Woodward-Clyde Consultants

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REPORT ON PHASE I
GROUND-WATER INVESTIGATION
EC INDUSTRIES
Emeryville, California

Prepared for

EC Industries
Technical Center
1401 Park Avenue
Emeryville, California 94608

Three Embarcadero Center, Suite 700
San Francisco, California 94111
415-956-7070

Woodward-Clyde Consultants

14929A

30 March 1981

EC Industries
Technical Center
1401 Park Avenue
Emeryville, California 94608

Attention: Douglas R. Swanson
Engineering Manager

REPORT ON PHASE I
GROUND-WATER INVESTIGATION
EC INDUSTRIES
Emeryville, California

Gentlemen:

We are pleased to submit this report presenting the results of Phase I of the ground-water investigations at your Emeryville plant site. We look forward to participating in Phase II of this interesting and important study.

Sincerely,

William R. Hansen

William R. Hansen
Project Manager

WRH/ech

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REPORT ON PHASE I
GROUND WATER INVESTIGATION
EC INDUSTRIES
Emeryville, California

INTRODUCTION

This report presents the results of our Phase I ground-water investigation of the EC Industries property at the intersection of Park Avenue and Holden Streets in Emeryville. The purposes of the Phase I investigation were to: (1) install pumping and observation wells; (2) perform pump tests to determine aquifer coefficients; (3) estimate the probable extent of chromium contamination in the ground-water body; and (4) evaluate the time involved and feasibility of pump-withdrawal of the contaminated ground water.

CONDUCT OF STUDY

To achieve the above objectives, the following program was conducted between December 9, 1980 and January 16, 1981.

1. Five test wells were drilled; wells 11 and 13 as production wells and wells 9, 10, and 12 as observation wells (Fig. 1).

2. Water levels were measured, by surveying the well casing elevations and measuring the depth to water at each well, to determine the water-level gradient.

3. A pump test was performed (8 hours) in well 11, utilizing wells 9 and 12 as observation wells.

4. Water quality samples were collected from wells 9 through 13 and analyzed for chromium content, pH, and specific conductance.

5. Pump test and slug test results were analyzed to determine the extent of the cone of depression in all monitoring wells after the 8-hour pump test, and to determine permeability values (slug tests were performed in wells 10 and 13 only).

6. The overall ground-water conditions were estimated by using the calculated aquifer parameters, the water table gradient, and the subsurface conditions as indicated from the boring logs.

ACKNOWLEDGEMENTS

The study was performed by the various Woodward-Clyde personnel. The pump test, water-level measurements and collection of water-quality samples were performed by Mark Howland, Senior Staff Hydrogeologist, and Richard Casias, Staff Hydrologist. The pump-test results were analyzed by David Dunbar, Senior Staff Hydrologist, and the report written by William Hansen, Senior Project Engineering Geologist. Peer review of the report was performed by Benjamin Lofgren, Senior Project Advisor. The wells were drilled by Pitcher Drilling Company, Palo Alto; the elevation survey was done by T.V. Tronoff Civil Engineer and Surveyor, Inc., Berkeley; and the chemical analyses were done by Ultrachem Corporation, Walnut Creek.

GEOLOGIC CONDITIONS

The drilling of five new monitoring wells, the interpretation of continuous core extracted from several of the wells, and the evaluation of previous reports provided a generalized profile of the subsurface geologic conditions of the study area. The locations of the five new monitoring wells (numbers 9-13) are shown in Figure 1 and the logs and construction details of these wells are shown in Figures 2 through 7.

The lithologic conditions of the sediments penetrated by borings beneath the subject site are shown in Figure 7. The upper 25-30 feet of alluvium is composed of interfingering layers of gravel, sand, silt and clay while the underlying alluvium appears to be finer-grained and contain extensive silty-clay layers. A blue silty-clay layer was encountered in all borings below a depth of 30 feet. This layer appears to be areally extensive and may correlate with a similar unit identified in borings 2,000 feet north of the subject site (Woodward-Clyde Consultants, 1977).

GROUND WATER CONDITIONS

Ground water exists in the vicinity of the site at a depth of approximately seven feet (Table 1). All of the monitoring wells encountered ground water in the coarse-grained sand and gravel and coarse silt layers penetrated. The static water levels in these monitoring wells define the configuration of the water table in the area; the water table slopes gently westward and has a gradient of about .006 or 32 feet per mile (Figure 8). The hydraulic gradient in the sand and gravel layer encountered in wells 3B, 11, and 12 is approximately .003.

Effect of Pumping

Pumping of well 11 during an 8-hour pump test created a cone of depression around the pumping well (Figure 9). All monitoring wells showed measureable drawdown, except wells 6 and 7 which are located farthest from the pumping well (Table 2 and Figure 9). This indicates that the aquifer system tapped by these wells is interconnected in the vicinity of the site. This widespread distribution of drawdown may also indicate that ground water withdrawn during the pump test was derived from the 12-foot thick sand and gravel layer at the base of the upper unit that the pumping well was screened against, and from the overlying fine-grained silty and clayey layers. The relative symmetry of the cone of depression is further evidence of the interconnection of the ground-water system.

Aquifer Coefficients

The 8-hour pump test and the two slug tests were performed to provide estimates of the aquifer parameters of transmissivity, permeability, and storage coefficient. The derived aquifer parameters are shown in Table 3.

During the 8-hour pump test, the drawdowns in wells 3C, 9, 12, and in pumping well 11, were measured on a continuous basis. This drawdown information was analyzed for each well using the Theis nonequilibrium type-curve method as described in Lohman (1972). This method involves the matching of the drawdown curve with a type curve, picking a match point, and calculating transmissivity and storage coefficient. The results of this method of analysis for observation well 12 are shown in Figure 10 to illustrate the method. Permeability was calculated by dividing the transmissivity by the thickness of the screened interval in the well (Table 3).

The logarithmic plots of time vs. drawdown for observation wells 9 and 12 and pumping well 11 exhibit slight irregularities between the early and late portions that may be due to geologic heterogenieties within the aquifer system.

Consequently, transmissivity, storage coefficient, and permeability were calculated for both the early and late data (Table 3). The traditional interpretation is that the early data represent conditions close to the pumping well, and the late data represent conditions over a larger volume of aquifer.

The drawdown curves for observation wells 9 and 12 and pumping well 11 were also analyzed for transmissivity by the Jacob straight-line method, as described in Lohman (1972), as a check against the Theis nonequilibrium type-curve results. The results of the application of the Jacob method to the data from observation well 12 are shown in Figure 11.

The results of the two methods are in reasonable agreement for the analysis of the late data. The storage coefficient ranges from a high of 1.9×10^{-3} for the early data in well 12, to 8×10^{-5} for the late data in well 9. As mentioned previously, early data represent conditions near the pumping well and late data conditions far from the pumping well. Low storage coefficients such as 8×10^{-5} normally indicate confined ground-water conditions and values in the range as high as 1.9×10^{-3} approach unconfined or water-table conditions. Therefore, it is our conclusion that the ground-water system is probably semi-confined near the pumping well and confined away from the pumping well. Confinement is most likely caused by the silty and sandy clay layers in the top portion of the upper 30 feet of alluvium which separates the sand and gravel layers from the ground surface (Figure 3).

The permeability values range from 24 feet per day for the early data in well 12 to 78 feet per day for the late data in well 9. Because the early data are most representative of the geologic conditions near the wells, conditions which are known from the well logs, we believe the early results are more reliable. Therefore, the average of the three early permeability values of 28 feet per day is chosen as most likely to represent the permeability of the gravel layer penetrated by wells 11 and 12. This is the most permeable unit encountered in the monitoring wells drilled on and near the property.

The slug tests were performed in wells 10 and 13 by introducing a five-gallon volume of water instantaneously into the well and measuring the water level in the well continually as the "slug" of water flows outward through the well screen. The slug test data was analyzed by the Hvorslev (1951) method.

The two slug tests were performed in the finer-grained portion of the alluvium encountered by the monitoring wells. The resulting permeability values of 1.1 feet per day in well 13 and 0.25 feet per day in well 10 are much lower than the values for the sand and gravel layer discussed above.

The aquifer coefficients can be summarized as follows:

Subsurface Material	Storage Coefficient	Permeability (ft/day)
Sand and gravel	6×10^{-4} to 8×10^{-5}	28*
Silty clay and gravelly clay	cannot be calculated	1.1
Clayey silt and sand and sandy clay	cannot be calculated	.25

These values show that the sand and gravel layer is approximately 25 times more permeable than the next most permeable unit tested.

*average of the 3 early values in Table 3.

Chemical Quality

The five monitoring wells drilled during this investigation were sampled for chromium, pH, and specific conductance. Well 11 was sampled periodically during the 8-hour pump test to identify changes in chromium content with time during the test. The results of these chemical analyses are shown in Table 4.

Over the 8-hour pumping period, the hexavalent chromium content increased from 90 to 134 milligrams per liter and the pH gradually increased from 4.3 to 4.7. These low pH values are perhaps the most unusual characteristic of the water pumped from well 11, because they are well within the acid range. In contrast, the pH in well 12, which is located only 8 feet from the pumping well and screened in the same gravel layer, had a pH of 9.2 well within the basic range. This suggests either that the ground water has unusual chemistry or that chemical reactions took place in sample bottle to change the pH between the times of sampling and analysis. The chemical changes could occur because the water came in contact with the atmosphere or because of a change in pressure at the time of sampling. A slight precipitate developed in the sample bottles just after sampling.

Calculated Rate of Movement

The rate of movement of ground water beneath the subject site can be calculated by the following formula:

$$V_e = \frac{KI}{n_e}$$

where

V_e = effective velocity
K = permeability
I = hydraulic gradient
n_e = effective porosity

Three values for permeability of the alluvium have been determined from field tests and are listed in the previous section entitled Aquifer Coefficients. The regional hydraulic gradient established from the contours in Figure 9 is .006, and the assumed value for porosity of 25% for sand and gravel and the finer-grained layers are reasonable estimates. The hydraulic gradient in the sand and gravel layer appears to be approximately .003 based on water level elevations in wells 3B, 11 and 12 (Table 1). The calculation of velocity for the three permeability cases (designated as I through III) are given below.

Case	Permeability (ft/day)	Hydraulic Gradient	Assumed Effective Porosity	Effective Velocity (ft/day)	Effective Velocity (ft/year)
I	28.0	.003	.25	.34	123.0
II	1.1	.006	.25	.026	10.0
III	.25	.006	.25	.006	2.0

From the above simple calculations, it is clear that the rate of movement of chromium-contaminated ground water is dependent most directly on the permeability of the alluvial sediments and the hydraulic gradient. If the sand and gravel layer is continuous within the finer-grained sediments, then the rate of movement is dependent on the hydraulic gradient and permeability of the gravel. In contrast, if the gravel layer identified in wells 11 and 12 is a discontinuous lens within the finer-grained sediments, then the rate of movement is largely dependent on the permeability and hydraulic gradient of these finer-grained sediments. The boring logs on site show the geologic conditions to be complicated; therefore, without additional borings it is not possible to identify which of these two conditions is present beyond the site. Further discussion of these two conditions is given below.

DISCUSSION OF RESULTS

To a depth of approximately 30 feet beneath the site ground water is contaminated by chromium from a source or sources as yet unidentified. The high levels of chromium in the shallow wells 5 and 13 and the lower, though significant, levels of chromium in wells 11 and 12, which tap the gravel layer, suggest two separate sources of chromium contamination.

The direction of ground-water movement in the study area is westerly. Therefore, the chromium-contaminated ground water will tend to move in that direction. If the movement of ground water in the sand and gravel layer was as rapid as that calculated above (123 feet per year), the zone of contaminated ground water would have moved down gradient to the west past wells 11 and 12. The chromium content of well 3B (Figure 7) is approximately 0.17 milligrams per liter, which suggests that the near-surface alluvium at that point is not transmitting chromium downward to the sand and gravel layer beneath it. The source of this contamination would appear to be either the shallow disposal well, a highly contaminated area of soil beneath or near the chromium waste storage pit, or another unknown source entering the sand and gravel layer. Whether the sand and gravel layer is a lens within the finer-grained silty clay layers can be tested by accurately determining the hydraulic gradient in the layer. The actual rate of movement is most likely to be less than the Case I condition and more likely to lie somewhere between the Case I and III conditions.

There are three major indications that the chromium contamination is isolated above a depth of 30 feet by the blue silty clay layer that underlies the sand and gravel layer. First, the chromium content and pH of well 3A, the deepest of the monitoring wells, suggest that contamination has not reached the level of the screened interval of this well (Figure 7). Second, the water level in well 3A is lower than that of any of the others monitoring wells (Table 1). Third, the water level in well 3A rose during the pumping test while the water levels in other wells declined (Table 2). This latter behavior is the characteristic response of a confined aquifer that is isolated from an overlying pumped aquifer.

The general feasibility of pump withdrawal of the chromium-contaminated ground water has been demonstrated by the results of the eight-hour pump test. Drawdown occurred throughout the upper 30 feet of alluvium - in both the coarser-grained sand and gravel layers and in the less permeable silty and clayey layers. Furthermore, the cone of depression due to pumping extended to all of the monitoring wells except for those (wells 6 and 7) farthest from the pumping well.

SUMMARY AND CONCLUSIONS

1. The subject site is underlain by alluvium composed of an upper unit and a lower unit. The former consists of layers of gravel, sand, silt and clay with a prominent sand and gravel layer near the base. The lower unit contains a finer-grained silty clay with one prominent blue silty clay layer that appears to correlate with boring logs 2,000 feet further north.

2. Ground water beneath the site to a depth of approximately 30 feet is contaminated by chromium from a source or sources as yet unidentified.

3. On the basis of both the 8-hour pump test and the slug tests, the sand and gravel layer is approximately 25 times more permeable than the next most permeable unit tested.

4. During the pumping test, the hexavalent chromium content in well 11 increased from 90 to 134 milligrams per liter and the pH gradually increased from 4.3 to 4.7. However, these pH values were not consistent with those measured in other monitoring wells.

5. Chromium-contaminated ground water exists in significant volume within the sand and gravel layer. The true rate of movement of contaminated ground water in the vicinity of the subject site is most likely less than 123 feet per year (Case I conditions) and more likely to lie somewhere between 2 feet per year (Case III conditions) and 123 feet per year.

6. The rate and direction of movement of contaminated ground water beyond the vicinity of the subject site depend in part on whether the sand and gravel layer is continuous within the finer-grained sediments, or whether the sand and gravel layer is a lens within the finer-grained sediments. Without additional borings, it is impossible to identify which of these two conditions are present beyond the site.

7. Pumping of well 11, which taps the sand and gravel layers near the bottom of the upper 30 feet of alluvium, caused measurable drawdown in all the monitoring wells except wells 6 and 7 which are located farther from the pumping well.

8. The results of this study indicate the general feasibility of a pump withdrawal scheme for removal of chromium-contaminated ground water present in the coarser-grained units beneath the site.

RECOMMENDATIONS

1. Investigate the peculiar chemistry of ground water pumped from well 11 by conducting complete chemical analyses of ground water from the 5 monitoring wells completed in Phase I. These should include standard minerals, heavy metals, organics, field pH and specific conductance.

2. Precisely measure the elevation of the water levels in 3 wells which tap the sand and gravel layer to determine the actual hydraulic gradient.

3. Drill additional monitoring wells down gradient and west of the site to better define the extent of chromium contamination in the ground water.

4. Obtain complete chemical analyses (the suite recommended in 1 above) of ground water collected from the new monitoring wells recommended in 3 above.

5. Analyze chromium content of the soil above the ground-water level in areas suspected of having high concentrations.

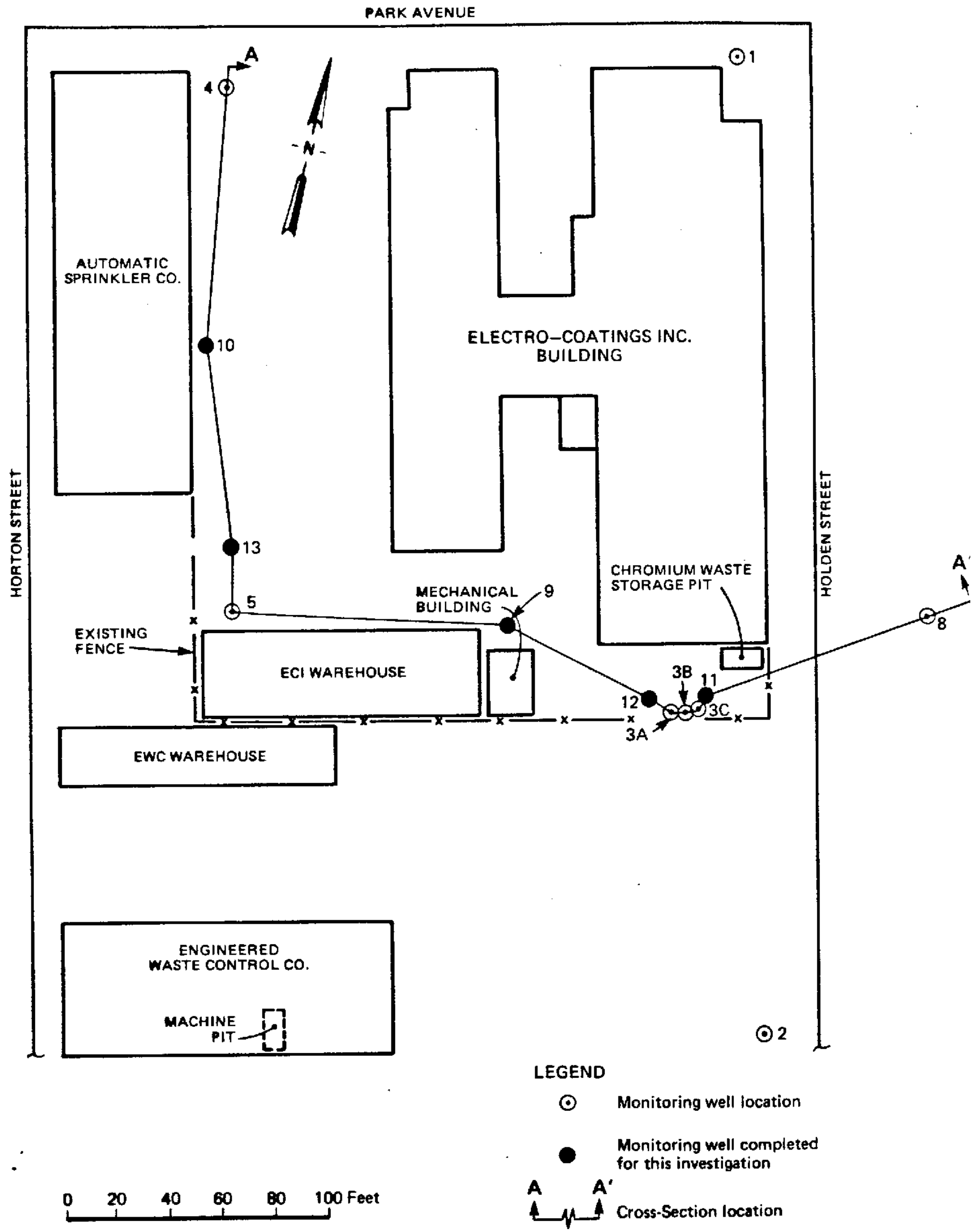
6. Estimate the volume of chromium contaminated ground water present at the site.

REFERENCES

Hvorslev, M. J., 1951, "Time Lag and Soil Permeability Groundwater Observations," Waterways Experiment Station Bulletin No. 36, Vicksburg, Miss.

Lohman, S. W., 1972, "Ground-Water Hydraulics," U.S.G.S. Prof. Paper No. 708.

Woodward-Clyde Consultants, 1977, "Report of Findings Data Study Regarding Subsurface Soil and Ground Water Conditions, Electro Coatings, Inc.," unpublished report dated July 22.



Project No. 14929A	ELECTRO-COATINGS INC. Emeryville, California	SITE & MONITORING WELL LOCATIONS	Figure 1
Woodward-Clyde Consultants			

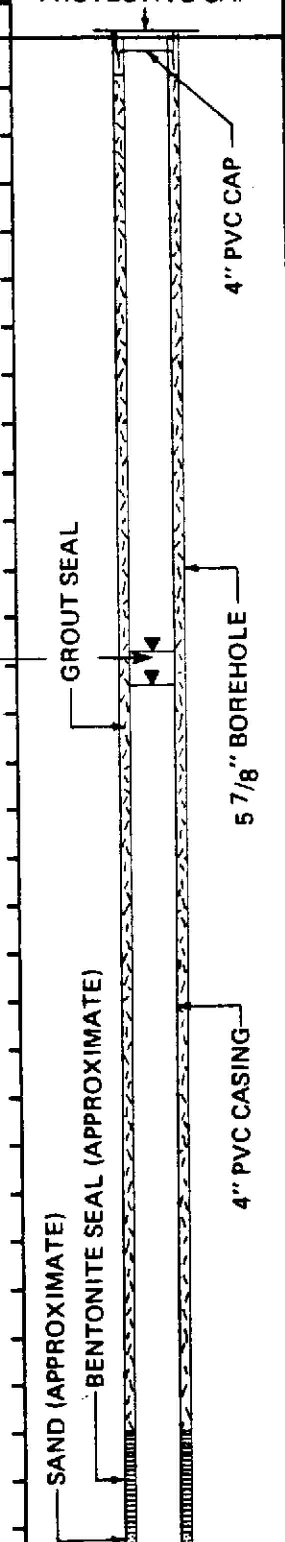
Project: ELECTRO COATINGS INC. Emeryville, California	**Log of Boring No. 9**

Date Drilled: 12/10/80 to 12/12/80
Type of Boring: 4 5/8" Pitcher Core Barrel
Hammer Weight:
Remarks:
(See Legend Sheet for sampler types and hammer weights)

Surface Elevation:

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
0 – 0.67			8" ASPHALT
0.67 – 3.4			GRAVEL FILL angular fragments (up to 1"), reddish-brown
3.4 – 5			CLAY medium hard, very dark gray
5 – 6	CONTINUOUS CORING (5 – 16.5)	0/1	lost sample in hole
6 – 8		2.15/2.5	CLAY firm to stiff, mottled, trace of coarse sand, fine gravel 12/29/80, 1/14/81 } Water Levels — grading more sandy and softer
8 – 8.5			CLAYEY SAND trace fine gravel, light green
8.5 – 9.1		1.5/1.5	CLAYEY SILT–SILTY CLAY soft, wet, gray
9.1 – 10			GRAVELLY SILTY SAND green, orange mottling
10 – 13.3		1.1/2.5	SILTY SANDY GRAVEL crumbly, moist, gravel is subangular-subrounded (maximum size of gravel is 1"), mottled, greenish-reddish brown — core loss
13.3 – 15		1.7/2.5	SAND fine-medium sand, trace gravel and clay, mottled, light brown to light green — — transitional — —
15 – 16.4		1.0/1.0	SANDY SILTY CLAY soft, light brown to light green
16.4 –			SANDY GRAVEL

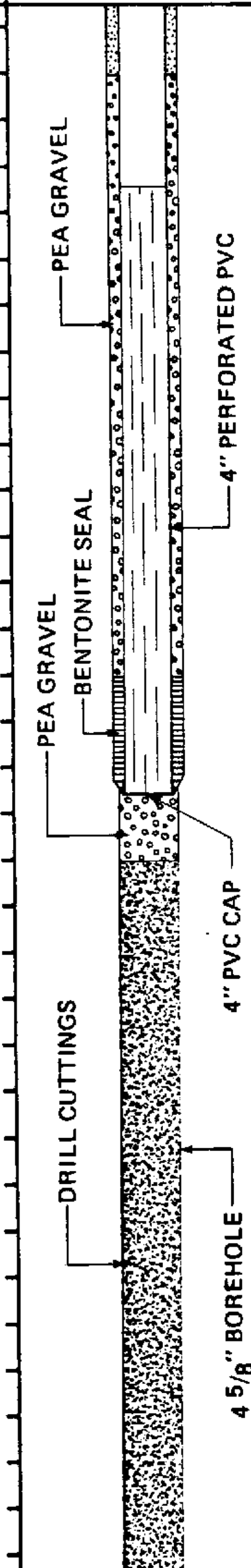
WELL INSTALLATION DETAILS



Project: ELECTRO COATINGS INC. Emeryville, California	Log of Boring No. 9 (Continued)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
16	CONTINUOUS CORING		subrounded gravel, crumbly
			more clayey
17		2.1/2.5	SANDY CLAY firm, light brown to light green
18			CLAYEY SAND trace of fine gravel, firm, slightly moist, in places sandy clay
19			core loss
20		1.3/2.5	SANDY CLAY fine sand, firm, slightly moist, light brown to light green, reddish-brown and brown mottling
21			SILTY CLAY moderately stiff, light brown to light green core loss
22		1.5/2.5	
23			
24			core loss more sandy — orange mottling more common
25		1.7/2.5	trace gravel near base
26			SILTY CLAY firm, common orange mottles, blue core loss
27		1.7/2.5	
28			angular fine gravel more predominant with minor sandy zones
29			SANDY CLAY fine sand, trace gravel, orange mottling, bluish-gray
30		2.3/2.5	
31			extensive orange mottling
32		2.2/2.5	grading more sandy

WELL INSTALLATION DETAILS

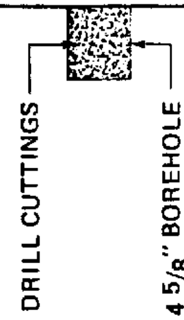


Proj. No. 14929A	Woodward-Clyde Consultants	Figure 2b

Project: ELECTRO COATINGS INC.
Emeryville, California

Log of Boring No. 9
(Continued)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION	WELL INSTALLATION DETAILS
33			as above	
			Bottom of boring @ 33.5 feet	



Project: ELECTRO COATINGS INC.
Emeryville, California

Log of Boring No. 10

Date Drilled: 12/12/80 to 12/16/80

Type of Boring: 4 5/8" Pitcher Core Barrel

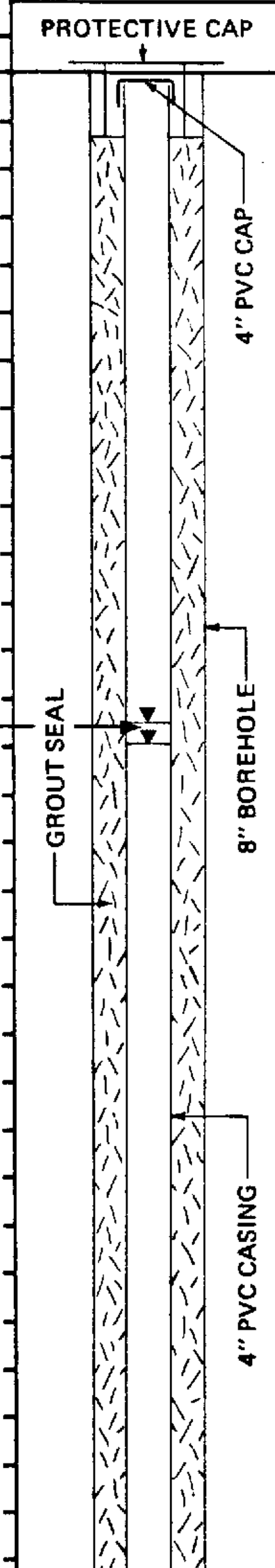
Hammer Weight:

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
			Surface Elevation:
0–0.5			6" ASPHALT
0.5–1			GRAVEL FILL (road ballast)
1–5			SILTY CLAY slightly stiff, moist, black
~2.5			more gravelly
3–4.5	CONTINUOUS CORING (3 to bottom of log)	1.5/1.5	crumbly with less silt
4.5–5		.5/.5	
5–8.2		2.6/2.5	SANDY CLAY moist, trace orange mottling, dark gray angular gravel (up to 3 cm) near top
~6.7–6.9			12/29/80, 1/14/81 } Water Levels
7.5–8.2		1.8/2.5	core loss
8.2–9.5			SILTY SAND firm, yellowish-brown
9.5–			SILTY CLAY trace coarse sand, firm, olive brown
10–11		1.5/2.5	core loss
11–12			some orange-brown color with coarse sand and fine gravel, orange mottling
12.5–13		2.0/2.5	core loss
13–15			more sandy
15–15.5			brown mottling

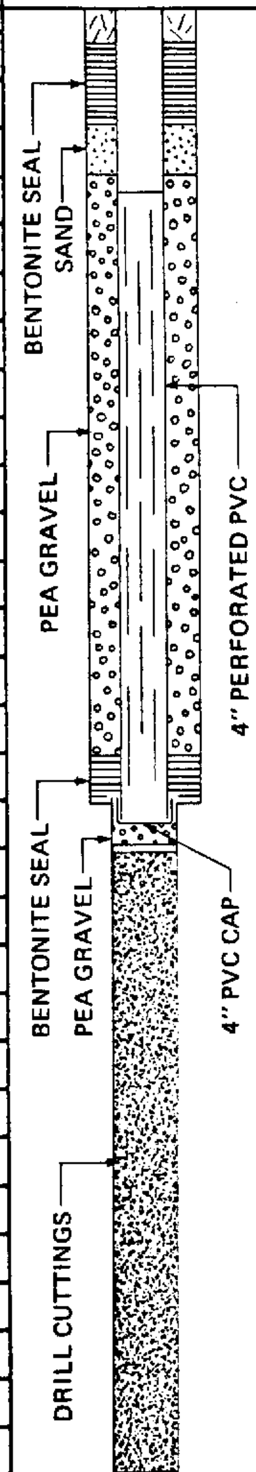
WELL INSTALLATION DETAILS



Project: ELCTRO COATINGS INC. Emeryville, California	Log of Boring No.10 (Continued)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
16	CONTINUOUS CORING (16–31 ft)	1.8/2.0	
17			
18		2.8/3.0	CLAYEY SAND gravelly, firm, wet, olive-brown
19			SANDY SILTY CLAY firm, moist, orange mottling, greenish-brown
20			
21		2.4/3.0	
22			core loss; grading more brown
23			
24			SILTY CLAY trace sand, firm, blue
25		2.9/3.0	grading more clayey
26			
27		2.3/2.5	
28			orange mottling predominant at base of core
29			SILTY SANDY CLAY firm, orange mottling, blue
30		2.2/2.5	grading to clayey fine sand
31			SILTY CLAY firm, reddish-orange mottling, blue
			Bottom of boring @ 31.0 feet
32			

WELL INSTALLATION DETAILS



Project: ELECTRO COATINGS INC.
Emeryville, California

Log of Boring No.11

Date Drilled: 12/16/80 to 12/18/80

Type of Boring: 4 5/8" Pitcher Core Barrel

Hammer Weight:

Remarks:

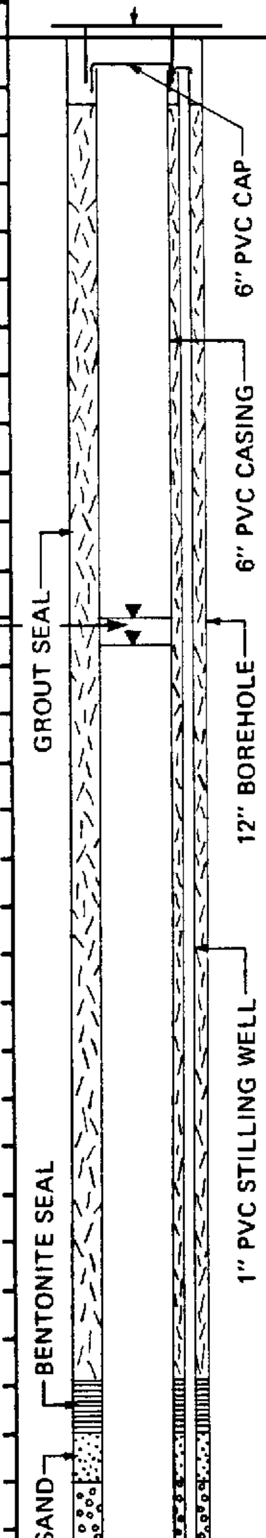
(See Legend Sheet for sampler types and hammer weights)

Surface Elevation:

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
0–0.7			8" ASPHALT
0.7–4			CLAY FILL medium soft, moist, black becoming firmer with depth (2–4)
3–5.5	CONTINUOUS CORING (3–15.5)	2.7 / 2.5	
4–8			SILTY CLAY trace sand and fine angular gravels, brown-orange mottling, dark gray core loss (5.5–6.1) grading more dark green (6.1–6.9) core loss (7.5–8)
5.5–8		1.3 / 2.5	
8–12		2.8 / 3.0 (8–11)	SANDY CLAY fine sand, trace angular gravel, minor orange mottling, moist, dark green to green-blue grading to more olive green (8.7–9.6) increased orange mottling (9.5–10.2) gravel more common (11–11.9)
11–13.5		2.3 / 2.5	
12–15.5			SANDY SILTY CLAY trace gravel, orange mottling, olive green increased fine gravel and orange mottling (15–15.5)
13.5–15.5		2.0 / 2.0	

12/29/80, 1/14/81 } Water Levels (at approx. 6 ft)

WELL INSTALLATION DETAILS



Proj. No. 14929A

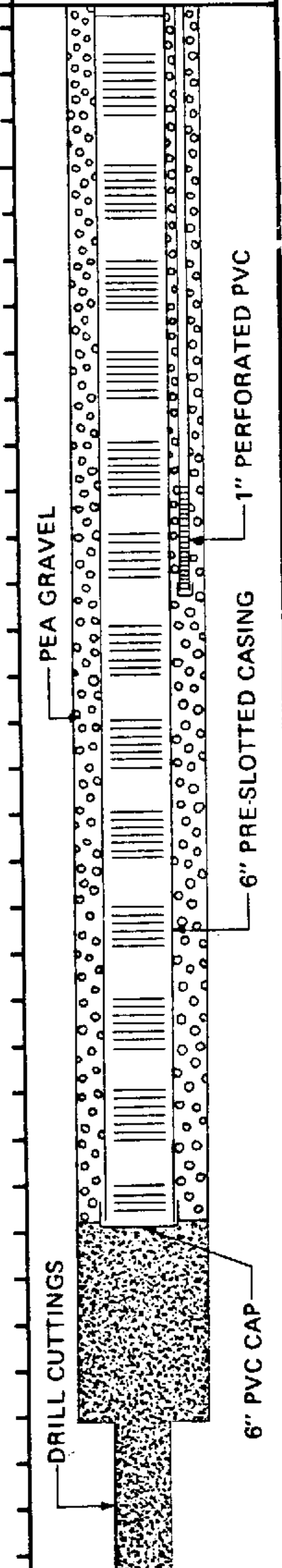
Woodward·Clyde Consultants

Figure 4a

Project: ELECTRO COATINGS INC. Emeryville, California	Log of Boring No. 11 (Continued)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
16	CONTINUOUS CORING		**GRAVELLY CLAYEY SAND** fine sand, poor to moderate sorting, moist to wet
17		2.2/2.5	**GRAVELLY SANDY CLAY** firm, wet, bright orange mottling, light brown
18–20		1.3/2.5	**GRAVELLY SAND** gravel up to 25mm across, predominantly medium to coarse sand, poor sorting, minor clay, wet, loose, permeable, dark brown
21		0/1	core loss
22–23		2.2/2.5	**CLAYEY GRAVELLY SAND** pebble to cobble sizes, fine to coarse sand, poorly sorted, wet, orange mottling throughout, tan brown to light brown; less clay, loose
24–26		2.0/2.5	as above, with less cobble-sized gravel, better sorting; gravel constituents: sandstone, chert, milky quartz, basalt; gravel is angular
27–29		1.3/2.5	core loss; as above, less clay, moderately sorted, saturated appearance; clayey gravelly sand near top and bottom of interval; core loss
30–31		1.8/2.5	**SILTY SANDY CLAY** trace fine angular gravel, moist, orange-dark brown mottling, green to light brown; minor gravel lense
32		2.5/2.5	**SANDY CLAY–CLAYEY SAND** firm, slightly moist, gray to olive-brown

WELL INSTALLATION DETAILS



Proj. No. 14929A	Woodward-Clyde Consultants	Figure 4b

Project: ELECTRO COATINGS INC.
Emeryville, California

Log of Boring No. 11

(Continued)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION	WELL INSTALLATION DETAILS
33			SILTY CLAY trace sand, orange mottling, some fat clay, bluish-gray	DRILL CUTTINGS
34			Bottom of boring @ 34 feet	

Proj. No. 14929A

Woodward-Clyde Consultants

Figure 4c

Project: ELECTRO COATINGS INC.
Emeryville, California

Log of Boring No.12

Date Drilled: 12/18/80 to 12/19/80

Type of Boring: 8" Rotary

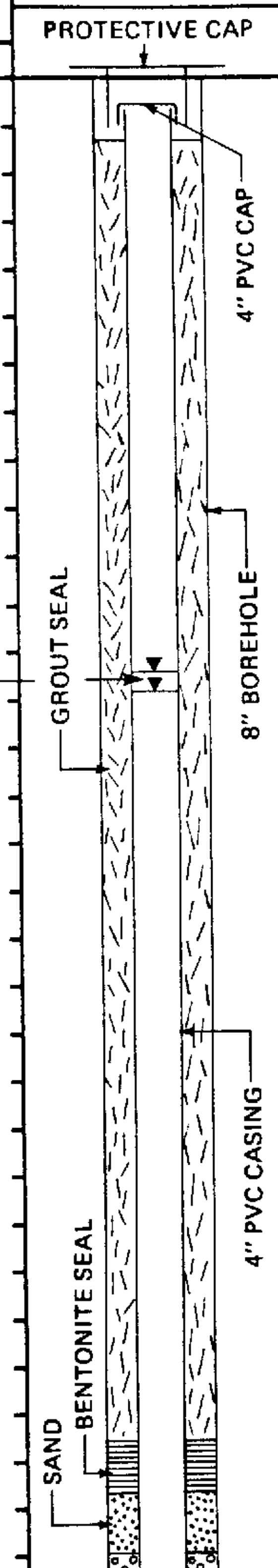
Hammer Weight:

Remarks:

(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
			Surface Elevation:
0–0.5			6" ASPHALT
0.5–3.5			FINE SAND brown to gray with angular chips of gray gravel fragments of granite (?) (very rough drilling)
3.5–6.5			SAND brown grading to SILTY CLAY black 12/29/81, 1/14/81 } Water Levels
6.5–8.2			SILTY CLAY gray
8.2–10.5			SILTY CLAY buff brown to blue-gray grading more brown
10.5–15.5			SANDY SILTY CLAY trace coarse sand and angular gravel, tan brown grading less gravel

WELL INSTALLATION DETAILS



Proj. No.14929A

Woodward-Clyde Consultants

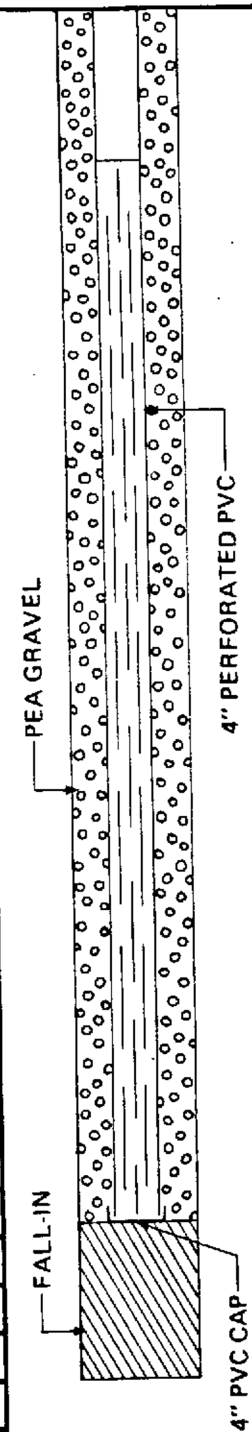
Figure 5a

Project: ELECTRO COATINGS INC.
Emeryville, California

Log of Boring No. 12
(Continued)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
16			
17			SAND AND GRAVEL coarse sand, fine gravel, brown to gray
18			
19			
20			
21			
22			
23			grading coarser
24			
25			
26			
27			
28			SILTY CLAY trace of fine sand, tan-brown
29			
30			Bottom of boring @ 30 feet
31			
32			

WELL INSTALLATION DETAILS



Proj. No. 14929A

Woodward-Clyde Consultants

Figure 5b

Project: ELECTRO COATING INC.
Emeryville, California

Log of Boring No. 13

Date Drilled: 12/22/80
Type of Boring: 4 5/8" Pitcher Core Barrel
Hammer Weight:

Remarks:
(See Legend Sheet for sampler types and hammer weights)

Depth, Ft.	Samples	Ft. recovered/ Ft. cored	MATERIAL DESCRIPTION
			Surface Elevation:
0			4" ASPHALT
			SILTY CLAY FILL
1–2			SILTY CLAY soft, moist
3	CONTINUOUS CORING (3–15.5)		core loss
4		2.0/2.5	grading more firm
6		2.5/2.5	transitional — 1/14/81 Water Level; trace fine gravels
7			SILTY CLAY trace coarse sub rounded gravel (≈20 mm) stiff, slight moist, light olive brown
8–9		2.4/2.5	becoming more tan brown, increasing gravel and sand
10			increased mottling
11		1.6/2.5	core loss
12			SANDY SILTY CLAY trace gravel, orange mottling around sand grains, tan-brown
13			fine gravels common near base
			core loss
		2.3/2.5	SANDY GRAVELLY CLAY heavy orange mottling
14–15			SANDY SILTY CLAY trace gravel, dark brown mottling common throughout, light olive green to brown, locally black-orange sand (weathered?) common
15.5			Bottom of boring @ 15.5 feet

WELL INSTALLATION DETAILS

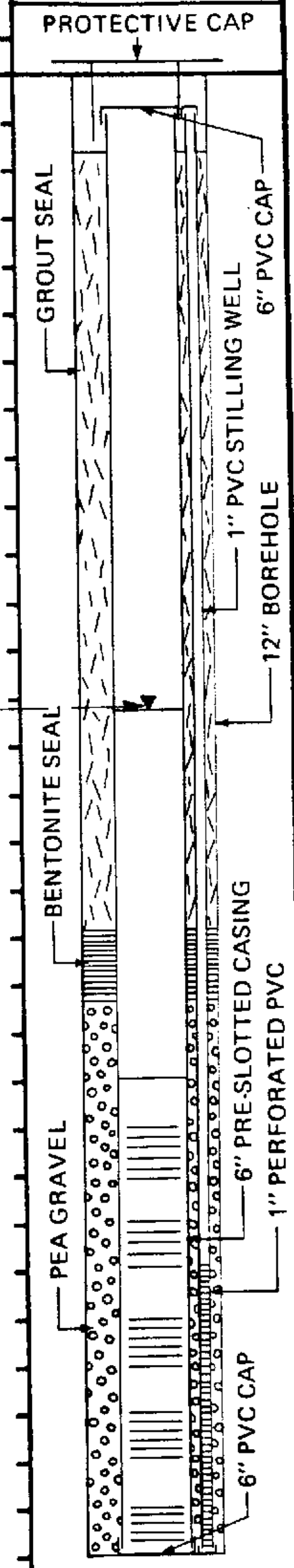


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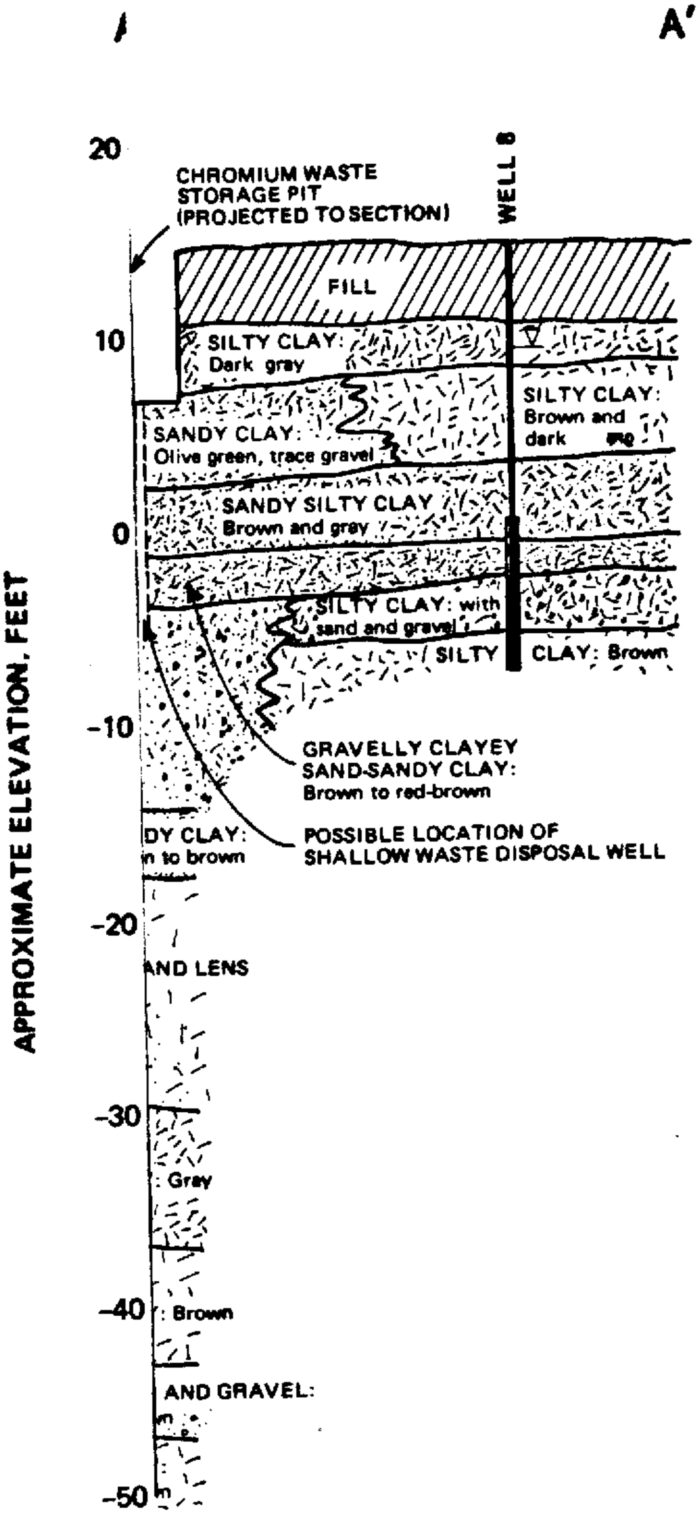
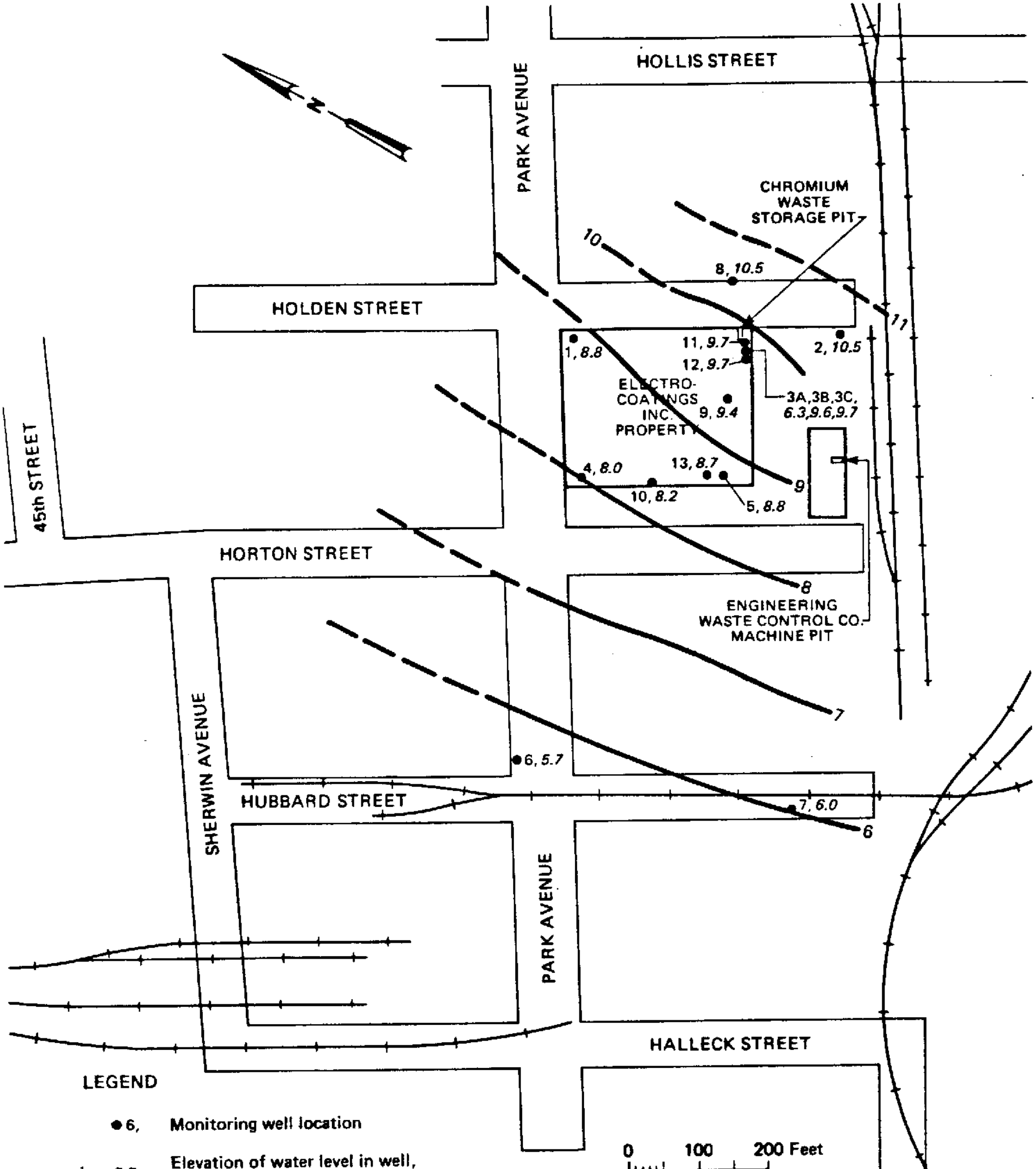
Figure 6



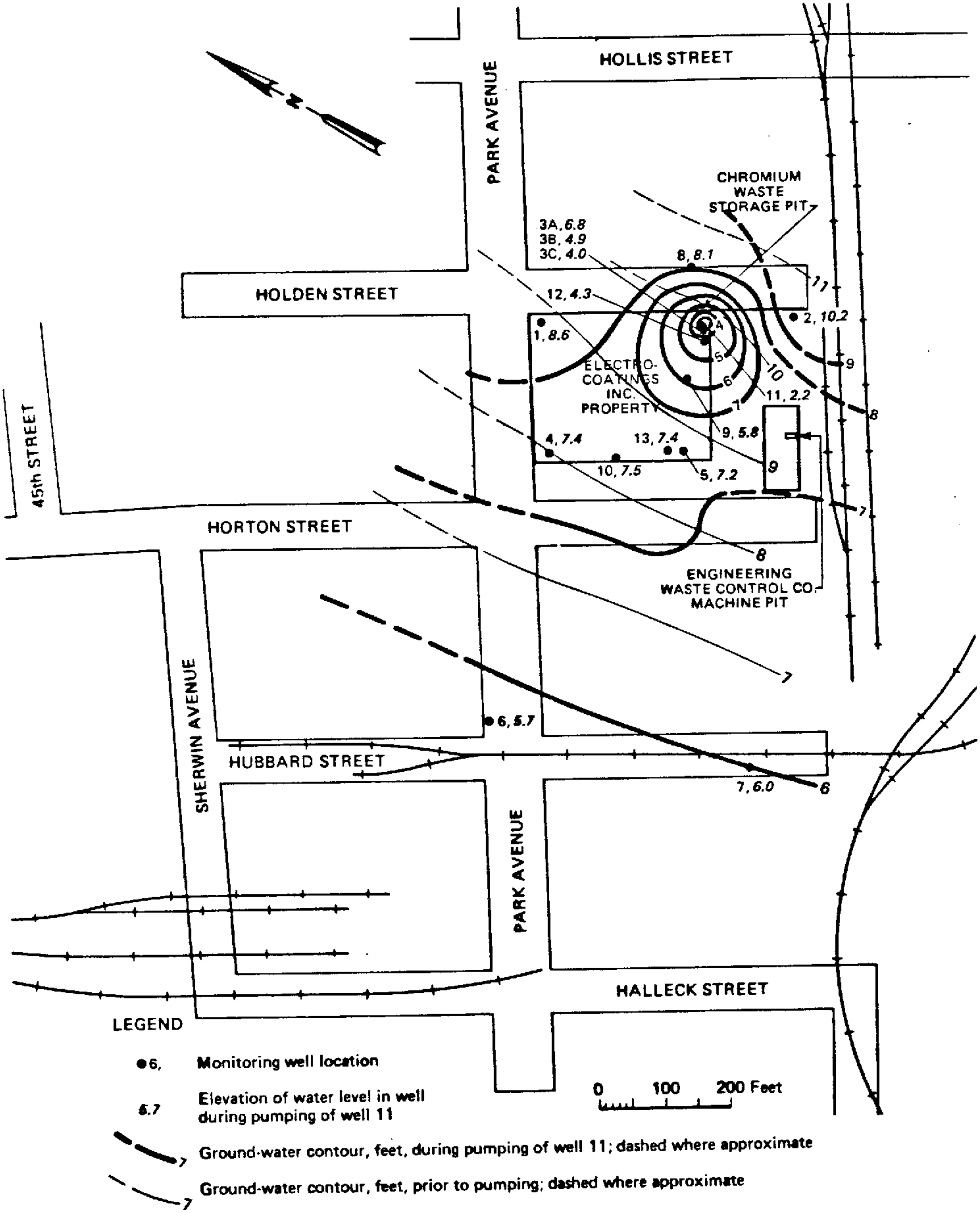
SOIL PROFILE A - A'	Figure 7



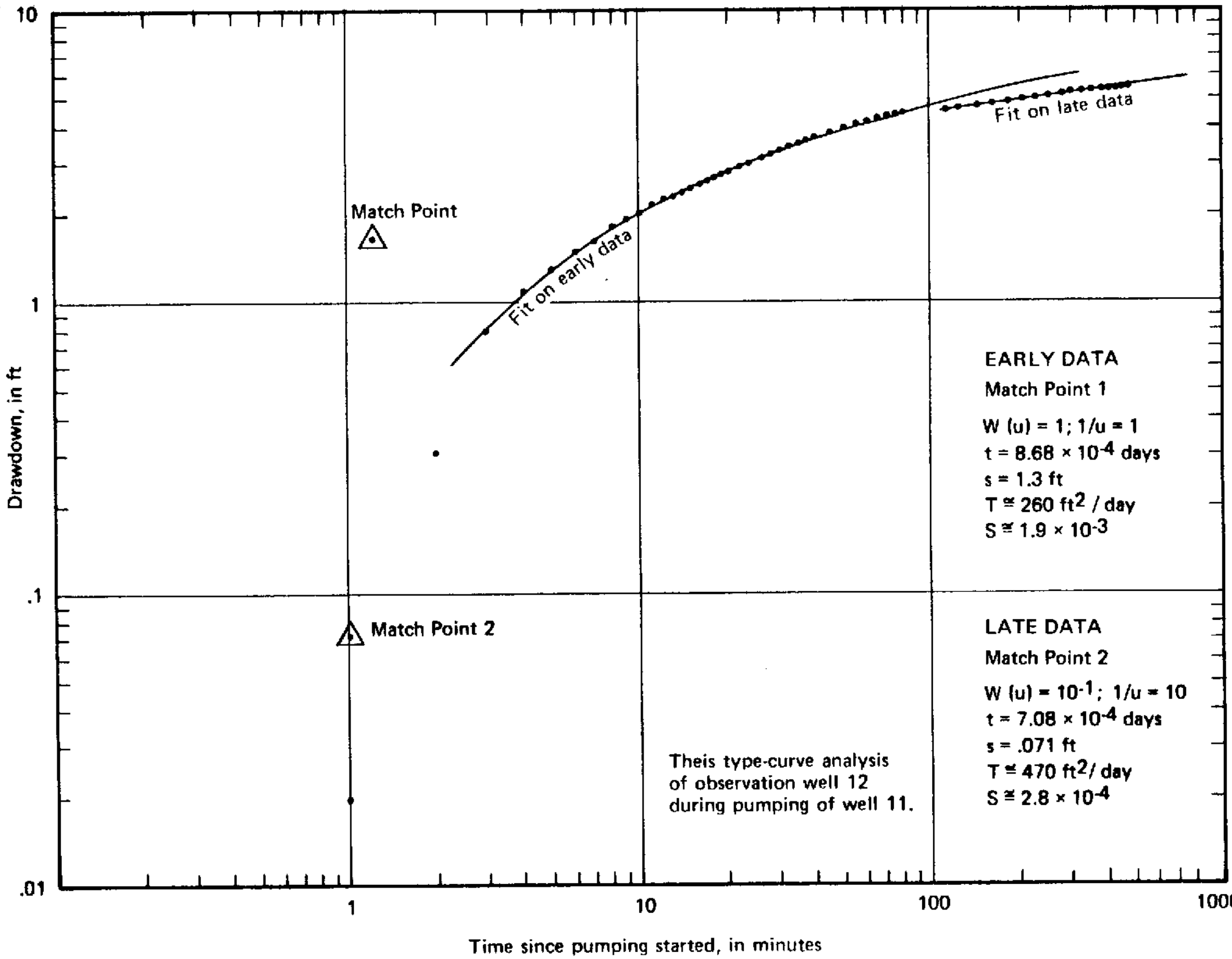
LEGEND

- ● 6, Monitoring well location
- *5.7* Elevation of water level in well, January 14, 1981; feet, USC&GS datum
- Ground-water contour, feet; dashed where approximate

Project No. 14929A	ELECTRO-COATING INC. Emeryville, California	GROUND-WATER LEVEL	Figure 8
Woodward-Clyde Consultants			



Project No. 14929A	ELECTRO-COATINGS INC. Emeryville, California	GROUND-WATER LEVEL DURING PUMPING OF WELL 11	Figure 9
Woodward-Clyde Consultants			



Project No. 14929A

ELECTRO-COATINGS INC.
Emeryville, California

Woodward-Clyde Consultants

LOGARITHMITIC PLOT OF TIME VS. DRAWDOWN, OBSERVATION WELL 12

Figure 10

Woodward-Clyde Consultants

Project No. 14929A

ELECTRO-COATINGS INC.
Emeryville, California

SEMILOGARITHMITIC PLOT OF TIME VS. DRAWDOWN, OBSERVATION WELL 12

Figure 11

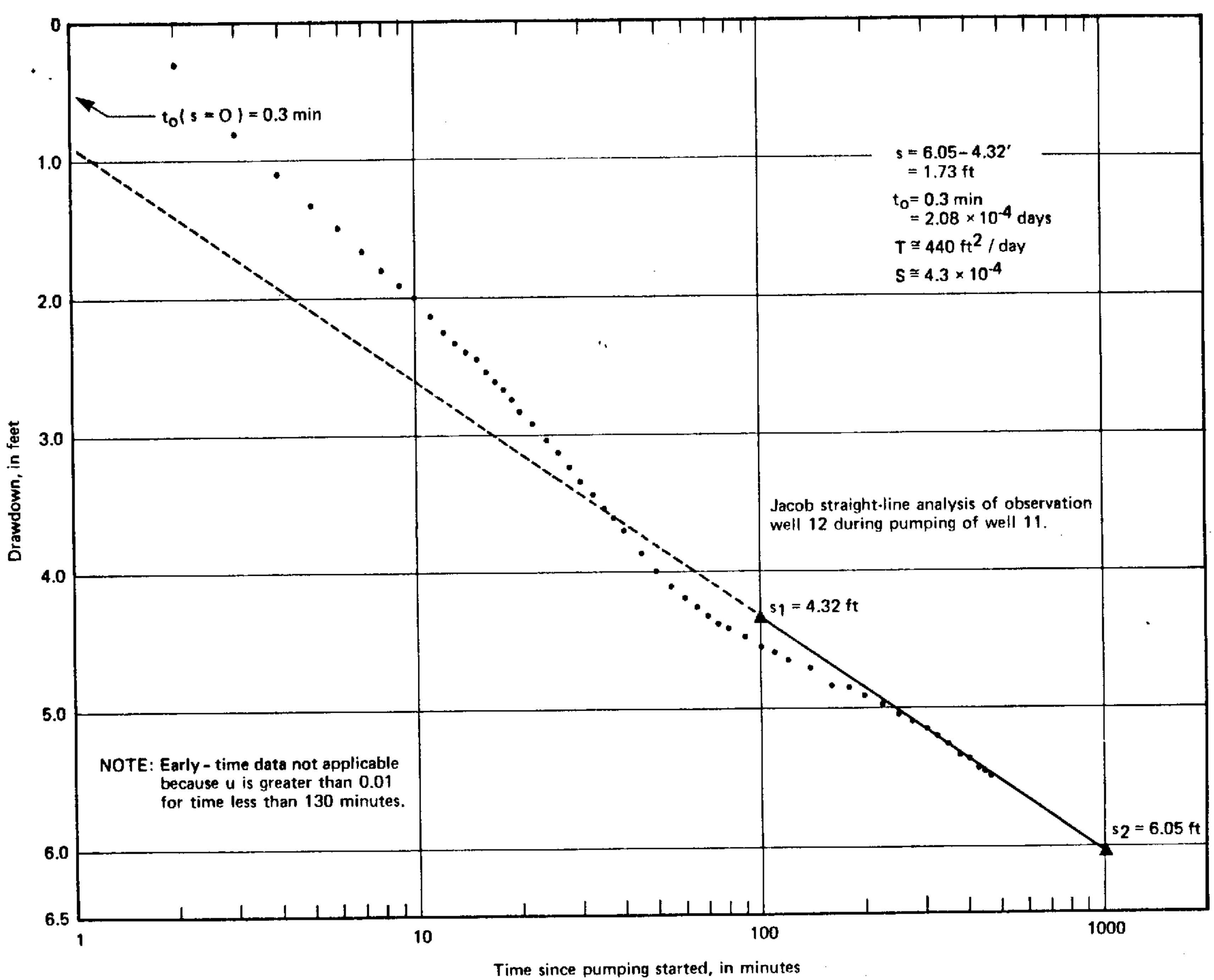


TABLE 1
GROUND-WATER LEVELS

Well Number	Reference-Point Elevation[1] (feet)	Depth to Water[2] (feet)	Water-Level Elevation (feet)
1	15.78	7.02	8.76
2	16.67	6.13	10.54
3A	16.10	9.80	6.30
3B	15.63	6.04	9.59
3C	16.31	6.63	9.68
4	14.29	6.37	7.92
5	15.87	7.08	8.79
6	9.24	3.56	5.68
7	9.71	3.73	5.98
8	15.63	5.09	10.54
9	16.08	6.70	9.38
10	15.10	6.86	8.24
11	16.04	6.32	9.72
12	16.05	6.39	9.66
13	15.36	6.64	8.72

---

[1] Reference point is top of casing. Surveyed elevations by T.V. Tronoff Civil Engineer and Surveyor, Inc.; USC&GS datum

[2] Measured on January 14, 1981

TABLE 2
PUMP-TEST DRAWDOWN

Well Number	Depth To Water Before Test (Feet)	Depth To Water Near End of Test[1] (Feet)	Water Level Elevation Near End of Test (Feet)	Drawdown (Feet)
1	7.02	7.16	8.62	0.14
2	6.13	6.51	10.16	0.38
3A	9.80	9.32	6.78	+0.48[2]
3B	6.04	10.73	4.90	4.69
3C	6.63	12.34	3.97	5.71
4	6.37	6.88	7.41	0.51
5	7.08	8.63	7.24	1.55
6	3.56	3.57	5.67	none
7	3.73	3.70	6.01	none
8	5.09	7.57	8.06	2.48
9	6.70	10.29	5.79	3.59
10	6.86	7.65	7.45	0.79
11[3]	6.32	13.78	2.26	7.46[3]
12	6.39	11.77	4.28	5.38
13	6.64	8.00	7.36	1.36

[1] Pumping ceased at 1716 hours on January 14, 1981

[2] Rise rather than drawdown

[3] Pumping well

TABLE 3 -- A[illegible]ER TEST RESULTS

Well No.	Depth (ft.)	Screened Interval Thickness (ft.)	Screened Interval Lithology	Test Method	Aquifer Coefficients Transmissivity (ft²/day)	Aquifer Coefficients Storage Coeff.	Aquifer Coefficients Permeability (ft/day)	Analysis Method	Comments
3C	20	3	upper portion: silty clay lower portion: sand and gravel	pump test of #11 (obs. well)				none used	Not analyzed due to minimal penetration of aquifers; drawdown was observed.
9	34	8	upper portion: clayey sand and gravel lower portion: silty clay	pump test of #11 (obs. well)	260*	6.3×10^{-4}*	33*	Theis type-curve	Significant change in time-drawdown slope after 100 min.
					620**	8×10^{-5}**	78**	Theis type-curve	
					460**	8.3×10^{-5}**	58**	Jacob str.-line	
10	31	7	upper portion: clayey silt and sand lower portion: silty clay	slug test			0.25	Hvorslev	Technique assumed unconfined conditions; confined curves did not fit.
11	34	10	extreme upper portion: silty clay, clayey sand-sandy clay major portion: sand and gravel extreme lower portion: sandy clay	pump test of #11 (pumping well)	280*		28*	Theis type-curve	Discontinuity in time-drawdown data, with later return (100 min.) to original time-drawdown slope.
					310**		31**	Theis type-curve	
					400**		40**	Jacob str.-line	
12	28	11	major portion: sand and gravel extreme upper portion: silty clay	pump test of #11 (obs. well)	260*	1.9×10^{-3}*	24*	Theis type-curve	Discontinuity in time-drawdown data similar to that in well 9.
					470**	2.8×10^{-4}**	43**	Theis type-curve	
					440**	4.3×10^{-4}**	40**	Jacob str.-line	
13	15	5.5	upper portion: clayey silt and sand major portion: silty clay; thin gravelly clay.	slug test			1.1	Hvorslev	

* - These aquifer coefficients were calculated using time-drawdown data from approximately the first 100 minutes of the 8-hr pump test.

** - These aquifer coefficients were calculated using time-drawdown data from after approximately the first 100 minutes of the 8-hr pump test.

TABLE 4

GROUND-WATER ANALYSES[1]

Well Number	Date and Time Sampled	Temp °C	pH	Specific Conductance mhos/cm at 20°C	Hexavalent Chromium mg/l	Trivalent Chromium[3] mg/l	Total Chromium mg/l
11[2]	1/14/81:1030	19	4.3	1620	90	8	98
11[2]	1/14/81:1130	20	4.4	1620	98	29	127
11[2]	1/14/81:1230	20	4.5	1600	120	17	137
11[2]	1/14/81:1330	20	4.5	1590	124	21	145
11[2]	1/14/81:1430	19.5	4.6	1570	101	15	116
11[2]	1/14/81:1530	19.5	4.6	1570	122	0	122
11[2]	1/14/81:1630	--	4.6	1610	135	19	154
11[2]	1/14/81:1700	--	4.7	1590	134	0	134
9	1/15/81	--	9.8	1330	185	73	258
10	1/15/81	--	10.2	590	14	3	17
12	1/15/81	--	9.2	880	12	20	32
13	1/15/81	--	6.5	1880	325	56	381

[1]Chemical analyses by Ultrachem Corporation

[2]Sample collected during period of continuous pumping of well 11 from 0930 to 1716 hours on 1/14/81.

[3]Calculated as the difference between total and hexavalent chromium.

Woodward-Clyde Consultants

ULTRACHEM CORPORATION
1150 Civic Drive, Walnut Creek, CA 94596 / Phone: (415) 935-3115 / Cable: Ultrachem

WATER ANALYSIS REPORT

January 23, 1981

Woodward-Clyde Consultants
Three Embarcadero Center, Suite #700
San Francisco, California 94111

Attention: William Hansen

Report #19723

Subject: Chemical analysis of 12 ground water samples for pH, Specific Conductance and total and hexavalent chromium.

Samples Submitted: Received on 1/15/81 eight (8) ground water samples; received on 1/16/81 four (4) ground water samples labeled as follows:

Woodward Clyde 14929A-4000
EC Ground Water
WH-8 1/14/80 10:30, 11:30, 12:30, 13:30, 14:30, 15:30, 16:30, 1700 (8 samples)

Woodward Clyde 14929A-4000
EC Ground Water 1/15/81
WH-6, WH-7, WH-9, WH-10 (4 samples)

Procedure: Analytical techniques were in accordance with Methods for Chemical Analysis of Water and Wastes, U.S. Environmental Protection Agency, EPA 600/4-79-020, March, 1979. Specifically, Methods 218.3 and 218.4 were used for the analysis of total and hexavalent chromium respectively. Samples to be analyzed for total chromium were first digested with potassium permanganate to convert all the chromium to the hexavalent state. Samples for both total and hexavalent chromium were then pH adjusted and the hexavalent chromium chelated with ammonium pyrrolidine dithiocarbamate, and extracted into methyl isobutyl ketone. The extracts were analyzed for chromium by atomic absorption spectroscopy.

ULTRACHEM CORPORATION

Woodward-Clyde Consultants
Report #19723

January 23, 1981

Results:

Sample	pH	Specific Conductance, μmhos/cm	Total Chromium, mg/L	Hexavalent Chromium, mg/L	Trivalent Chromium, mg/L (by difference)
1030	4.3	1620	98	90	8
1130	4.4	1620	127	98	29
1230	4.5	1600	137	120	17
1330	4.5	1590	145	124	21
1430	4.6	1570	116	101	15
1530	4.6	1570	122	122	0
1630	4.6	1610	154	135	19
1700	4.7	1590	134	134	0
WH-6	9.8	1330	258	185	73
WH-7	10.2	590	17	14	3
WH-9	9.2	880	32	12	20
WH-10	6.5	1880	381	325	56

Quality Assurance Data

Sample	Duplicate Agreement	Fortified ("Spiked") Sample Recovery
1030		105%
WH-9		96%
1330	91% (138,152)	
1700	92% (130,141)	
WH-9	97% (32,33)	

Submitted by,

Marshall Allen
Project Supervisor

Joel Bird
Laboratory Analyst

MA/JB/dfh

APPENDIX B
GLOSSARY OF HYDROGEOLOGIC TERMS

Alluvium - A general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water.

Aquifer - A water-bearing unit or group of units that contains sufficient saturated permeable material to conduct ground water and to yield significant quantities of ground water to wells.

Cone of Depression - A depression in the piezometric surface of a body of ground water; it has the shape of an inverted cone and it develops around a well from which water is being withdrawn.

Confined Ground Water - Water in an aquifer under pressure significantly greater than atmospheric. Its upper limit is the bottom of a bed of distinctly lower hydraulic conductivity than that of the material in which the confined water occurs.

Drawdown - The difference between the elevations of the water level in a well under non-pumping (static) conditions and under pumping conditions.

Effective Velocity - The actual velocity of ground water percolating through water-bearing material.

Effective Porosity - The percent of the total volume of a given mass of soil or rock that consists of interconnecting interstices.

Hydraulic Gradient - In an aquifer, the rate of change of pressure head per unit of distance of flow at a given point and in a given direction.

Lithology - The description of rocks based on such characteristics as color, structures, mineralogic composition, and grain size.

Monitoring Well - A well from which the water is not pumped. Changes in the water levels in such wells are observed and recorded to aid in determining ground-water parameters in the immediate given area.

Permeability - A measure of a material's capacity to transmit water. The degree of permeability depends upon the size and shape of the pores, the size and shape of their interconnections, and the extent of the latter.

pH - The negative logarithm of the hydrogen-ion activity.

Piezometric Level or Surface - The static ground-water head in a particular aquifer or aquifer zone, as defined by water levels in wells open exclusively to that aquifer or aquifer zone.

Porosity - The ratio of the volume of interstices in a soil or rock to the volume of its mass. Expressed as a percentage of the bulk volume of a material occupied by interstices, whether isolated or connected.

Production Well - See pumping well.

Pumping Well - A well that is pumped to obtain water or data for estimating ground-water parameters.

Semi-Confined Ground Water - Ground water in an aquifer where free movement is inhibited sufficiently to cause differences in water levels within the aquifer during the heavy pumping from wells. However, during periods of light pumping, water levels recover to a level coincident with the water table.

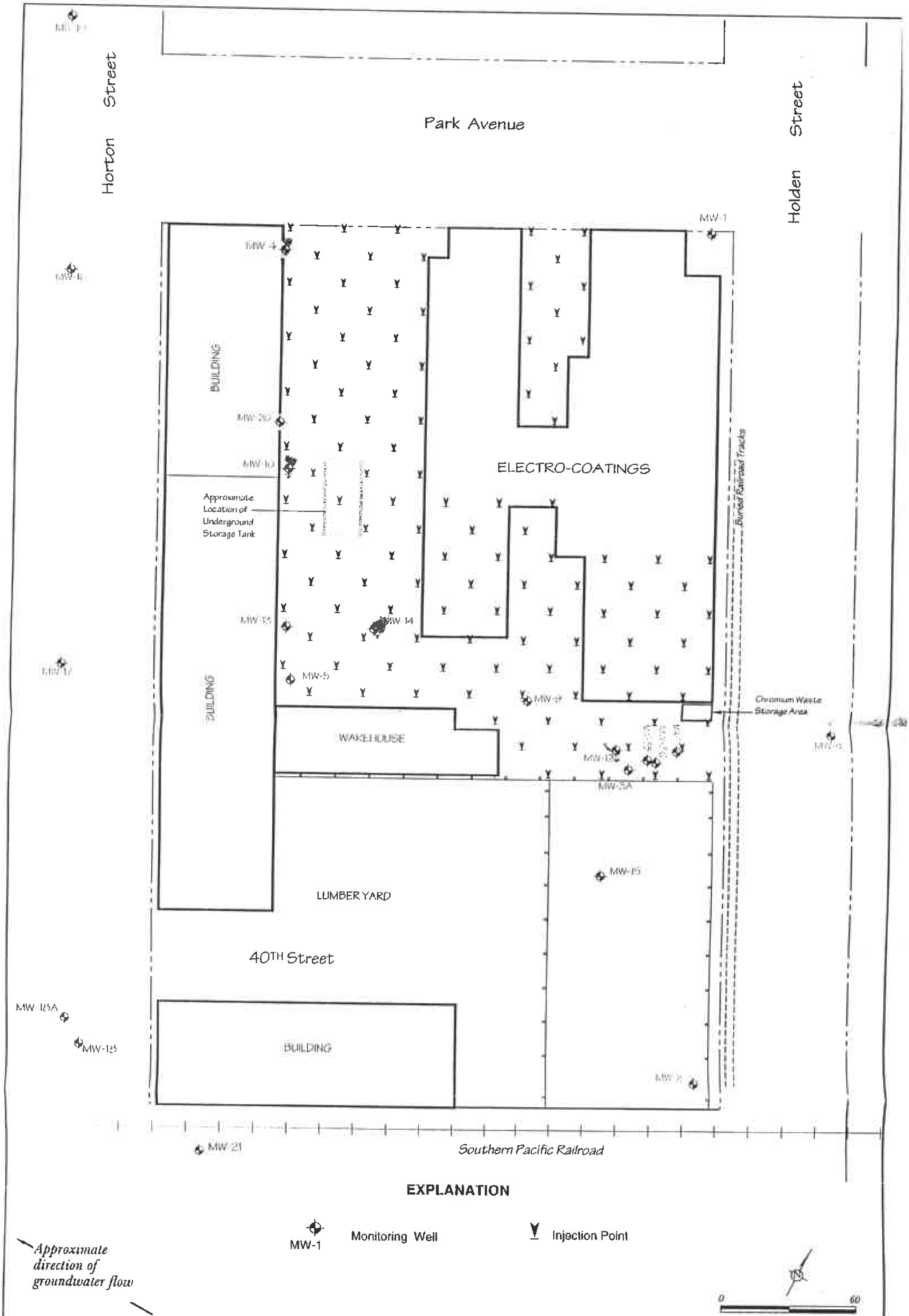
Specific Conductance - A measure of the conductivity of the water; a measure of the ions in solution, which in turn is a measurement of the dissolved solids.

Static Water Level - Water level that is stabilized due to the fact that it has attained the maximum possible from its source and is not being dimished by loss.

Storage Coefficient - In an aquifer, the volume of water released from storage in each vertical column having a base of one foot square when the water table or other piezometric surface declines one foot.

Transmissivity - The rate of flow of water through a vertical strip of an aquifer one foot wide extending through the full saturated thickness of the aquifer under unit hydraulic gradient.

Water Table - The surface between the saturated zone and the unsaturated zone; that surface of a body of unconfined ground water at which the pressure is equal to that of the atmosphere.



GERAGHTY & MILLER, INC.
Environmental Services
A Heidemij Company

Project No. RC0304.000

INJECTION POINT LOCATIONS
Electro-Coatings, Inc.
1401 and 1421 Park Avenue
Emeryville, California

FIGURE
1