in ppb

Aldrin	< 0.1	Endrin	< 0.1
α-BHC	< 0.1	Endrin Aldehyde	< 0.1
β-BHC	< 0.1	Heptachlor	< 0.1
δ-BHC	< 0.1	Heptachlor Epoxide	< 0.1
γ-BHC	< 0.1	Toxaphene	< 0.1
Chlordane	< 0.1	PCB-1016	< 0.1
4,4'-DDD	< 0.1	PCB-1221	< 0.1
4,4'-DDE	< 0.1	PCB-1232	< 0.1
4,4'-DDT	< 0.1	PCB-1242	< 0.1
Dieldrin	< 0.1	PCB-1248	< 0.1
Endosulfan I	< 0.1	PCB-1254	< 0.1
Endosulfan II	< 0.1	PCB-1260	< 0.1
Endosulfan Sulfate	< 0.1		

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Date Sampled: 12/19/86
Date Received: 12/22/86
Date Extracted: 12/30/86
Date Reported: 01/08/87
Project #20-8200

Sample Number

6121507

Sample Description

Bay Center - Emeryville, MWC, Water Sample

PRIORITY POLLUTANTS

VOLATILE ORGANIC COMPOUNDS
results in ppb

Acrolein	<100	trans-1,2-Dichloroethene	< 0.5
Acrylonitrile	<100	1,2-Dichloropropane	< 0.5
Benzene	61	1,3-Dichloropropene	< 0.5
Bromomethane	< 0.5	Ethylbenzene	89
Bromodichloromethane	< 0.5	Methylene chloride	< 0.5
Bromoform	< 0.5	1,1,2,2-Tetrachloroethane	< 0.5
Carbon tetrachloride	< 0.5	Tetrachloroethene	< 0.5
Chlorobenzene	< 0.5	1,1,1-Trichloroethane	< 0.5
Chloroethane	< 0.5	1,1,2-Trichloroethane	< 0.5
2-Chloroethylvinyl ether	< 0.5	Trichloroethene	< 0.5
Chloroform	< 0.5	Toluene	85
Chloromethane	< 0.5	Vinyl chloride	< 0.5
Dibromochloromethane	< 0.5	1,2-Dichlorobenzene	< 0.5
1,1-Dichloroethane	< 0.5	1,3-Dichlorobenzene	< 0.5
1,2-Dichloroethane	< 0.5	1,4-Dichlorobenzene	< 0.5
1,1-Dichloroethene	< 0.2		

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Date Extracted: 12/30/86
Date Reported: 01/08/87
Project #20-8200

Sample Number	Sample Description
6121507	Bay Center - Emeryville, MWC, Water Sample

PRIORITY POLLUTANTS

ACID EXTRACT ORGANICS
results in ppb

4-Chloro-3-methylphenol	< 1
2-Chlorophenol	< 1
2,4-Dichlorophenol	< 1
2,4-Dimethylphenol	< 1
2,4-Dinitrophenol	< 1
2-Methyl-4,6-dinitrophenol	< 1
2-Nitrophenol	< 1
4-Nitrophenol	< 1
Pentachlorophenol	< 1
Phenol	< 1
2,4,6-Trichlorophenol	< 1

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Date Extracted: 12/30/86
Date Reported: 01/08/87
Project #20-8200

Sample Number

6121507

Sample Description
Bay Center - Emeryville,
MWC, Water Sample

PRIORITY POLLUTANTS

BASE/NEUTRAL EXTRACT ORGANICS
results in ppb

Acenaphthene	< 1	Diethylphthalate	< 10
Acenaphthylene	< 1	Dimethylphthalate	< 1
Anthracene	< 1	Di-n-octylphthalate	< 1
Benzo (a) anthracene	< 1	Dibutylphthalate	< 1
Benzo (b) fluoranthene	< 1	Isophorone	< 1
Benzo (k) fluoranthene	< 1	Benzidine	< 10
Benzo (a) pyrene	< 1	2,4-Dinitrotoluene	< 1
Benzo (g,h,i) perylene	< 1	2,6-Dinitrotoluene	< 1
Chrysene	< 1	1,2-Diphenylhydrazine	< 1
Dibenzo (a,h) anthracene	< 1	Nitrobenzene	< 1
Fluoranthene	< 1	N-Nitrosodimethylamine	< 1
Fluorene	< 1	N-Nitrosodi-n-Propylamine	< 1
Indeno (1,2,3-c,d) pyrene	< 1	N-Nitrosodiphenylamine	< 1
Naphthalene	22	2-Chloronaphthalene	12
Phenanthrene	< 1	1,3-Dichlorobenzene	< 1
Pyrene	< 1	1,4-Dichlorobenzene	< 1
Bis (2-chloroethyl) ether	< 1	1,2-Dichlorobenzene	< 1
Bis (2-chloroethoxy) methane	< 1	3,3-Dichlorobenzidine	< 10
Bis (2-ethylhexyl) phthalate	< 1	Hexachlorobenzene	< 1
Bis (2-chloroisopropyl) ether	< 1	Hexachlorobutadiene	< 1
4-Bromophenyl phenyl ether	< 1	Hexachloroethane	< 1
Butyl benzyl phthalate	< 1	Hexachlorocyclopentadiene	< 1
4-Chlorophenyl phenyl ether	< 1	2,3,7,8-Tetrachlorodibenzo-p-dioxin	< 1
		1,2,4-Trichlorobenzene	< 1

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Date Reported: 01/09/87
Project #20-8200

Sample Number

6121507

Sample Description

Bay Center - Emeryville, MWC, Water Sample

PRIORITY POLLUTANTS

PESTICIDE AND PCB COMPOUNDS

results in ppb

Aldrin	<	10	Endrin	<	10
α-BHC	<	10	Endrin Aldehyde	<	10
β-BHC	<	10	Heptachlor	<	10
δ-BHC	<	10	Heptachlor Epoxide	<	10
γ-BHC	<	10	Toxaphene	<	10
Chlordane	<	10	PCB-1016	<	10
4,4'-DDD	<	10	PCB-1221	<	10
4,4'-DDE	<	10	PCB-1232	<	10
4,4'-DDT	<	10	PCB-1242	<	10
Dieldrin	<	10	PCB-1248	<	10
Endosulfan I	<	10	PCB-1254	<	10
Endosulfan II	<	10	PCB-1260	<	10
Endosulfan Sulfate	<	10			

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Date Sampled: 12/19/86
Date Received: 12/22/86
Date Extracted: 12/30/86
Date Reported: 01/08/87
Project #20-8200

Sample Number

6121509

Sample Description
Bay Center - Emeryville, MWD, Water Sample

PRIORITY POLLUTANTS

VOLATILE ORGANIC COMPOUNDS
results in ppb

Acrolein	<100	trans-1,2-Dichloroethene	< 0.5
Acrylonitrile	<100	1,2-Dichloropropane	< 0.5
Benzene	< 0.5	1,3-Dichloropropene	< 0.5
Bromomethane	< 0.5	Ethylbenzene	< 0.5
Bromodichloromethane	< 0.5	Methylene chloride	< 0.5
Bromoform	< 0.5	1,1,2,2-Tetrachloroethane	< 0.5
Carbon tetrachloride	< 0.5	Tetrachloroethene	< 0.5
Chlorobenzene	< 0.5	1,1,1-Trichloroethane	< 0.5
Chloroethane	< 0.5	1,1,2-Trichloroethane	< 0.5
2-Chloroethylvinyl ether	< 0.5	Trichloroethene	< 0.5
Chloroform	< 0.5	Toluene	< 0.5
Chloromethane	< 0.5	Vinyl chloride	< 0.5
Dibromochloromethane	< 0.5	1,2-Dichlorobenzene	< 0.5
1,1-Dichloroethane	< 0.5	1,3-Dichlorobenzene	< 0.5
1,2-Dichloroethane	< 0.5	1,4-Dichlorobenzene	< 0.5
1,1-Dichloroethene	< 0.2		

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Date Extracted: 12/30/86
Date Reported: 01/08/87
Project #20-8200

Sample Number	Sample Description
6121509	Bay Center - Emeryville, MWD, Water Sample

PRIORITY POLLUTANTS

ACID EXTRACT ORGANICS

results in ppb

4-Chloro-3-methylphenol	< 1
2-Chlorophenol	< 1
2,4-Dichlorophenol	< 1
2,4-Dimethylphenol	< 1
2,4-Dinitrophenol	< 1
2-Methyl-4,6-dinitrophenol	< 1
2-Nitrophenol	< 1
4-Nitrophenol	< 1
Pentachlorophenol	< 1
Phenol	17
2,4,6-Trichlorophenol	< 1

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Date Reported: 01/08/87
Project #20-8200

Sample Number

6121509

Sample Description

Bay Center - Emeryville, MWD, Water Sample

PRIORITY POLLUTANTS

BASE/NEUTRAL EXTRACT ORGANICS

results in ppb

Acenaphthene	< 1	Diethylphthalate	< 10
Acenaphthylene	< 1	Dimethylphthalate	< 1
Anthracene	< 1	Di-n-octylphthalate	< 1
Benzo (a) anthracene	< 1	Dibutylphthalate	< 1
Benzo (b) fluoranthene	< 1	Isophorone	< 1
Benzo (k) fluoranthene	< 1	Benzidine	< 10
Benzo (a) pyrene	< 1	2,4-Dinitrotoluene	< 1
Benzo (g,h,i) perylene	< 1	2,6-Dinitrotoluene	< 1
Chrysene	< 1	1,2-Diphenylhydrazine	< 1
Dibenzo (a,h) anthracene	< 1	Nitrobenzene	< 1
Fluoranthene	< 1	N-Nitrosodimethylamine	< 1
Fluorene	< 1	N-Nitrosodi-n-Propylamine	< 1
Indeno (1,2,3-c,d) pyrene	< 1	N-Nitrosodiphenylamine	< 1
Naphthalene	< 1	2-Chloronaphthalene	< 1
Phenanthrene	< 1	1,3-Dichlorobenzene	< 1
Pyrene	< 1	1,4-Dichlorobenzene	< 1
Bis (2-chloroethyl) ether	< 1	1,2-Dichlorobenzene	< 1
Bis (2-chloroethoxy) methane	< 1	3,3-Dichlorobenzidine	< 10
Bis (2-ethylhexyl) phthalate	< 1	Hexachlorobenzene	< 1
Bis (2-chloroisopropyl) ether	< 1	Hexachlorobutadiene	< 1
4-Bromophenyl phenyl ether	< 1	Hexachloroethane	< 1
Butyl benzyl phthalate	< 1	Hexachlorocyclopentadiene	< 1
4-Chlorophenyl phenyl ether	< 1	2,3,7,8-Tetrachlorodibenzo-p-dioxin	< 1
		1,2,4-Trichlorobenzene	< 1

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Groundwater Technology Laboratory
4080 Pikelane, Suite D
Concord, CA 94520
Attn: Joyce Miley

Date Sampled: 12/19/86
Date Received: 12/22/86
Date Extracted: 12/30/86
Date Reported: 01/09/87
Project #20-8200

Sample Number

6121509

Sample Description
Bay Center - Emeryville, MWD, Water Sample

PRIORITY POLLUTANTS

PESTICIDE AND PCB COMPOUNDS

results in ppb

Aldrin	<	10	Endrin	<	10
α-BHC	<	10	Endrin Aldehyde	<	10
β-BHC	<	10	Heptachlor	<	10
δ-BHC	<	10	Heptachlor Epoxide	<	10
γ-BHC	<	10	Toxaphene	<	10
Chlordane	<	10	PCB-1016	<	10
4,4'-DDD	<	10	PCB-1221	<	10
4,4'-DDE	<	10	PCB-1232	<	10
4,4'-DDT	<	10	PCB-1242	<	10
Dieldrin	<	10	PCB-1248	<	10
Endosulfan I	<	10	PCB-1254	<	10
Endosulfan II	<	10	PCB-1260	<	10
Endosulfan Sulfate	<	10			

SEQUOIA ANALYTICAL LABORATORY

Arthur G. Burton
Laboratory Director

sls

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6121508

Sample Description
Bay Center - Emeryville,
MWE, New Well, Water Sample

PRIORITY POLLUTANTS

VOLATILE ORGANIC COMPOUNDS
results in ppb

Acrolein	<100	trans-1,2-Dichloroethene	< 0.5
Acrylonitrile	<100	1,2-Dichloropropane	< 0.5
Benzene	4400	1,3-Dichloropropene	< 0.5
Bromomethane	< 0.5	Ethylbenzene	1700
Bromodichloromethane	< 0.5	Methylene chloride	< 0.5
Bromoform	< 0.5	1,1,2,2-Tetrachloroethane	< 0.5
Carbon tetrachloride	< 0.5	Tetrachloroethene	< 0.5
Chlorobenzene	< 0.5	1,1,1-Trichloroethane	< 0.5
Chloroethane	< 0.5	1,1,2-Trichloroethane	< 0.5
2-Chloroethylvinyl ether	< 0.5	Trichloroethene	< 0.5
Chloroform	< 0.5	Toluene	6600
Chloromethane	< 0.5	Vinyl chloride	< 0.5
Dibromochloromethane	< 0.5	1,2-Dichlorobenzene	< 0.5
1,1-Dichloroethane	< 0.5	1,3-Dichlorobenzene	< 0.5
1,2-Dichloroethane	< 0.5	1,4-Dichlorobenzene	< 0.5
1,1-Dichloroethene	< 0.2		

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Sample Number	Sample Description
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PRIORITY POLLUTANTS

ACID EXTRACT ORGANICS
results in ppb

4-Chloro-3-methylphenol	< 1
2-Chlorophenol	< 1
2,4-Dichlorophenol	< 1
2,4-Dimethylphenol	< 1
2,4-Dinitrophenol	< 1
2-Methyl-4,6-dinitrophenol	< 1
2-Nitrophenol	< 1
4-Nitrophenol	< 1
Pentachlorophenol	< 1
Phenol	< 1
2,4,6-Trichlorophenol	< 1

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PRIORITY POLLUTANTS

BASE/NEUTRAL EXTRACT ORGANICS
results in ppb

Acenaphthene	< 1	Diethylphthalate	< 10
Acenaphthylene	< 1	Dimethylphthalate	< 1
Anthracene	< 1	Di-n-octylphthalate	< 1
Benzo (a) anthracene	< 1	Dibutylphthalate	< 1
Benzo (b) fluoranthene	< 1	Isophorone	< 1
Benzo (k) fluoranthene	< 1	Benzidine	< 10
Benzo (a) pyrene	< 1	2,4-Dinitrotoluene	< 1
Benzo (g,h,i) perylene	< 1	2,6-Dinitrotoluene	< 1
Chrysene	< 1	1,2-Diphenylhydrazine	< 1
Dibenzo (a,h) anthracene	< 1	Nitrobenzene	< 1
Fluoranthene	< 1	N-Nitrosodimethylamine	< 1
Fluorene	< 1	N-Nitrosodi-n-Propylamine	< 1
Indeno (1,2,3-c,d) pyrene	< 1	N-Nitrosodiphenylamine	< 1
Naphthalene	150	2-Chloronaphthalene	< 1
Phenanthrene	< 1	1,3-Dichlorobenzene	< 1
Pyrene	1.3	1,4-Dichlorobenzene	< 1
Bis (2-chloroethyl) ether	< 1	1,2-Dichlorobenzene	< 1
Bis (2-chloroethoxy) methane	< 1	3,3-Dichlorobenzidine	< 10
Bis (2-ethylhexyl) phthalate	< 1	Hexachlorobenzene	< 1
Bis (2-chloroisopropyl) ether	< 1	Hexachlorobutadiene	< 1
4-Bromophenyl phenyl ether	< 1	Hexachloroethane	< 1
Butyl benzyl phthalate	< 1	Hexachlorocyclopentadiene	< 1
4-Chlorophenyl phenyl ether	< 1	2,3,7,8-Tetrachlorodibenzo-p-dioxin	< 1
		1,2,4-Trichlorobenzene	< 1

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APPENDIX V
GROUNDWATER TREATMENT SYSTEM

In general, treatment system objectives are to:

1. Accommodate the initial maximum flow rate to the system.

2. Provide system effluent water quality as defined by the Regional Water Quality Control Board or as required by the appropriate municipality.

3. Meet Regional Air Quality Standards for emissions, if applicable.

There are three basic steps in the groundwater treatment process:

1. Inorganic treatment
2. Microbiological treatment
3. Removal of dissolved volatile organics

The purpose of and technologies potentially employed in each of these treatment steps are explained below.

INORGANIC TREATMENT

The potential for inorganic fouling exists in any water treatment process. Inorganic fouling manifests itself in the form of precipitation reaction products; insoluble reaction products of an aqueous chemical reaction. Once water has been taken from its source, where it may have been in a state of equilibrium, it is often exposed to pumping, aeration, and heating, any of which may upset its stability and lead to corrosion or scaling. These insoluble reaction products (scale) form in contacting equipment such as stripping towers, reverse osmosis units and boilers. Ionic species of concern are carbonates (CO_3^{-2}) sulfates (SO_4^{-2}), phosphates (PO_4^{-3}) and hydroxides (OH^-).

As with any prescription or treatment, a thorough system evaluation and diagnosis is a prerequisite. In evaluating equilibrium conditions of an aquatic system for the possibility of scale formation, reaction rates and mechanisms must be considered.

A technique that has found wide spread use, due to its cost effectiveness for scale prevention has been threshold treatment. These chemical dosing systems possess unusual threshold properties which effectively stabilize conditions of supersauration. This phenomenon results when the inhibitor species (usually a phosphate or phosphonate polymer) is adsorbed on the nuclei from which crystalization would normally proceed. The result is an inactivation of the nuclei and the prevention of precipitation of the scaling constituents.

MICROBIOLOGICAL TREATMENT

In considering aquatic systems, micro-organisms may be placed in three catagories: bacteria, fungi and algae. Fungi and bacteria are classified as reducers. Reducers breakdown chemical compounds to more simple species, thereby extracting the energy needed for their growth. Algae are classified as producers because they utilize light energy and store it as chemical energy. In a sense, bacteria and fungi may be looked upon as environmental catalysts, whereas algae are aquatic "solar fuel cells".

THE PROBLEM

Contacting systems whether they be liquid-vapor, liquid-solid or vapor-solid, are utilized for transferring mass, heat and/or momentum between phases, subject to constants of physical and chemical equilibrium. The development, design and implementation of groundwater and waste water treatment systems require mass transfer and separatory equipment; specifically packed towers, filter beds and granular activated carbon beds. Micro-organism growth may occur in contacting and recovery equipment due to the large surface area of micro-organisms through either the makeup water or through air contact. Another factor to be considered is the availability of nutrients and sunlight that promote growth in, and during the contact process.

Chlorine is the most commonly used disinfectant employed for killing bacteria in water. Oxidizing biocides such as chlorine and the hypochlorites will kill organisms present in the system, if the free chlorine comes into direct contact with organisms long enough and at a strong enough level. They also retain their effectiveness because organisms can not adapt to or become resistant to chlorine.

However, oxidizing biocides also react with contaminants and other organics. This increases the amount of chlorine required for biocidal effects. They are not persistent and they decay quickly after the chemical feed stops. Also, they do not penetrate slime masses, they lose their effectiveness as PH increases and chlorinated biocides increase the total dissolved solids (TDS) content of the water. Another disadvantage is the formation of trihalomethanes (THM's), known carcinogens, from the reaction of chlorine with organic compounds.

When micro-organisms are exposed to ultraviolet light, a constant fraction of the number present die in each time increment. The fraction of the initial number of micro-organisms present at a given time is called the survival ratio. The fraction killed is one minus the survival ratio.

For each given micro-organism and UV wave length, the fraction killed depends upon the product of UV light intensity and exposure time. This product is known as the dosage, which is the single most important parameter for rating UV disinfection equipment.

Advantages of ultraviolet treatment include its ability to destroy slime forming bacteria and pathogens at relatively low dosages, its ability to leave treated water unchanged with respect to color, PH, temperature, conductance or scaling tendency. Also there are no adverse health effects for operators. The major drawback to UV treatment is the limited quantity of influent treated per pass.

Ozone is sometimes used as a disinfectant in place of chlorine. Basically, air is filtered, cooled, dried, and pressurized, then subjected to an electrical discharge of approximately 20,000 volts. The ozone produced is then pumped into a contact chamber where water contacts the ozone for 10-15 minutes. The recent concern over possible production of toxic organochlorine compounds, such as THM's, by water chlorination processes has increased interest in ionization.

VOLATILE ORGANIC COMPOUND REMOVAL

Either of two technologies are commonly employed in the removal of organic compounds from groundwater: air stripping or liquid phase granular activated carbon.

AIR STRIPPING

Air stripping is a technique for the removal of volatile compounds which are either dispersed or dissolved in water. The water is fed over a large surface area, maximizing the surface contact between water and air, thus allowing the contaminants to be stripped from the water.

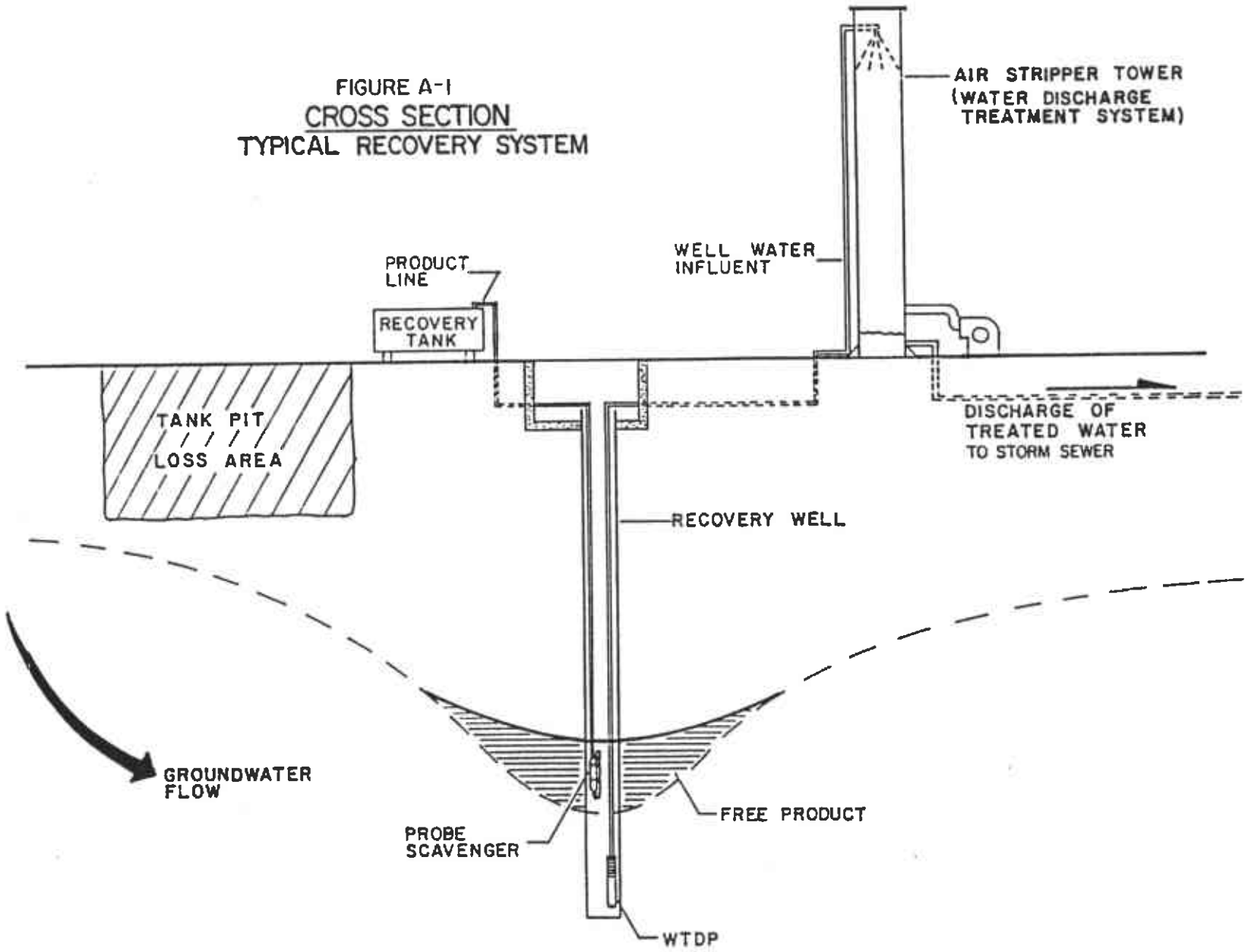
The Groundwater Technology (GT) Air Stripping system quickly and economically removes volatile organic pollutants from water. Applications include groundwater and waste water contaminated by petroleum hydrocarbons and chlorinated organics.

The Groundwater Technology design, shown in Figure A-1 utilizes the packed tower method of air stripping. The air stripping system consists of a vertical column containing a unique packing material, air blower, motor and controls. Standard GT towers feature the highest quality contact molded FRP (Fiberglass Reinforced Plastic) construction available. All standard towers have a minimum of 1/4" wall thickness and a minimum wind load design rating of 100 mph. Where local codes exceed 100 mph, or tower extensions are used, guy wire assemblies are required. Flow rates up to 1000 gpm can be handled by a single unit. Larger flows and/or higher concentrations can be handled with units in series or parallel configurations.

FIGURE A-1

CROSS SECTION

TYPICAL RECOVERY SYSTEM



MARTIN COMPANY
EMERYVILLE, CALIFORNIA

NO SCALE

GROUNDWATER
TECHNOLOGY

Inherent features of all standard GT Air Strippers include:

- FRP tower shell
- Polypropylene Tripack packing
- Packing support
- Explosion proof blower motor
- Non-sparking aluminum blower wheel
- Blower inlet guard
- Air flow regulator
- Blower flexible duct
- Explosion proof On/Off switch
- 12' cord with ENP plug
- Mist eliminator with safety hold downs
- Removable sight tube assembly
- Top accessory flange
- Full cone spray nozzle (Orifice type)
- Integral sump
- Lifting lugs
- Concrete anchor bolts (tower and blower)
- Sch. 80 PVC influent pipe with sample port
- Guy wire and turnbuckle assemblies

Standard Groundwater Technology, Inc. Air Stripping systems will provide removal efficiencies in excess of 99 percent for the following compounds:

Benzene	Ethylbenzene	1, 2 dichloroethylene
Toluene	Trichloroethylene	1, 1, 1 trichloroethane
Xylene	1, 1 dichloroethylene	Tetrachloroethylene
		Napthelene

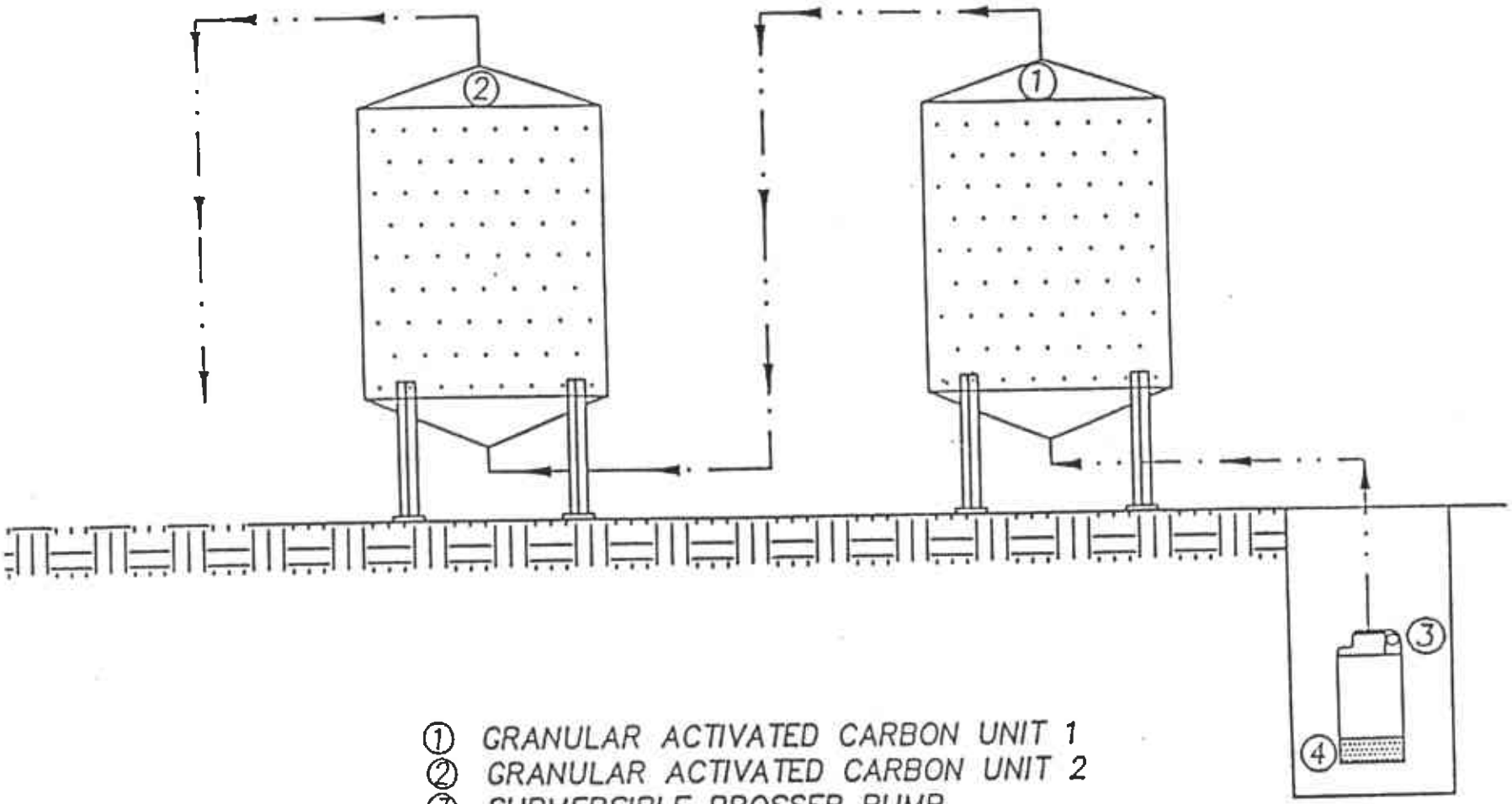
Removal efficiencies for phenols will be approximately 30 percent. If treatment objectives require higher removal efficiencies, several options are viable: an air stripping system with recycle capabilities, air stripping tower with height extensions or substituted high performance packing. Groundwater Technology has been designing and operating air stripping towers for over 6 years. There are currently over 200 installations in operation for flows ranging from 1 to 1000 gpm. Installations have been designed to accommodate both municipal drinking water and industrial waste water standards.

GRANULAR ACTIVATED CARBON

Activated carbon adsorbs a great variety of dissolved organic materials including many which are non-biodegradable. Adsorption is facilitated by the large surface area on the carbon granules which are attributable to its highly porous structure. Biological degradation occurring on the granules complements the adsorption process in removing dissolved organic material. Carbon, in certain configurations, also functions as a filter. The greatest cost within the carbon treatment process is the cost of the carbon itself. Thermal regeneration of the spent carbon makes the process economically feasible; the cost of the regenerating equipment, however, represents only a small fraction of the total capital equipment costs.

FIGURE A-2

GRANULATED ACTIVATED CARBON UNITS UPFLOW IN SERIES



① GRANULAR ACTIVATED CARBON UNIT 1
② GRANULAR ACTIVATED CARBON UNIT 2
③ SUBMERSIBLE PROSSER PUMP
④ INFLUENT CLEAR WELL RESERVOIR

The most important design parameter to consider for adsorption vessels is contact time. Hydraulic loading, within the ranges normally used, has little effect on adsorption. The process configurations of the system includes downflow under pump pressure, with fixed beds, and single (parallel) arrangement.

APPENDIX VI

MARTIN COMPANY

AIR STRIPPING SYSTEM

Worst Case Mass Balance Analysis

Operating Parameters:

Liquid Loading - 5 gpm (max)

Vapor Loading - 50 scfm

Volatile Priority Pollutant

Total Concentration - 13.0 ppm

Assume 100% Transfer of Contaminants to Vapor Phase from the Liquid Phase

Assume Vapor Influent has no Contamination Characteristics

Mass Balance Equation

$$(L_{in})(X_{in}) + (V_{in})(Y_{in}) = (L_{out})(X_{out}) + (V_{out})(Y_{out})$$

Where, L = Liquid Loading

X = Contaminant Concentration, Liquid Phase

V = Vapor Loading

Y = Contaminant Concentration, Vapor Phase

and $Y_{in} = X_{out} = 0$

Simplifying, $(L_{in})(X_{in}) = (V_{out})(Y_{out})$

or

$$(V_{out})(Y_{out}) = \frac{(5\ gal)}{min.} \frac{(13.0\ mg)}{l} \frac{(3.785\ l)}{gal.} \frac{(\ g\ )}{1000mg} \frac{(\ lb\ )}{453.6g} \frac{(60min)}{hr} \frac{(24hr)}{day} = 0.78\ lbs/da$$

Concentration of hydrocarbon in discharge, Y_{out}:

$$Y_{out} = \frac{(L_{in})(X_{in})}{V_{out}} = \frac{(5\ gpm)(13.0\ ppm)}{(50\ cfm)(7.481 \frac{gal}{ft.^3})}$$

$$Y_{out} = 0.174\ ppm$$