PACIFIC
ENVIRONMENTAL
GROUP INC.

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October 12, 1993
Project 330-06.22

Mr. Mike Whelan
ARCO Products Company
P.O. Box 5811
San Mateo, California 94402

Re: ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Dear Mr. Whelan:

This letter presents the results of conducting aquifer testing, air sparge, soil vapor extraction (SVE), and in-situ bioremediation feasibility testing at the site referenced above (Figure 1). Relevant site background is presented in PACIFIC's *Additional Investigation Work Plan*, dated February 4, 1993, and PACIFIC's *Investigation Report*, dated July 27, 1993. A summary of each test is described below.

AQUIFER TESTING

During the week of March 29, 1993, aquifer testing was performed at the site to determine the hydraulic characteristics of the shallow water-bearing zone both on and off site. The testing consisted of step-discharge tests in Wells E-1A and MW-10 to determine appropriate flow rates for 8-hour constant discharge tests to be conducted in each well. The pumping tests were conducted in wells completed in coarser-grained geologic materials (silty sand and sandy silt), at the site (Well E-1A), and downgradient of the site (Well MW-10). The purpose of the tests was to collect aquifer characterization data in order to understand and simulate groundwater flow and hydrocarbon transport phenomena, and for later use in remedial system design.

In addition to the pumping tests, slug tests were performed in Wells MW-14 and MW-23. These wells are completed in finer-grained geologic materials (clays and sandy clays). The purpose of performing the slug tests was to obtain contrasting hydraulic conductivity data for the finer-grained materials at the lateral and downgradient hydrocarbon plume boundaries.

The procedures for the aquifer testing were described in a Work Plan dated February 14, 1993, prepared by PACIFIC. The pump used for tests in Wells E-1A and MW-10 was a 3-inch diameter Grundfos, Model JS 10-05, 0.5 horsepower electric submersible, rated at 10 gallons per minute (gpm) at 160 feet of pumping head. At the total discharge head encountered during these tests (less than 40 feet), the pump is capable of discharging more than 15 gpm. The pump was placed in each well such that approximately 11 feet of drawdown was available for testing. All groundwater pumped during the testing program was discharged through the existing site treatment system. Construction details for pumping and monitoring wells used in the testing program are presented in Table 1. Well locations are shown on Figure 2.

Barometric pressure data were obtained from the National Weather Service station located at San Francisco International Airport for the periods during which the 8-hour constant discharge tests were conducted. These data indicated that during the 8 hours of pumping in Well E-1A, barometric pressure decreased by an amount equivalent to 0.1 feet of water, and during the test in Well MW-10, barometric pressure decreased by an amount equivalent to 0.08 feet of water. Since the barometric efficiency of a well usually ranges from 20 to 75 percent (Kruseman and de Ridder, 1990), these pressure fluctuations could have produced up to 0.075 feet of water level *increase* in monitoring wells during the test in Well E-1A, and less during the test in Well MW-10. The small magnitude of the possible fluctuations in conjunction with the direction of the possible effect (increasing water levels) suggests all drawdown observed during the pumping test was due to pumping, or influences other than barometric pressure changes. Therefore, the pumping test data were not corrected for the influence of possible barometric fluctuation effects.

Pumping Test Observations

Plots of drawdown and recovery data for both the step discharge and the constant discharge tests, and slug tests, are included as Figures A-1 through A-22 in Attachment A.

Well E-1A

The step discharge test for Well E-1A was started at a discharge rate of 0.5 gpm. After pumping at this rate for approximately 20 minutes, the water level well stabilized at 1.6 feet of drawdown. Forty minutes into the test the flow rate was increased to 1 gpm. This increased drawdown in the well to approximately 2.2 feet. The water level stabilized at approximately 60 minutes into the test. The flow rate was increased to 2 gpm at 70 minutes into the test. This discharge rate created approximately 58 feet of drawdown before the water level stabilized. After 1 hour at 2 gpm, the flow rate was increased to 4 gpm. The well was unable to sustain 4 gpm and dewatered within 10 minutes. These data along with calculated values of specific capacity are summarized in Table 2.

Based on the findings of the step discharge test, a pumping rate of 2 gpm was selected for the 8-hour constant discharge test in Well E-1A. The constant discharge test was performed March 31, 1993. The pumping began at 8:00 AM and within 80 minutes, drawdown stabilized at approximately 5.4 feet. Following 8 hours of pumping, the pump was deenergized and the recovery water levels were monitored.

Water levels during the test were monitored in Wells MW-5, MW-8, MW-9, MW-13, and SP-1/V-4. The distance from the pumping well and maximum drawdowns observed were as follows:

Well Number	Distance (feet)	Maximum Drawdown (feet)
MW-5	36	0.04
MW-8	40	0.05
MW-9	81	0.05*
MW-13	115	0.08*
SP-1	~29	0.15
V-4	~29	0.05

* = Due to fluctuations of the water levels in Wells MW-9 and MW-13 during the test, it is uncertain that the drawdown observed was due to the pumping of Well E-1A.

Well MW-10

The step discharge test in Well MW-10 was started at a discharge rate of 0.5 gpm. After pumping at this rate for approximately 15 minutes the water level in the well stabilized at 0.30 feet of drawdown. Thirty minutes into the test the flow rate was increased to 1 gpm. At approximately 35 minutes into the test the water level in the well stabilized at approximately 0.38 feet of drawdown. The flow rate was increased again at 70 minutes into the test, to 2 gpm. This flow rate created approximately 0.83 feet of drawdown before the water level stabilized. After 1 hour at 2 gpm the flow rate was increased to 4 gpm. The 4 gpm flow rate created approximately 3.5 feet of drawdown. This pumping rate was maintained for 90 minutes after which the pumping rate was increased to 6 gpm. The well was unable to sustain a flow rate of 6 gpm and dewatered within approximately 10 minutes. These data and calculated specific capacity values are summarized in Table 2.

Based on the findings of the step discharge test, a pumping rate of 4 gpm was selected for the 8-hour constant discharge test. The constant discharge test was performed on April 2, 1993. Pumping began at 8:30 AM and within 20 minutes drawdown stabilized at approximately 3.8 feet. Following 8 hours of pumping the pump was deenergized and the well was monitored while it recovered.

Drawdown during the test was observed in Wells MW-9, MW-11, MW-14, MW-15, and SP-2/V-5. The distance from the pumping well and maximum drawdowns observed were as follows:

Well Number	Distance (feet)	Maximum Drawdown (feet)
MW-9	225	0.03*
MW-11	113	0.08*
MW-14	212	0.02*
MW-15	223	0.03*
SP-2	16	0.35
V-5	16	0.15

* = Due to the small magnitude of the drawdown observed, it is uncertain that it was due to the pumping of Well MW-10.

Analysis and Results

Data collected during the recovery of the constant rate pump tests were used to determine transmissivity values for Wells E-1A and MW-10 using the **Cooper and Jacob (1946) straight line technique**. The equations and parameters used in these analyses are shown on the appropriate figure in Attachment A. A summary tabulation of pumping test analytical results is presented below.

Well	Transmissivity	Hydraulic Conductivity	Storage Coefficient
E-1A	112	5.3E-4	N/A
MW-10	310	2.1E-3	N/A
SP-2	130	5.0E-2	0.012
V-5	800	4.0E-2	0.34

N/A = Not available
Notes: Transmissivity in gallons per day per foot.
Hydraulic conductivity in centimeters per second.
Storage coefficient is dimensionless.

The values of hydraulic conductivity determined from this testing program are typical of geologic materials consisting of fine to coarse sand (Kruseman and de Ridder, 1990). Transmissivity values are based on estimated aquifer thicknesses and assume each well used in the test fully penetrated the aquifer. This and other simplifying assumptions (the aquifer is infinite in areal extent, isotropic, homogeneous, and of uniform thickness; the aquifer is confined, or if unconfined, drawdown is small relative to aquifer thickness) necessarily limit the accuracy of the calculated hydraulic parameters to within an order of magnitude.

The test data allowed storativity values to be calculated only for Wells SP-2 and V-5. The value determined for Well SP-2 from this test (0.012) is at the low end of the range typical of unconfined storativity values. Typical unconfined storativity values range from 0.02 to 0.3, (Kruseman and de Ridder, 1990). The value calculated for Well V-5 (truly unconfined) is near the high end of the range typical for unconfined formations. The difference in values is not unexpected since Well SP-2 is screened at some depth below the water table. The layer of saturated soils above the well screen behaves similarly to a leaky confining layer; thus producing a corresponding response to pumping, and a correspondingly lower storativity value.

Specific capacity is a measure of well yield and indicates the volume of flow a well can support at a given level of drawdown. Table 2 shows the calculated specific capacities for Wells E-1A and MW-10.

Slug Test Results

Slug tests were performed in Wells MW-14 and MW-23 on April 29, 1993. Falling head and rising head tests were performed on each well. Slug test data was analyzed using a method developed by Bouwer and Rice (1976). This method is designed to determine the hydraulic conductivity within an unconfined aquifer and is based on the **Thiem equation** of steady state flow to a well. Plots of the falling and rising head test data are presented on Figures A-17 through A-22.

The general equation to derive hydraulic conductivity is:

$$K = [(r_c^2/2Lt)/((1.1/\ln(H/r_w)) + (C/(L/r_w)))]\ln(y_o/y_t)$$

Where:

r_c = Well casing radius (feet)
L = Length of saturated well screen (feet)
t = time (minutes)
H = Distance from the top of the water table to the bottom of the screened interval open to the aquifer (feet)
C = Dimensionless parameter correlating to L/r_w
r_w = Borehole radius (feet)
y_o = Initial water level (feet)
y_t = Level at time t (feet)
K = Hydraulic conductivity (feet/minute)

Transmissivity is then derived from the relation **T = K/B, where B (aquifer thickness) is usually treated as being equivalent to parameter H above, for the purpose of analysis.**

The values of transmissivity and hydraulic conductivity for Wells MW-14 and MW-23 calculated using this method are tabulated below. The parameters used in the equation above for each analysis are listed on Figures A-17 through A-22. Note that two falling and rising head tests were performed on Well MW-14; the values displayed below represent the arithmetic mean of the results of the two tests.

Well and Test	Hydraulic Conductivity	Transmissivity
MW-14		
Falling head	2.2E-3	700
Rising head	7.8E-4	240
Mean	1.5E-3	470
MW-23		
Falling head	1.4E-3	320
Rising head	1.7E-3	400
Mean	1.6E-3	360

Notes: Hydraulic conductivity is in centimeters per second.
Transmissivity is in gallons per day per foot.

The calculated values are typical of formations consisting of fine sand or silt. Since the materials in which these wells are screened consist predominantly of clays, secondary permeability characteristics such as cracks in the soil structure, or rootlet holes, may be contributing to the higher than expected permeability values.

Aquifer Test Conclusions

Although the grain-size distribution of geologic materials at and downgradient of the site ranges from clays to silts to fine and coarse sands, the distribution of hydraulic conductivities determined from the aquifer test program did not show a strong correlation to predominant grain sizes noted on the boring logs of the wells tested. Especially noted were higher than expected hydraulic conductivities from slug test results. The shallow, unconfined aquifer appears to be capable of producing 2 to 4 gallons per minute, or more, in the vicinity of the site. The radius of groundwater capture of pumping wells tested is discussed in detail below.

Pumping test results and aquifer geometric factors were used to estimate typical capture zones of Wells E-1A and MW-10. Since capture zone determination depends upon achieving steady-state drawdown conditions, for this analysis, steady state was assumed to be reached after 1 day of pumping. A computer model was employed for this analysis. The model is called AqModel (O'Neill, 1990), and is distributed by *WellWare* of Davis, California.

The time-dependent head distribution from which the capture zone was determined is based on the Theis analytical solution for flow to a pumping well. The capture zones thus determined have a radius of approximately 30 to 40 feet for Well E-1A, and approximately 70 to 80 feet for Well MW-10. These capture zones are shown as shaded areas on Figure 2.

AIR SPARGE TESTING

PACIFIC conducted an off-site air sparge (sparge) test on May 4, 1993, and an on-site sparge test on May 5, 1993. The objective of testing was to evaluate the feasibility of using sparge technology at the site. A description of testing, including procedures, results, and conclusions is presented below. Field data sheets are presented as Attachment B.

Sparge Test Procedures

Sparge testing consisted of two phases. The first phase consisted of injecting a mixture of helium and air at the sparge point (Well SP-1 or SP-2), and the second phase consisted of helium/air injection at the sparge point and SVE at a monitoring point (Well MW-5 or MW-10). The first phase was conducted to verify the radius of sparge influence. The second phase was conducted to determine if the radius of sparge influence could be increased using SVE (SVE may create preferential subsurface flow paths).

Immediately before each test was performed, depth to groundwater was measured in the sparge well. Measurements were used to determine the initial sparge injection pressure (based on the pressure head due to standing water in the sparge well).

Each test was performed by connecting an oil-less air compressor and a compressed helium-gas cylinder to the sparge well. Helium was utilized as a tracer gas to verify the radius of sparge influence. Air was injected to monitor the changes in volatile organic compounds (VOCs) and dissolved oxygen (DO) concentrations. During testing, the injection pressure and flow rate were measured at the sparge well. Helium, VOCs, and DO were also measured at the surrounding monitoring wells. Helium was measured using a portable detector, VOCs were measured using a flame-ionization detector (FID), and DO was measured using a portable meter.

During the second phase of testing, helium/air injection continued as described above, and a 2.5-horsepower regenerative blower was connected to the extraction well head (MW-5 and MW-10) in order to create a vacuum. Extracted soil vapor was treated using vapor-phase activated carbon prior to atmospheric discharge. Helium, VOCs, and DO were also measured at the surrounding monitoring wells during the second phase of testing.

Sparge Test Results

- o During the first phase of off-site testing, VOCs in Wells V-5, MW-10, and MW-11 were at background levels and remained unchanged during testing. During the second phase, VOCs in Well V-5 increased from 2.5 to 20 parts per million (ppm), VOCs in Well MW-10 remained a background levels, and VOCs were not measured in MW-11.
- o During the first phase of off-site testing, helium levels increased from 0 to 0.18 percent in V-5. Helium was not detected in MW-10 or MW-11 during testing. During the second phase, helium levels in Well V-5 increased from 0.14 to 3.2 percent, helium was not detected in MW-10, and helium was not measured in MW-11.

- During the first phase of off-site testing, DO concentrations in V-5 increased from 2.1 to 5.1 micrograms per liter (ug/L) and 1.61 to 3.68 ug/L in Well MW-10. DO concentrations remained unchanged in Well MW-11. During the second phase, the DO meter malfunctioned preventing further DO measurement.
- During the first phase of on-site testing, VOCs in Well V-4 increased from 1,100 to +10,000 ppm, and from 4.5 to +10,000 ppm in Well MW-5. VOCs in Well MW-8 were at background levels and remained unchanged during testing. During the second phase, VOCs in Wells V-4 and MW-5 were measured at +10,000 ppm and remained unchanged. VOCs were not measured in Well MW-8 during the second phase of testing.
- During the first phase of on-site testing, helium levels ranged from 0 to 5.3 percent in Well V-4. Helium was not detected in Wells MW-5, E1-A, and MW-8. During the second phase, helium levels ranged from 4.9 to 9.3 percent in V-4, and from 0 to 12 percent in Well MW-5. Helium was not measured in Well MW-8 during the second phase of testing.
- During on-site testing, measurement of DO was not possible; the DO meter malfunctioned during the second phase of off-site testing.
- The data for both tests indicate that the radius of sparge influence did not encompass the nearest monitoring point (approximately 16 feet).

Sparge Test Conclusions

The objective of conducting sparge testing was to determine the feasibility of using sparge technology at the site. Given the observed radius of sparge influence and changes in VOC, DO, and helium concentrations, **PACIFIC concludes that the feasibility of using sparge technology at this site is limited. PACIFIC recommends conducting a comparison of alternative groundwater remedial technologies prior to initiation of sparge remedial system design.**

SOIL VAPOR EXTRACTION TESTING

PACIFIC conducted an off-site SVE test on April 29, 1993, and an on-site SVE test on April 30, 1993. The objective of testing was to evaluate the feasibility of using SVE technology at the site. A description of testing, including relevant subsurface conditions, procedures, data analysis, results, and conclusions is presented below. Field data sheets and computer modeling worksheets are presented as Attachment C. Certified analytical reports and chain-of-custody documentation are provided as Attachment D.

Relevant Subsurface Conditions

Soils underlying the site consist primarily of clay, sandy clay, sand, and clayey sand. Based on site lithology, permeability to air flow was expected to range between 1 and 10 darcys (1 darcy = 9.87×10^{-9} cm^2). The boring logs of Wells SP-2/V-5, MW-10, and MW-11 for the off-site test, and Wells SP-1/V-4, MW-5, MW-8, and E1-A for the on-site test are referenced from previous reports prepared by Applied GeoSystems and PACIFIC.

Based on previous quarterly groundwater monitoring reports, depth to groundwater was estimated to be 10 to 12 feet below ground surface across the site.

SVE Test Procedures

Prior to testing, PACIFIC notified the Bay Area Air Quality Management District (BAAQMD) regarding the proposed testing. Copies of these notifications are available on request.

Immediately before each test was performed, depth to groundwater was measured in all applicable groundwater monitoring wells. Measurements were compared with estimated well screen intervals to determine the feasibility of using groundwater monitoring wells as extraction/monitoring points. Based on the available data, it appeared all wells could serve as monitoring points. After accounting for the upwelling of groundwater during vacuum application, it was determined that Wells V-4 and MW-8 (on-site) and Well V-5 (off-site) could serve as extraction points.

Each test was performed by connecting a 2.5-horsepower regenerative blower to the extraction well head in order to create a vacuum. Extracted soil vapor was treated using vapor-phase activated carbon prior to atmospheric discharge. During testing, vacuum influence at the surrounding monitoring well head(s), and extracted soil vapor flow rate and applied vacuum at the extraction well head were measured. Bag samples of extracted soil vapor were also collected during testing, and analyzed for VOCs by EPA Methods 8015 and 8020.

During vacuum application, the measured radial influence was minimal. Therefore, PACIFIC also applied positive pressure in an attempt to collect additional radial influence data. During both tests however, the pressure hose ruptured and the positive pressure tests were terminated.

SVE Test Data Analysis

Radial pressure distribution was modeled using field measurements and the steady-state solution to the radial flow equation,, Permeability to air flow was calculated using field data and the steady-state solution for the radial volumetric flow rate. Additionally, the radial volumetric flow rate and permeability results were used to generate flow rate versus applied vacuum curves. These curves provided several SVE system design parameters, including effective radius of influence, blower sizing, and maximum design flow rate. Initial petroleum hydrocarbon removal rates were calculated using the soil vapor sample concentration data and maximum design flow rate. Field data sheets are presented as Attachment C. Data analysis calculations and solutions are available upon request.

SVE Test Results

- The data for both tests indicate that the vacuum application limit was restricted to a radial boundary which did not encompass the nearest monitoring point.
- By fitting field data from the off-site test to the steady-state radial flow equation, the effective radius of influence (R_e) was determined to be 9.5 feet. The radius of influence was generated by a pressure differential of 40 inches of water. The air flow rate was less than 3 scfm. A value for R_e could not be determined from the data collected from the on-site test.
- The intrinsic permeability to air flow (k) was estimated from boring logs and field data. Boring log data indicated k ranges between 1 and 10 darcys, or an average of 5 darcys. Field data applied to the steady-state flow equations determined k as 3.96 darcys. A value for k could not be determined from the data collected from the on-site test.
- Two extracted soil vapor samples were collected from Well V-4 during the on-site test. Sample V4-1 was collected prior to beginning SVE, and sample V4-2 was collected just SVE termination. The certified analytical reports indicate that TPH-g concentra-

tions ranged from 100 to 8,500 ug/L. Benzene, toluene, ethylbenzene, and xylenes were detected in both samples.

- Three extracted soil vapor samples were collected from Well V-5 during the off-site test. Sample V5-0 was collected prior to beginning SVE, sample V5-1 was collected after approximately 15 minutes, and sample V5-2 was collected just prior to SVE termination. The certified analytical reports indicate that TPH-g concentrations ranged from 6.7 to 13 ug/L. Benzene was not detected in any sample, however, toluene, ethylbenzene, and xylenes were detected in all samples.

SVE Test Conclusions

The objective of conducting a SVE test was to determine the feasibility of using SVE technology at the site. Given the estimated flow rate and extraction well spacing requirements, **PACIFIC concludes that the feasibility of using SVE technology at this site is very limited. PACIFIC recommends conducting a comparison of alternative soil remedial technologies prior to initiation of SVE remedial system design.**

IN-SITU BIOREMEDIATION FEASIBILITY TESTING

PACIFIC initiated an off-site in-situ bioremediation feasibility on March 9, 1993. The objective of testing was to evaluate the feasibility of using in-situ bioremediation technology at the site. A description of testing, including procedures, results, and conclusions is presented below. Certified analytical reports and chain-of-custody documentation are provided as Attachment E.

In-situ Bioremediation Testing Procedures

Six soil samples were collected during the exploratory soil boring program from various locations (Figure 3), and were evaluated to determine if in-situ bioremediation is occurring at the referenced site. PACIFIC contracted BioScreen Testing Services, Inc. to perform a baseline analysis on the six soil samples.

The baseline analysis consisted of nutrient analysis, and moisture content, pH, and microbial testing. Nutrient analysis, and moisture and pH testing is performed to determine if conditions will support in-situ microbial growth. Nutrient analysis consisted of measuring ammonia, nitrate, phosphate, potassium, calcium, magnesium, and iron concentrations. Microbiological testing is performed to determine if bioremediation was occurring at the time a soil sample was collected. Microbiological testing consisted of a heterotrophic plate count, and florescent *Pseudomonas* and hydrocarbon degraders count.

In-situ Bioremediation Testing Results

- o Nutrient Analysis: Ammonia and phosphate were not detected in any sample. Nitrate was not detected in any sample, except for sample B-11 at a concentration of 2.4 ppm. Elevated concentrations of potassium, calcium, magnesium, and iron were detected in all samples:
  - Potassium concentrations ranged from 333 to 756 ppm.
  - Calcium concentrations ranged from 3,100 to 4,340 ppm.
  - Magnesium concentrations ranged from 2,820 to 6,150 ppm.
  - Iron concentrations ranged from 9,460 to 19,200 ppm.
- o Moisture Content and pH: The moisture content and pH of all samples were within the normal range to support microbial growth:
  - Moisture concentrations ranged from 11.76 to 23.82 percent.
  - pH concentrations ranged from 7.24 to 8.28 units.
- o Microbiological Testing: Normal levels of heterotrophic plate count organisms should be in the 10^5 to 10^6 colony forming units per gram (CFU/gm) range. The results of the heterotrophic plate counts show levels that are below normal, which ranged from non-detected (less than 1,000 CFU/gm) to 6.2×10^4 CFU/gm. The florescent *Pseudomonas* and hydrocarbon degraders levels should be in the 10^3 and 10^5 CFU/gm range, respectively. Florescent *Pseudomonas* were not detected in any sample. Hydrocarbon degraders were not detected in any sample, except for sample B-11 at a concentration of 4.0×10^3 CFU/gm.

In-situ Bioremediation Testing Conclusions

Based on the baseline analytical results, it appears that insignificant bioremediation is taking place at this time. Further, column testing was not performed on any sample since the observed characteristics favorable to bioremediation were not sufficient to warrant further study.

It may be possible to enhance in-situ bioremediation with nutrient addition. However, nutrient addition could be severely limited due to site lithology, and would have to be carefully buffered to prevent inorganic precipitation due to the high minerals content observed in all samples. In order to conclude to the feasibility of enhancing bioremediation with nutrient addition, further field study would be necessary. Given the results of the baseline analysis and the site lithology, further field study is not recommended at this time. PACIFIC recommends conducting a comparison of alternative soil remedial technologies prior to initiation of further field study.

SUMMARY

PACIFIC conducted aquifer testing, air sparge, SVE, and in-situ bioremediation feasibility testing at the referenced site. The results of the feasibility testing indicate that air sparge, SVE, and in-situ bioremediation technologies have no or limited feasibility at the site. **PACIFIC recommends conducting a comparison of alternative groundwater and soil remedial technologies prior to initiation of any remedial system design. PACIFIC will conduct this comparison in the proposed Remedial Investigation and Feasibility Study.**

If you have any questions regarding this letter, please call us at (408) 441-7500.

Sincerely,

Pacific Environmental Group, Inc.

Keith Winemiller
Senior Staff Engineer

Shaw Garakani
Project Engineer

REFERENCES

Cooper, H.H. and C.E. Jacob, 1946, A generalized graphical method for evaluating formation constants and summarizing well field history, Am. Geophys, union Trans, vol. 27: 526:534.

Bouwer, H. and R.C. Rice, 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Res. vol. 12: 423-428.

Kruseman, G.P and N.A. de Ridder, 1990, *Analysis and Evaluation of Pumping Test Data*, Second Edition, International Institute for Land Reclamation and Improvement, Wageningan, The Netherlands.

O'Neill, G. T., 1990, *AqModel*, Version 2.11 for DOS, Wellware, Davis, California

Attachments:
- Table 1 - Well Construction Details
- Table 2 - Step Discharge Test Data
- Figure 1 - Site Location Map
- Figure 2 - Well Location Map
- Figure 3 - Soil Boring Location Map
- Attachment A - Aquifer Test Data and Figures
- Attachment B - Air Sparge Test Field Data
- Attachment C - Soil Vapor Extraction Test, Field Data, and Computer Modeling Worksheets
- Attachment D - Soil Vapor Extraction Test, Certified Analytical Reports, and Chain-of-Custody Documentation
- Attachment E - In-Situ Bioremediation Feasibility Testing, Certified Analytical Reports, and Chain-of-Custody Documentation

cc: Ms. Juliett Shin, Alameda County Health Care Services Agency
Mr. Chris Winsor, ARCO Products Company
Mr. Richard Hiett, San Francisco Regional Water Quality Control Board

Table 1
Well Construction Details

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

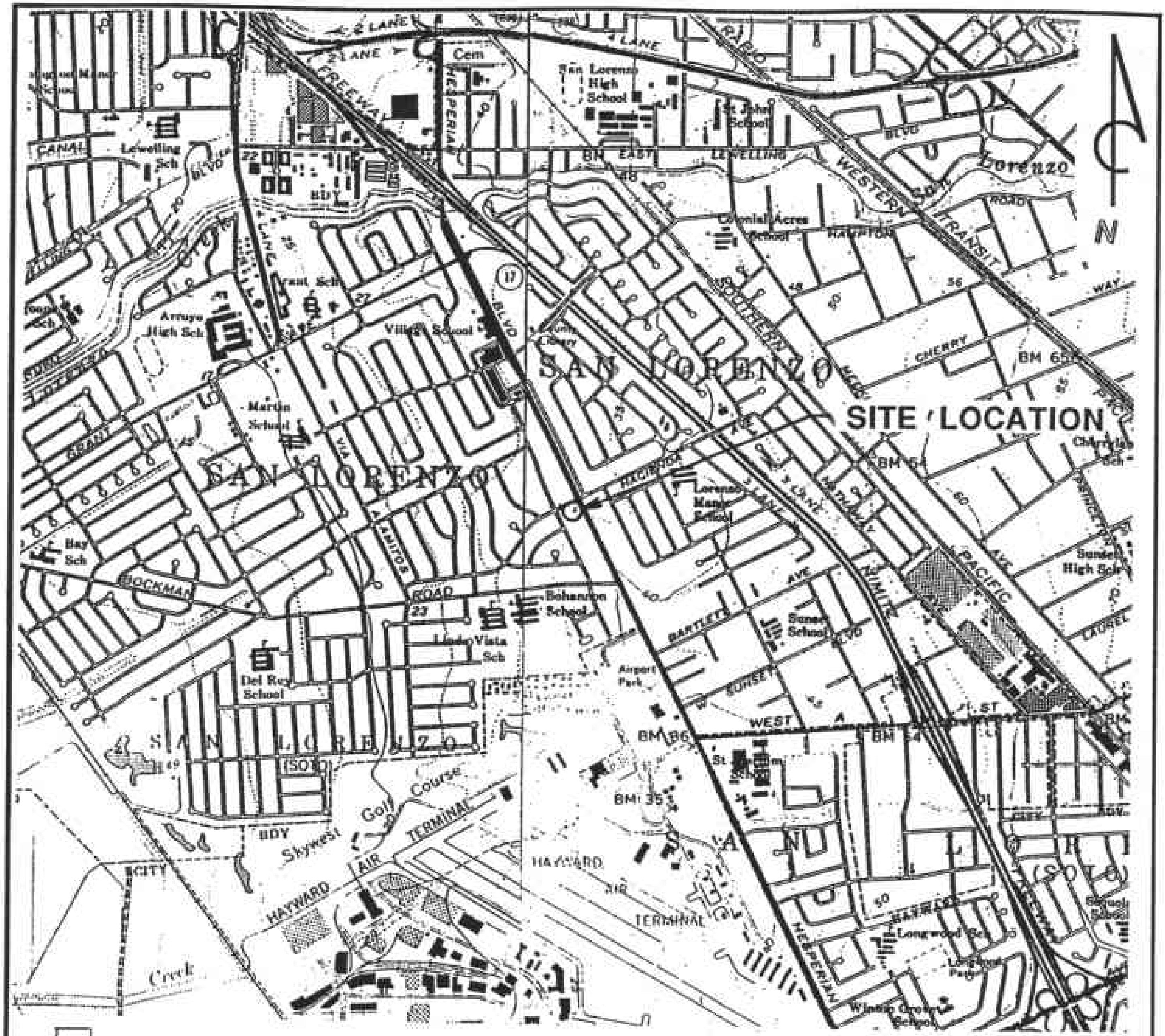
Well Number	Total Depth (feet)	Screened Interval (feet)	Casing Diameter (inches)
E-1A	26	6 - 26	6
MW-5	14	4 - 14	4
MW-8	21.5	6.5 - 21.5	3
MW-9	19.5	6 - 19.5	3
MW-13	23	8 - 23	3
MW-10	23	6 - 23	3
MW-11	19.5	6 - 19.5	3
MW-14	23	8 - 23	3
MW-15	23	8 - 23	3
SP-1	21	20 - 21	2
SP-2	19	18 - 19	2
V-4	15	6 - 15	2
V-5	11	6 - 11	2

Table 2
Step Discharge Test Data

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Step Number	Discharge Rate (gpm)	Duration of of Step (minutes)	Maximum Drawdown (feet)	Specific Capacity (gpm/ft)
Well E-1A				
1	0.5	40	1.58	0.32
2	1	30	2.15	0.47
3	2	60	5.80	0.34
4	4	8	>11	NA
Well MW-10				
1	0.5	30	0.33	1.5
2	1	40	0.41	2.4
3	2	60	0.85	2.4
4	4	90	3.66	1.1
5	6	10	>11.23	NA

gpm = Gallons per minute
NA = Not applicable



QUADRANGLE
LOCATION

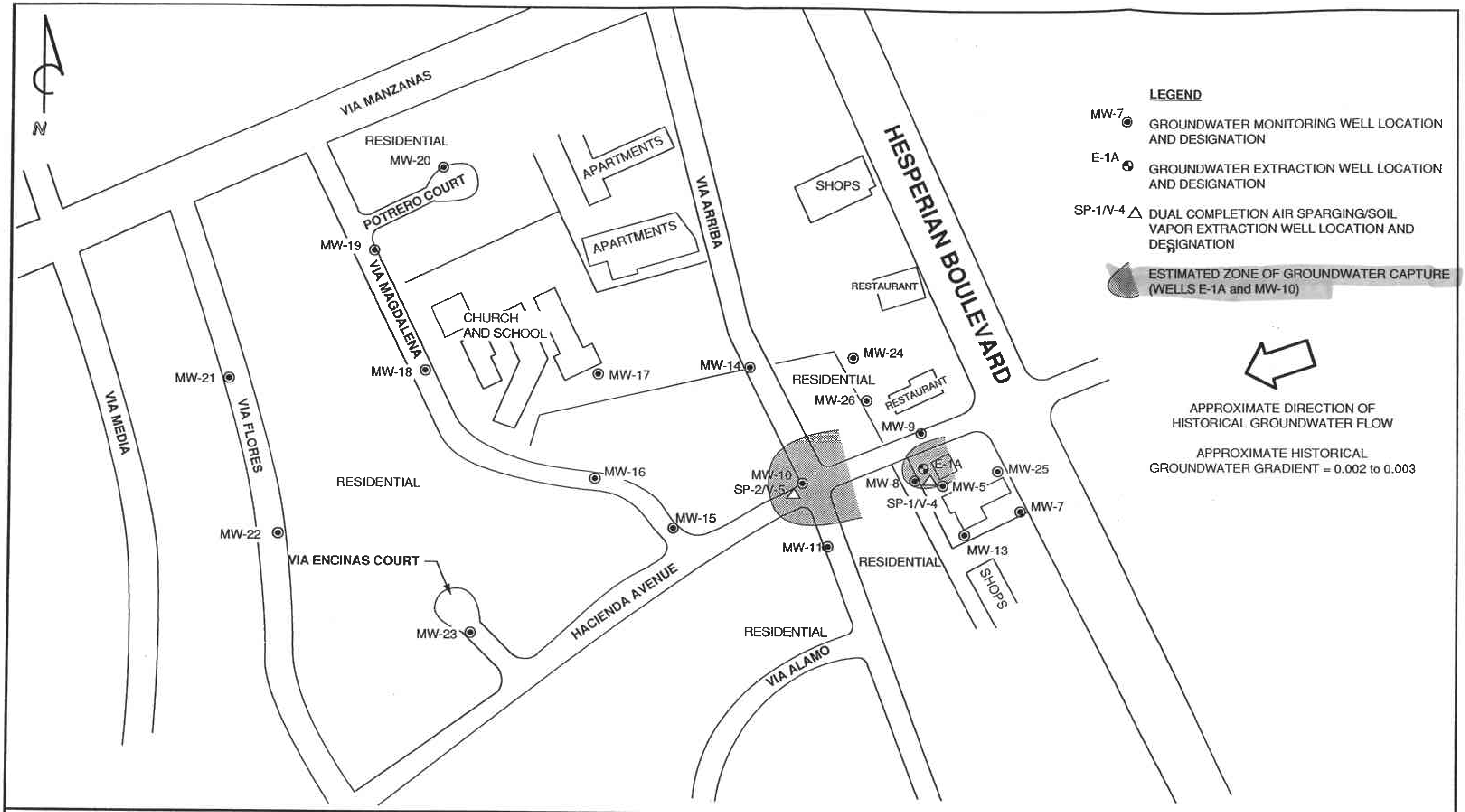
REFERENCES:

USGS 7.5 MIN. TOPOGRAPHIC MAP
TITLED: HAYWARD, CALIFORNIA
DATED: 1959 REVISED: 1980
TITLED: SAN LEANDRO, CALIFORNIA
DATED: 1959 REVISED: 1980

SCALE

2000 0 2000 FEET

PACIFIC ENVIRONMENTAL GROUP, INC.	**ARCO SERVICE STATION 0608** 17601 Hesperian Boulevard San Lorenzo, California	FIGURE: 1
	SITE LOCATION MAP	PROJECT: 330-06.22



PACIFIC
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GROUP, INC.

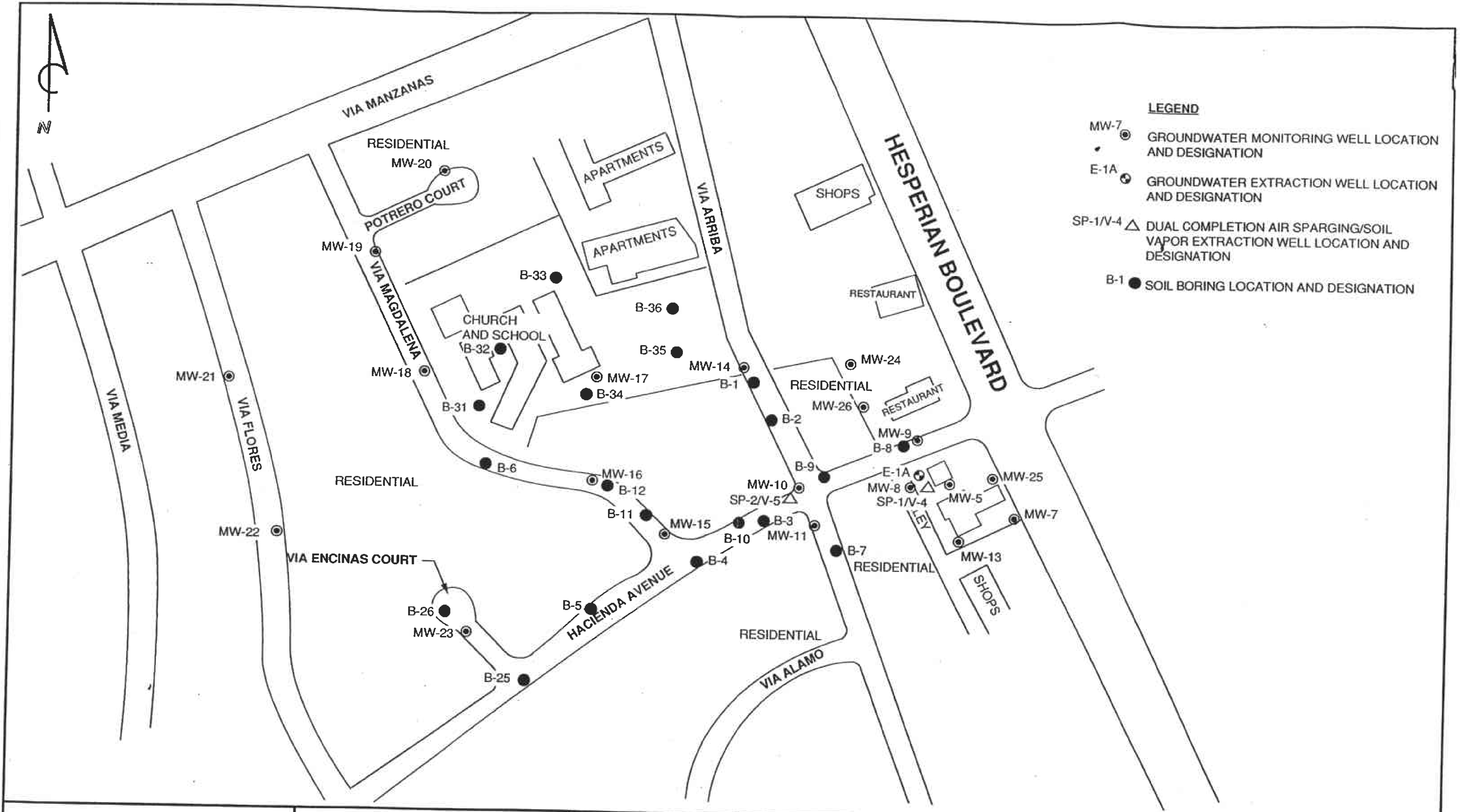
APPROXIMATE SCALE

0 150 300 FEET

ARCO SERVICE STATION 0608
17601 Hesperian Boulevard
San Lorenzo, California

WELL LOCATION MAP

FIGURE:
2
PROJECT:
330-06.22



PACIFIC
ENVIRONMENTAL
GROUP, INC.

APPROXIMATE SCALE
0 150 300 FEET

ARCO SERVICE STATION 0608
17601 Hesperian Boulevard
San Lorenzo, California

SOIL BORING LOCATON MAP

FIGURE:
3
PROJECT:
330-06.22

ATTACHMENT A

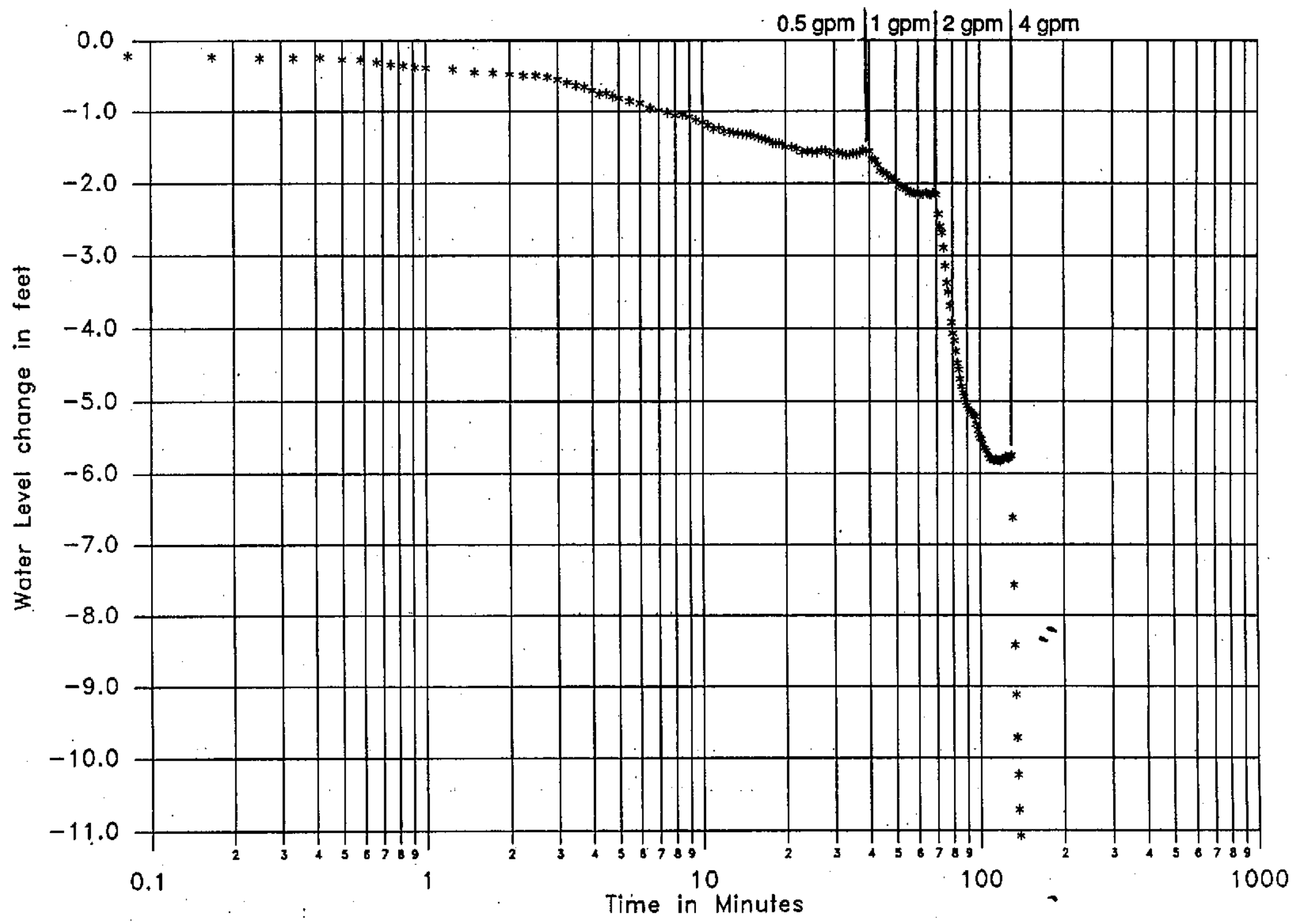
AQUIFER TEST DATA AND FIGURES

Table A-1
Pump Test Data Summary

ARCO Service Station 0608
17601 Hesperian Boulevard
San Lorenzo, California

Well Identification	Step Number	Discharge Rate (gpm)	Duration of Step (minutes)	Drawdown (feet)	Specific Capacity (gpm/feet)
E-1A	1	0.5	40	1.6	0.31
	2	1	30	2.2	0.45
	3	2	60	5.8	0.34
	4	4	10	>11.07	NA
E-1A	Constant Discharge	2	480	5.4	0.37
MW-10	1	0.5	30	0.30	1.67
	2	1	40	0.38	2.63
	3	2	60	0.83	2.41
	4	4	90	3.5	1.14
	5	6	10	>11.22	NA
MW-10	Constant Discharge	4	480	3.8	1.05

gpm = Gallons per minute
NA = Not available



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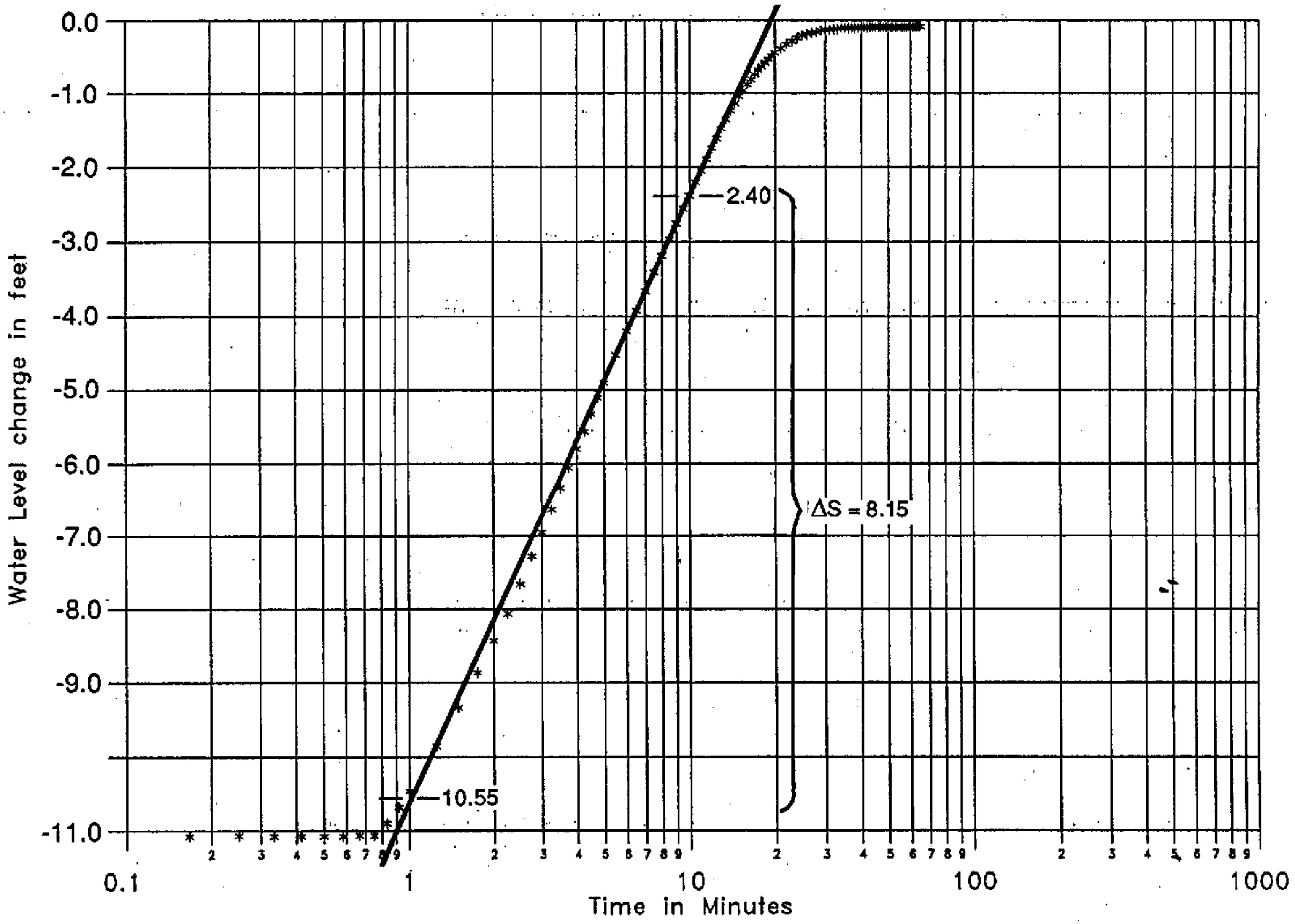
STEP DISCHARGE TEST IN WELL E-1A

FIGURE:
A-1
PROJECT:
330-06.23



JACOB:

$T = \frac{264Q}{\Delta s}$

$= \frac{264\ (4gpm)}{8.15}$

≈130 gpd/ft

≈ 17.4 ft^2/d

K = T/B

B = 10'

K = 1.74 ft/d

= 6 x 10^{-4} cm/sec

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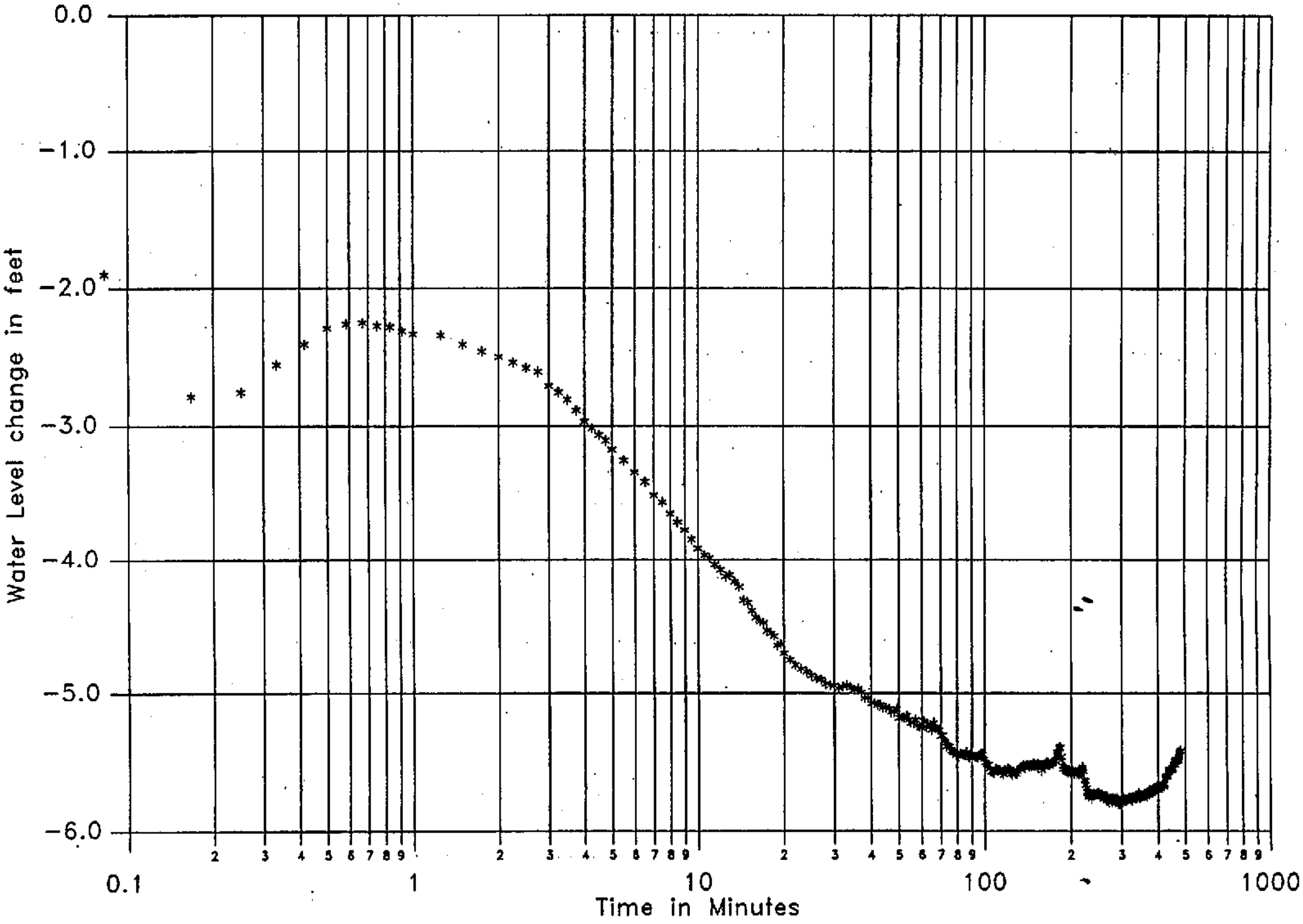
STEP DISCHARGE TEST RECOVERY IN WELL E-1A

FIGURE:
A-2
PROJECT:
330-06.23



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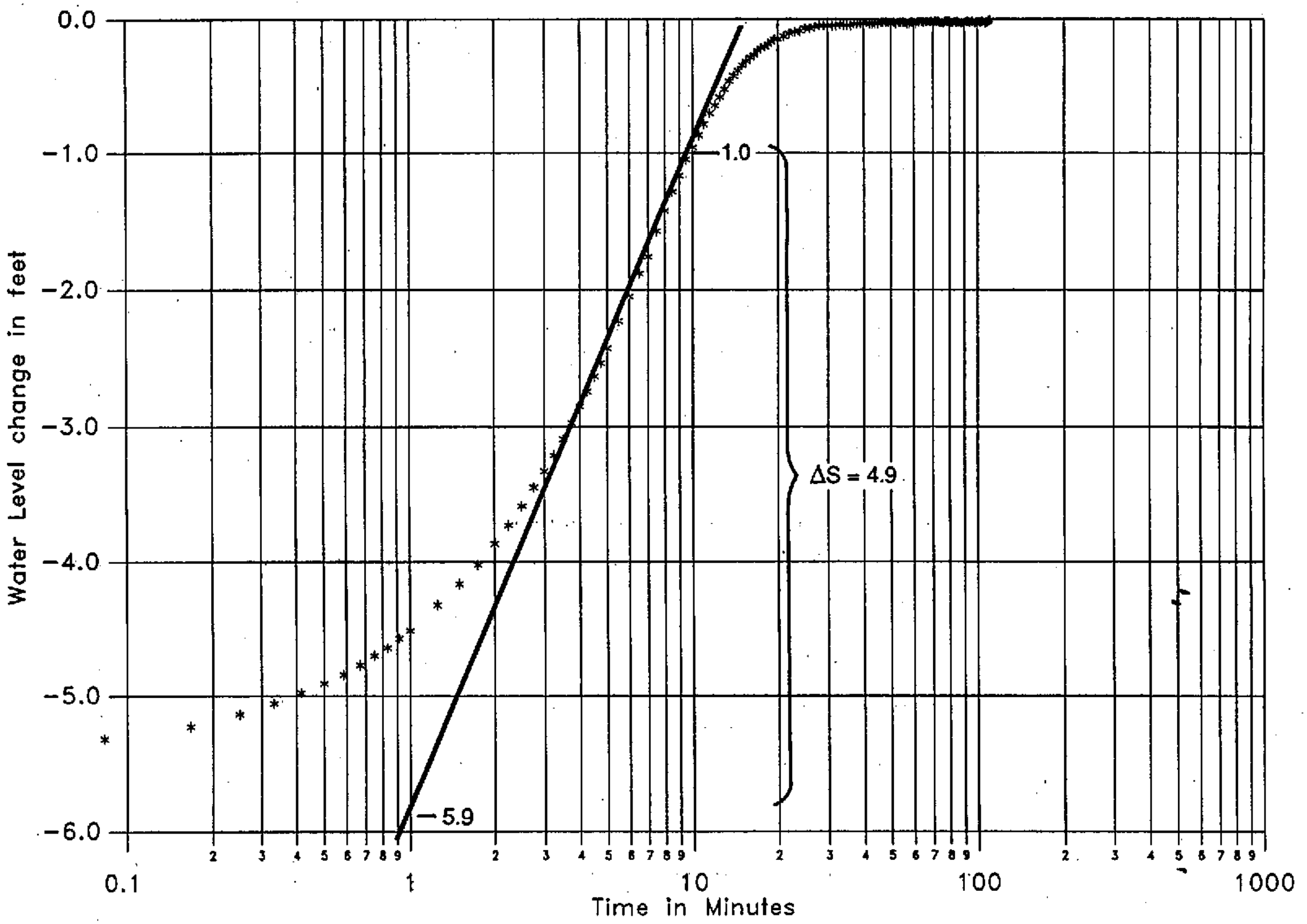
CONSTANT DISCHARGE TEST IN WELL E-1A

FIGURE:
A-3
PROJECT:
330-06.23



JACOB:

$T = \frac{264Q}{\Delta s}$

$= \frac{264\ (2\ gpm)}{4.9}$

= 100 gpd/ft

= 13 ft^2/d

K = T/B

B = 10'

K = 1.3 ft/d

= 4.7 E-4 cm/sec

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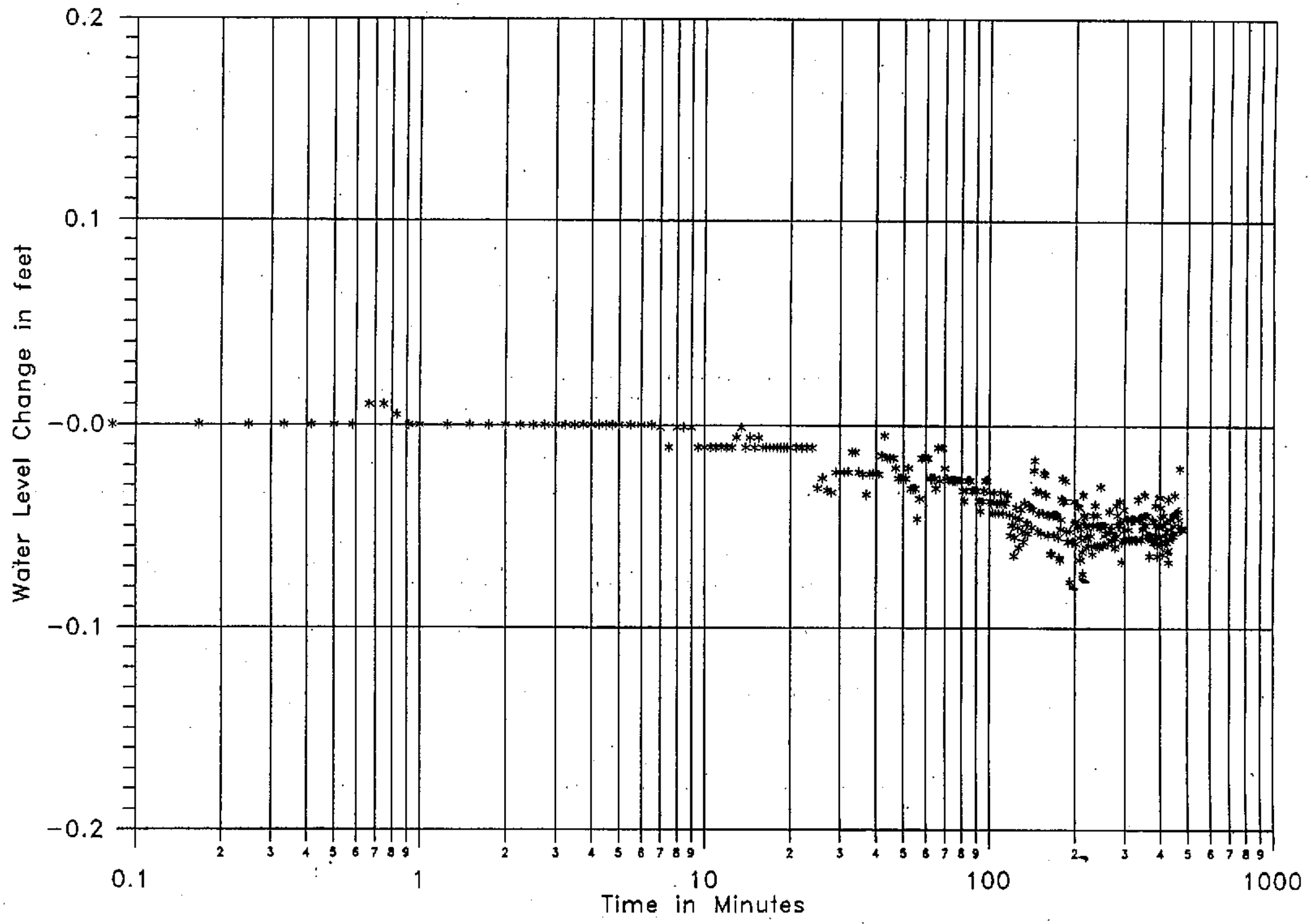
CONSTANT DISCHARGE TEST RECOVERY PLOT IN WELL E-1A

FIGURE:
A-4
PROJECT:
330-06.23



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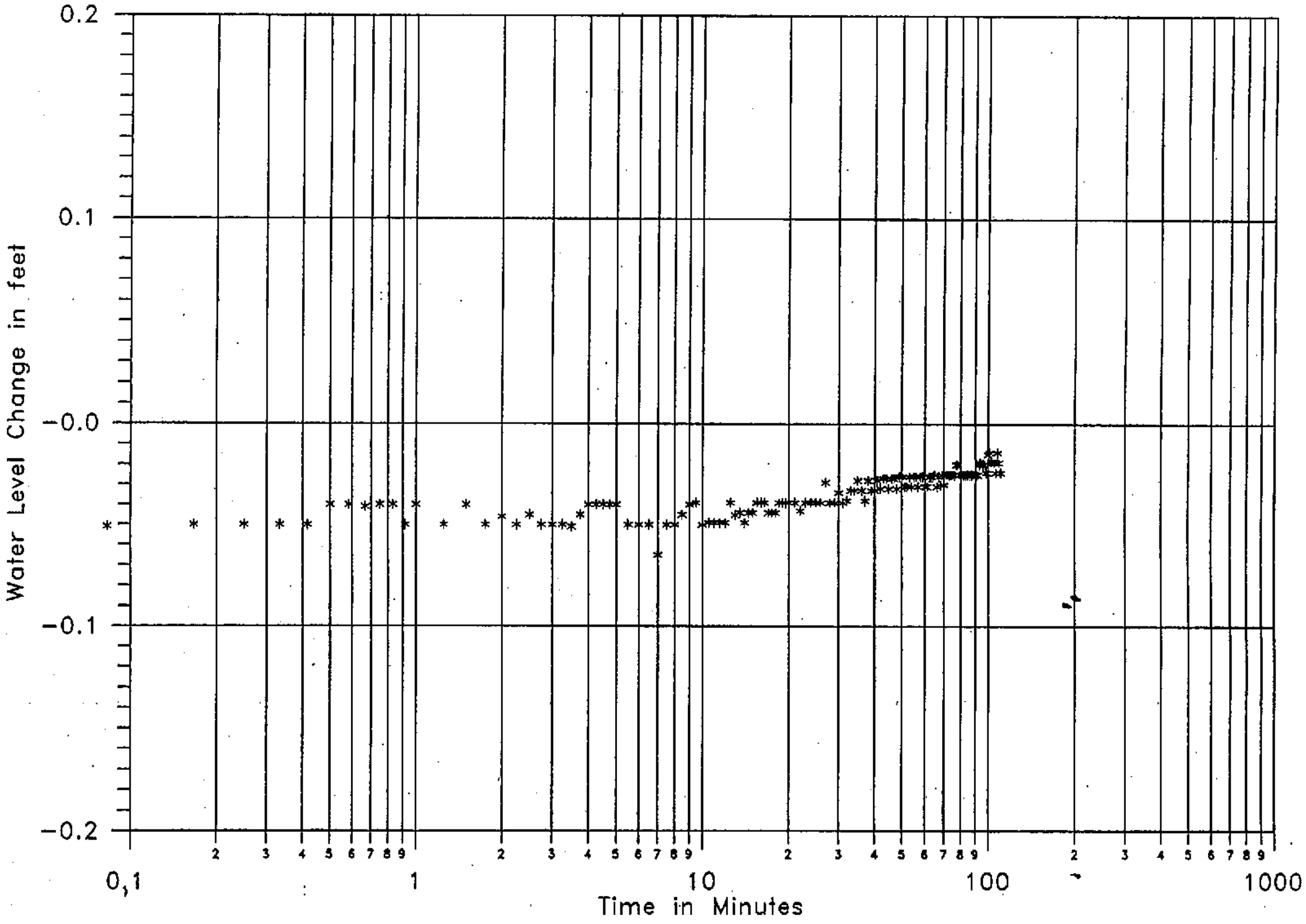
DRAWDOWN IN WELL V-4 DURING THE CONSTANT DISCHARGE TEST IN WELL E-1A

FIGURE:
A-5
PROJECT:
330-06.23



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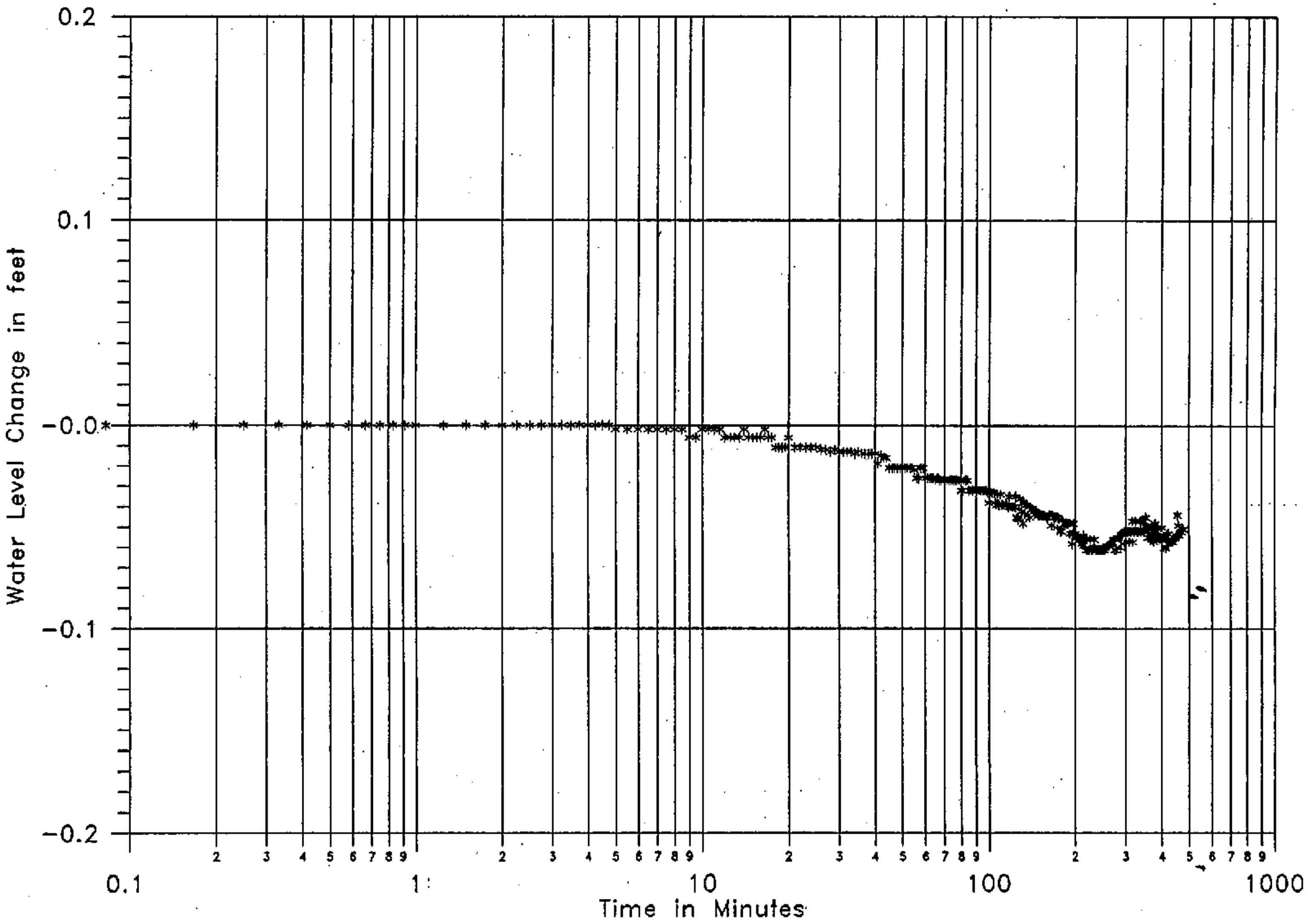
DRAWDOWN IN WELL V-4 DURING THE CONSTANT DISCHARGE TEST RECOVERY IN WELL E-1A

FIGURE:
A-6
PROJECT:
330-06.23



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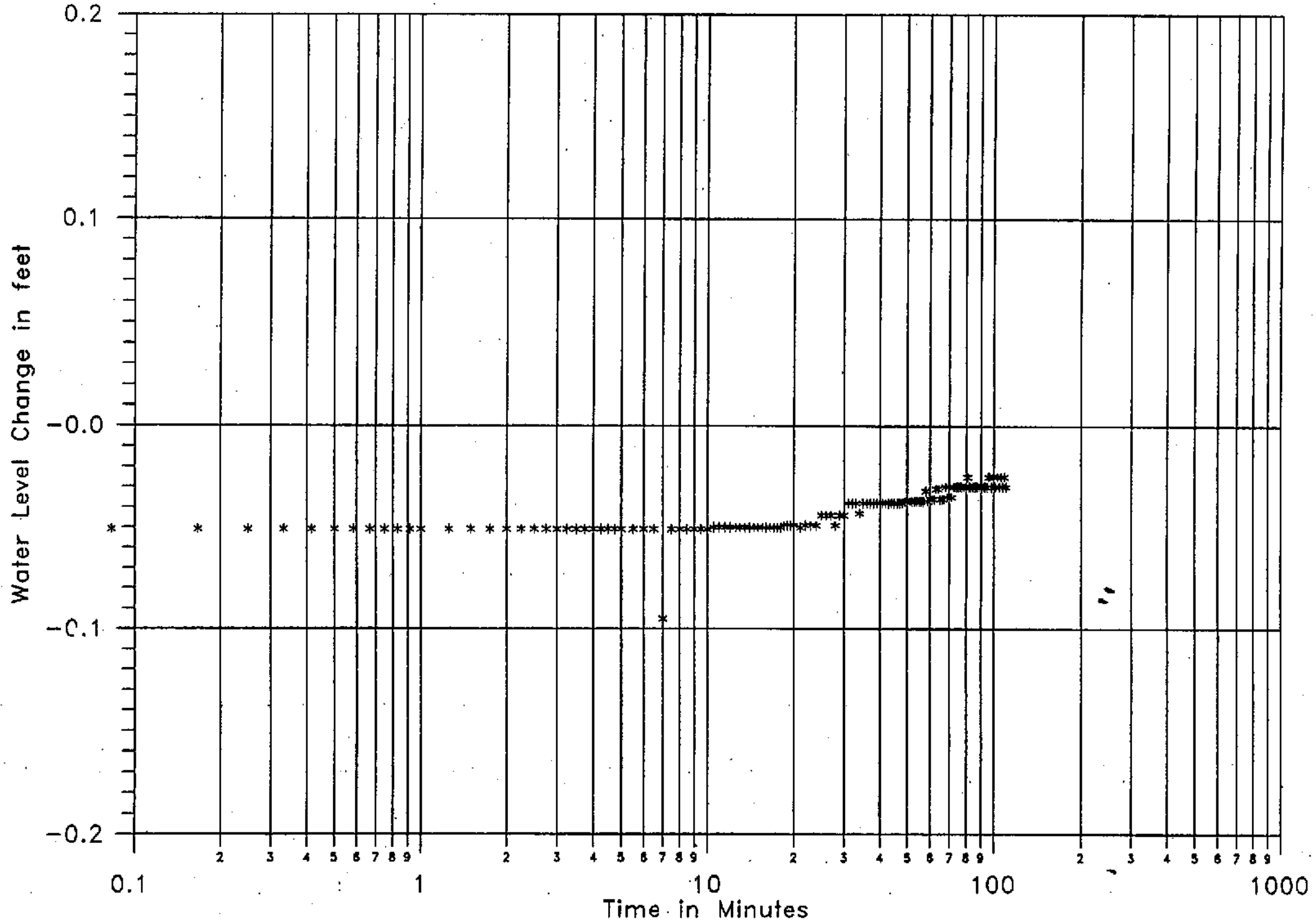
DRAWDOWN IN WELL MW-5 DURING THE CONSTANT DISCHARGE TEST RECOVERY IN WELL E-1A

FIGURE:
A-7
PROJECT:
330-06.23



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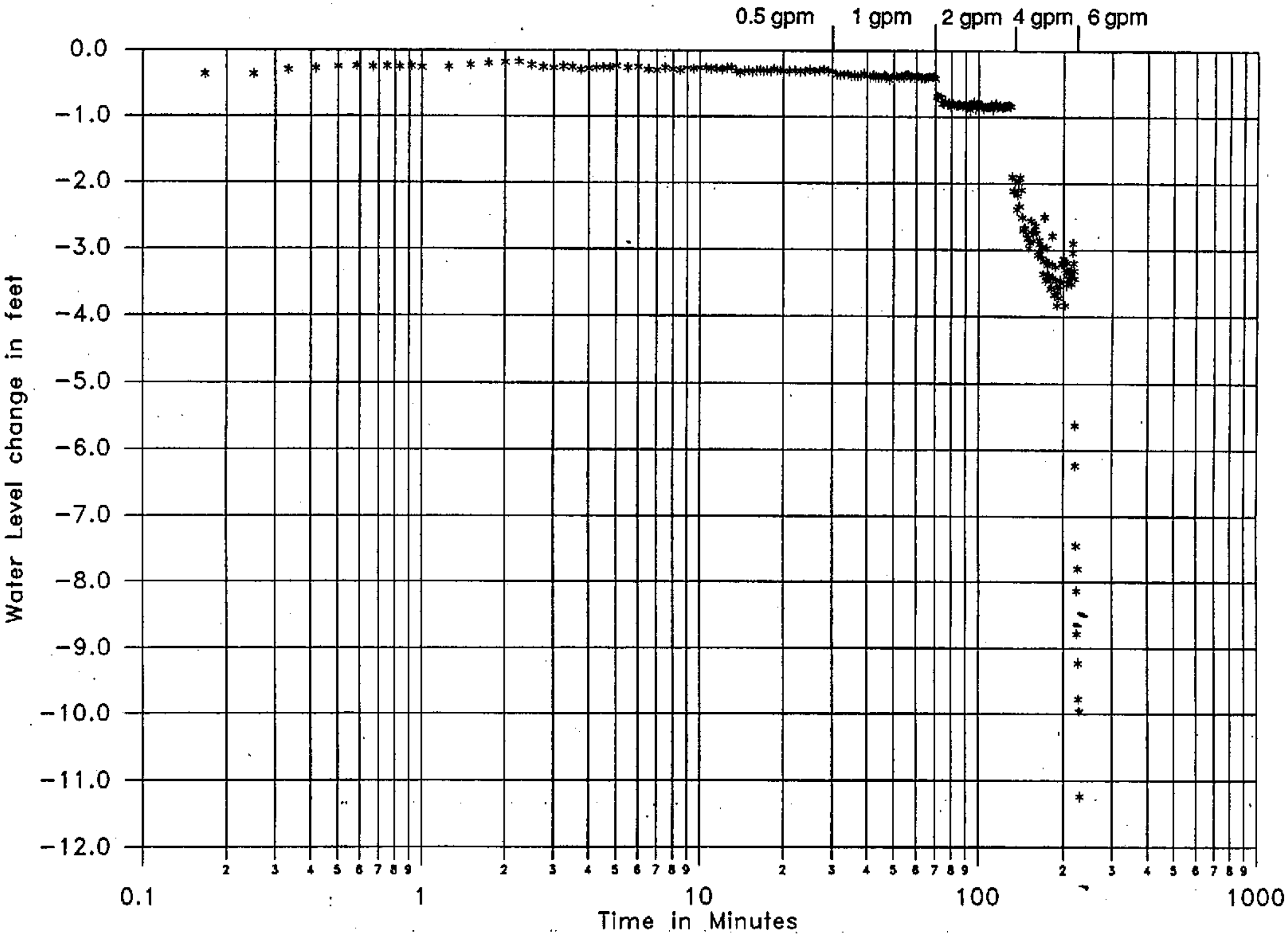
DRAWDOWN IN WELL MW-5 DURING THE CONSTANT DISCHARGE TEST RECOVERY IN WELL E1-A

FIGURE:
A-8
PROJECT:
330-06.23



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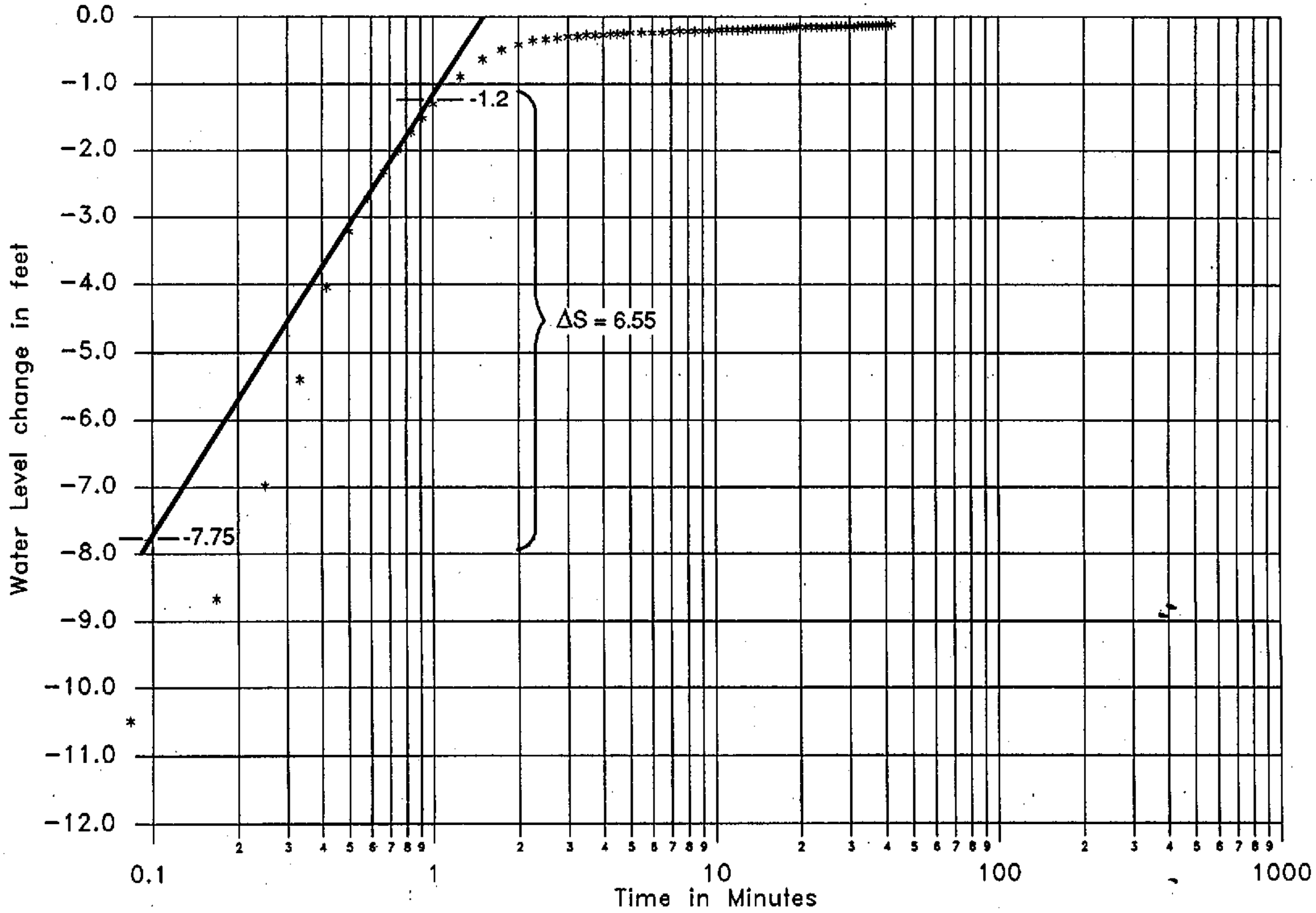
San Lorenzo, California

STEP DISCHARGE TEST IN WELL MW-10

FIGURE:
A-9
PROJECT:
330-06.23



JACOB:

$$T = \frac{264Q}{\Delta s}$$

$$= \frac{264\ (6)}{(6.55)}$$

= 242 gpd/ft

=35 gpd/ft ^{2}

K = T/B
B = 7'
K = 4.6 ft/d

= 1.6 E-3 cm/sec

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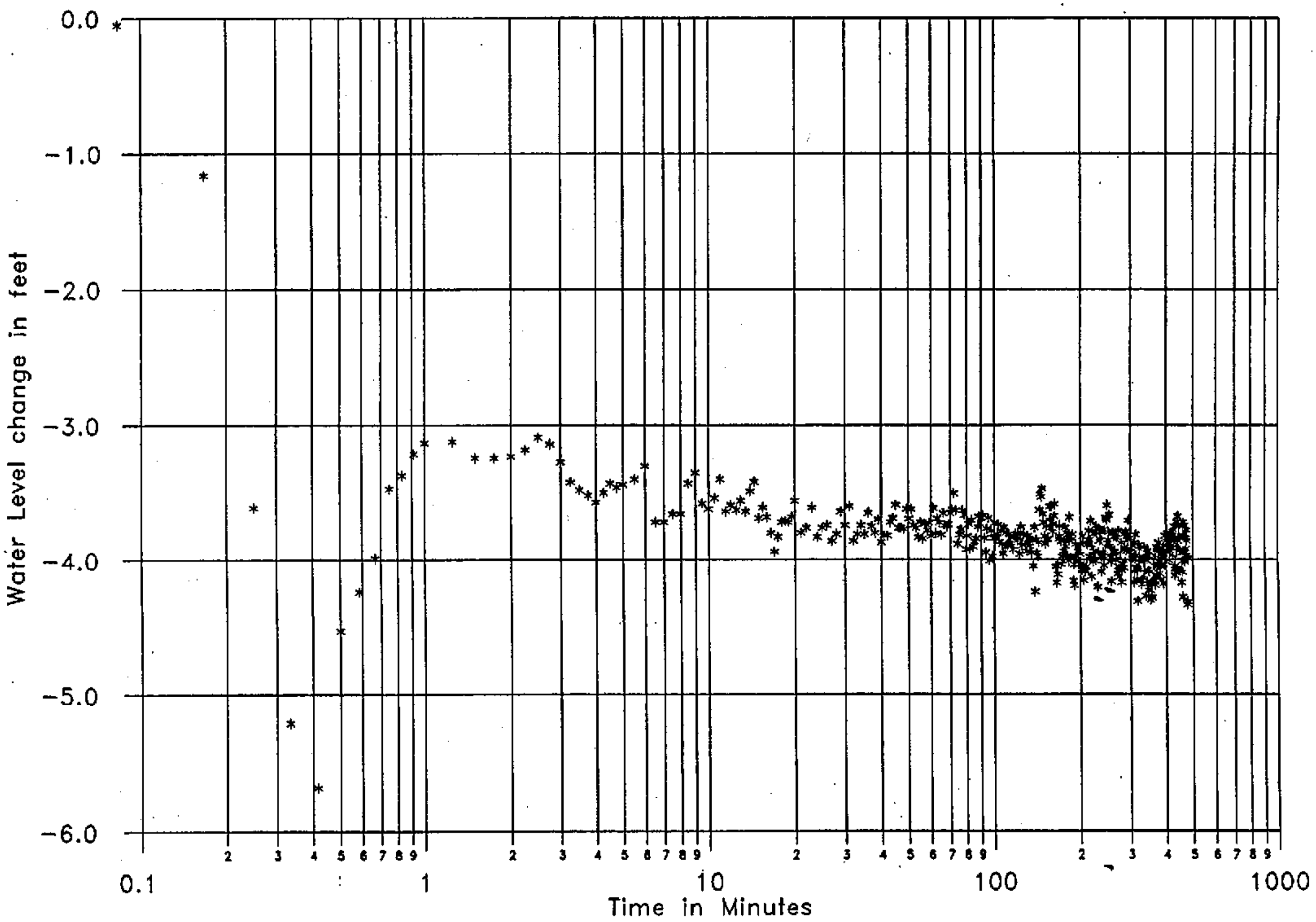
STEP DISCHARGE TEST RECOVERY IN WELL MW-10

FIGURE:
A-10
PROJECT:
330-06.23



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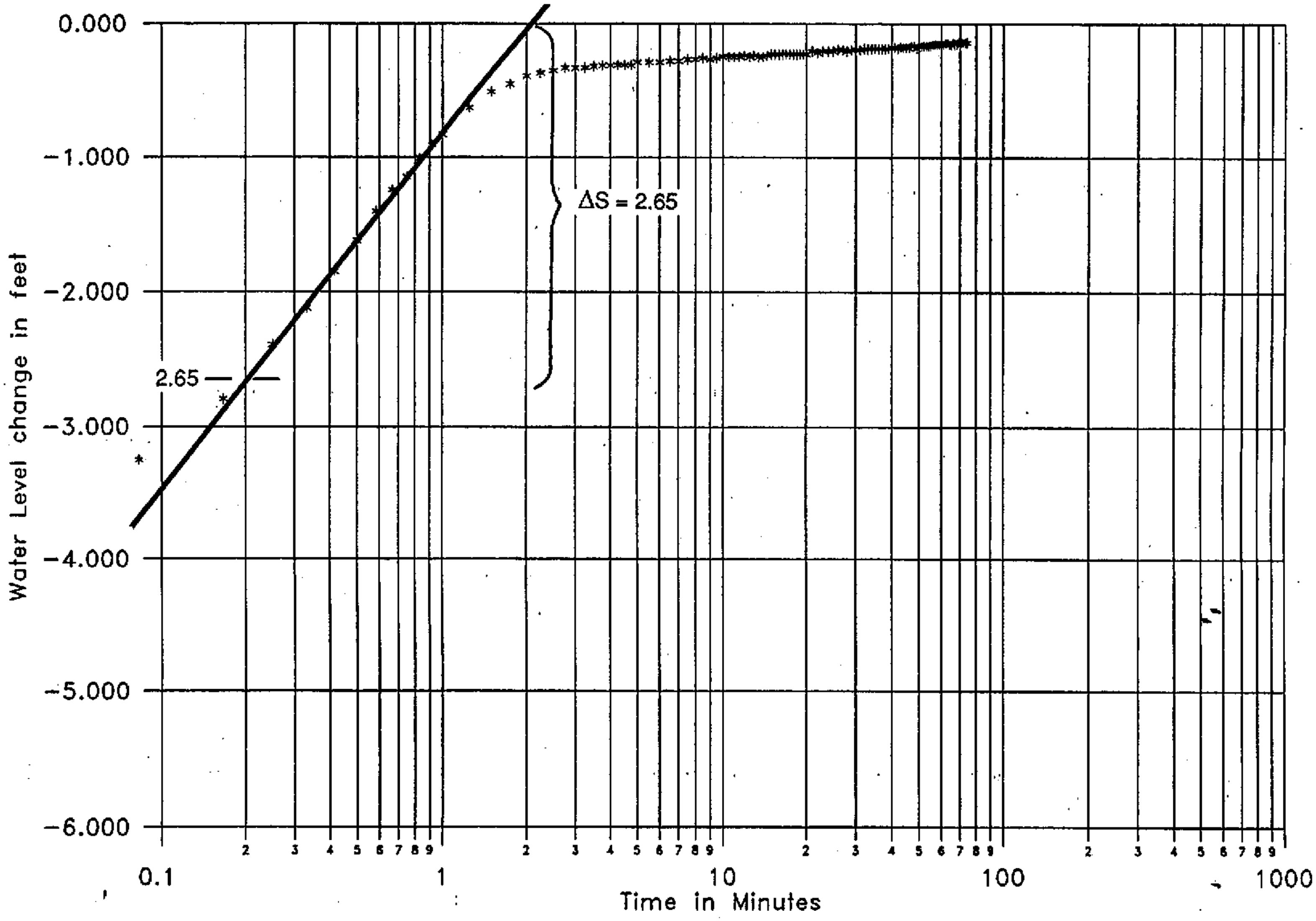
CONSTANT DISCHARGE TEST IN WELL MW-10

FIGURE:
A-11
PROJECT:
330-06.23



JACOB:

$T = \frac{264Q}{\Delta s}$

$= \frac{264\ (4)}{2.65}$

= 400 gpd/ft

$= 53\ ft^2/d$

K = T/B

B = 7'

K = 7.6 ft/d

= 2.7 E-3 cm/sec

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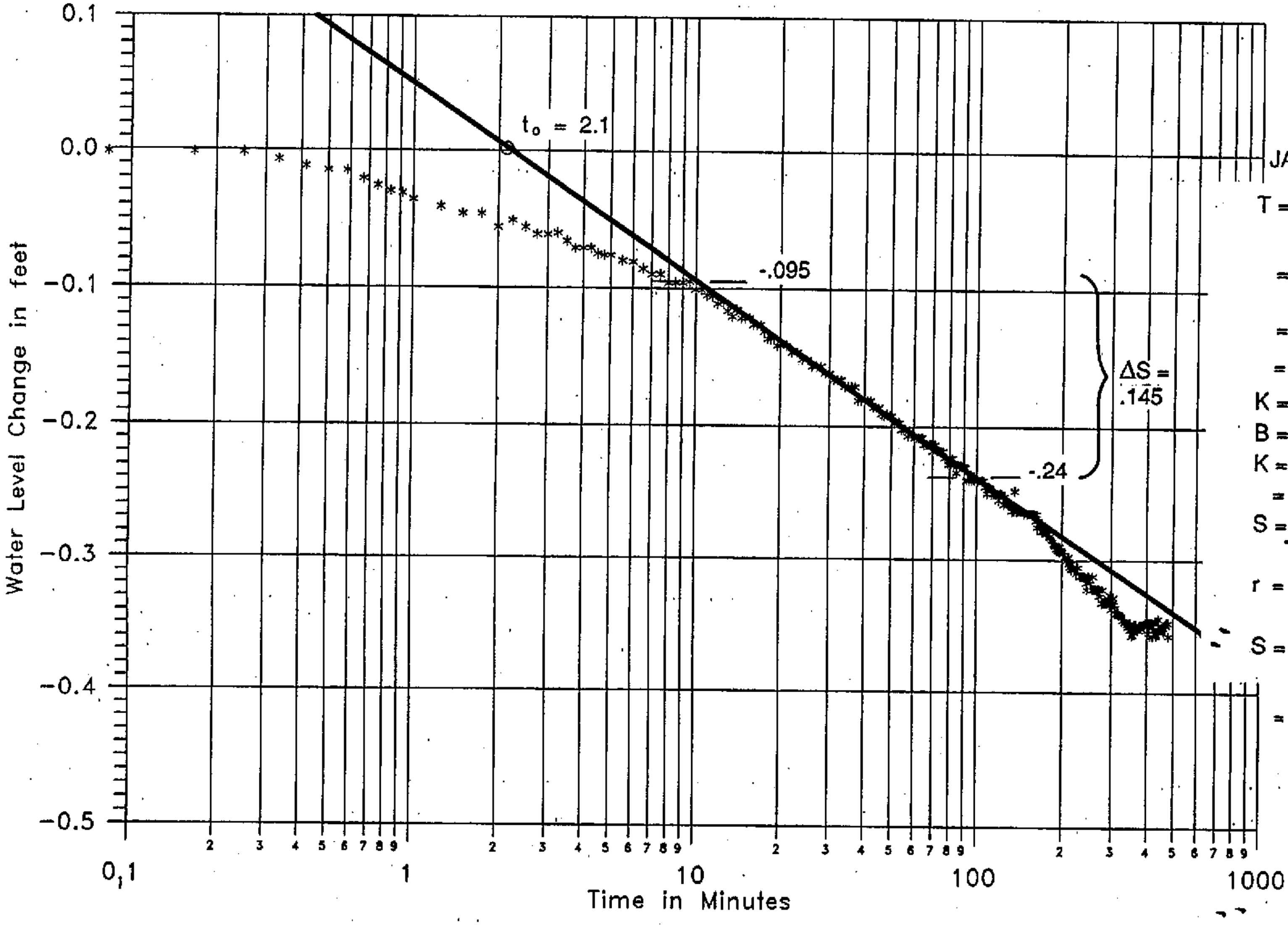
San Lorenzo, California

CONSTANT DISCHARGE TEST RECOVERY IN WELL MW-10

FIGURE:
A-12
PROJECT:
330-06.23



JACOB:

$$T = \frac{264Q}{\Delta s}$$

$$= \frac{264\ (4)}{(.145)}$$

= 7.5 E3 gpd/ft

= 970 ft^2/d

K = T/B

B = 7'

K = 140 ft/d

= 5 E-2 cm/sec

$$S = \frac{2.25\ T\ t_o}{r^2}$$

r = 16' t_o = 2.1 min

$$S = \frac{2.25\ (970\ \text{ft}^2/\text{d})\ \left(\frac{2.1}{1440}\text{d}\right)}{(16\ \text{ft})^2}$$

= 1.2 E-2 (no units)

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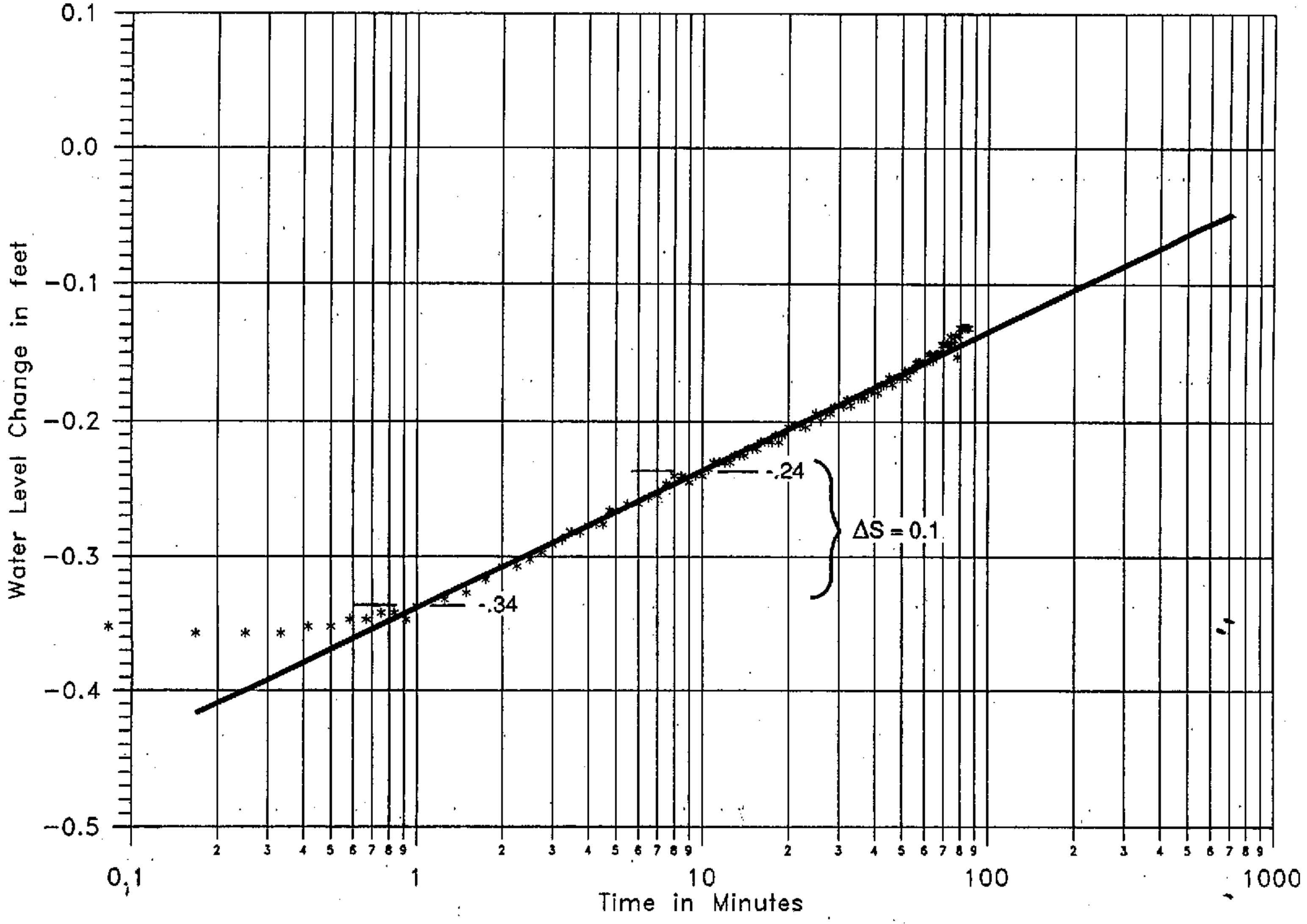
DRAWDOWN IN WELL SP-2 DURING THE CONSTANT DISCHARGE TEST IN WELL MW-10

FIGURE:
A-13
PROJECT:
330-06.23



JACOB:

$$T = \frac{264Q}{\Delta s}$$

$$= \frac{264\ (4)}{0.1}$$

= 1 E4 gpd/ft

= 1,400 ft^2/d

K = T/B

B = 7'

K = 200 ft/d

= 7 E-2 cm/sec

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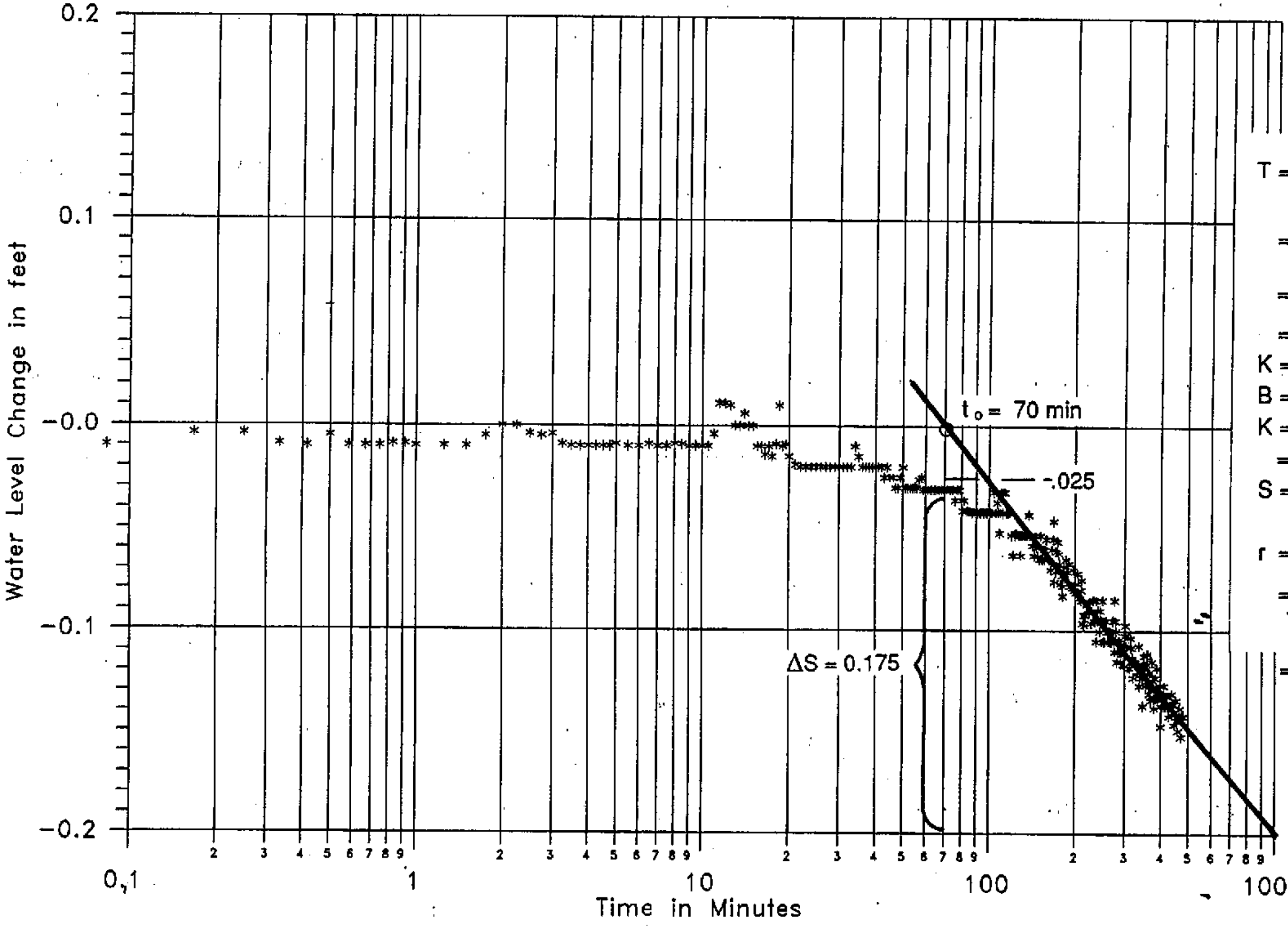
DRAWDOWN IN WELL SP-2 DURING THE CONSTANT DISCHARGE RECOVERY IN WELL MW-10

FIGURE:
A-14
PROJECT:
330-06.23



JACOB:

$$T = \frac{264Q}{\Delta s}$$

$$= \frac{264\ (4)}{0.175}$$

= 6 E3 gpd/ft

$= 806\ ft^2/d$

K = T/B

B = 7'

K = 115 ft/d

= 4 E-2 cm/sec

$$S = \frac{2.25\ T\ t_0}{r^2}$$

$r = 16'\ t_0 = 70$ min

$$= \frac{2.25\ (806\ ft^2/d)\left(\frac{t_o}{1,440}\ d\right)}{(16\ ft)^2}$$

= .34

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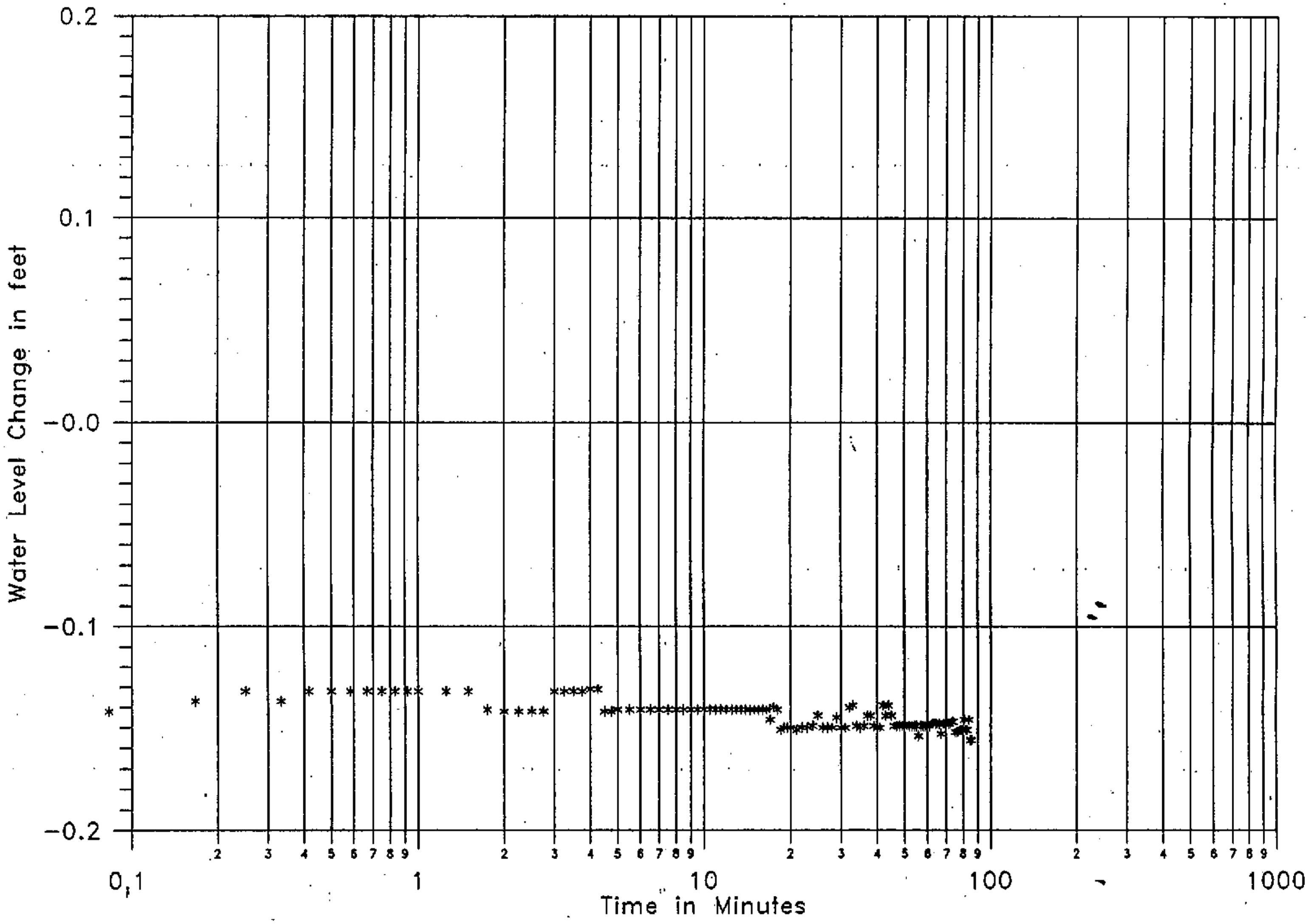
DRAWDOWN IN WELL V-5 DURING THE CONSTANT DISCHARGE TEST IN WELL MW-10

FIGURE:
A-15
PROJECT:
330-06.23



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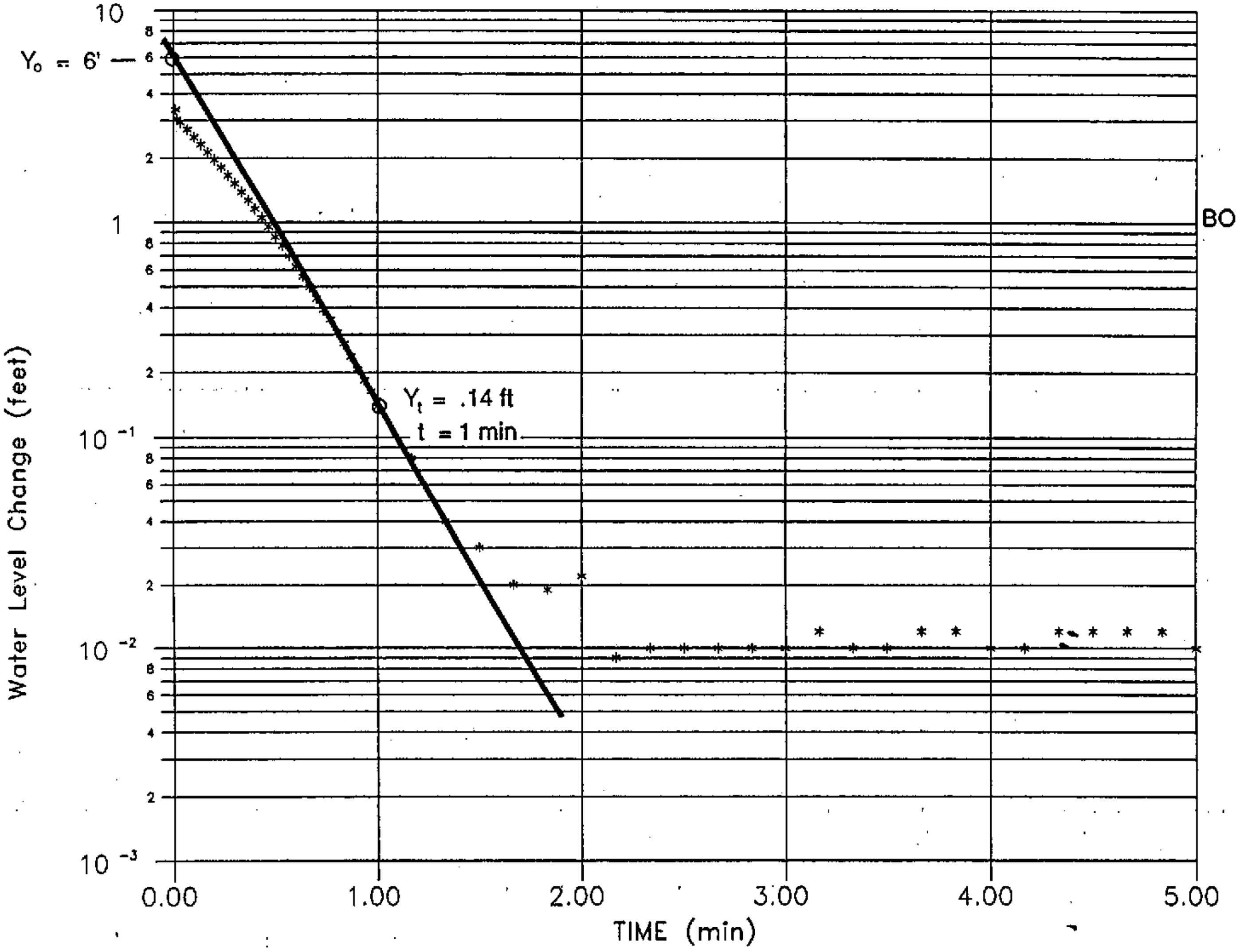
DRAWDOWN IN WELL V-5 DURING THE CONSTANT DISCHARGE RECOVERY IN WELL MW-10

FIGURE:
A-16
PROJECT:
330-06.23



BOWER PARAMETERS
(equation in text)

r_c = 0.125 ft

r_w = 0.33 ft

D = 15 ft

L = 15 ft

Y_o = 6 ft

Y_t = 0.14 ft

t = 1 min

H = 15 ft

C = 2.5

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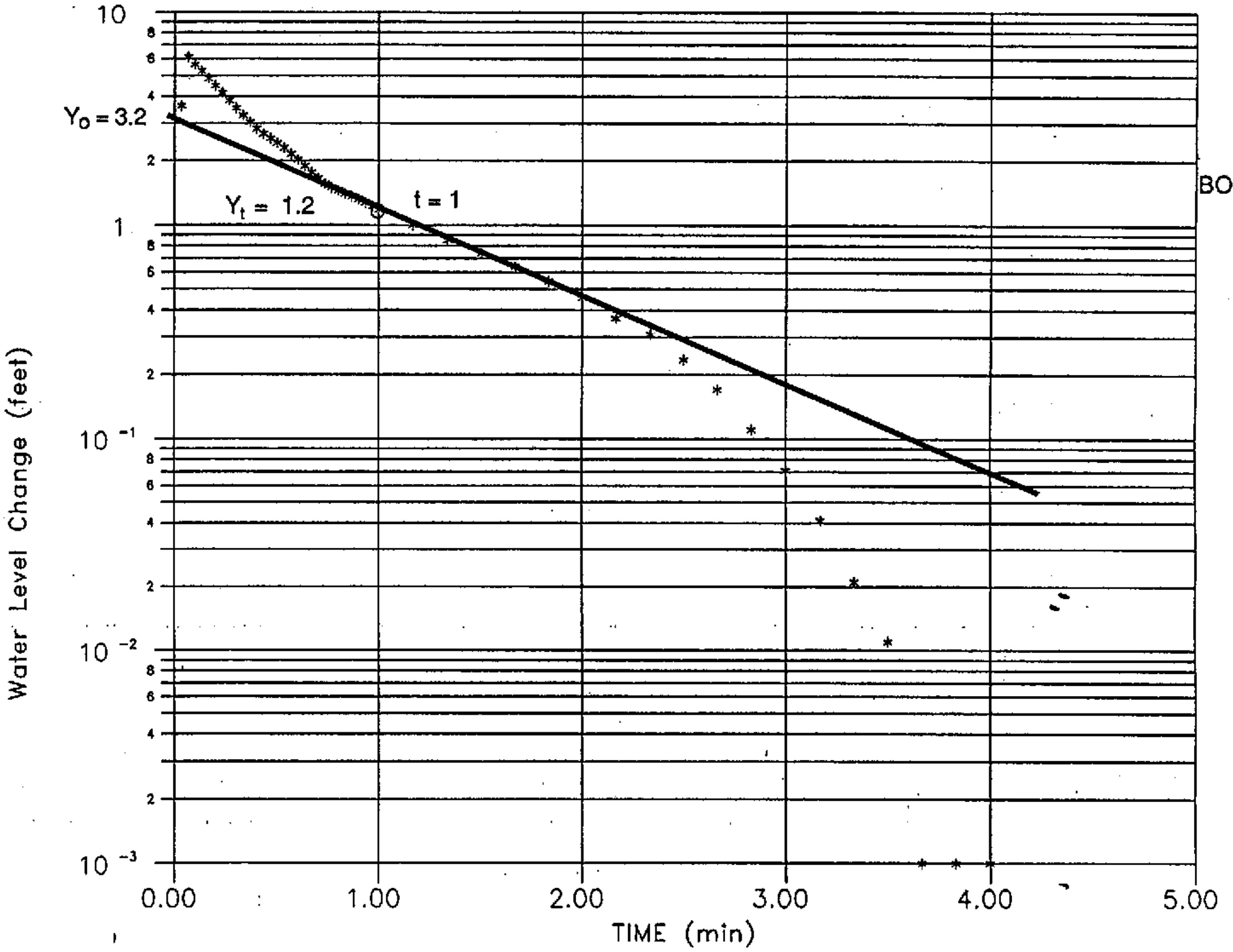
WELL MW-14 FALLING HEAD TEST #1

FIGURE:
A-17
PROJECT:
330-06.23



BOWER PARAMETERS
(equation in text)

r_c = 0.125 ft

r_w = 0.33 ft

D = 15 ft

L = 15 ft

Y_o = 3.2 ft

Y_t = 1.2 ft

t = 1 min

H = 15 ft

C = 2.5

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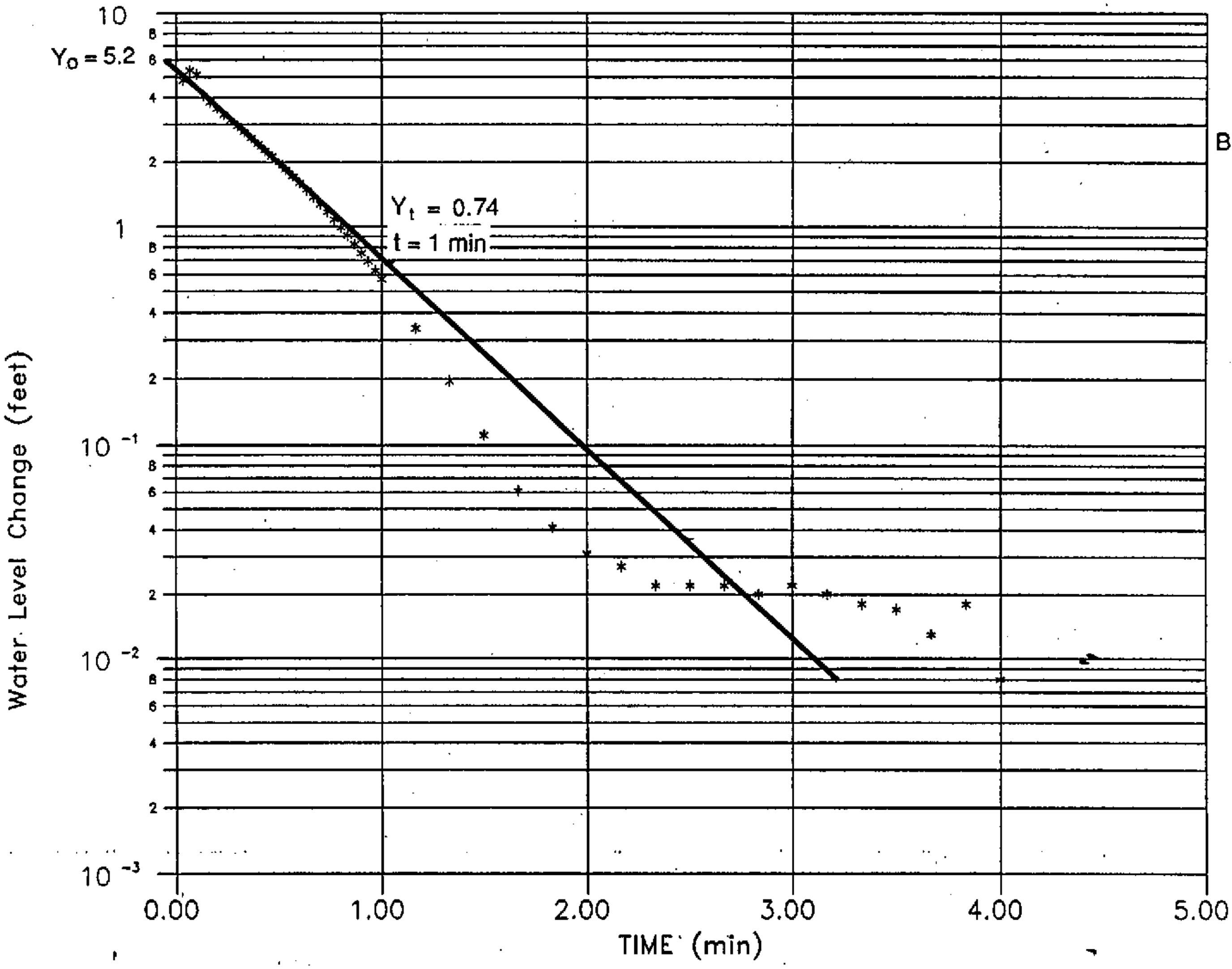
WELL MW-14 RISING HEAD TEST #1

FIGURE:
A-18
PROJECT:
330-06.23



BOWER PARAMETERS
(equation in text)

$r_c = 0.125$ ft

$r_w = 0.33$ ft

D = 15 ft

L = 15 ft

$Y_o = 5.2$ ft

$Y_t = 0.74$ ft

t = 1 min

H = 15 ft

C = 2.5

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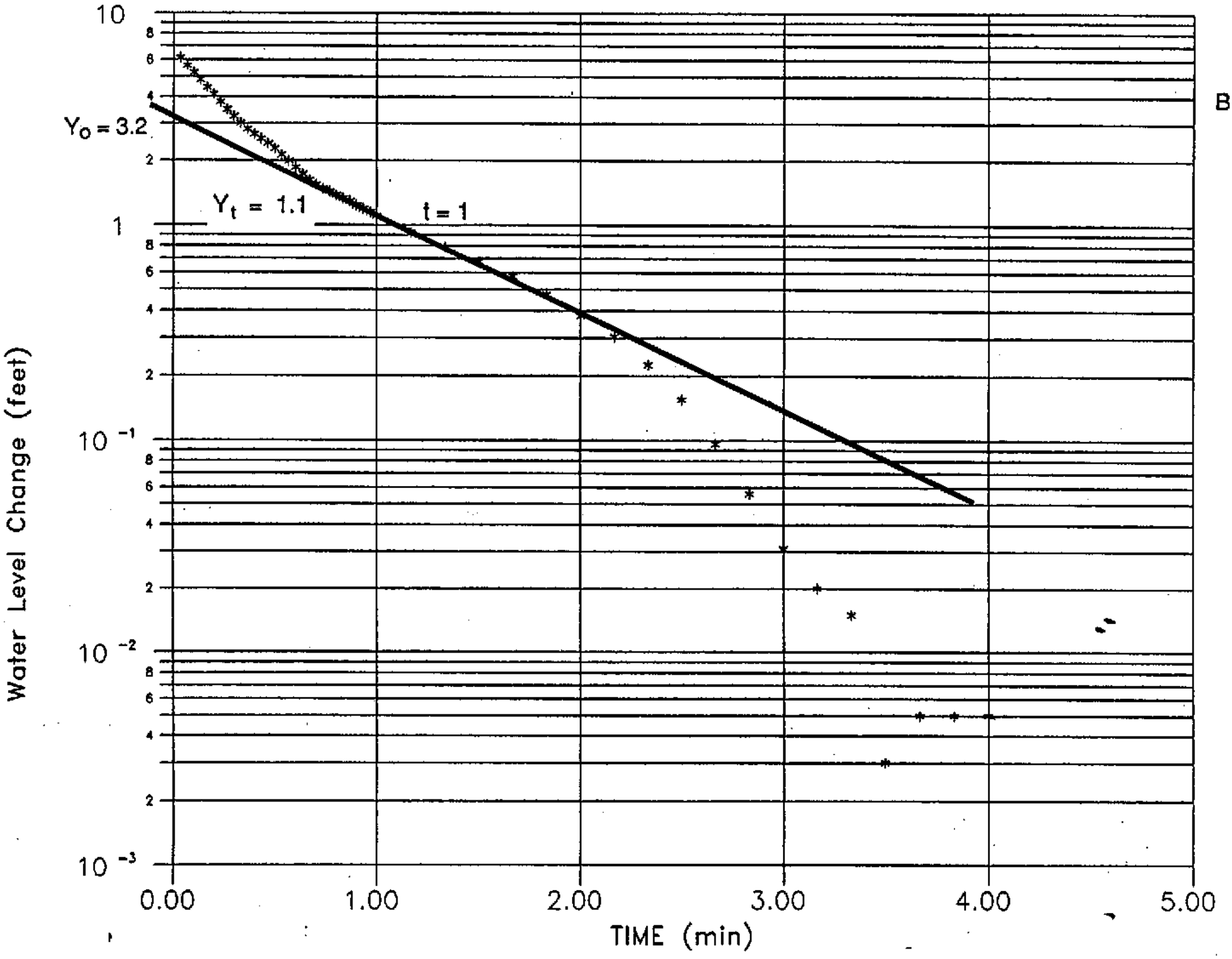
WELL MW-14 FALLING HEAD TEST #2

FIGURE:
A-19
PROJECT:
330-06.23



BOWER PARAMETERS
(equation in text)

$r_c = 0.125$ ft

$r_w = 0.33$ ft

D = 15 ft

L = 15 ft

$Y_o = 3.2$ ft

$Y_t = 1.1$ ft

t = 1 min

H = 15 ft

C = 2.5

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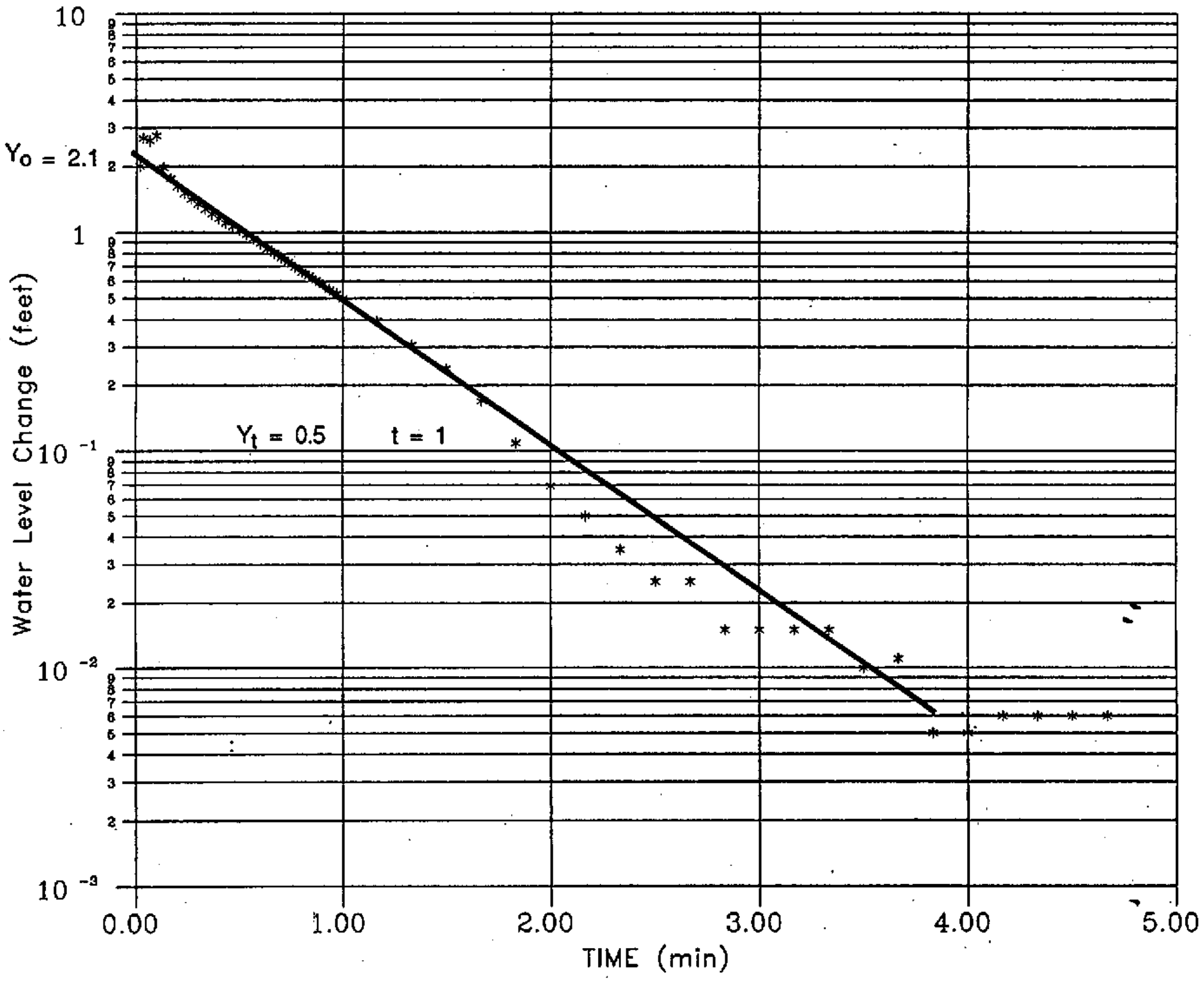
San Lorenzo, California

WELL MW-14 RISING HEAD TEST #2

FIGURE:
A-20
PROJECT:
330-06.23



BOWER PARAMETERS
(equation in text)

r_c = 0.125 ft

r_w = 0.33 ft

D = 11 ft

L = 11 ft

Y_o = 2.1 ft

Y_t = 0.5 ft

t = 1 min

H = 11 ft

C = 2

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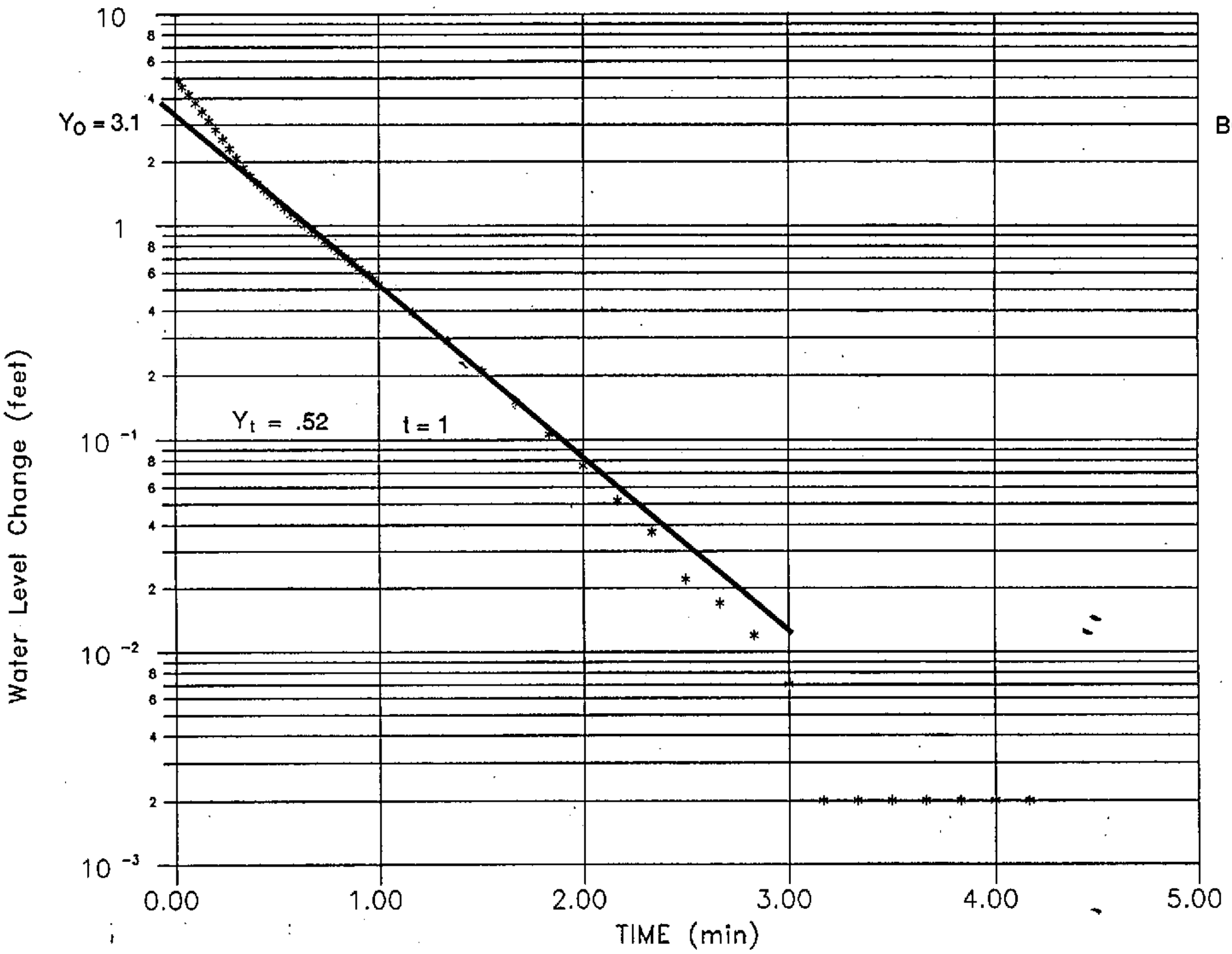
WELL MW-23 FALLING HEAD TEST

FIGURE:
A-21
PROJECT:
330-06.23



BOWER PARAMETERS
(equation in text)

$r_c = 0.125$ ft

$r_w = 0.33$ ft

D = 11 ft

L = 11 ft

$Y_o = 3.1$ ft

$Y_t = 0.52$ ft

t = 1 min

H = 11 ft

C = 2

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WELL MW-23 RISING HEAD TEST

FIGURE:
A-22
PROJECT:
330-06.23

ATTACHMENT B

AIR SPARGE TEST FIELD DATA

ON-SITE SPARGE TEST

WELL	DTW	TIME	DISTANCE
V-4	10.95	12:45	0
AS-1	10.92	"	<1
MW-5	11.36	"	16
MW-8	9.98	"	33

STARTING PRESSURE

DT SCREEN 20'
DTW 10.98
9.08' ~> 5psi

AIR COMPRESSOR @ 20 psi
HELIUM @ 100psi
Q = <10

PACIFIC ENVIRONMENTAL GROUP, INC.

Project No: 330-06.19	Figure No: 1/3	Date: 5/4/93	Drawn By: KW

Title: ON-SITE SPARGE

WELL	TIME	DO	FID	HE
MW-5	1:30	METER BROKEN	4.5	0.00
	1:35		6	0.00
	1:40		9.5	0.00
	1:45		8.0	0.00
	1:50		6.0	0.00
	1:55		NA	0.00
	2:00		4.0	0.00
	2:05		NA	0.00
	2:10		4.5	0.00
	2:15		NA	0.00
	2:20		30	0.00
	2:25		+10000	0.00
	2:30		+10000	0.00
	2:35		+10000	0.00
V-4	1:30		100	0
	1:35		4000	0.26
	1:40		7000	0.50
	1:45		1750	0.66
	1:50		2100	0.69
	1:55		NA	NA
	2:00		1750	0.97
	2:05		2000	0.25
	2:10		NA	NA
	2:15		NA	NA
	2:20		+10000	5.3
	2:25		+10000	NA
	2:30		+10000	4.3
	2:35		+10000	4.9

WELL	TIME	FID	HE
MW-8	1:30	BKG	0.00
	1:35	"	0.00
	1:40	"	0.00
	1:45	"	0.00
	1:50	"	0.00
	1:55	"	0.00
	2:00	"	0.00
	2:05	"	0.00
	2:10	"	0.00
	2:15	"	0.00
	2:20	"	0.00
	2:25	"	0.00
	2:30	"	0.00
	2:35	"	0.00

PACIFIC ENVIRONMENTAL GROUP, INC.

Project No: 330-06.19

Figure No: 2/3

Date: 5/4/93

Drawn By: KW

Title: OFFSITE SPARGE TEST DATA - HELIUM ONLY

	HE		FID	
TIME	MW-5	V-4	MW-5	V-4
3:25	0	NA		
3:26	2.1	NA	+10000	
3:28	1.5	NA	+10000	
3:30	NA	5.6		+10000
3:34	NA	5.1	+10000	
3:35	4.5	NA		
3:37	2.5	"		
3:39	5.5	"		
3:41	4.7	"		
3:43	NA	9.3		+10000
3:45	NA	8.4		
3:47	8.8	NA		
3:49	NA	8.2		
3:50	9.3	NA	+10000	+10000
3:52	11	"		
3:54	NA	6.9		
3:55	NA	5.9	+10000	+10000
3:57	12	NA		
3:58	11	NA	+10000	+10000
4:00	NA	8.4		
4:02	14	NA		
4:04	NA	7.0		
4:06	11	NA	+10000	+10000
4:08	NA	6.2		
4:10	12	NA		

TEST 2 W/SVE @ MW-5

SPARGE P, Q = SAME

SVE P = 40"
Q = <3

DO METER INOPERATIVE
DTW IRRELEVANT

HE USAGE

He_0 = 2750
He_{20} = 2200
He_{32} = 1875
He_{37} = 1650
He_{42} = 1275
He_{47} = 1075

PACIFIC ENVIRONMENTAL GROUP, INC.

Project No: 330-06.19

Figure No: 3/3

Date: 5/4/93

Drawn By: KW

Title: ON-SITE SPARGE - PHASE 2

SPARGE WELL - AS-2

DTW @ 12:00 = 10.8'

MONITORING WELLS

WELL	DISTANCE FROM AS-2	DTW
V-5	<1'	10.1' *
MW-10	16.5'	9.8'
MW-11	113'8'	10.8'

* BOTTOM OF CASING

STARTING PRESSURE

DT SCREEN = 18'
DTW = 10.8'
7.2' STANDING WATER

7.2' = 3.1 psi ⇒ MIMMUM REQUIRED

TEST BEGAN AT 1:00.

AIR COMPRESSOR SET AT 20 PSI

HELIUM TANK SET AT 100 PSI

COMBINED PRESSURE AT 10 PSI

FLOW SET AT <10 SCFM

OVER

PACIFIC
ENVIRONMENTAL
GROUP, INC.

Project No: 330-06.19

Figure No: 1/3

Date: 5/3/93

Drawn By: KW

Title: OFF-SITE SPARGE TEST DATA

WELL	DIST	TIME	DTW	DO	FID	HE	EST	P
AS-2	0	1:00	10.8	NA	NA	NA	<10	10 psi
		1:05	NA	"	"	"	"	7
		1:15	"	"	"	"	"	"
		1:30	"	"	"	"	"	"
V-5	<1	1:00	10.1	2.1	BKG	0.	NA	NA
		1:05	9.4	NA	"	0.16	"	"
		1:15	NA	"	"	0.08	"	"
		1:30	9.83	5.1	"	0.14	"	"
MW-10	16.5	1:00	9.8	1.62	BKG	0	NA	NA
		1:05	9.8	NA	"	"	"	"
		1:15	NA	"	"	"	"	"
		1:30	9.6	3.68	"	"	"	"
MW-11	13.8	1:00	10.8	2.4	BKG	NA	NA	NA
		1:05	NA	NA	"	"	"	"
		1:15	"	"	"	"	"	"
		1:30	10.55	"	"	"	"	"

NOTES:

NO INCREASE IN FID/HE READINGS AFTER 30 MINUTES IN EITHER WELLS - TEST DISCONTINUED.

STARTED TEST @ 1:00

BKG ~ 3 ppm

PACIFIC
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GROUP, INC.

Project No: 320-06.19

Figure No: 2/3

Date: 5/3/93

Drawn By: KW

Title: HELIUM-ONLY TEST - OFF-SITE SPARGE

							SPARGE		SVE	
WELL	DIST	TIME	DTW	FID	HE	DO	EST Q	P	Q	P
AS-2	0	2:00	NA	NA	NA	*	<10	12 psi	NA	NA
		2:05	"	"	"	"	"	7	"	"
		2:15	"	"	"	"	"	"	"	"
		2:30	"	"	"	"	"		"	"
V-5	<1	2:00	9.83	+2.5	0.14	*	NA	NA	<5	40"
		2:05	9.90	+5.5	0.39	"	"	"	"	"
		2:15	9.98	+7.5	2.7	"	"	"	"	"
		2:30	9.95	+20	3.2	"	"	"	"	"
MW-10	16.5	2:00	9.7	BKG	0	*	NA	NA	NA	NA
		2:05	9.7	"	"	"	"	"	"	"
		2:15	9.58	"	"	"	"	"	"	"
		2:30	9.58	"	"	"	"	"	"	"
MW-11	113.8	2:00	10.54	NA	NA	*	NA	NA	NA	NA
		2:05	10.55	"	"	"	"	"	"	"
		2:15	NA	"	"	"	"	"	"	"
		2:30	10.55	"	"	"	"	"	"	"

NOTES:

NO INCREASE IN MW-10 – TEST DISCONTINUED

STARTED TEST @ 2:00

BKG ≈ 3ppm
* - DO METER FAILED - SAMPLE COULD NOT BE MEASURED

PACIFIC
ENVIRONMENTAL
GROUP, INC.

Project No: 320-06.19

Figure No: 3/3

Date: 5/3/93

Drawn By: KW

Title: HELIUM/SVE AT AS-2 OFF-SITE SPARGE

ATTACHMENT C

SOIL VAPOR EXTRACTION TEST
FIELD DATA AND
COMPUTER MODELLING WORKSHEETS

TEST WELL - V-5

DTW @ 10:30AM = 9.87

MONITORING WELLS:

WELL	DIST FROM V-5	DTW
MW-10	16.5'	9.63'
MW-11	113.8'	NA

BEGIN TEST AT 11:00 AM

SVE PRESSURE @ 40"
FLOW @ <3 SCFM

TIME	VACUUM PRESSURE MW-10	VACUUM PRESSURE MW-11
11:00 *	0.00	0.00
11:05	0.01	0.00
11:10	0.01	0.00
11:15 *	0.01	0.00
11:20	0.01	0.00
11:25	0.01	0.00
11:30	0.01	0.00
11:35	0.01	0.00
11:40 *	0.01	0.00
11:45	0.01	0.00

* SAMPLE COLLECTED FOR 8015/8020 ANALYSIS

PRESSURE APPLICATION ATTEMPTED TO PROVIDE ADDITIONAL DATA - HOSE RUPTURED.

WELL SCREEN NOT SUBMERGED AT VACUUM APPLICATION

POOR RESULTS - STEP TEST NOT CONDUCTED

PACIFIC
ENVIRONMENTAL
GROUP, INC.

Project No: 330-06.19

Figure No:

Date: 4/29/93

Drawn By: KW

Title: OFF-SITE SVE TEST DATA

TEST WELL - V-4

DTW @ 1:30 = 11' EVEN

MONITORING WELLS

WELL	DISTANCE FROM V-5	DTW
MW-5	16'	11.45'
MW-8	33'	9.10'
E1-A	20''	9.85'

BEGIN TEST AT 2:00 PM

SVE PRESSURE @ 40"
FLOW @ <3 SCFM

TIME	VACUUM PRESSURE		
	MW-5	MW-8	E1-A
2:00 *	0.00	0.00	0.00
2:05	0.00	0.00	0.00
2:10	0.00	0.00	0.00
2:15	0.00	0.00	0.00
2:30	0.00	0.00	0.00
2:45 *	0.00	0.00	0.00

* SAMPLE COLLECTED FOR 8015/8020 ANALYSIS

PRESSURE APPLICATION ATTEMPTED TO PROVIDE ADDITIONAL DATA - HOSE RUPTURED.

WELL SCREEN NOT SUBMERGED AT VACUUM APPLICATION

POOR RESULTS - STEP TEST NOT CONDUCTED

PACIFIC
ENVIRONMENTAL
GROUP, INC.

Project No: 330-06.19

Figure No:

Date: 4/30/93

Drawn By: KW

Title: ON-SITE SVE

Pacific Environmental Group
Project: 330-06.22
August 27, 1993

EFFECTIVE RADIUS OF INFLUENCE

This program is designed to determine an effective radius of influence of a vapor extraction well. Data from feasibility tests or an operating system may be entered. A best fit curve is generated to fit raw field data.
For more detail on this technic please read:
Timothy E. Buscheck, P.E. and Thomas R. Peargin, R.G., November 1991, Proceedings of the Petroleum Hydrocarbons and Organic Chemicals in Groundwater: Prevention, Detection, and Restoration, Houston, Texas
Summary of a Nation-Wide Vapor Extraction System Performance Study

$n := 1$	Number of monitoring points
$m := 1$	Number of data points per well
$i := 0 \,..\, n$	Matrix array size for pressure data
$j := 0 \,..\, m - 1$	Matrix array size for number of data points per well

P (i,j) = Well vacuum pressure, inches of H2O

Pn (i,j) = Normalized well vacuum pressure, inches of H2O

R (i) = Radial distance from extraction well to monitoring point, feet

FIELD DATA

Well Pressure (inches of water)

Extraction Well	Well MW-10
$P_{0,j} := 40$	$P_{1,j} := 0.01$

Radial Distance

$$R_i := \boxed{\begin{array}{c} 0.0 \\ \hline 17 \end{array}}$$

Calculate the normalized vacuum:

$$Pn_{i,j} := \frac{P_{i,j}}{P_{0,j}} \qquad Pn = \begin{bmatrix} 1 \\ 2.5 \cdot 10^{-4} \end{bmatrix}$$

Calculate the average values for normalized data:

$$Pave_{i} := \sum_{j} \frac{Pn_{i,j}}{m} \qquad Pave = \begin{bmatrix} 1 \\ 2.5 \cdot 10^{-4} \end{bmatrix}$$

LINEAR REGRESSION OF VACUUM DATA

Covert an equation of the form $Y = e^{ax} + b$ into linear form:

$$\mathrm{Ln}(y) = ax + \mathrm{Ln}(b)$$

$$\mathrm{Plog}_i := \ln\left[\mathrm{Pave}_i\right] \qquad \mathrm{Plog} = \begin{bmatrix} 0 \\ -8.294 \end{bmatrix}$$

Calculate the slope, y - intercept and the correlation coefficient:

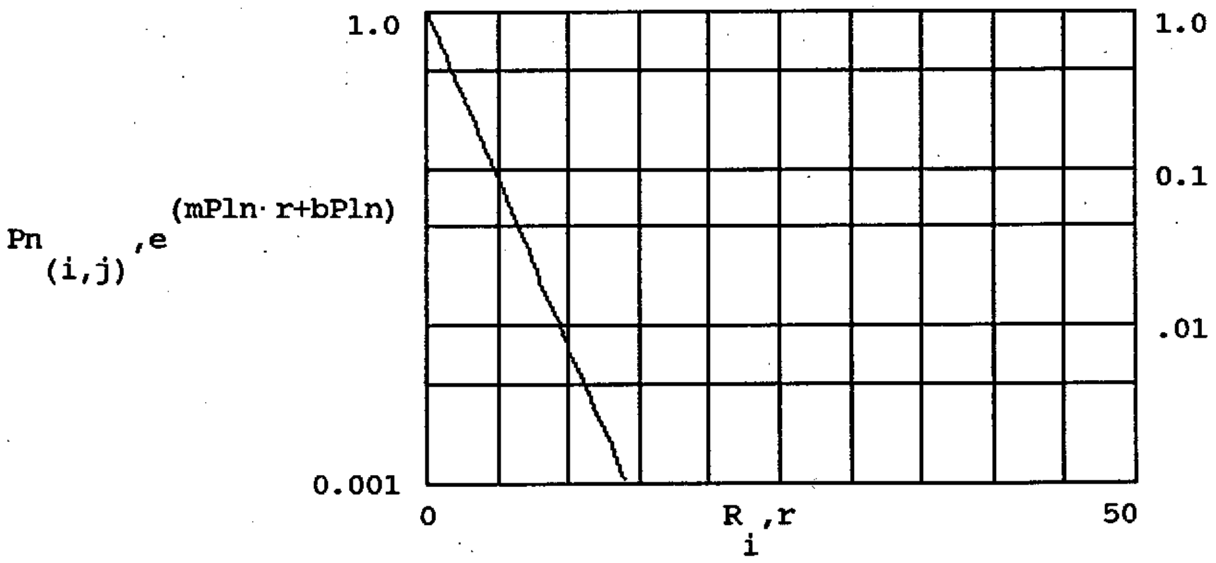
$\mathrm{mPln} := \mathrm{slope}(R,\mathrm{Plog})$ $\quad$ $\mathrm{mPln} = -0.488$ $\quad$ linear regression slope

$\mathrm{bPln} := \mathrm{intercept}(R,\mathrm{Plog})$ $\quad$ $\mathrm{bPln} = 0$ $\quad$ linear regression intercept

$\mathrm{rPln} := \mathrm{corr}(R,\mathrm{Plog})$ $\quad$ $\mathrm{rPln} = -1$ $\quad$ correlation coefficient

Plot the field data and the regressed curve in semi-log form:

$r := 0 \,..50$



Calculate the effective radius of influence at 1% of total vacuum:

$$\mathrm{Re} := \frac{\ln(0.01) - \mathrm{bPln}}{\mathrm{mPln}} \qquad \mathrm{Re} = 9.439 \quad \text{Feet}$$

Project: 330-06.22
Date: August 27, 1993

This program uses the radial flow equation, to estimate soil permeability given flow rate, well vacuum, radius of influence and well construction data. Once a value for permeability is determined, a plot of flow rate versus vacuum is generated. Field step test data is shown on the same plot for comparison.

Define Major Parameters for extraction well

$n := 1$ Number of data sets (including step test data)

$i := 0 \,..\, n - 1$ Range Variable Used for Calculations

$H := 1 \cdot ft$ Screened Interval

$\mu := 0.000018 \cdot \left[\frac{kg}{m \cdot sec}\right]$ Air Viscosity

$Patm := 1 \cdot atm$ Atmospheric Pressure - Absolute

$Rw := 5 \cdot in$ Well Radius

$Ri := 9.5 \cdot ft$ Radius of Influence

$Q_i := 3 \cdot cfm$ Flow Rate

$Pwg_i := 40 \cdot in\_H2O$ Well Pressure - Gauge

Convert Gauge Pressure to Absolute:

$Pw_i := Patm - Pwg_i$

Solve Radial Flow Equation for k (permeability)

$$kdarcy_i := \left[\frac{Q_i}{H}\right] \cdot \left[\frac{\mu}{\pi}\right] \cdot \frac{\ln\left[\frac{Rw}{Ri}\right]}{Pw_i \cdot \left[1.0 - \left[\frac{Patm}{Pw_i}\right]^2\right]} \qquad \frac{kdarcy_i}{darcy} = 3.96$$

Note: Permeability in darcies (1 darcy = 1*10^-8 cm^2)

Pacific Environmental Group
Project: 330-06.22
Date: August 27, 1993

Compute Average Permiability, Kave:

$$\mathrm{Kave} := \sum_{i} \frac{\mathrm{kdarcy}_i}{n} \qquad \frac{\mathrm{Kave}}{\mathrm{darcy}} = 3.96$$

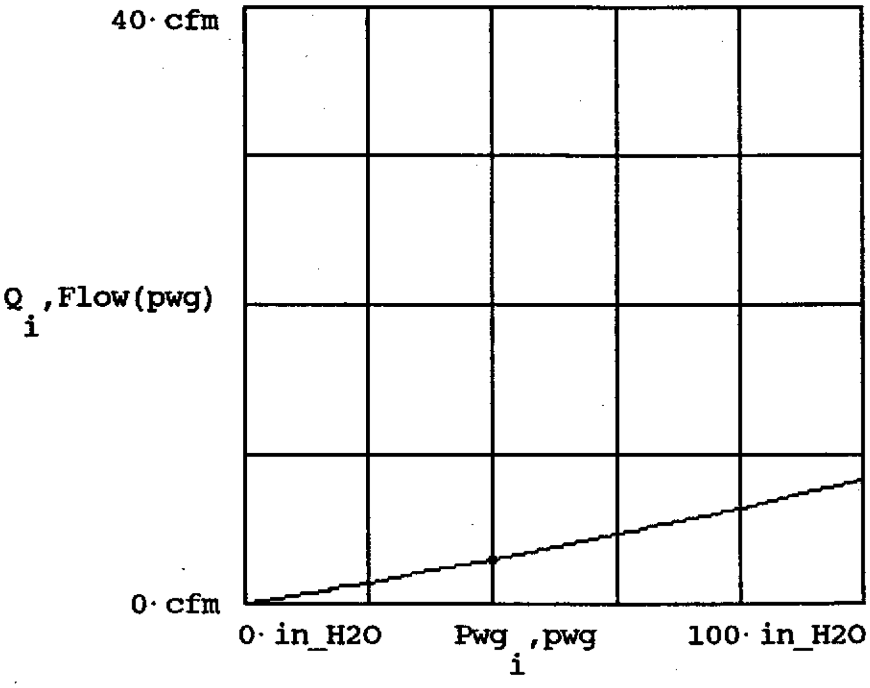
Radial Flow Equation Solved for Flow vs. Vacuum:

$$P(\mathrm{pwg}) := \mathrm{Patm} - \mathrm{pwg}$$

$$\mathrm{Flow}(\mathrm{pwg}) := \frac{\mathrm{Kave} \cdot H \cdot \pi}{\mu} \cdot \frac{P(\mathrm{pwg}) \cdot \left[1.0 - \left[\frac{\mathrm{Patm}}{P(\mathrm{pwg})}\right]^2\right]}{\ln\left[\frac{\mathrm{Rw}}{\mathrm{Ri}}\right]}$$

Plot field data and theoretical data for Flow (cfm) versus Vacuum (in H2O):

$$\mathrm{pwg} := 0 \cdot \mathrm{in\_H2O}, 10 \cdot \mathrm{in\_H2O} \,..\, 100 \cdot \mathrm{in\_H2O}$$



pwg in H2O	Flow(pwg) cfm
0	0
10	0.72
20	1.459
30	2.219
40	3
50	3.805
60	4.636
70	5.496
80	6.386
90	7.31
100	8.271

UNIT DEFINITIONS MKS (SI) unit system

I. Base units

$\mathrm{m} \equiv 1L$ $\mathrm{kg} \equiv 1M$ $\mathrm{sec} \equiv 1T$ $\mathrm{coul} \equiv 1Q$

II. Angular measure

$\mathrm{rad} \equiv 1$

$\mathrm{deg} \equiv \frac{\pi}{180} \cdot \mathrm{rad}$

III. Derived units: Length

$\mathrm{cm} \equiv .01 \cdot \mathrm{m}$ $\mathrm{km} \equiv 1000 \cdot \mathrm{m}$ $\mathrm{mm} \equiv .001 \cdot \mathrm{m}$

$\mathrm{ft} \equiv .3048 \cdot \mathrm{m}$ $\mathrm{in} \equiv 2.54 \cdot \mathrm{cm}$ $\mathrm{yd} \equiv 3 \cdot \mathrm{ft}$ $\mathrm{mi} \equiv 5280 \cdot \mathrm{ft}$

IV. Derived units: Mass

$\mathrm{gm} \equiv 10^{-3} \cdot \mathrm{kg}$ $\mathrm{tonne} \equiv 1000 \cdot \mathrm{kg}$ (metric ton) $\mathrm{lb} \equiv 453.59247 \cdot \mathrm{gm}$ (use convention that lb represents pounds mass.

$\mathrm{oz} \equiv \frac{\mathrm{lb}}{16}$ $\mathrm{ton} \equiv 2000 \cdot \mathrm{lb}$ ("short" ton) $\mathrm{slug} \equiv 32.174 \cdot \mathrm{lb}$

V. Derived units: Time

$\mathrm{min} \equiv 60 \cdot \mathrm{sec}$ $\mathrm{hr} \equiv 3600 \cdot \mathrm{sec}$ $\mathrm{day} \equiv 24 \cdot \mathrm{hr}$

$\mathrm{yr} \equiv 365.2422 \cdot \mathrm{day}$ (tropical year)

VI. Derived units: Area, Volume

$\mathrm{hectare} \equiv 10^{4} \cdot \mathrm{m}^{2}$ $\mathrm{acre} \equiv 4840 \cdot \mathrm{yd}^{2}$

$\mathrm{liter} \equiv (.1 \cdot \mathrm{m})^{3}$ (Sometimes defined with "L" symbol.)

$\mathrm{mL} \equiv 10^{-3} \cdot \mathrm{liter}$

$\mathrm{fl\_oz} \equiv 29.57353 \cdot \mathrm{cm}^{3}$

$\mathrm{gal} \equiv 128 \cdot \mathrm{fl\_oz}$

$\mathrm{darcy} \equiv 10^{-8} \cdot \mathrm{cm}^{2}$

VII. Derived units: Velocity, Acceleration

$\mathrm{mph} \equiv \frac{\mathrm{mi}}{\mathrm{hr}}$ $\mathrm{kph} \equiv \frac{\mathrm{km}}{\mathrm{hr}}$ $\mathrm{cfm} \equiv \frac{\mathrm{ft}^{3}}{\mathrm{min}}$

$g \equiv 9.80665 \cdot \frac{\mathrm{m}}{\mathrm{sec}^{2}}$ (acceleration of gravity)

VIII. Derived units: Force, Energy, Power

$\mathrm{newton} \equiv \mathrm{kg} \cdot \frac{\mathrm{m}}{2}$ $\mathrm{dyne} \equiv 10^{-5} \cdot \mathrm{newton}$ $\mathrm{lbf} \equiv g \cdot \mathrm{lb}$ (pound force) sec

$kgf \equiv g \cdot kg$
(kilogram force)

$joule \equiv newton \cdot m$

$erg \equiv 10^{-7} \cdot joule$

$cal \equiv 4.1868 \cdot joule$

$kcal \equiv 1000 \cdot cal$

$BTU \equiv 1.05505585262 \cdot 10^{3} \cdot joule$

$watt \equiv \dfrac{joule}{sec}$

$kW \equiv 1000 \cdot watt$

$hp \equiv 550 \cdot \dfrac{ft \cdot lbf}{sec}$
(standard horsepower)

IX. Derived units: Pressure, Viscosity ',

$Pa \equiv \dfrac{newton}{m^{2}}$

$psi \equiv \dfrac{lbf}{in^{2}}$

$atm \equiv 1.01325 \cdot 10^{5} \cdot Pa$

$torr \equiv 1.33322 \cdot 10^{2} \cdot Pa$

$\mathrm{in\_Hg} \equiv 3.38638 \cdot 10^{3} \cdot Pa$

$\mathrm{in\_H2O} \equiv \dfrac{\mathrm{in\_Hg}}{13.596}$

$stokes \equiv 10^{-4} \cdot \dfrac{m^{2}}{sec}$

$poise \equiv .1 \cdot Pa \cdot sec$

Pacific Environmental Group, Inc.
Project: 330-06.22
Date: August 27, 1993

CONCENTRATION DECAY

This document shows the results of decay in influent concentrations to a soil vapor extraction system. And calculates the theoretical mass of TPH removed from soils at a site.

Initial conditions:

Initial concentration $C0 := 13 \cdot \frac{ug}{l}$

Half-concentration: $thalfA := 50 \cdot day$

Flow Rate: $flow := 9 \cdot \frac{cf}{m}$

Asymtote: (Percent of initial concentration,C0): $Cf := 5$

Compute decay constant, kA:

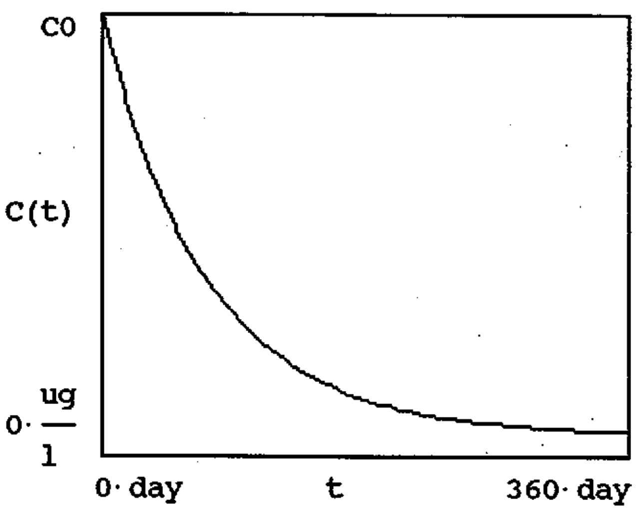
$$kA := \frac{\ln(2)}{thalfA} \qquad kA = 0.014 \cdot time^{-1}$$

Decay function:

$$C(t) := C0 \cdot \left[\left[1 - \left[\frac{Cf}{100}\right]\right] \cdot e^{-(kA \cdot t)} + \left[\frac{Cf}{100}\right]\right]$$

Graph the decay in concentration, C over time:

$t := 0 \cdot day, 5 \cdot day \,..360 \cdot day$ $\qquad$ $t2 := 0 \cdot day, 90 \cdot day \,..360 \cdot day$



$\frac{t2}{day}$	$C(t2) \cdot \frac{1}{ug}$
0	13
90	4.2
180	1.7
270	0.9
360	0.7

C

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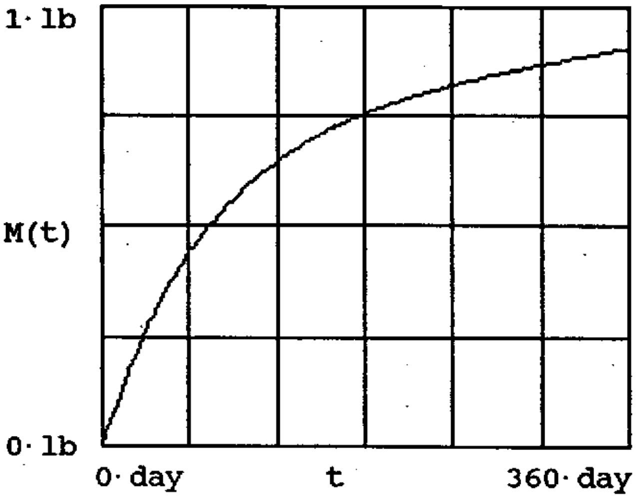
Project: 330-06.22
Date: August 27, 1993

Calculate Mass Removal Over Time:

$$M(t) := (C0 \cdot flow) \cdot \left[\left[1 - \left[\frac{Cf}{100}\right]\right] \cdot \left[\frac{1}{kA}\right] \cdot (1 - \exp(-kA \cdot t)) + \left[\frac{Cf}{100} \cdot t\right]\right]$$

Graph the mass removal, M over time:

$t := 0 \cdot day, 2 \cdot day \,..360 \cdot day$



$t2 := 0 \cdot day, 90 \cdot day \,..360 \cdot day$

$\frac{t2}{day}$	$\frac{M(t2)}{lb \cdot 1000}$
0	0
90	$5.612 \cdot 10^{-4}$
180	$7.561 \cdot 10^{-4}$
270	$8.458 \cdot 10^{-4}$
360	$9.053 \cdot 10^{-4}$

$t2 := 1 \cdot day$

$\frac{M(t2)}{lb} = 0.0$

Units and conversions:

$gm \equiv 1M$

$day \equiv 1T$

$cm \equiv 1L$

$m \equiv \frac{day}{1440}$

$l \equiv 1000 \cdot cm^3$

$cf \equiv 28.32 \cdot l$

$ug \equiv 10^{-6} \cdot gm$

$lb \equiv 453.6 \cdot gm$

ATTACHMENT D

SOIL VAPOR EXTRACTION TEST
CERTIFIED ANALYTICAL REPORTS
AND CHAIN-OF-CUSTODY DOCUMENTATION

SEQUOIA ANALYTICAL
680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

RECEIVED
MAY 06 1993
PACIFIC ENVIRONMENTAL GROUP, INC.

Pacific Environmental Group
2025 Gateway Place, Suite 440
San Jose, CA 95110
Attention: Keith Winemiller

Project: 330-06.19/Arco 0608, San Lorenzo

Enclosed are the results from 2 air samples received at Sequoia Analytical on April 30,1993. The requested analyses are listed below:

3DC5401	Air, V4-1	4/29/93	EPA 5030/8015/8020
3DC5402	Air, V4-2	4/29/93	EPA 5030/8015/8020

Please contact me if you have any questions. In the meantime, thank you for the opportunity to work with you on this project.

Very truly yours,

SEQUOIA ANALYTICAL

Eileen A. Manning
Project Manager

SEQUOIA ANALYTICAL
680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Pacific Environmental Group	Client Project ID:	330-06.19/Arco 0608, San Lorenzo	Sampled:	Apr 29, 1993
2025 Gateway Place, Suite 440	Sample Matrix:	Air	Received:	Apr 30, 1993
San Jose, CA 95110	Analysis Method:	EPA 5030/8015/8020	Reported:	May 5, 1993
Attention: Keith Winemiller	First Sample #:	3DC5401		

TOTAL PURGEABLE PETROLEUM HYDROCARBONS with BTEX DISTINCTION

Analyte	Reporting Limit μg/L	Sample I.D. 3DC5401 V4-1	Sample I.D. 3DC5402 V4-2
Purgeable Hydrocarbons	5.0	100	8,500
Benzene	0.050	0.72	100
Toluene	0.050	1.5	47
Ethyl Benzene	0.050	2.0	35
Total Xylenes	0.050	6.2	63
Chromatogram Pattern:		Gas + Non-gas < C8	Non-gas < C8

Quality Control Data

Report Limit Multiplication Factor:	1.0	100
Date Analyzed:	4/30/93	4/30/93
Instrument Identification:	GCHP-3	GCHP-3
Surrogate Recovery, %: (QC Limits = 70-130%)	98	112

Purgeable Hydrocarbons are quantitated against a fresh gasoline standard.
Analytes reported as N.D. were not detected above the stated reporting limit.

SEQUOIA ANALYTICAL

Eileen A. Manning
Project Manager

SEQUOIA ANALYTICAL
680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Pacific Environmental Group
2025 Gateway Place, Suite 440
San Jose, CA 95110
Attention: Keith Winemiller

Client Project ID: 330-06.19/Arco 0608, San Lorenzo
QC Sample Group 3DC5401-02
Reported: May 5, 1993

QUALITY CONTROL DATA REPORT

ANALYTE	Benzene	Toluene	Ethyl-Benzene	Xylenes
Method:	EPA 8020	EPA 8020	EPA 8020	EPA 8020
Analyst:	M. Nipp	M. Nipp	M. Nipp	M. Nipp
Conc. Spiked:	10	10	10	30
Units:	µg/L	µg/L	µg/L	µg/L
LCS Batch#:	GBLK043093	GBLK043093	GBLK043093	GBLK043093
Date Prepared:	N.A.	N.A.	N.A.	N.A.
Date Analyzed:	4/30/93	4/30/93	4/30/93	4/30/93
Instrument I.D.#:	GCHP-3	GCHP-3	GCHP-3	GCHP-3
LCS % Recovery:	100	100	100	100
Control Limits:	80-120	80-120	80-120	80-120

MS/MSD Batch #:	G9304B4502	G9304B4502	G9304B4502	G9304B4502
Date Prepared:	N.A.	N.A.	N.A.	N.A.
Date Analyzed:	4/30/93	4/30/93	4/30/93	4/30/93
Instrument I.D.#:	GCHP-3	GCHP-3	GCHP-3	GCHP-3
Matrix Spike % Recovery:	110	110	110	107
Matrix Spike Duplicate % Recovery:	110	110	110	107
Relative % Difference:	0.0	0.0	0.0	0.0

Quality Assurance Statement: All standard operating procedures and quality control requirements have been met.

SEQUOIA ANALYTICAL

Eileen A. Manning
Project Manager

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation and analytical methods employed for the samples. The LCS % recovery data is used for validation of sample batch results. Due to matrix effects, the QC limits for MS/MSD's are advisory only and are not used to accept or reject batch results.

SEQUOIA ANALYTICAL SAMPLE RECEIPT LOG

CLIENT NAME: P.E.G.
MASTER LOG NO. / PAGE:
REC. BY (PRINT): T.C.
DATE OF LOG-IN: 4/30/93

CIRCLE THE APPROPRIATE RESPONSE

1. Custody Seal(s): Present / [✓ Absent]
   Intact / Broken*
2. Custody Seal Nos.:
3. Chain-of-Custody Records: [✓ Present] / Absent*
4. Traffic Reports or Packing List: Present / [✓ Absent]
5. Airbill: Airbill / Sticker
   Present / [✓ Absent]
6. Airbill No.:
7. Sample Tags: [✓ Present] / Absent*
   Sample Tag Nos.: [✓ Listed] / Not Listed on Chain-of-Custody
8. Sample Condition: [✓ Intact]/Broken*/Leaking*
9. Does information on custody reports, traffic reports and sample tags agree? [✓ Yes] / No*
10. Proper Preservatives Used: [✓ Yes] / No*
11. Date Rec. at Lab: 4·30·93
12. Time Rec. at Lab: 10:40 am

LAB SAMPLE #	DASH #	CLIENT IDENTIFICATION	CONTAINER DESCRIPTION	SAMPLE MATRIX	DATE SAMP.	REMARKS: CONDITION (ETC)
9304C54.01	A	V4-1	tedlar bag	A	4/29	
↓ 02	↓	V4-2	↓	↓	↓	

* If Circled, contact Project Manager and attach record of resolution

Form SC001.

Page 1 of 1

[redacted]uct[redacted]omp[redacted] ◆ [redacted]30-0619 [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted] [redacted]Ch[redacted]of C[redacted]ody[redacted] [redacted]

Division of AtlanticRichfieldCompany

Task Order No.

y no. 0608

City (Facility) San Lorenzo

Project manager (Consultant) Keith Winemiller

Laboratory name Sequoia

eer Mike Whelan

Telephone no. (ARCO)

Telephone no. (Consultant) (408) 441-7500

Fax no. (Consultant) (408) 441-7539

Contract number

ame Pacific Environmental Group

Address (Consultant) 2025 Gateway Pl. Ste. 440 San Jose CA

Lab no.	Container no.	Matrix Soil	Matrix Water	Matrix Other AIR	Preservation Ice	Preservation Acid	Sampling date	Sampling time	BTEX 602/EPA 8020	BTEX/TPH EPA M602/8020/8015 GAS	TPH Modified 8015 Gas ☐ Diesel ☐	Oil and Grease 413.1 ☐ 413.2 ☐	TPH EPA 418.1/SM503E	EPA 601/8010	EPA 624/8240	EPA 625/8270	TCLP Metals ☐ Semi VOA ☐ VOA ☐	CAM Metals EPA 6010/7000 TTLC ☐ STLC ☐	Lead Org./DHS ☐ Lead EPA 7420/7421 ☐		
	1			X			4/29/93	2:00		X											
	1			X			↓	2:47		↓											

Method of shipment

Special detection Limit/reporting

Special QA/QC

Remarks Tedlars appear to be deflating. Analyze immediately

Lab number

Turnaround time

Priority Rush 1 Business Day ☐

Rush 2 Business Days ☐

Expedited 5 Business Days ☐

Standard 10 Business Days AIR ☒

/ sample:

Temperature received:

d by sampler | Date 4/30/93 | Time 8:00 | Received by M Doden

d by Doden | Date 4/30/93 | Time 9:50 | Received by M Otto

d by M Otto | Date 4/30/93 | Time 10:40 | Received by laboratory | Date 4·30·93 | Time 10·40 am

hite copy — Laboratory; Canary copy — ARCO Environmental Engineering; Pink copy — Consultant

SEQUOIA ANALYTICAL
680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

RECEIVED
MAY 07 1993
PACIFIC ENVIRONMENTAL GROUP, INC.

Pacific Environmental Group
2025 Gateway Place, Suite 440
San Jose, CA 95110
Attention: Keith Winemiller

Project: 330-06.19/Arco 0608, San Lorenzo

Enclosed are the results from 3 air samples received at Sequoia Analytical on April 30,1993. The requested analyses are listed below:

3DD5101	Air, V5-0	4/30/93	EPA 5030/8015/8020
3DD5102	Air, V5-1	4/30/93	EPA 5030/8015/8020
3DD5103	Air, V5-2	4/30/93	EPA 5030/8015/8020

Please contact me if you have any questions. In the meantime, thank you for the opportunity to work with you on this project.

Very truly yours,

SEQUOIA ANALYTICAL

Eileen A. Manning
Project Manager

SEQUOIA ANALYTICAL
680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Pacific Environmental Group	Client Project ID:	330-06.19/Arco 0608, San Lorenzo	Sampled:	Apr 30, 1993
2025 Gateway Place, Suite 440	Sample Matrix:	Air	Received:	Apr 30, 1993
San Jose, CA 95110	Analysis Method:	EPA 5030/8015/8020	Reported:	May 5, 1993
Attention: Keith Winemiller	First Sample #:	3DD5101		

TOTAL PURGEABLE PETROLEUM HYDROCARBONS with BTEX DISTINCTION

Analyte	Reporting Limit µg/L	Sample I.D. 3DD5101 V5-0	Sample I.D. 3DD5102 V5-1	Sample I.D. 3DD5103 V5-2
Purgeable Hydrocarbons	5.0	13	N.D.	6.7
Benzene	0.050	N.D.	N.D.	N.D.
Toluene	0.050	0.093	N.D.	0.061
Ethyl Benzene	0.050	0.31	0.10	0.19
Total Xylenes	0.050	1.9	0.63	1.2
Chromatogram Pattern:		Gas	--	Gas

Quality Control Data

Report Limit Multiplication Factor:	1.0	1.0	1.0
Date Analyzed:	4/30/93	4/30/93	4/30/93
Instrument Identification:	GCHP-3	GCHP-3	GCHP-3
Surrogate Recovery, %: (QC Limits = 70-130%)	104	96	102

Purgeable Hydrocarbons are quantitated against a fresh gasoline standard.
Analytes reported as N.D. were not detected above the stated reporting limit.

SEQUOIA ANALYTICAL

Eileen A. Manning
Project Manager

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680 Chesapeake Drive • Redwood City, CA 94063
(415) 364-9600 • FAX (415) 364-9233

Pacific Environmental Group
2025 Gateway Place, Suite 440
San Jose, CA 95110
Attention: Keith Winemiller

Client Project ID: 330-06.19/Arco 0608, San Lorenzo

QC Sample Group 3DD5101-03

Reported: May 5, 1993

QUALITY CONTROL DATA REPORT

ANALYTE	Benzene	Toluene	Ethyl-Benzene	Xylenes
Method:	EPA 8020	EPA 8020	EPA 8020	EPA 8020
Analyst:	M. Nipp	M. Nipp	M. Nipp	M. Nipp
Conc. Spiked:	10	10	10	30
Units:	µg/L	µg/L	µg/L	µg/L
LCS Batch#:	GBLK043093	GBLK043093	GBLK043093	GBLK043093
Date Prepared:	N.A.	N.A.	N.A.	N.A.
Date Analyzed:	4/30/93	4/30/93	4/30/93	4/30/93
Instrument I.D.#:	GCHP-3	GCHP-3	GCHP-3	GCHP-3
LCS % Recovery:	100	100	100	100
Control Limits:	80-120	80-120	80-120	80-120
MS/MSD Batch #:	G9304B4502	G9304B4502	G9304B4502	G9304B4502
Date Prepared:	N.A.	N.A.	N.A.	N.A.
Date Analyzed:	4/30/93	4/30/93	4/30/93	4/30/93
Instrument I.D.#:	GCHP-3	GCHP-3	GCHP-3	GCHP-3
Matrix Spike % Recovery:	110	110	110	107
Matrix Spike Duplicate % Recovery:	110	110	110	107
Relative % Difference:	0.0	0.0	0.0	0.0

Quality Assurance Statement: All standard operating procedures and quality control requirements have been met.

SEQUOIA ANALYTICAL

Eileen A. Manning
Project Manager

Please Note:
The LCS is a control sample of known, interferent free matrix that is analyzed using the same reagents, preparation and analytical methods employed for the samples. The LCS % recovery data is used for validation of sample batch results. Due to matrix effects, the QC limits for MS/MSD's are advisory only and are not used to accept or reject batch results.

IT NAME: PEG

BY (PRINT): PH

MASTER LOG NO. / PAGE: 9304D51

DATE OF LOG-IN: 4-30-93

E THE APPROPRIATE RESPONSE

ustody Seal(s): Present / [✓ Absent]
Intact / Broken*

ustody Seal Nos.: ——

hain-of-Custody ecords: [✓ Present] / Absent*

affic Reports or acking List: Present / [✓ Absent]

irbill: Airbill / Sticker
Present / [✓ Absent]

irbill No.:

mple Tags: [✓ Present] / Absent*

mple Tag Nos.: [✓ Listed] / Not Listed on Chain-of-Custody

mple Condition: [✓ Intact]/Broken*/Leaking*

es Information on stody reports, traffic orts and sample tags agree? [✓ Yes] / No*

roper reservatives Used: [✓ Yes] / No*

ate Rec. at Lab: 4-30-93

me Rec. at Lab: 1615

LAB SAMPLE #	DASH #	CLIENT IDENTIFICATION	CONTAINER DESCRIPTION	SAMPLE MATRIX	DATE SAMP.	REMARKS: CONDITION (ETC)
	0	V4-0	TEDLAR	AIR	4-30	
	↓	V4-1	↓	↓	↓	
		V4-2				
		Samples labelled				
		V5-0				
		V5-1				
		V5-2				

ircled, contact Project Manager and attach record of resolution

Form SC001.

Page 1 of 1

Task Order No.

y no. 0608 (Facility) 7601 HESPERIAN BLVD

Project manager (Consultant) KEITH WINEMILLER

Laboratory name SEQUOIA

engineer MIKE WHELAN

Telephone no. (ARCO)

Telephone no. (Consultant) 408-441-7500

Fax no. (Consultant) 408-441-7539

tant name PACIFIC ENV. GROUP

Address (Consultant) 2025 GATEWAY, STE 440 SAN JOSE 95110

Contract number 07-073

	Lab no.	Container no.	Matrix: Soil	Matrix: Water	Matrix: Other AIR	Preservation: Ice	Preservation: Acid	Sampling date	Sampling time	BTEX 602/EPA 8020	BTEX/TPH EPA M602/8020/8015	TPH Modified 8015 Gas ☐ Diesel ☐	Oil and Grease 413.1 ☐ 413.2 ☐	TPH EPA 418.1/SM503E	EPA 601/8010	EPA 624/8240	EPA 625/8270	TCLP Metals ☐ VOA ☐ Semi VOA ☐	CAM Metals EPA 6010/7000 TTLC ☐ STLC ☐	Lead Org./DHS ☐ Lead EPA 7420/7421 ☐		
-0		1			x			4/30			X			930405				01				
-1		1			x			4/30			X							02				
-2		1			x			4/30			X							03				

Method of shipment

Special detection Limit/reporting

Special QA/QC

Remarks

Lab number

Turnaround time

Priority Rush 1 Business Day ☐

Rush 2 Business Days ☐

Expedited 5 Business Days ☐

Standard 10 Business Days ☒ AIR

on of sample: 9001

Temperature received: 60°

ished by sampler | Date 4/30/93 | Time 1525 | Received by

ished by | Date 4/30/93 | Time 4:15 | Received by

ished by | Date | Time | Received by laboratory | Date 4-30-93 | Time 1615

White copy — Laboratory; Canary copy — ARCO Environmental Engineering; Pink copy — Consultant

ATTACHMENT E

IN-SITU BIOREMEDIATION FEASIBILITY TESTING CERTIFIED ANALYTICAL REPORTS AND CHAIN-OF-CUSTODY DOCUMENTATION

BioScreen Testing Services, Inc.
Microbiology • Chemistry • Environmental • Asbestos

ANALYTICAL REPORT

PACIFIC ENVIRONMENTAL GROUP
2025 Gateway Place
#440
San Jose, CA 95110

REPORT DATE: 04/05/93
ACCESSION #: 7338 - 7341
PROJECT #: 0693-4

ATTN: Kelly Brown

SAMPLE:

ACC #	SAMPLES:		
7338	ARCO Products Soil	B- 9	10-12′
7339	ARCO Products Soil	B-10	11-13′
7340	ARCO Products Soil	B-11	11-13′
7341	ARCO Products Soil	B-12	11-13′

TEST(S) PERFORMED:

	METHOD REFERENCE
Heterotrophic Plate Count	BTS 227
Fluorescent *Pseudomonas*	BTS 228
Hydrocarbon Degraders	BTS 229
Ammonia	EPA 350.3
Nitrate	EPA 300.0
Phosphate	EPA 300.0
Potassium	EPA 601.0
pH	BTS 544
Moisture	BTS 554
Calcium	EPA 601.0
Magnesium	EPA 601.0
Iron	EPA 601.0

RESULTS:

ACCESSION #: 7338 **ARCO PRODUCTS SOIL B- 9 10-12′**

	RESULTS:	**DETECTION LIMIT**
Heterotrophic Plate Count	1.0 x 10^3 CFU/gm	1000 CFU/gm
Fluorescent *Pseudomonas*	<1000 CFU/gm	1000 CFU/gm
Hydrocarbon Degraders	<1000 CFU/gm	1000 CFU/gm
Ammonia	ND	10 ppm
Nitrate	ND	2.1 ppm
Phosphate	ND	5 ppm
Potassium	531	60 ppm
pH	8.28	---
Moisture	19.97 %	---
Calcium	3250 ppm	10 ppm
Magnesium	4,850 ppm	300 ppm
Iron	14,700 ppm	400 ppm

ACCESSION #: 7339 **ARCO PRODUCTS SOIL B-10 11-13′**

	RESULTS:	**DETECTION LIMIT**
Heterotrophic Plate Count	1.1 x 10^4 CFU/gm	1000 CFU/gm
Fluorescent *Pseudomonas*	<1000 CFU/gm	1000 CFU/gm
Hydrocarbon Degraders	<1000 CFU/gm	1000 CFU/gm
Ammonia	ND	10 ppm
Nitrate	ND	2.1 ppm
Phosphate	ND	5 ppm
Potassium	684	60 ppm
pH	8.19	---
Moisture	21.18 %	---
Calcium	4,340 ppm	10 ppm
Magnesium	5,670 ppm	300 ppm
Iron	15,100 ppm	400 ppm

RESULTS: (cont.)

ACCESSION #: 7340 ARCO PRODUCTS SOIL B-11 11-13'

	RESULTS:	**DETECTION LIMIT**
Heterotrophic Plate Count	6.2 x 10^4 CFU/gm	1000 CFU/gm
Fluorescent *Pseudomonas*	<1000 CFU/gm	1000 CFU/gm
Hydrocarbon Degraders	4.0 x 10^3 CFU/gm	1000 CFU/gm
Ammonia	ND	10 ppm
Nitrate	2.4	2.1 ppm
Phosphate	ND	5 ppm
Potassium	620	60 ppm
pH	7.24	---
Moisture	23.25 %	---
Calcium	3920 ppm	10 ppm
Magnesium	2,820 ppm	300 ppm
Iron	16,100 ppm	400 ppm

ACCESSION #: 7341 ARCO PRODUCTS SOIL B-10 11-13'

	RESULTS:	**DETECTION LIMIT**
Heterotrophic Plate Count	3.0 x 10^3 CFU/gm	1000 CFU/gm
Fluorescent *Pseudomonas*	<1000 CFU/gm	1000 CFU/gm
Hydrocarbon Degraders	<1000 CFU/gm	1000 CFU/gm
Ammonia	ND	10 ppm
Nitrate	ND	2.1 ppm
Phosphate	ND	5 ppm
Potassium	333	60 ppm
pH	7.91	---
Moisture	11.76 %	---
Calcium	3,100 ppm	10 ppm
Magnesium	5,510 ppm	300 ppm
Iron	9,460 ppm	400 ppm

Discussion:

The microbiological results show levels of heterotrophic organisms in the soil are below normal values. Based on results of samples tested at BioScreen Testing normal levels of total organism counts should be in the 1 x 10^5 to 1 x 10^6 range. The *fluorescent Pseudomonas* and hydrocarbon degraders levels are below normal values. Based on results of samples tested at BioScreen testing normal levels of *fluorescent Pseudomonas* and hydrocarbon degraders should be in the 1 x 10^5 and 1 x 10^3 range respectively. The low levels of microorganisms could be due to the depth at which samples were taken.

The nutrient data shows that ammonia, nitrate and phosphate are non detected except for sample number 7340. Potassium levels are not of concern at this time.

In addition the levels of calcium and magnesium are high. This is a cause for some concern and the nutrient amendment will have to be carefully buffered so that inorganic precipitation does not take place.

The moisture and pH seem to be within normal levels for supporting microbial growth.

The indication from the initial assessment data is that no bioremediation is taking place. With proper nutrient amendment of the soil it may be possible to stimulate bioremediation. The final ability to bioremediate a site is dependent on the type of contaminant present and the outcome of a treatability study.

Bradford L. Rope
Laboratory Director

Ranil M. Fernando
Ranil M. Fernando, B.S.
Operations Supervisor

ARCO Products Company Division of AtlanticRichfieldCompany 330-06.20 **Task Order No.** 0608-93-2

Chain of Custody

ARCO Facility no. 0608
City (Facility) San Lorenzo
Project manager (Consultant) Kelly Brown
Laboratory name BioScreen Testing Services
ARCO engineer Michael Whelan
Telephone no. (ARCO)
Telephone no. (Consultant) (408)441-7500
Fax no. (Consultant) (408)441-7539
Contract number 000151 (Quotation #)
Consultant name Pacific Environmental Group
Address (Consultant) 2025 Gateway Pl. #440, San Jose CA 95110
Method of shipment Federal Express

Sample I.D.	Lab no.	Container no.	Matrix: Soil	Matrix: Water	Matrix: Other	Preservation: Ice	Preservation: Acid	Sampling date	Sampling time	BTEX 602/EPA 8020	BTEX/TPH EPA M602/8020/8015	TPH Modified 8015 Gas ☐ Diesel ☐	Oil and Grease 413.1 ☐ 413.2 ☐	~~TPH EPA 418.1/SM503E~~ Nutrient Anal.	Ca, Fe, Mg EPA 601/8010	~~EPA 624/8240~~	Moisture ~~EPA 625/8270~~	~~TCLP Metals ☐ VOA ☐ Semi VOA ☐~~	~~CAM Metals EPA 6010/7000 TTLC ☐ STLC ☐~~	~~Lead Org./DHS ☐ Lead EPA 7420/7421 ☐~~ pH	Microbiology Testing	Microtoxicity
B-9@10-12'		1	X			X		3/9/93	12:30PM					X	X		X			X	X	X
B10@11-13'		1	X			X		↓	1:30PM					↓	↓		↓			↓	↓	↓
B-11 @ 11-13'		1	X			X		↓	2:30PM					↓	↓		↓			↓	↓	↓
B12@11-13'		1	X			X		↓	3:30PM					↓	↓		↓			↓	↓	↓

Special detection Limit/reporting

Special QA/QC

Remarks
Note: Very Short Hold times!

Lab number

Turnaround time

Priority Rush 1 Business Day ☐
Rush 2 Business Days ☐
Expedited 5 Business Days ☐
Standard 10 Business Days ☒

Condition of sample:
Temperature received:

Relinquished by sampler Roger Hoffmane	Date 3/9/93	Time 1710	Received by C. Huntsman	
Relinquished by	Date	Time	Received by	
Relinquished by	Date	Time	Received by laboratory	Date / Time

Distribution: White copy — Laboratory; Canary copy — ARCO Environmental Engineering; Pink copy — Consultant
ARCO 2002 (2-91)

BioScreen Testing Services, Inc.
Microbiology • Chemistry • Environmental • Asbestos

RECEIVED
APR 15 1993
PACIFIC ENVIRONMENTAL GROUP, INC.

ANALYTICAL REPORT

PACIFIC ENVIRONMENTAL GROUP
2025 Gateway Place
#440
San Jose, CA 95110

REPORT DATE: 04/05/93
ACCESSION #: 7344 - 7345
PROJECT #: 0713-1

ATTN: Kelly Brown

SAMPLE:

ACC #	SAMPLES:		
7344	ARCO Products Soil	B-25	12-14′
7345	ARCO Products Soil	B-26	12-14′

TEST(S) PERFORMED:

	METHOD REFERENCE
Heterotrophic Plate Count	BTS 227
Fluorescent *Pseudomonas*	BTS 228
Hydrocarbon Degraders	BTS 229
Ammonia	EPA 350.3
Nitrate	EPA 300.0
Phosphate	EPA 300.0
Potassium	EPA 601.0
pH	BTS 544
Moisture	BTS 554
Calcium	EPA 601.0
Magnesium	EPA 601.0
Iron	EPA 601.0
Microtoxicity	

RESULTS:

ACCESSION #: 7344 **ARCO PRODUCTS SOIL** **B- 25** **12-14'**

	RESULTS:	**DETECTION LIMIT**
Heterotrophic Plate Count	3.0 x 10^3 CFU/gm	1000 CFU/gm
Fluorescent *Pseudomonas*	<1000 CFU/gm	1000 CFU/gm
Hydrocarbon Degraders	<1000 CFU/gm	1000 CFU/gm
Ammonia	ND	10 ppm
Nitrate	ND	2.1 ppm
Phosphate	ND	5 ppm
Potassium	513	60 ppm
pH	7.66	---
Moisture	19.35 %	---
Calcium	4,240 ppm	10 ppm
Magnesium	5,280 ppm	300 ppm
Iron	18,000 ppm	400 ppm
Microtoxicity	Non Toxic to Microorganism	

ACCESSION #: 7345 **ARCO PRODUCTS SOIL** **B-26** **12-14'**

	RESULTS:	**DETECTION LIMIT**
Heterotrophic Plate Count	<1000 CFU/gm	1000 CFU/gm
Fluorescent *Pseudomonas*	<1000 CFU/gm	1000 CFU/gm
Hydrocarbon Degraders	<1000 CFU/gm	1000 CFU/gm
Ammonia	ND	10 ppm
Nitrate	ND	2.1 ppm
Phosphate	ND	5 ppm
Potassium	756	60 ppm
pH	7.54	---
Moisture	23.82 %	---
Calcium	4,120 ppm	10 ppm
Magnesium	6,150 ppm	300 ppm
Iron	19,200 ppm	400 ppm
Microtoxicity	Non Toxic to Microorganism	

Discussion:

The microbiological results show levels of heterotrophic organisms in the soil are below normal values. Based on results of samples tested at BioScreen Testing normal levels of total organism counts should be in the 1 x 10^5 to 1 x 10^6 range. The *fluorescent Pseudomonas* and hydrocarbon degraders levels are below normal values. Based on results of samples tested at BioScreen testing normal levels of *fluorescent Pseudomonas* and hydrocarbon degraders should be in the 1 x 10^5 and 1 x 10^3 range respectively. The low levels of microorganisms could be due to the depth at which samples were taken.

The nutrient data shows that ammonia, nitrate and phosphate are non detected in all samples. Potassium levels are not of concern at this time.

In addition the levels of calcium and magnesium are high. This is a cause for some concern and the nutrient amendment will have to be carefully buffered so that inorganic precipitation does not take place.

The moisture and pH seem to be within normal levels for supporting microbial growth.

The indication from the initial assessment data is that no bioremediation is taking place. With proper nutrient amendment of the soil it may be possible to stimulate bioremediation. The final ability to bioremediate a site is dependent on the type of contaminant present and the outcome of a treatability study.

Bradford L Rope
Bradford L. Rope
Laboratory Director

Ranil M. Fernando
Ranil M. Fernando, B.S.
Operations Supervisor

ARCO Products Company ◆ 330-06,20
Division of AtlanticRichfieldCompany

Task Order No. 0608-93-2

Chain of Custody

ARCO Facility no. 0608
City (Facility) San Lorenzo
Project manager (Consultant) Kelly Brown
Laboratory name BioScreen Testing
ARCO engineer Michael Whelan
Telephone no. (ARCO)
Telephone no. (Consultant) (408)441-7500
Fax no. (Consultant) (408)441-7539
Consultant name Pacific Environmental Group
Address (Consultant) 2025 Gateway Place #440 San Jose, CA 95110
Contract number 000151
Method of shipment Federal Express

Sample I.D.	Lab no.	Container no.	Matrix			Preservation		Sampling date	Sampling time	BTEX 602/EPA 8020	BTEX/TPH EPA M602/8020/8015	TPH Modified 8015 Gas ☐ Diesel ☐	Oil and Grease 413.1 ☐ 413.2 ☐	~~TPH EPA 418.1/SM503E~~ Nutrient Alkalinity	~~EPA 601/8010~~ Ca Fe Mg	~~EPA 624/8240~~ Moisture	~~EPA 625/8270~~ PH	TCLP Metals ☐ VOA ☐ Semi VOA ☐	CAM Metals EPA 6010/7000 TTLC ☐ STLC ☐	Lead Org./DHS ☐ Lead EPA 7420/7421 ☐	Microbo Testing	[illegible]-oxidity
			Soil	Water	Other	Ice	Acid															
B-25@12-14'		2	X			X		3/11/93	10:30AM					X	X	X	X				X	X
B-26@12-14'		2	X			X		3/11/93	11:30AM					X	X	X	X				X	X

Special detection Limit/reporting

Special QA/QC

Remarks Note: very short Hold time

Lab number

Turnaround time

[✓ Priority Rush 1 Business Day] ☐

Rush 2 Business Days ☐

Expedited 5 Business Days ☐

Standard 10 Business Days ☐

Condition of sample:

Temperature received:

Relinquished by sampler Roger Hoffmore — Date 3/11/93 — Time

Received by M Rodriguez #745

Relinquished by M Rodriguez #745 — Date — Time

Received by Tiffany [illegible]

Relinquished by — Date 3/11/93 — Time 2:05

Received by laboratory — Date — Time

Distribution: White copy — Laboratory; Canary copy — ARCO Environmental Engineering; Pink copy — Consultant

ARCO 3292 (2-91)

3/11/93 1527