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July 24, 2002

Mr. Joseph Jones
New York State Department of Environmental Conservation
Bureau of Eastern Remedial Action
50 Wolf Road
Albany, New York 12233

Re: Photocircuits Corp. – Glen Cove, NY
Groundwater Hydraulic Control System - Revised Report

File: 643.001

Dear Mr. Jones:

In your letter of July 3, 2002, you provided comments on the Remedial Design for the Groundwater Hydraulic Control System which had been submitted in April 2002. We have revised the design report in response to your comments; enclosed please find three copies of the revised report. Responses to your comments are provided below.

1. Comment: In principle, the installation of a hydraulic control system should be a significant step forward, if not in remediating the contamination at the subject site, then at least in reducing its impacts on downgradient properties.

Response: As a point of clarification, the ongoing bioremediation at the site is the principal method for reducing site-related contaminant concentrations, and will therefore play a significant role in the reduction of potential impacts , if any, on downgradient properties.

2. Comment: The work plan should include a description of the nature and extent of the groundwater contamination that the Interim Remedial Measure (IRM) is intended to contain. This description should include estimates of the concentrations of contaminants that are expected in the effluent of the proposed system.

Response: The IRM is intended to contain contaminated groundwater in the area downgradient of the bioremediation pilot test area; anticipated concentrations of contaminants are based on recent analyses of samples collected from monitoring wells located in this area. The report has been modified accordingly.

3. Comment: It is understood that the extracted water is to be discharged to the City of Glen Cove sanitary sewer system. The work plan should verify that Photocircuits has notified the appropriate municipal authorities of this plan and has obtained their consent.

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Response: A letter has been sent to the City of Glen Cove advising them of the anticipated flow rate and water quality. A copy of the City's approval letter will be forwarded to you when received.

4. Comment: The work plan should verify which monitoring wells are to be used to monitor the performance of the system, and should include a monitoring schedule and sampling protocol for the specified wells.

Response: The data from the groundwater monitoring program for the bioremediation pilot test will be used for monitoring the hydraulic control system. The frequency and analytical parameters are discussed in the revised report.

5. Comment: The sections of the report that deal with hydraulic conductivity tests done in January are confusing, and it is never made clear which hydraulic conductivity value was actually used in designing the proposed hydraulic control system. Please clarify.

Response: We have revised the text to clarify the referenced section. The design for the hydraulic control system was based on the modeling effort, which employed a range of hydraulic conductivity values to evaluate different numbers and configurations of wells to achieve hydraulic control. The number and locations of the pumping wells in the proposed system represent a somewhat conservative "over design" (i.e. – hydraulic control can be achieved with a lower number of wells) for the number of wells that will be needed to achieve hydraulic control. We believe that this number of wells has the added benefit of allowing for flexibility in pumping configurations (i.e. – varying which wells are pumped and their flow rates) in response to changes in contaminant concentrations over time.

6. Comment: It appears that the Bouwer and Rice method was used to analyze recovery data from wells that had been pumped. It is our understanding that the Bouwer and Rice method was derived specifically for slug tests, in which the water level in a well changes instantaneously at the beginning of the test. It seems that applying it to a well that has been pumped down would lead to an underestimate of the hydraulic conductivity.

Response: The Bouwer and Rice method was derived to analyze slug test data. We use the term slug test to refer to a water well hydraulic testing method that creates a sudden change in static water level by the rapid addition or removal of water from the well (some references differentiate between a slug test (addition of water) from a bail test (removal of water)). In either case, the method of data collection and analysis is the same; in our experience, removal of water by pumping then shutting the pump off is more reliable than manual bailing. Finally, the recovery data from the testing of MW-12 and MW-13 was analyzed by two methods, and the results obtained by the Bouwer and Rice method were comparable to the results obtained from the QUICKFLOW model. The report has been modified to clarify the data analyses.

7. Comment: The basis of the hydraulic conductivity values reported in Table 1 and on page 3 of the text should be made clear. If the values are based on the results shown on Figures 1 through 3, errors were made in converting two of the three values to metric units. The value on Figure 1 (3.41E-5 ft/sec) is equivalent to 1.04E-3 cm/sec, not 1.04E-4 cm/sec as reported in the text. The value on Figure 2 also appears to be in error when compared to the text and Table 1. Please check all these numbers. Overall, the proposed pumping rates for the extraction well are lower than expected. Higher hydraulic conductivity would allow for (and require) greater extraction rates.

Response: We have re-checked the calculations made in support of the findings presented in the report. A typographical error was made in the text and in Table 1; these errors have been corrected in the revised report. These typographical errors did not affect the modeling effort. We had also anticipated somewhat higher pumping rates (as evidenced by the rates that we were planning to pump wells MW-12 and MW-13).

8. Comment: The text on page 2 suggests that the monitoring well MW-13 could sustain a flow rate of only one gallon per minute. If this is the case, it should be explained why the title of Figure 3 refers to a 3 GPM Test at MW-13.

Response: As indicated in the text, water-level recovery measurements in well MW-13 were recorded both manually and with a pressure transducer/data logger. In initializing the data logger, the test was identified as "MW-13 3 GPM Test", as the planned pumping rate was 3 gallons per minute (gpm). The title of this data set was then carried through the data analysis and preparation of the figure. The title of the figure has been changed in the revised report.

Should you have any questions, please feel free to call.

Very truly yours,

BARTON & LOGUIDICE, P.C.

Andrew J. Barber
Senior Managing Environmental Scientist

AJB/mfg

Enclosure

cc: L. Stans - Photocircuits
Charlie Nehrig - Photocircuits
Mark Pennington, Esq. - Morgan, Lewis & Bockius, LLP

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REMEDIAL DESIGN

GROUNDWATER HYDRAULIC CONTROL SYSTEM

REVISION 1
JULY, 2002

Prepared for:

PHOTOCIRCUITS CORPORATION
31 SEA CLIFF AVENUE
GLEN COVE, NEW YORK

Prepared by:

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REMEDIAL DESIGN

GROUNDWATER HYDRAULIC CONTROL SYSTEM

REV. 1

PHOTOCIRCUITS CORPORATION

31 SEA CLIFF AVENUE, GLEN COVE , NEW YORK

Introduction

A bioremediation pilot test has been ongoing at the Photocircuits facility located at 31 Sea Cliff Avenue in Glen Cove, New York since August 2000. A meeting was held with the New York State Department of Environmental Conservation (NYSDEC) on October 11, 2001 to discuss the progress of the bioremediation pilot test. As a result of that meeting, Photocircuits agreed to review available options for containment of groundwater along the northern boundary of the Photocircuits site (31 Sea Cliff Avenue). By letter dated October 26, 2001, Photocircuits presented the results of the review, with the recommended approach being the use of hydraulic control downgradient of the bioremediation pilot test area. Photocircuits submitted a work plan for the performance of pumping tests necessary for the design of a hydraulic control system on November 13, 2001; following receipt of verbal comments from NYSDEC, Photocircuits submitted a revised work plan on December 7, 2001. Approval for implementation of the work plan was received from NYSDEC by letter dated December 19, 2001. The pumping tests were conducted in early January 2002. This report contains the analyses of the pumping test data and the design for the hydraulic control system; this report was originally submitted in April 2002 and has been revised in response to NYSDEC comments dated July 3, 2002.

Pumping Test Methodology and Results

Per the approved work plan, pumping tests were conducted using wells MW-12 and MW-13. A variable flow rate, air-driven pump was used for each of the pumping tests. Pumping rates were varied in response to drawdown during the initial step testing to achieve reasonably stable pumping levels, but it became evident that the pumping tests could not be conducted for the full

24 hours as originally planned because appreciable drawdown was experienced at the initial pumping rates. An attempt was made to find the pumping rates that could be sustained by the wells (approximately 1 gallon per minute (gpm) in well MW-13 and approximately 3 gpm in well MW-12). It was determined that the best means of performing the hydraulic testing was to individually pump each well down, discontinue pumping and then collect recovery data. Data was collected manually for both wells and also using a data logger for well MW-13. Pumping and recovery data for both wells are provided in Appendix A.

Permeability Testing Analysis

Data obtained during the step-drawdown and short term pumping tests in wells MW-12 and MW-13 were used to assess the subsurface permeability using two methods. The first method utilized the recovery data for each of the short-term pump tests. For the first method the recovery data were analyzed using AQTESOLV™ to obtain permeability values for each of the recovery intervals. The second method analyzed the recovery data using the QUICKFLOW model, as discussed in the next section.

The recovery water levels were used to simulate re-equilibration after removal of a "slug" of water. Water-level measurements were continuously recorded using the m-scope and/or pressure transducers attached to data loggers. Each well recovery was monitored for a minimum of 30 minutes, or until the water level recovered to within at least 90 percent of the static water level.

AQTESOLV™ was used to perform the slug test calculations and provide graphical output. Using the Bouwer and Rice method, drawdown is plotted on a log scale versus time on a linear scale. A line of best fit is constructed and hydraulic conductivity is computed from:

$$K = \frac{r_{ec}^{2} \ln\left(\frac{R_e}{r_w}\right) \ln\left(\frac{y_0}{y_t}\right)}{2Lt}$$

where;

K = hydraulic conductivity in feet per minute (ft/min)

r_{ec} = effective radius of casing in feet (ft)

R_e = effective radius of influence in ft

r_w = borehole radius in ft

L = initially saturated screen length in ft

y_0 = drawdown at time t_0 in ft (on line of best fit)

y_1 = drawdown at time t_1 in ft (on line of best fit)

t = elapsed time between t_0 and t_1 in minutes (i.e., t_1 - t_0).

Ideally, this formula is derived for fully penetrating wells in confined aquifers with a fixed radius of influence. However, the Bouwer-Rice method uses an empirically derived effective radius value that allows for application to varying aquifer conditions.

Analysis of slug test data is provided on Figures 1-3. Hydraulic conductivity values and AQTESOLV input parameters are summarized on Table 1. The hydraulic conductivity measured in well MW-12 was 1.04 x 10^{-3} centimeters per second (cm/sec)) and in well MW-13 ranged from 4.43 x 10^{-5} to 7.19 x 10^{-5} cm/sec using AQTESOLV.

Table 1 also shows hydraulic conductivities measured in other site wells that range from approximately 8.73 x 10^{-4} cm/sec (well MW-9) to 3.29 x 10^{-2} cm/sec (well MW-11). Further analysis of site hydraulic conductivity values is presented in the following section using data obtained under pumping conditions.

Pumping Test Analysis

For the second method, the QUICKFLOW model was used to evaluate the hydraulic data acquired during the step drawdown and short term pump testing conducted as described in the previous section. QUICKFLOW is a two-dimensional analytical groundwater flow model that simulates steady state and transient groundwater flow conditions. The steady state module of the model is based upon equations developed by Strack (1989) while the transient model was developed using equations by Theis (1935) for confined aquifers and Hantush and Jacob (1955) for leaky aquifers. The module evaluates effects from multiple analytical functions such as wells, ponds, etc. in a uniform flow field. Input parameters for the QUICKFLOW model include hydraulic conductivity, hydraulic gradient, reference head elevations, groundwater flow direction, porosity, and other physical site specific parameters. The QUICKFLOW model assumes homogeneous subsurface conditions.

Drawdown measurements were obtained from water level measurements collected during the short term pump testing and step drawdown testing. The water level measurements are presented in Appendix A. The data were used to calibrate the model to site conditions and to generate extraction well network design scenarios.

Initially, the steady state module was used to calibrate the model to static conditions. Water level measurements in wells MW-12, MW-13 and MW-14 were used to establish the model gradient and static water levels. A hydraulic gradient of 0.00684 feet per foot was used for the model calibration and provided a good fit to static water levels. This gradient was utilized throughout the modeling activities.

The transient module was then used to calibrate the model to site conditions based upon the recovery data collected during the step drawdown and short term pump testing activities and to compare the hydraulic conductivity values obtained using AQTESOLV. Drawdown measurements observed in wells MW-12 and MW-13 were used to assess the hydraulic conductivity values discussed in the previous section. Matches to observed conditions during pump testing in well MW-12 were obtained using hydraulic conductivity ranging from 1.06×10^{-4} cm/sec to 4.41×10^{-5} cm/sec. Matches to observed conditions during pump testing of well MW-13 were obtained with hydraulic conductivity values of 1.06×10^{-4} centimeters per second (cm/sec) and 1.76×10^{-4} cm/sec as summarized on Table 1.

Model Application to Remedial Evaluation

The permeability values and static model calibration parameters were used to assess the appropriate configuration of a pumping well network to control groundwater contamination downgradient of the bioremediation pilot test area . The steady state module of the QUICKFLOW model package was used to estimate the required number of wells, extraction rates, and well locations in the downgradient area. Particle tracking was used to assess the well network capture across the downgradient area.

Several model runs varying the permeability and model aquifer bottom were used to assess the configuration of the well network and pumping rates. The modeled pumping wells were fully screened, to depths of approximately 80 feet below grade (ft bgs). The model aquifer bottom was varied from 80 to 100 feet to determine whether hydraulic control can also be achieved at depths greater than 80 feet. In each case the minimum number of wells to provide capture across the downgradient area was selected for varying extraction rates.

Figures 4 through 7 provide model output showing the well locations and particle tracking for hydraulic conductivity values obtained in wells MW-12 and MW-13. The model input parameters as well as extraction well network configurations for each of the model runs are summarized on Table 2.

Figures 4 through 6 were generated using the hydraulic conductivity values obtained for well MW-12 using the AQTESOLV and QUICKFLOW modeling discussed in the previous sections. The aquifer bottom was varied up to 100 ft bgs to provide conservative estimation of the well network capture. As depicted on Table 2 and Figures 4 through 6, three (3) to five (5) these modeled scenarios show that extraction wells pumping at total flow rates of up to 10 gallons per minute (gpm) provide particle capture across the downgradient area. As shown on Figure 7, for the highest hydraulic conductivity value obtained from well MW-13 testing, three (3) extraction wells pumping at a total rate of 1.5 gpm provided model particle capture across the downgradient area.

To provide the most conservative estimates for the well configuration and pumping scenarios, the hydraulic conductivity obtained for well MW-11 by previous testing (McLaren/Hart, 1998) was utilized to estimate adequate extraction well rates and locations. Figure 8 shows the model output utilizing the hydraulic conductivity of 3.29×10^{-2} cm/sec obtained for well MW-11. The model aquifer bottom for this run was also conservatively estimated at 100 ft bgs. For this scenario it appears that 6 wells installed across the downgradient area pumping at a total rate of 15 gpm provides particle capture for those particles originating within the bioremediation pilot test area.

Design of Hydraulic Control System

The design criteria for the remedial design of the hydraulic control system is the bending of the groundwater flow contour lines in the area downgradient of the bioremediation pilot test area, showing that the pumping influence of each well partially overlaps the influence of the nearest pumping well. The previous section demonstrated that hydraulic control can be achieved at the Photocircuits site by different combinations of pumping wells and flow rates; the modeled scenarios (which used a range of hydraulic conductivity values) employed three wells up to six wells to achieve hydraulic control. Although the modeling indicated that fewer wells could be used to achieve hydraulic control, the remedial design for the Photocircuits site will include the installation of five pumping wells to ensure full coverage. The use of five pumping wells also allows for flexibility in pumping configurations (i.e. – varying which wells are pumped and their flow rates) in response to changes in contaminant concentrations over time. The proposed locations for these wells are shown on Figure 9. Based on the results of groundwater modeling, it is anticipated that each well will be pumped at a rate of roughly 2 gpm. The wells will be equipped with air driven pumps, that are capable of providing variable flow rates. The wells will be constructed of 4-inch diameter PVC screen and casing. The wells will be screened from the top of the water table to 80 feet bgs. The proposed well construction and pump installation are shown on Figure 10.

Pumped groundwater will be discharged into the sewer manhole shown on Figure 9. This manhole is part of the Photocircuits sewer system that discharges to the City of Glen Cove sanitary sewer system. Pumped groundwater will contain volatile organic compounds (VOCs). Photocircuits has a discharge limitation of 2 mg/L of Total Toxic Organics (TTO); the TTO list that includes the VOCs that have been detected in groundwater in this area. It is not anticipated that the discharge of the pumped groundwater will cause exceedance of the TTO limitation due to the relatively low flow (when combined with Photocircuits overall discharge) and the VOC concentrations that have been detected in this area Recent analytical results from samples from MW-8, MW-12 and MW-13 are provided in Table 3; the contaminant concentrations detected in these wells provides a good indication of the anticipated range of concentrations in pumped groundwater.

Once installed, the system will be put into operation by adjusting the pumping rate of each well to roughly 2 gpm. Water levels will be monitored in the pumping wells and nearby monitoring wells for the first 24-48 hours; pumping rates will be decreased if needed to avoid drawing the pumping levels down to the pump intake. After about one week of pumping, a round of water level measurements will be collected and groundwater flow maps will be prepared. Depending upon the flow maps and the bending of the groundwater flow contour lines, pumping rates will be adjusted. Also at this time, a sample will be collected from each pumping well and analyzed for VOCs by USEPA Method 8260B. A sample of the combined discharge from the pumping wells will be collected on a quarterly basis and analyzed for VOCs by USEPA Method 8260B.

The groundwater quality data from the bioremediation pilot test (which includes wells MW-8, MW-12 and MW-13) will also be used for monitoring the performance of the hydraulic control system. Monitoring well sampling will continue to be conducted on a quarterly basis, with samples being analyzed for VOCs, light hydrocarbon gases, iron, nitrate, sulfate, total organic carbon (TOC), and field parameters.

Table 1. Summary of In-Situ Permeability Testing Results
Photocircuits Corp.
31 Sea Cliff Ave.
Glen Cove, NY

Well ID	Well Depth (ft, bgs)	Saturated Thickness (ft)	Casing Diameter (inches)	Screen Length (ft)	Borehole Diameter (inches)	Kft/sec[1]	K cm/sec[1]	K Model Match (cm/sec)	Model Aquifer Bottom (ft, bgs)
MW-12	50	41.52	4	10	11	3.41E-05	1.04E-03	4.41E-05	50
								1.06E-04	50
MW-13	50	41.3	4	10	11	1.45E-6 to 2.36E-6	4.43E-5 to 7.19E-5	1.06E-04	50
								1.76 E-4	29.7
Other Site Wells[2]									
MW-8	170	163.4	2	15	4	2.75E-04	8.39E-03		
MW-9	25	20.92	2	15	4	2.86E-05	8.73E-04		
MW-10	130	124.57	2	15	4	1.12E-04	3.43E-03		
MW-11	170	164.13	2	15	4	1.08E-03	3.29E-02		

1. Values obtained from short term pump test well recovery conducted by B&L between January 11 and January 14, 2002.

2. Values taken from McLaren/Hart, 1998.

Table 2. Summary of Model Input Parameters and Extraction Well Network Configuration
Photocircuits Corp.
31 Sea Cliff Ave.
Glen Cove, NY

Well ID	Figure #	K cm/sec[1]	Model Aquifer Bottom (ft, bgs)	# of Extraction Wells	Total Flow Rate of Extraction Wells
MW-12	4	4.41E-05	80	3	0.5
	5	1.06E-04	80	3	1.18
	6	1.00E-03	100	5	10
MW-13	7	1.76 E-4	80	3	1.5
Other Site Wells[2]					
MW-11	8	3.29E-02	100	6	15

1. Values obtained from short term pump test well recovery conducted by B&L between January 11 and January 14, 2002.

2. Values taken from McLaren/Hart, 1998.

Figure 1. MW-12 Recovery Test Analysis
Photocircuits, Corp.
31 Sea Cliff Road, Glen Cove, NY

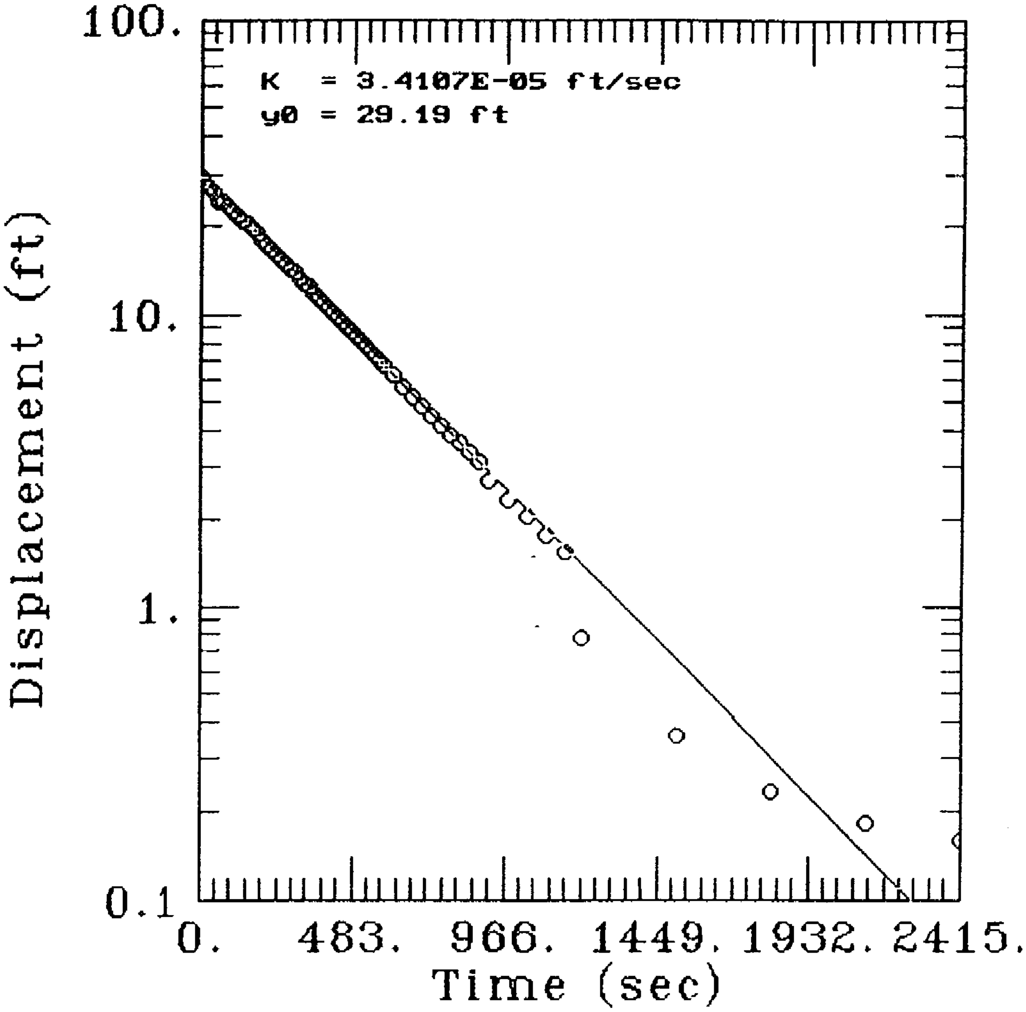


Figure 2. Recovery Test Analysis of Well MW-13
Photocircuits, Corp.
31 Sea Cliff Avenue, Glen Cove, NY

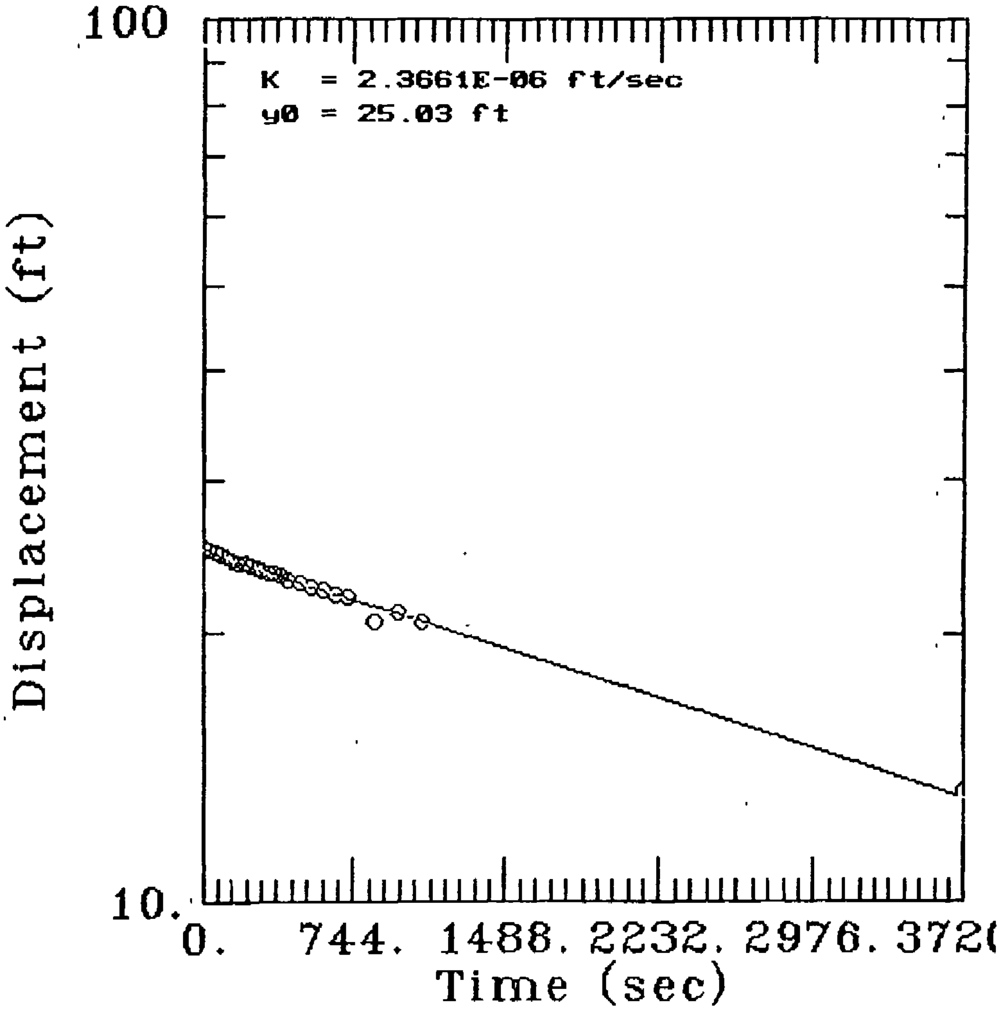
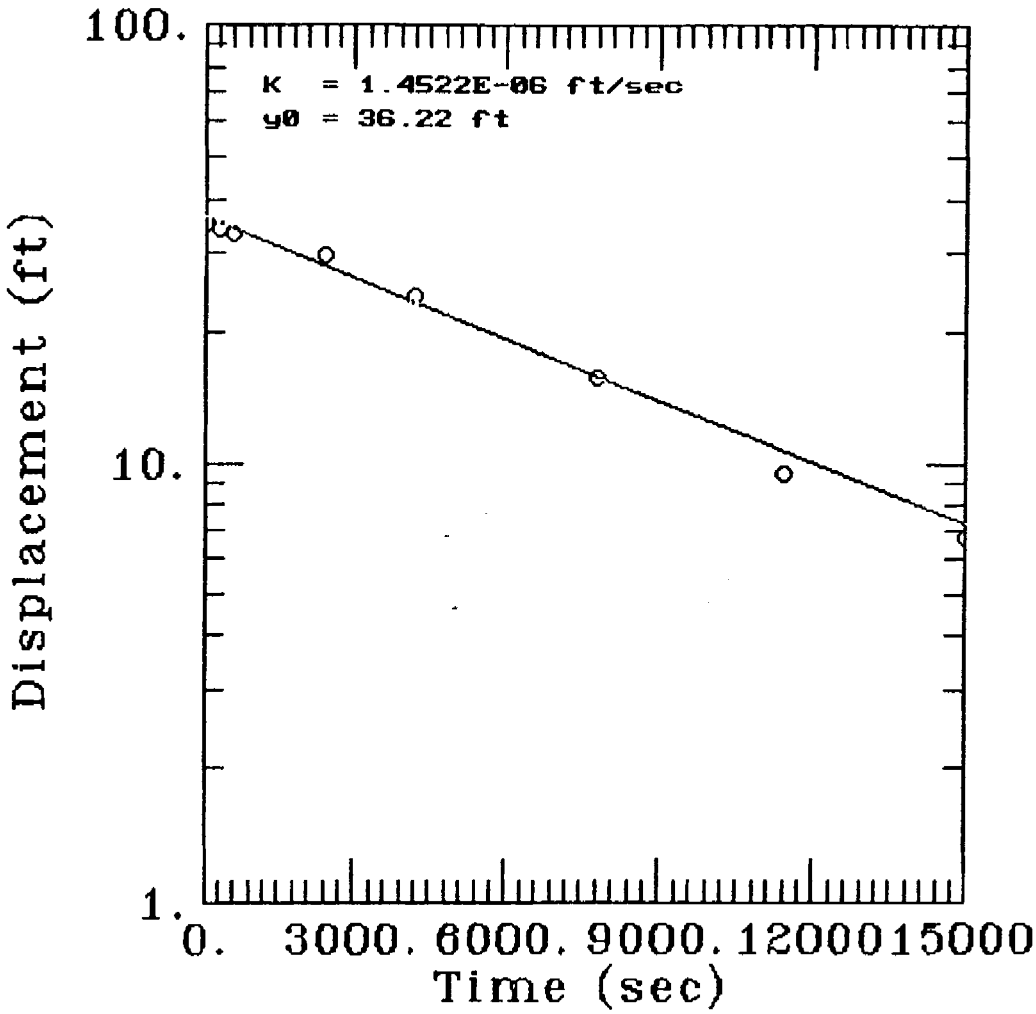
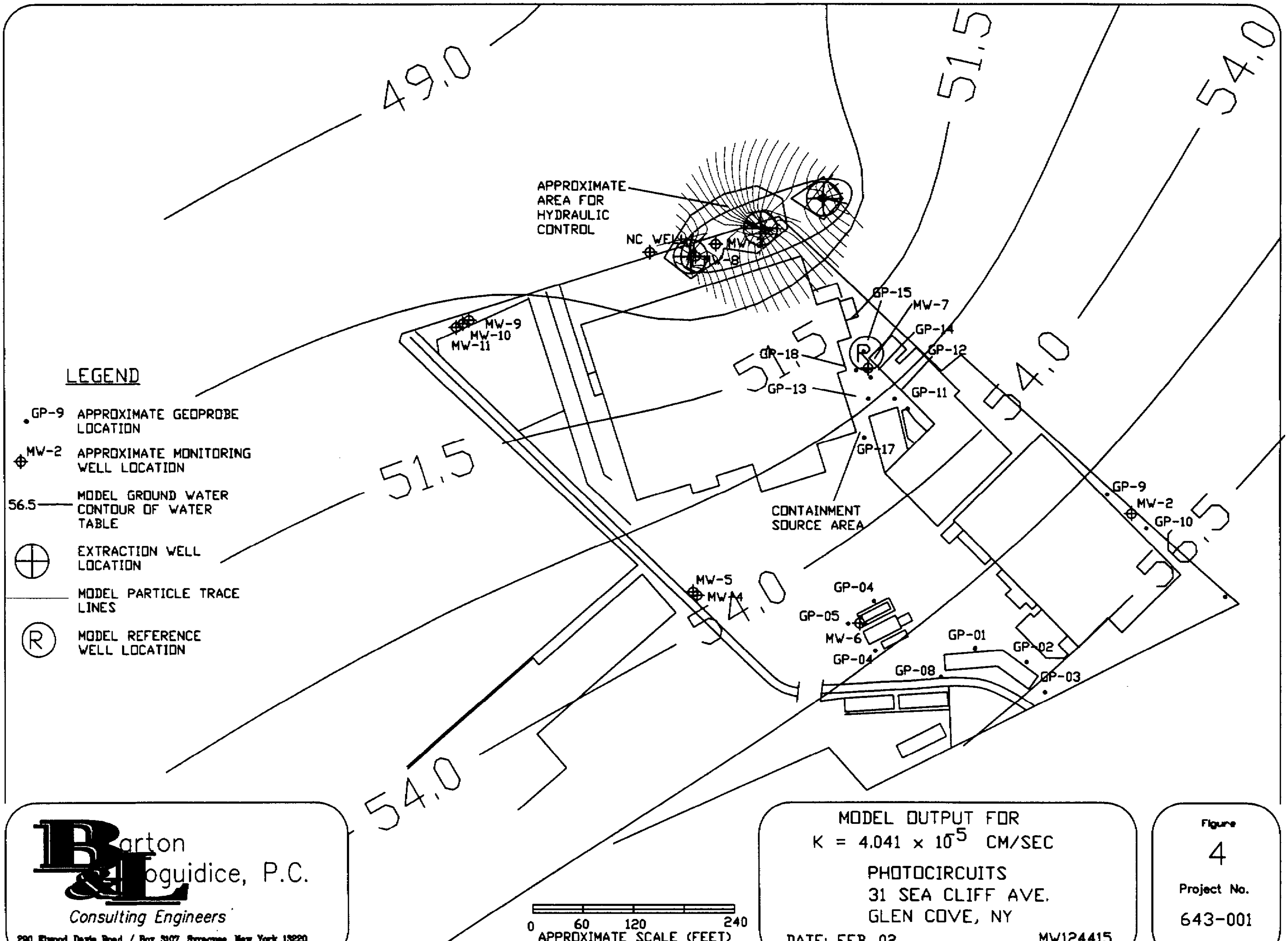


Figure 3. Recovery Test Analysis of Well MW-13
Photocircuits Corp.
31 Sea Cliff Avenue, Glen Cove, NY





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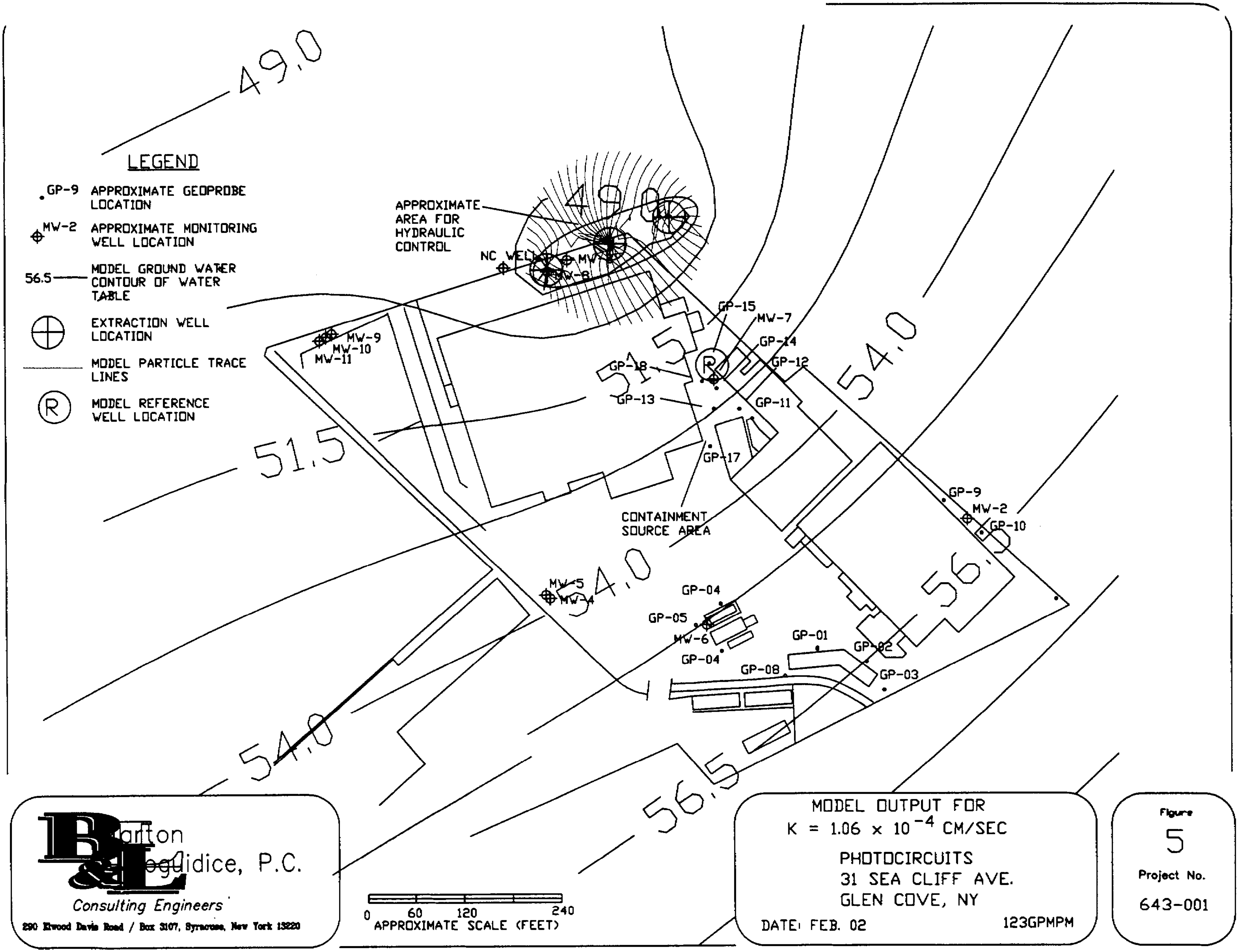
290 Elwood Davis Road / Box 3107, Syracuse, New York 13220

MODEL OUTPUT FOR
K = 4.041 x 10^{-5} CM/SEC

PHOTOCIRCUITS
31 SEA CLIFF AVE.
GLEN COVE, NY

DATE: FEB. 02 MW124415

Figure
4
Project No.
643-001



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Consulting Engineers

290 Elwood Davis Road / Box 3107, Syracuse, New York 13220

MODEL OUTPUT FOR
$K = 1.06 \times 10^{-4}$ CM/SEC

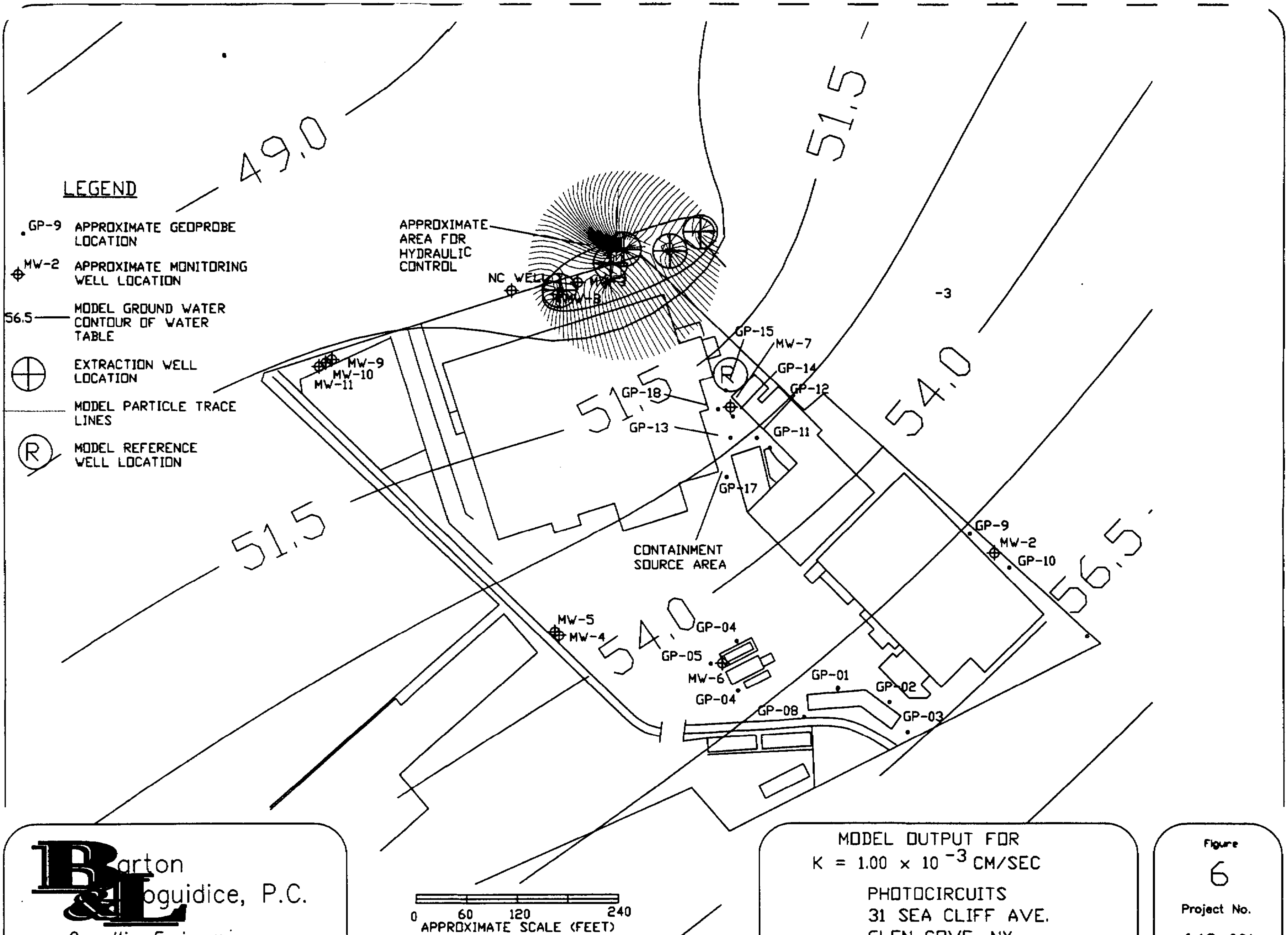
PHOTOCIRCUITS
31 SEA CLIFF AVE.
GLEN COVE, NY

DATE: FEB. 02

123GPMPM

Figure
5

Project No.
643-001



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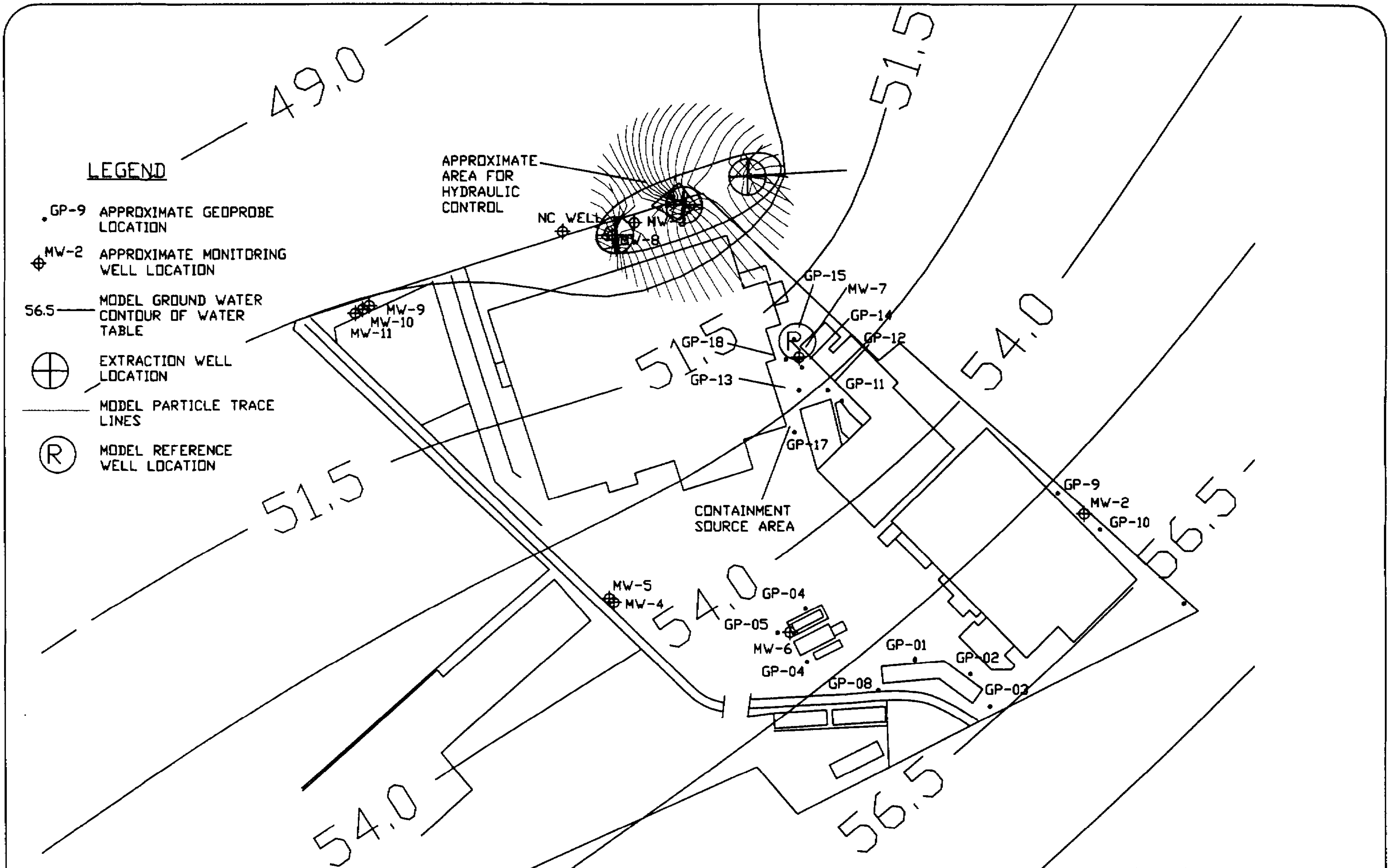
MODEL OUTPUT FOR
K = 1.00 x 10 $^{-3}$ CM/SEC
PHOTOCIRCUITS
31 SEA CLIFF AVE.
GLEN COVE, NY
DATE: FEB. 02 125WELL

Figure
6
Project No.
643-001



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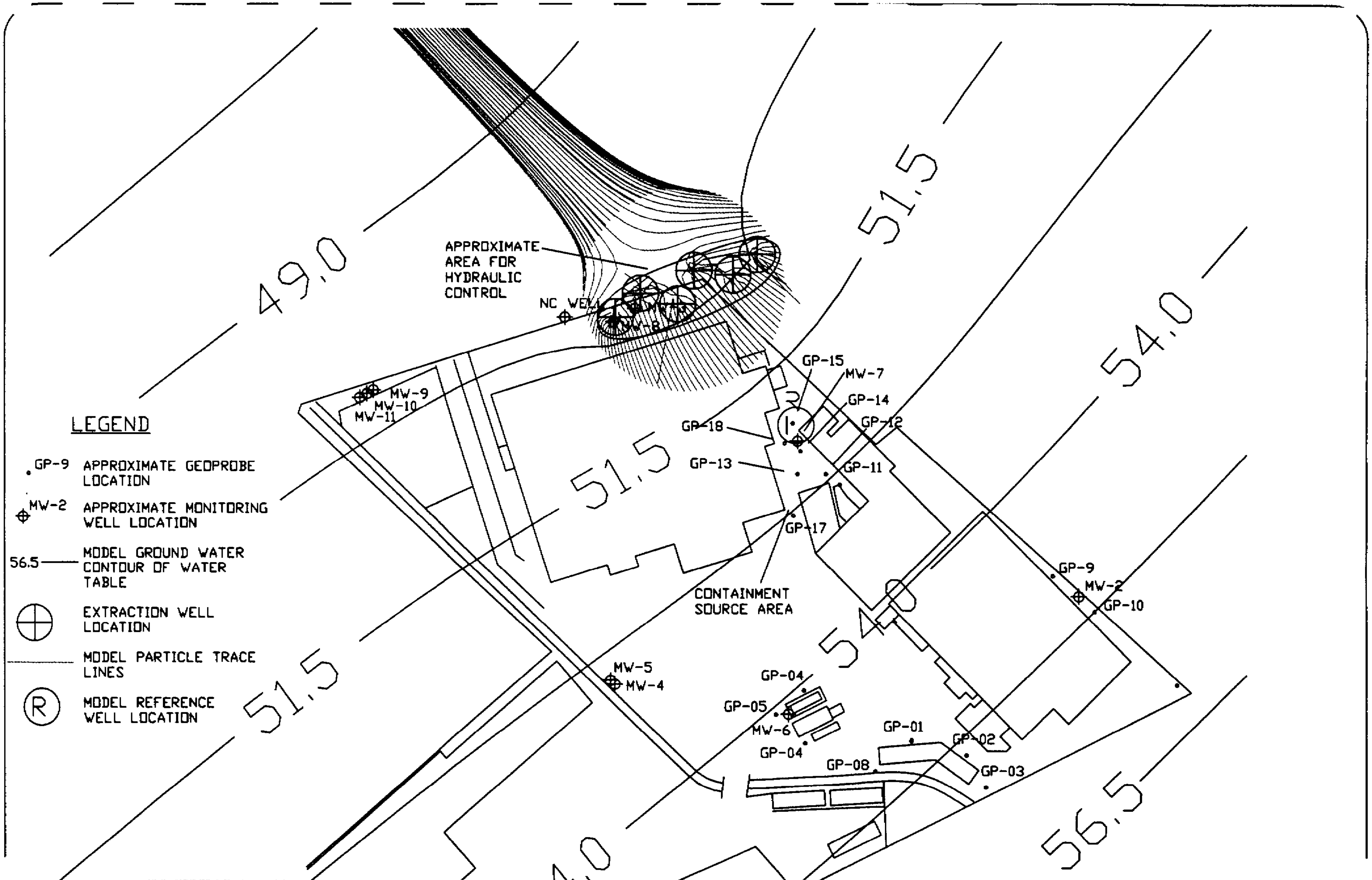
MODEL OUTPUT FOR
K = 1.76 x 10^{-4} CM/SEC
PHOTOCIRCUITS
31 SEA CLIFF AVE.
GLEN COVE, NY
DATE: FEB. 02 13MIN

Figure
7
Project No.
643-001



0 60 120 240
APPROXIMATE SCALE (FEET)

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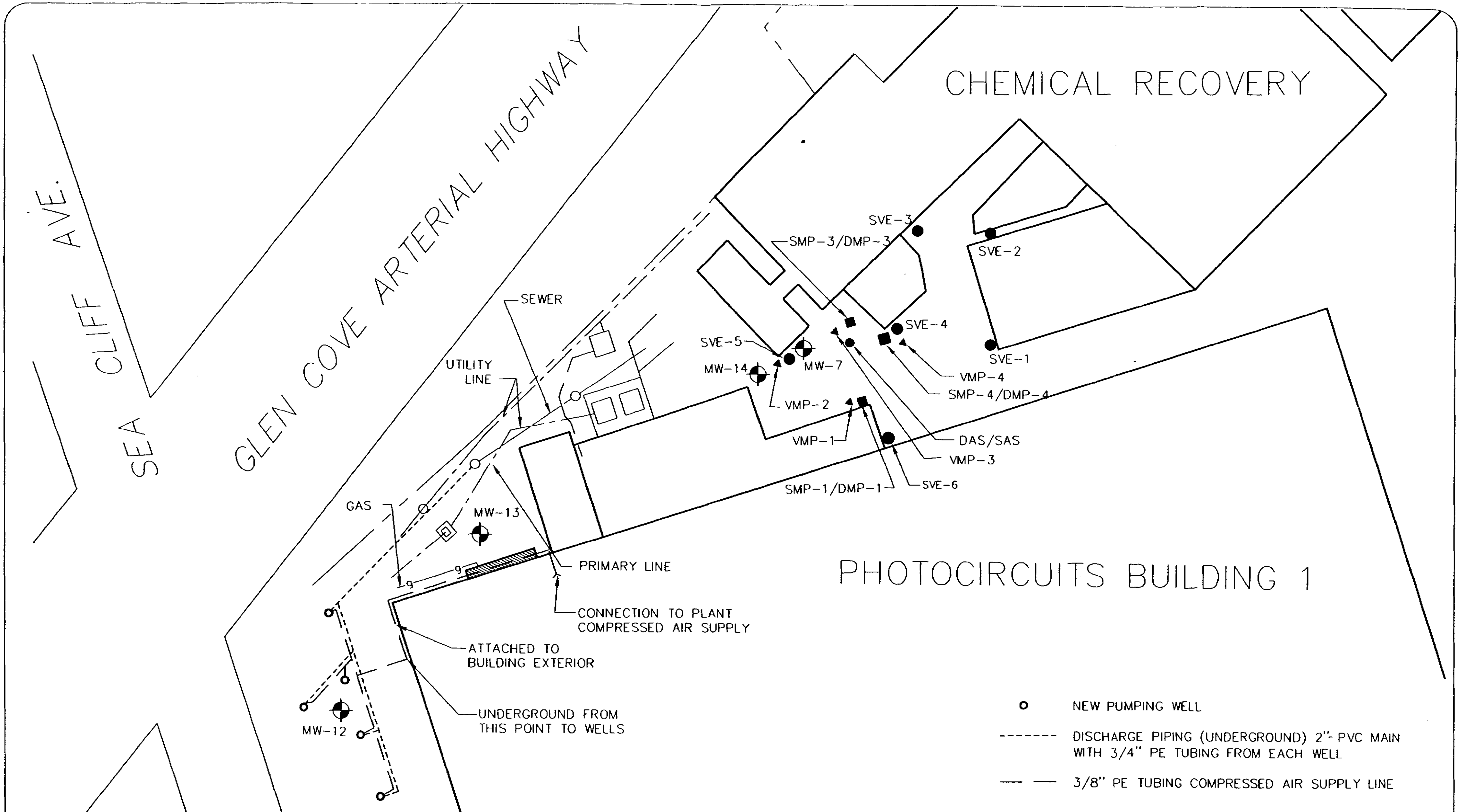
MODEL OUTPUT FOR
K = 3.29×10^{-2} CM/SEC

PHOTOCIRCUITS
31 SEA CLIFF AVE.
GLEN COVE, NY

DATE: FEB. 02 11HIK

Figure
8

Project No.
643-001



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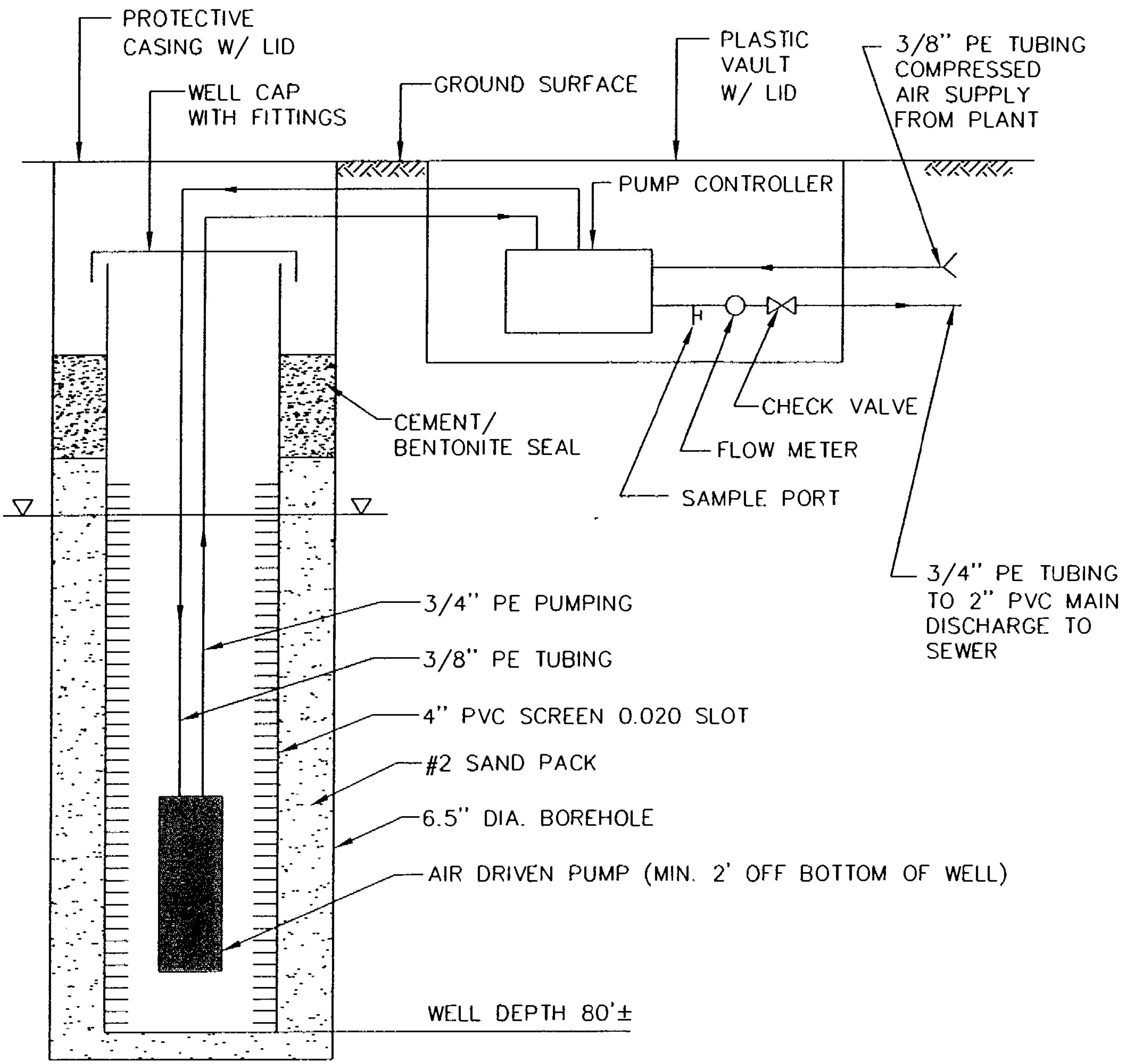
PHOTOCIRCUITS CORPORATION

PROPOSED LOCATION OF PUMPING WELLS AND PIPING LAYOUT

Figure 9

Project No. 643.001



NOTE: WELL SCREEN SLOT SIZE AND SAND PACK MAY BE CHANGED DEPENDING UPON OBSERVED HYDROLOGIC CONDITIONS DURING DRILLING.

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PHOTOCIRCUITS CORP.

WELL CONSTRUCTION AND PUMP INSTALLATION

GLEN COVE COUNTY, NEW YORK

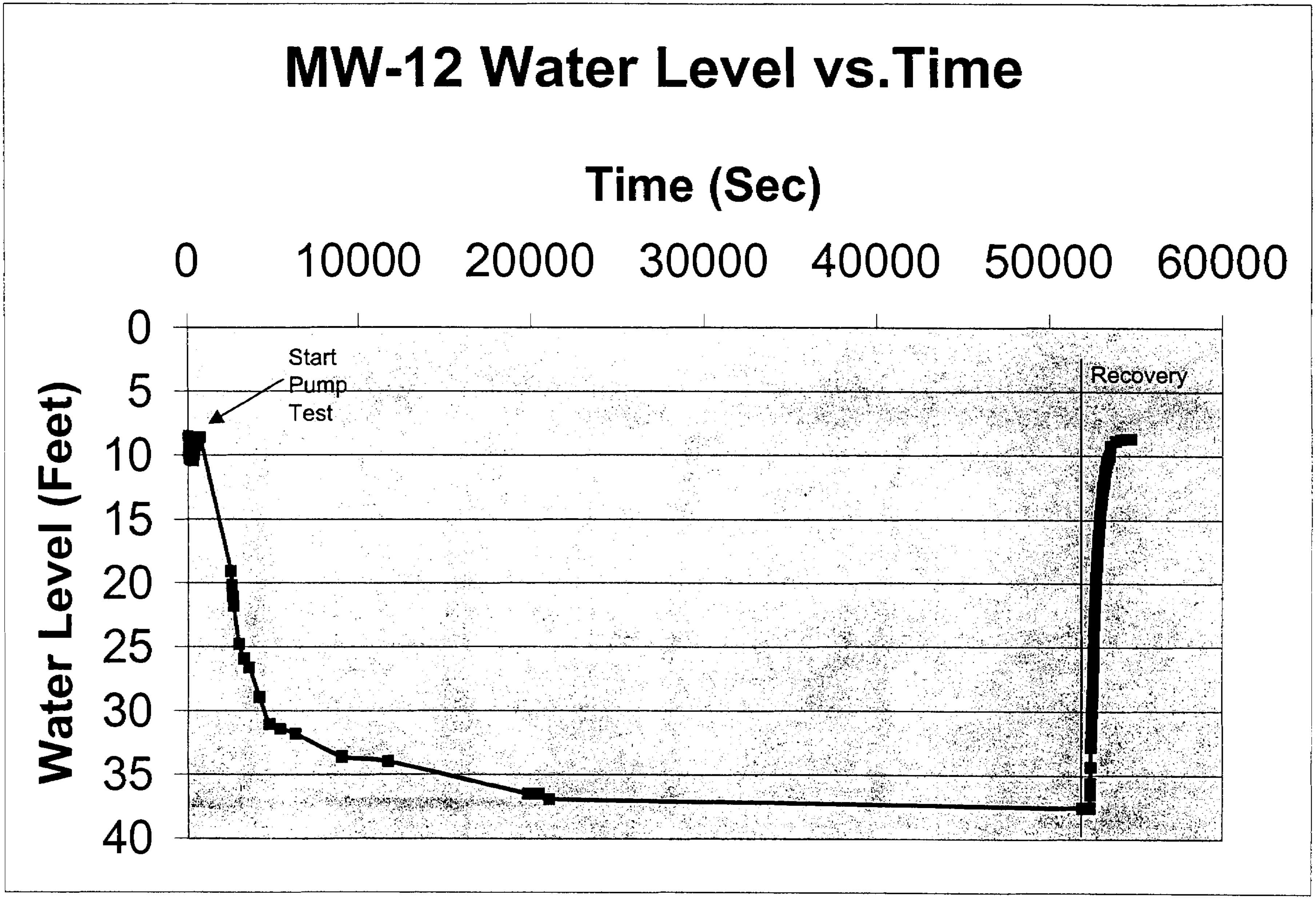
Figure 10

Project No. 643.001

Photocircuits (MW-12)		
Date 1/11/02		
Time Start:10:43 AM		
Elapsed Time (Sec)	Water Level (Feet)	
0	8.48	Pump started - flow rate of 1 gpm
30	9.78	
60	9.46	
90	10.18	
120	9.80	
150	10.32	
180	9.93	
210	10.30	
240	9.94	
270	10.31	
300	10.02	
330	10.40	Pump Off
360	9.94	Recovery
390	9.63	
420	9.32	
450	9.22	
480	9.07	
510	8.88	
540	8.81	
570	8.75	
600	8.71	
630	8.66	
660	8.64	
690	8.61	
720	8.58	Pump started - flow rate of 3 gpm
2520	19.10	
2580	20.20	
2640	21.05	
2700	21.80	
3000	24.78	
3300	25.90	
3600	26.60	
4200	28.91	
4800	31.05	
5400	31.40	
6300	31.80	
9000	33.57	
11700	33.95	
19800	36.50	Pumping rate increase to 5 gpm
20400	36.51	Pumping rate decreased to 3 gpm
21000	36.92	
51900	37.56	
52320	37.56	Pump Off
52335	37.50	Recovery
52350	36.50	
52365	35.58	
52380	34.30	

52395	32.56				
52410	32.78				
52425	31.92				
52440	31.04				
52455	30.10				
52470	29.25				
52485	28.72				
52500	27.96				
52515	27.24				
52530	26.48				
52545	25.69				
52560	25.10				
52575	24.40				
52590	23.93				
52605	23.22				
52620	22.78				
52635	22.32				
52650	21.79				
52665	21.25				
52680	20.84				
52695	20.37				
52710	19.90				
52725	19.48				
52740	19.05				
52755	18.62				
52770	18.23				
52785	17.90				
52800	17.48				
52815	17.15				
52830	16.83				
52845	16.52				
52860	16.21				
52875	15.92				
52890	15.66				
52905	15.40				
52920	15.11				
52950	14.64				
52980	14.14				
53010	13.73				
53040	13.34				
53070	12.97				
53100	12.62				
53130	12.35				
53160	12.11				
53190	11.86				
53220	11.61				
53250	11.17				
53310	10.82				
53370	10.51				
53430	10.22				
53490	10.00				
53550	9.26				

53850	8.84				
54150	8.71				
54450	8.66				
54750	8.64	End of Test			

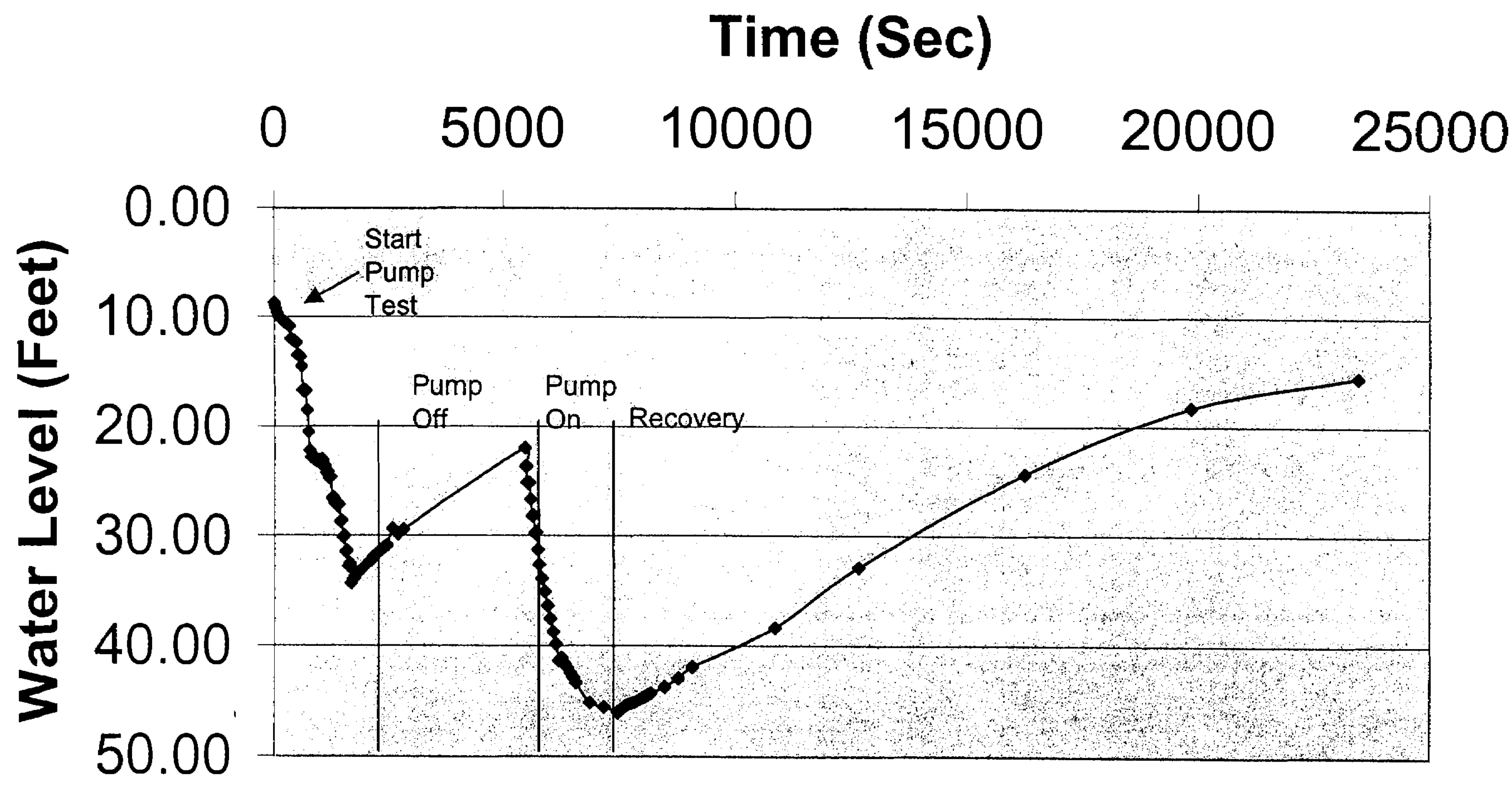

MW-12 Water Level vs.Time
Time (Sec)
0
10000
20000
30000
40000
50000
60000
Water Level (Feet)
0
5
10
15
20
25
30
35
40
Start
Pump
Test
Recovery

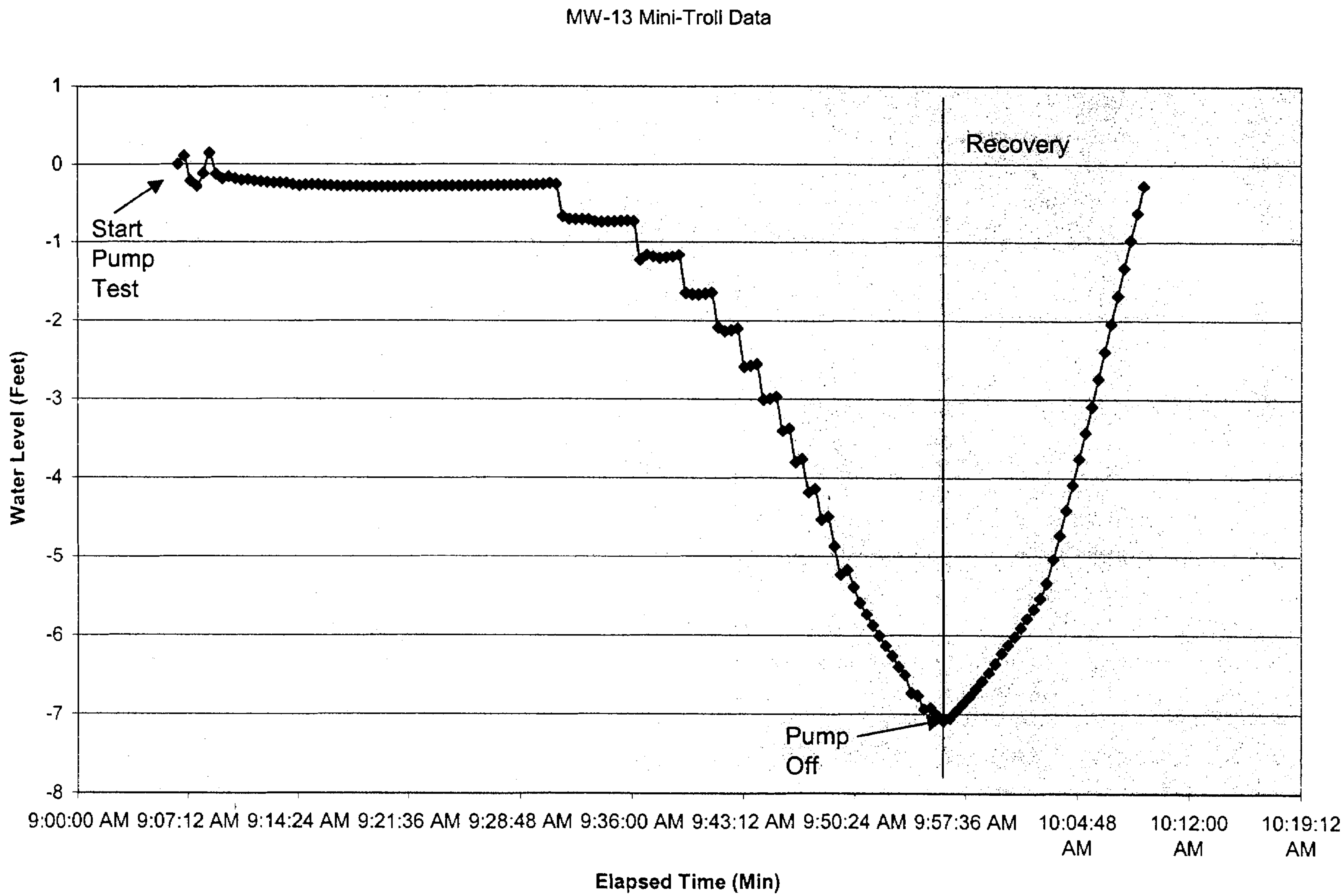
Photocircuits (MW-13)				
Date 1/9/02				
Time Start 09:06				
Test ran concurrently w/ troll data on separate spreadsheet				
Elapsed Time (Sec)	Water Level	Notes		
0	8.70	Pump started - flow rate of 1 gpm		
15	8.90			
30	9.20			
60	9.60			
90	9.94			
120	10.05			
150	10.20			
180	10.30			
210	10.42			
240	10.51			
270	10.60			
300	10.70			
330	10.81			
360	11.98			
390	12.05			
420	12.12			
450	12.22			
480	12.32			
510	13.45			
540	13.48			
570	13.57			
600	14.52			
630	16.71			
660	16.72			
690	16.73			
720	18.48			
750	20.50			
780	22.24			
810	22.84			
840	22.84			
870	23.03			
900	22.92			
930	23.18			
960	23.08			
990	23.24			
1020	23.17			
1050	23.05			
1080	23.71			
1110	23.60			
1140	24.24			
1170	24.12			
1200	24.72			
1230	24.62			
1260	26.58	pumping at 2 gpm		
1290	26.48			
1320	27.03			

1350	26.90			
1380	27.28			
1410	27.16			
1440	28.74			
1470	28.62			
1500	30.14			
1530	30.00			
1560	31.44	pumping at 1 gpm		
1590	31.34			
1620	32.75			
1650	32.50			
1680	34.30	Pump off		
1710	33.00			
1740	33.90			
1770	33.62			
1800	33.50			
1830	33.38			
1860	33.24			
1890	33.11			
1920	32.99			
1950	32.86			
1980	32.75			
2010	32.64			
2040	32.50			
2070	32.38			
2100	32.27			
2130	32.14			
2160	31.90			
2220	31.70			
2280	31.46			
2340	31.25			
2400	31.04			
2460	30.84			
2580	29.38			
2700	29.86			
2820	29.45			
5460	21.98			
5475	23.65			
5490	23.66			
5505	25.12			
5520	25.20			
5550	25.14			
5580	26.7			
5610	28.2			
5640	28.15			
5670	29.78			
5700	29.7			
5730	31.25			
5760	32.61			
5820	33.88			
5880	35.10			
5940	36.35			

6000	37.51			
6060	38.70			
6120	39.82			
6180	41.32			
6240	41.04			
6300	41.54			
6360	41.96			
6420	42.40			
6480	42.82			
6540	43.32	pumping at 3/4 gpm		
6840	45.14			
7140	45.54			
7440	46.07	Pump off		
7470	45.90	Recovery		
7500	45.82			
7530	45.71			
7560	45.64			
7590	45.53			
7620	45.43			
7650	45.36			
7680	45.30			
7740	45.21			
7800	45.13			
7860	45.02			
7920	44.86			
7980	44.72			
8040	44.58			
8100	44.44			
8160	44.28			
8460	43.70			
8760	42.92			
9060	41.92			
10860	38.33			
12660	32.85			
16260	24.34			
19860	18.21			
23460	15.48	End of Test		

MW-13 Manual Data (Change In Water Level vs. Time)





MW-13 Mini-Troll Data
Water Level (Feet)
1
0
-1
-2
-3
-4
-5
-6
-7
-8
Start
Pump
Test
Recovery
Pump
Off
9:00:00 AM
9:07:12 AM
9:14:24 AM
9:21:36 AM
9:28:48 AM
9:36:00 AM
9:43:12 AM
9:50:24 AM
9:57:36 AM
10:04:48 AM
10:12:00 AM
10:19:12 AM
Elapsed Time (Min)

In-Situ Inc.	MiniTroll Pro					
Report generated:	########	11:27:38				
Report from file:	A:\SN04240 1999-01-23 022835 MW-13.bin					
DataMgr Version	3.7					
Serial number:	4240					
Firmware Version	3.01					
Unit name:	MiniTroll		The test was started at 0906 on 1/09/02.			
			The SWL at the start of the test was 8.70.			
Test name:		MW-13				
Test defined on:	########	9:00:32				
Test started on:	########	9:06:35				
Test stopped on:	########	10:09:05				
Test extracted on: N/A						
Data gathered using Logarithmic testing						
Maximum time between data	Minutes.					
Number of data samples:	161					
TOTAL DATA SAMPLES	161					
Channel number [1]						
Measurement type:	Temperature					
Channel name:	OnBoard Temp					
Channel number [2]						
Measurement type:	Pressure					
Channel name:	OnBoard Pressure					
Sensor Range:	100 PSI.					
Specific gravity:	1					
Mode:	Surface					
User-defined reference:	0	Meters H2O				
Referenced on:	test start					
Pressure head at reference:	8.3	Meters H2O				
		Chan[1]	Chan[2]			
Date Time	ET (min)	Celsius	Meters H2O			
-------- --------	------------	------------	------------			
9:06:35 AM	0	17.68	0			
9:07:00 AM	0.0048	17.69	0.105			
9:07:25 AM	0.0098	17.7	-0.211			
9:07:50 AM	0.015	17.7	-0.281			
9:08:15 AM	0.0198	17.7	-0.118			
9:08:40 AM	0.025	17.7	0.141			
9:09:05 AM	0.03	17.72	-0.126			
9:09:30 AM	0.035	17.72	-0.184			
9:09:55 AM	0.0398	17.72	-0.16			
9:10:20 AM	0.045	17.72	-0.184			

9:10:45 AM	0.05	17.72	-0.202			
9:11:10 AM	0.0548	17.72	-0.196			
9:11:35 AM	0.06	17.72	-0.213			
9:12:00 AM	0.0648	17.72	-0.218			
9:12:25 AM	0.07	17.73	-0.229			
9:12:50 AM	0.075	17.72	-0.233			
9:13:15 AM	0.0798	17.73	-0.235			
9:13:40 AM	0.0848	17.73	-0.238			
9:14:05 AM	0.09	17.73	-0.255			
9:14:30 AM	0.095	17.73	-0.271			
9:14:55 AM	0.1	17.73	-0.26			
9:15:20 AM	0.1057	17.73	-0.256			
9:15:45 AM	0.1118	17.73	-0.258			
9:16:10 AM	0.1185	17.73	-0.264			
9:16:35 AM	0.1255	17.73	-0.267			
9:17:00 AM	0.1327	17.73	-0.276			
9:17:25 AM	0.1405	17.73	-0.28			
9:17:50 AM	0.1488	17.73	-0.276			
9:18:15 AM	0.1578	17.73	-0.275			
9:18:40 AM	0.167	17.73	-0.28			
9:19:05 AM	0.1768	17.72	-0.28			
9:19:30 AM	0.1875	17.72	-0.282			
9:19:55 AM	0.1985	17.72	-0.282			
9:20:20 AM	0.21	17.72	-0.28			
9:20:45 AM	0.2225	17.7	-0.28			
9:21:10 AM	0.2358	17.72	-0.282			
9:21:35 AM	0.2498	17.72	-0.28			
9:22:00 AM	0.2647	17.7	-0.28			
9:22:25 AM	0.2803	17.7	-0.28			
9:22:50 AM	0.297	17.7	-0.278			
9:23:15 AM	0.3145	17.7	-0.278			
9:23:40 AM	0.3333	17.7	-0.276			
9:24:05 AM	0.3532	17.7	-0.276			
9:24:30 AM	0.374	17.7	-0.276			
9:24:55 AM	0.3963	17.7	-0.274			
9:25:20 AM	0.4198	17.7	-0.274			
9:25:45 AM	0.4445	17.7	-0.272			
9:26:10 AM	0.4695	17.7	-0.271			
9:26:35 AM	0.4963	17.7	-0.271			
9:27:00 AM	0.5247	17.7	-0.269			
9:27:25 AM	0.5547	17.7	-0.267			
9:27:50 AM	0.5862	17.7	-0.265			
9:28:15 AM	0.6213	17.7	-0.265			
9:28:40 AM	0.6578	17.7	-0.261			
9:29:05 AM	0.6963	17.7	-0.261			
9:29:30 AM	0.738	17.7	-0.26			
9:29:55 AM	0.7813	17.69	-0.256			
9:30:20 AM	0.8278	17.69	-0.252			
9:30:45 AM	0.8762	17.69	-0.236			
9:31:10 AM	0.9278	17.69	-0.249			
9:31:35 AM	0.9828	17.69	-0.667			
9:32:00 AM	1.0412	17.69	-0.7			

9:32:25 AM	1.103	17.69	-0.705			
9:32:50 AM	1.1678	17.69	-0.704			
9:33:15 AM	1.238	17.69	-0.705			
9:33:40 AM	1.3113	17.69	-0.733			
9:34:05 AM	1.3895	17.69	-0.738			
9:34:30 AM	1.4728	17.69	-0.731			
9:34:55 AM	1.5613	17.69	-0.731			
9:35:20 AM	1.6547	17.69	-0.725			
9:35:45 AM	1.753	17.69	-0.722			
9:36:10 AM	1.858	17.68	-0.727			
9:36:35 AM	1.9678	17.68	-1.231			
9:37:00 AM	2.0845	17.68	-1.164			
9:37:25 AM	2.2097	17.68	-1.186			
9:37:50 AM	2.3412	17.68	-1.206			
9:38:15 AM	2.4812	17.68	-1.198			
9:38:40 AM	2.6297	17.68	-1.189			
9:39:05 AM	2.7863	17.68	-1.166			
9:39:30 AM	2.953	17.68	-1.648			
9:39:55 AM	3.1297	17.68	-1.664			
9:40:20 AM	3.3162	17.68	-1.666			
9:40:45 AM	3.5145	17.68	-1.655			
9:41:10 AM	3.7245	17.68	-1.641			
9:41:35 AM	3.9463	17.68	-2.083			
9:42:00 AM	4.1812	17.66	-2.132			
9:42:25 AM	4.4295	17.68	-2.118			
9:42:50 AM	4.6928	17.66	-2.097			
9:43:15 AM	4.9728	17.66	-2.583			
9:43:40 AM	5.2697	17.66	-2.569			
9:44:05 AM	5.583	17.66	-2.547			
9:44:30 AM	5.9145	17.66	-3.004			
9:44:55 AM	6.2663	17.66	-2.993			
9:45:20 AM	6.6395	17.66	-2.968			
9:45:45 AM	7.0345	17.66	-3.399			
9:46:10 AM	7.453	17.66	-3.367			
9:46:35 AM	7.8962	17.66	-3.8			
9:47:00 AM	8.3663	17.66	-3.76			
9:47:25 AM	8.8645	17.66	-4.181			
9:47:50 AM	9.3913	17.66	-4.135			
9:48:15 AM	9.9497	17.66	-4.529			
9:48:40 AM	10.5413	17.66	-4.491			
9:49:05 AM	11.168	17.66	-4.864			
9:49:30 AM	11.8312	17.66	-5.23			
9:49:55 AM	12.5347	17.66	-5.171			
9:50:20 AM	13.2795	17.66	-5.384			
9:50:45 AM	14.0695	17.66	-5.58			
9:51:10 AM	14.9062	17.66	-5.729			
9:51:35 AM	15.7913	17.66	-5.869			
9:52:00 AM	16.7295	17.66	-6.001			
9:52:25 AM	17.723	17.66	-6.131			
9:52:50 AM	18.7762	17.68	-6.259			
9:53:15 AM	19.8913	17.68	-6.396			
9:53:40 AM	21.073	17.68	-6.501			

9:54:05 AM	22.3247	17.66	-6.732			
9:54:30 AM	23.6497	17.66	-6.762			
9:54:55 AM	25.0545	17.68	-6.933			
9:55:20 AM	26.5428	17.68	-6.918			
9:55:45 AM	28.1178	17.68	-7.011			
9:56:10 AM	29.7863	17.69	-7.078			
9:56:35 AM	31.5545	17.69	-7.047			
9:57:00 AM	33.428	17.7	-6.955			
9:57:25 AM	35.4112	17.7	-6.868			
9:57:50 AM	37.513	17.7	-6.777			
9:58:15 AM	39.7397	17.7	-6.681			
9:58:40 AM	42.098	17.7	-6.582			
9:59:05 AM	44.5963	17.7	-6.473			
9:59:30 AM	47.2428	17.7	-6.359			
9:59:55 AM	50.0463	17.7	-6.228			
10:00:20 AM	53.0147	17.7	-6.123			
10:00:45 AM	56.1595	17.7	-6.018			
10:01:10 AM	59.4913	17.7	-5.904			
10:01:35 AM	63.0195	17.7	-5.788			
10:02:00 AM	66.758	17.7	-5.666			
10:02:25 AM	70.7178	17.7	-5.53			
10:02:50 AM	74.9113	17.7	-5.336			
10:03:15 AM	79.3545	17.69	-5.035			
10:03:40 AM	84.0613	17.69	-4.723			
10:04:05 AM	89.0462	17.69	-4.406			
10:04:30 AM	94.3262	17.69	-4.083			
10:04:55 AM	99.9197	17.69	-3.753			
10:05:20 AM	105.8447	17.68	-3.418			
10:05:45 AM	112.1197	17.68	-3.084			
10:06:10 AM	118.7678	17.68	-2.736			
10:06:35 AM	125.8095	17.68	-2.386			
10:07:00 AM	133.2678	17.68	-2.036			
10:07:25 AM	141.1678	17.68	-1.679			
10:07:50 AM	149.5363	17.68	-1.327			
10:08:15 AM	158.4012	17.68	-0.974			
10:08:40 AM	167.7912	17.66	-0.625			
10:09:05 AM	177.738	17.68	-0.272			