

1 Introduction

During the 1950's and 1960's a railroad yard located in Oneida, Tennessee, was used as a creosote treatment facility for railroad ties. After the cross-ties were treated with creosote, the excess creosote was stored in an holding pond located about 100 feet north of Pine Creek (Fetterolf 1998). In 1990, during a creek modification project, creosote was discovered seeping through the banks of Pine Creek. The creosote had leached through the bottom of the pond and migrated towards the creek.

In 1997, the Tennessee Department of Environment and Conservation authorized a remedial strategy prepared by Geraghty & Miller, Inc (Fetterolf 1998). The strategy involved the use of phytoremediation and a previously installed interception trench system. The primary goals of the phytoremediation plan are to stimulate biodegradation and to decrease groundwater flow, thus minimizing the migration of the contaminant into Pine Creek. Poplar trees were selected for the phytoremediation plan and were planted in two sections. The first section contains 836 trees in 10 rows that run from the southeast to the northwest, while the second section contains 184 trees in 8 rows that run from the southwest to the northeast. For the interception system, a sump pump in the interception trench transports collected groundwater into an oil/water separator. A layout of the site with the location of the trees and interception system can be found in Figure 1.1.

Since June 1997, Virginia Tech and Geraghty & Miller have worked to characterize and monitor the site. The tasks conducted by Virginia Tech included measuring water levels, collecting rainfall data, and sampling the soil and groundwater. The objective of this report is to investigate the impacts due to phytoremediation and the interception trench on the water table and hydraulic gradient (i.e. groundwater flow). This will be accomplished by analyzing the water level data and using finite difference models. One model will serve as the calibrated model, while two uncalibrated models will be used to quantify hydrologic impacts of phytoremediation and the interception trench. Additionally, all collected data from the site is included in the appendices.

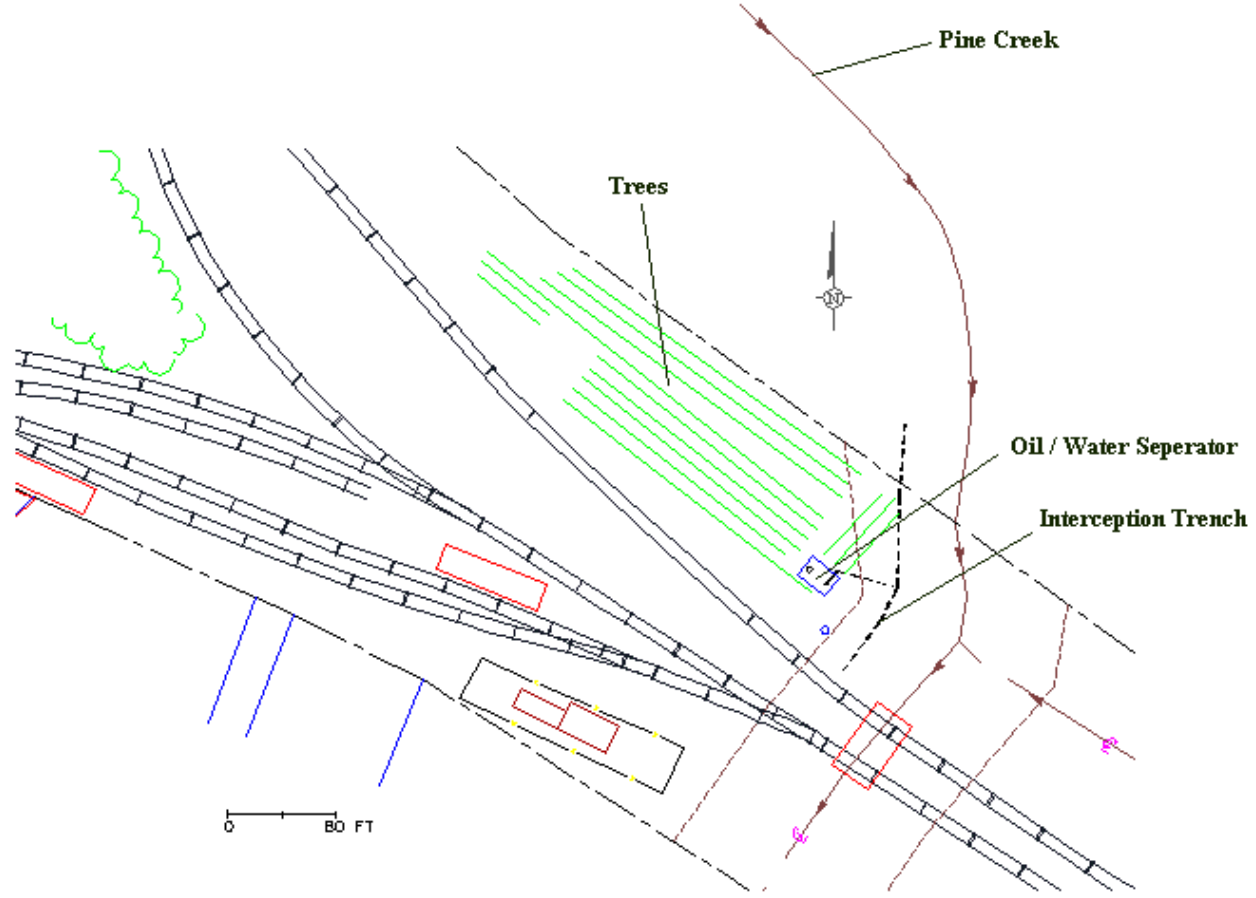


Figure 1.1: Site Layout (Geraghty & Miller, Inc.)

2 Hydrogeologic Setting

2.1 Geology

The site is located on the Norfolk and Southern Railroad Yard in the Blue Rige Mountains near Oneida, Tennessee. The climate is mild with an average precipitation of 55 inches per year. The majority of the site contains fescue grass and poplar trees, but there are also some grass study plots that contain rye, fescue, and clover. The eastern and northern sides of the site are bordered by Pine Creek, which can be seen in Figure 1.1. The geology is characterized by an overburden shallow unconfined aquifer that consists of a layer of sand that is overlain by a layer of clay. Within the clay layer, there are pockets of sand and coal, which will be discussed later in the report. These materials rest on shale bedrock, which varies between 9 and 12 ft in depth throughout the site. The bedrock elevation data is summarized in Table 2.1 below.

Table 2.1: Bedrock Data

Location	X-Coordinate (ft)	Y-Coordinate (ft)	Elevation of Bedrock (ft)
ML-1	1399.62	721.32	1422.33
ML-2	1429.69	772.88	1422.90
ML-3	1429.17	733.50	1422.03
ML-4	1429.15	692.63	1421.87
ML-5	1562.77	772.95	1422.30
ML-6	1455.20	691.05	1420.60
ML-7	1516.47	639.18	1419.94
ML-8	1566.17	596.05	1418.32
ML-9	1506.80	546.89	1421.46
ML-10	1443.35	535.58	1418.74
ML-11	1442.36	599.44	1418.34
ML-12	1425.02	647.16	1419.54
ML-13	1430.71	677.47	1419.19
ML-14	1428.47	707.14	1421.77
ML-15	1470.41	624.03	1421.16
ML-16	1549.13	658.97	1420.66

The upper layer of soil contains material that was excavated to construct the interception trench. After the trench excavation was complete, the soil was placed in three stockpiles and eventually spread over the entire site. Geologic cross-sections from Geraghty &

Miller's June 1997 Remediation Strategy Workshop are shown in Figures 2.1, 2.2, and 2.3.

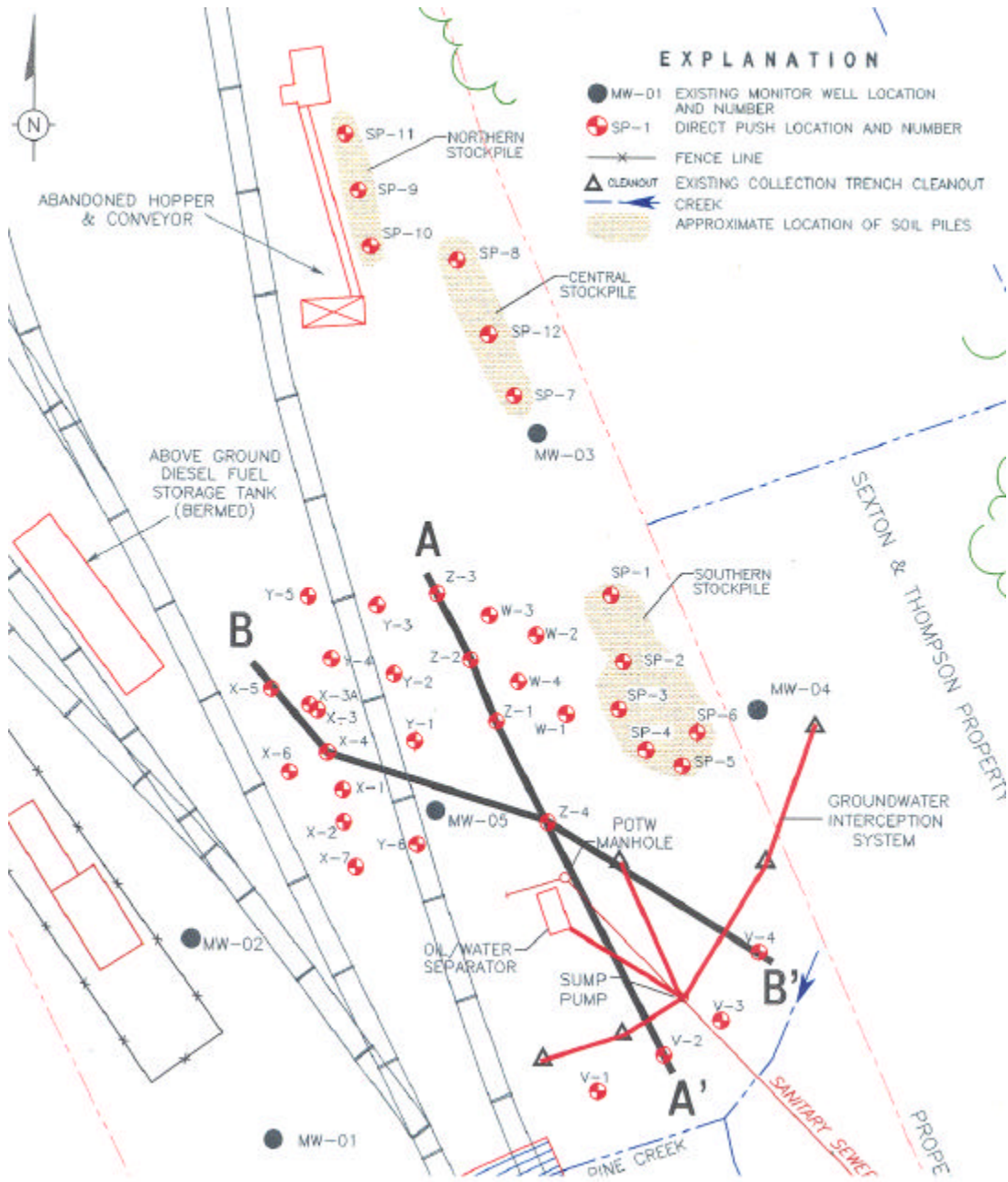
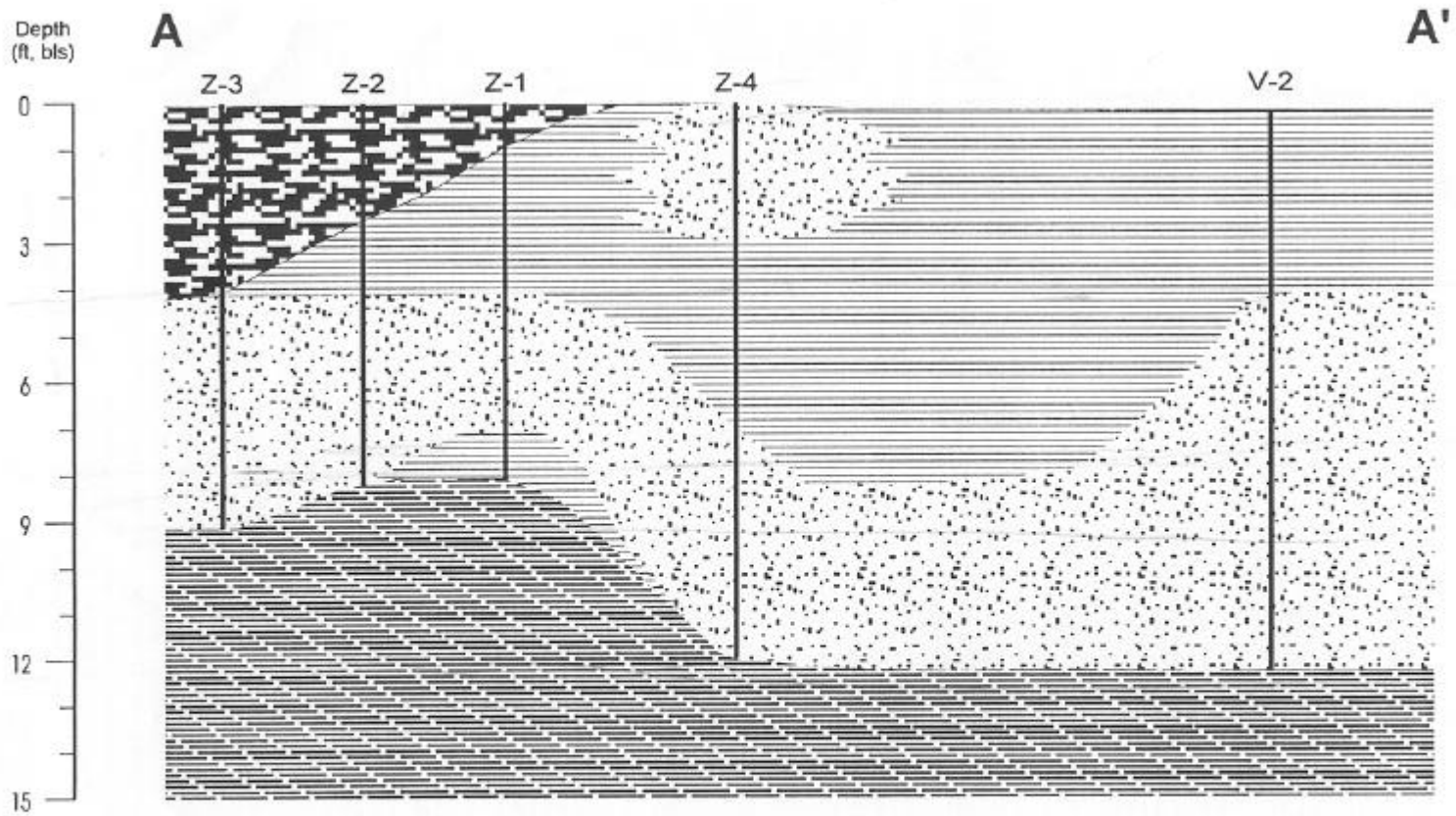


Figure 2.1: Location of Geologic Cross-Sections (Geraghty & Miller, Inc. 1997)



VERTICAL EXAGGERATION: 10X

LEGEND

- V-2 Direct Push Locations
- Coal and Coal Dust
- Clay
- Sand
- Bedrock

Figure 2.2: A-A' Geologic Cross-Section (Geraghty & Miller, Inc. 1997)

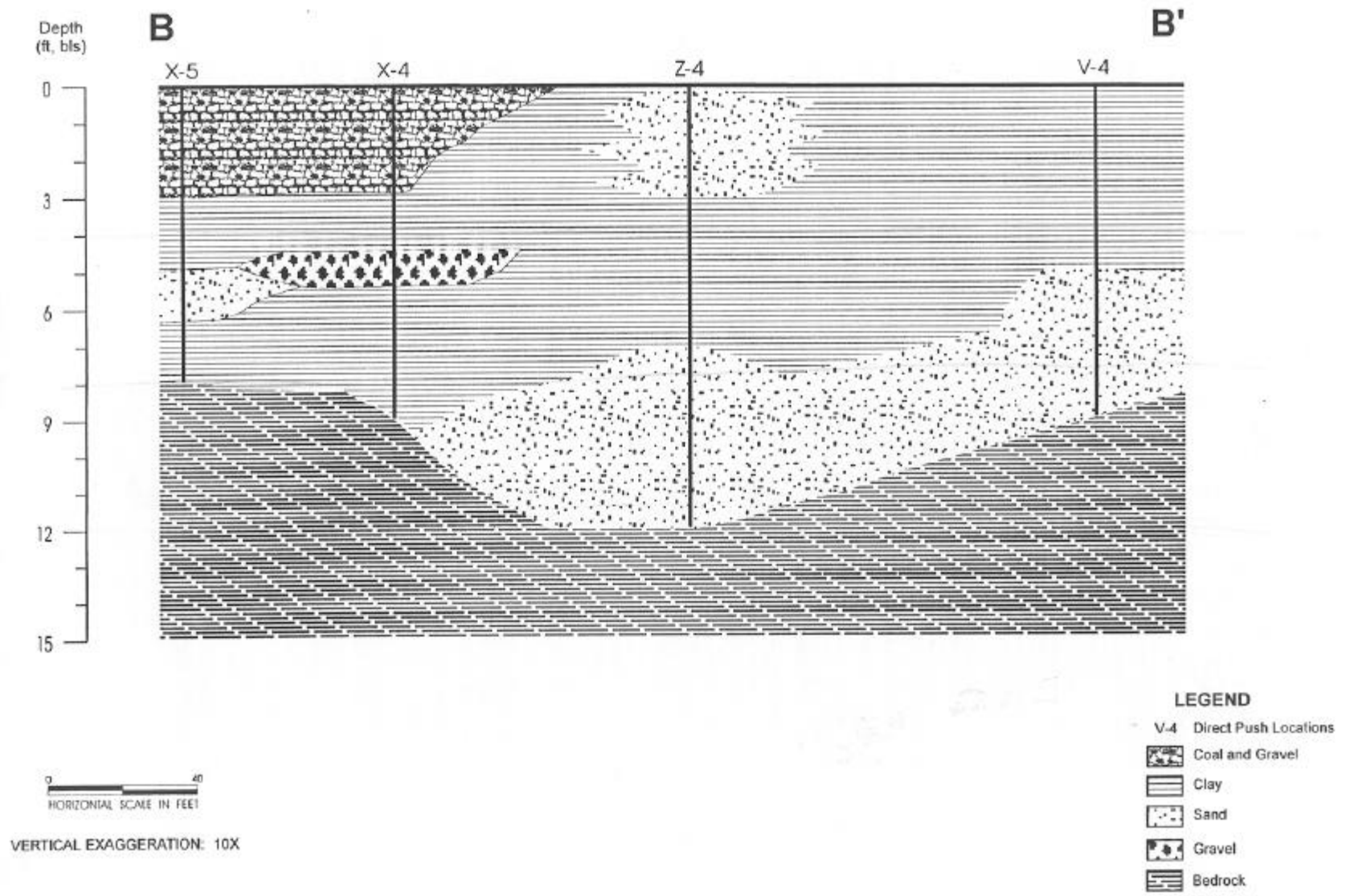


Figure 2.3: B-B' Geologic Cross-Section (Geraghty & Miller, Inc. 1997)

2.2 Hydrogeology

2.2.1 Water Levels

Water elevation data (see Appendix A) was collected to monitor water table fluctuations during the lifetime of the remediation strategy. The water levels were measured using the piezometers (20) and monitoring wells (7) shown in Figure 2.4. The piezometers and monitoring wells 6 and 7 were installed by Virginia Tech. Figure 2.5 is a diagram showing the specifics of the piezometer construction.

In order to understand how the water level elevations change with respect to the amount of rainfall and well location, plots Figures 2.6, 2.7, and 2.8 were constructed. The piezometers and monitoring wells were grouped together according to their location. Figure 2.6 shows the water levels for monitoring wells MW-1 and MW-2 compared with the rainfall for that period. Monitoring wells MW-1 and MW-2 were selected as control wells, since they were located far enough from the trench and trees that rainfall would only contribute to the change in water levels. Figure 2.7 is a plot of the water level elevations for P-2, P-15, and P-16. At these piezometers, the water levels will be affected by the amount of rainfall and potential evapotranspiration by the poplar trees. During the sampling periods from June 3, 1998 to July 29, 1998, the water level dropped an average of 1.5 ft in MW-1 and MW-2. During that same period, the water level dropped about 2.5 ft in piezometers P-2, P-15, and P-16. This difference in water elevation decrease can be potentially attributed to groundwater uptake by the poplar trees or, most likely, the decrease in recharge caused by the coal layer. The coal layer appears to diminish recharge, therefore the decreased rainfall in July 1998 would do little to increase the water level. Figure 2.9 is a plan view is the estimated location of the coal layer.

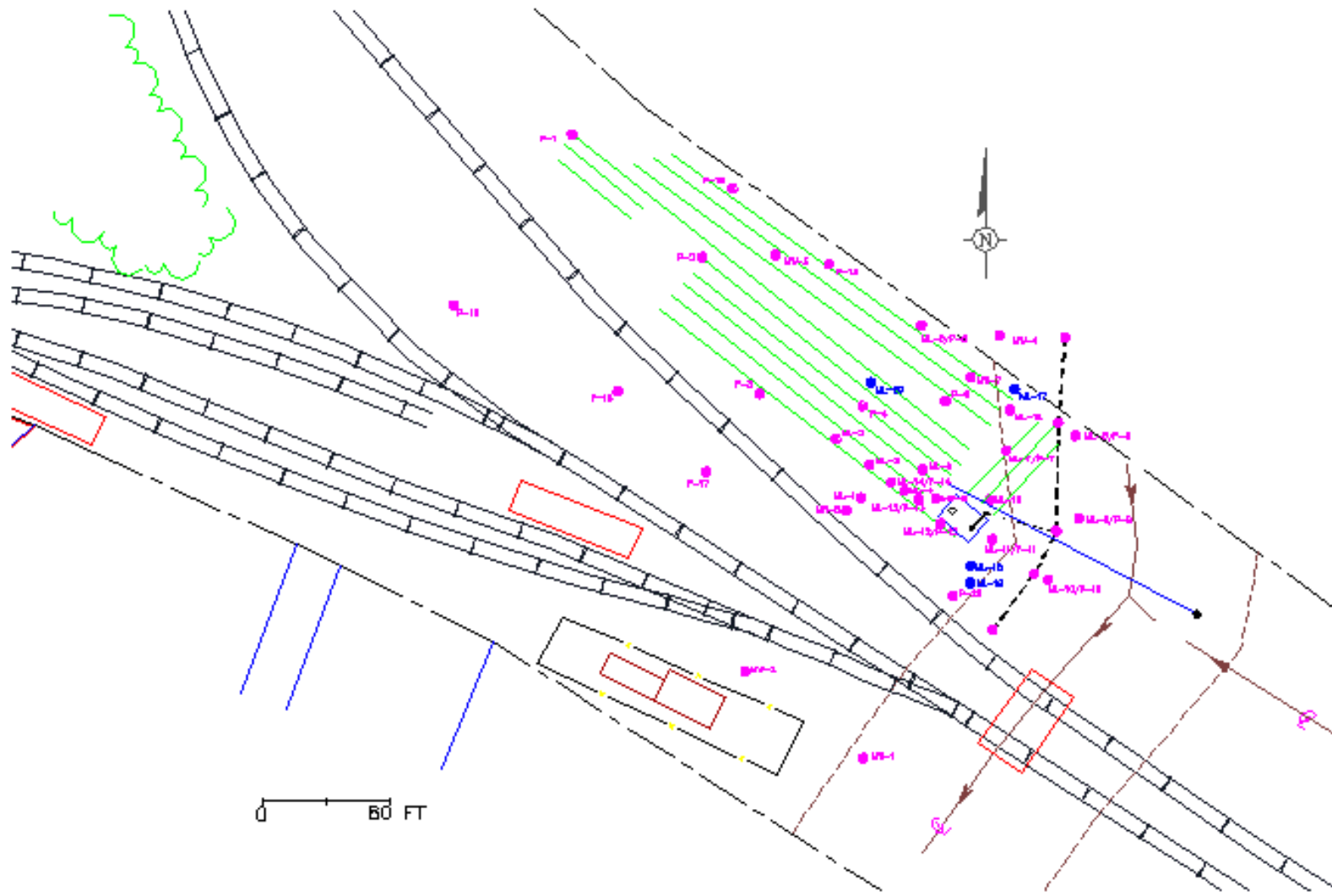
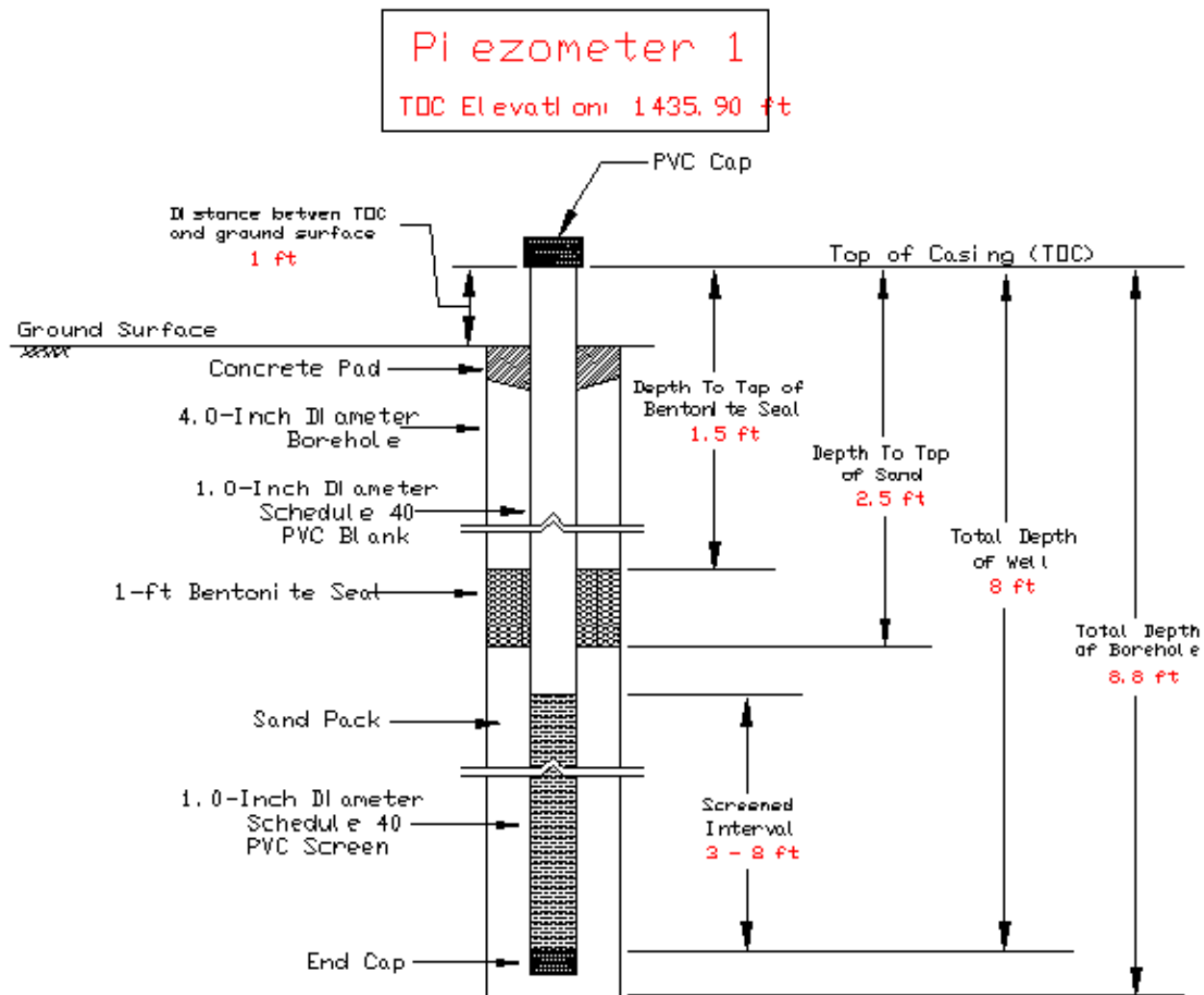


Figure 2.4: Location of Piezometers and Monitoring Wells (Geraghty & Miller, Inc.).



* Note: All measurements are made relative to the TDC

Figure 2.5: Schematic of a Piezometer (provided by Geraghty & Miller, Inc.)

Rainfall and Water Level Comparisons for MW-1 and MW-2

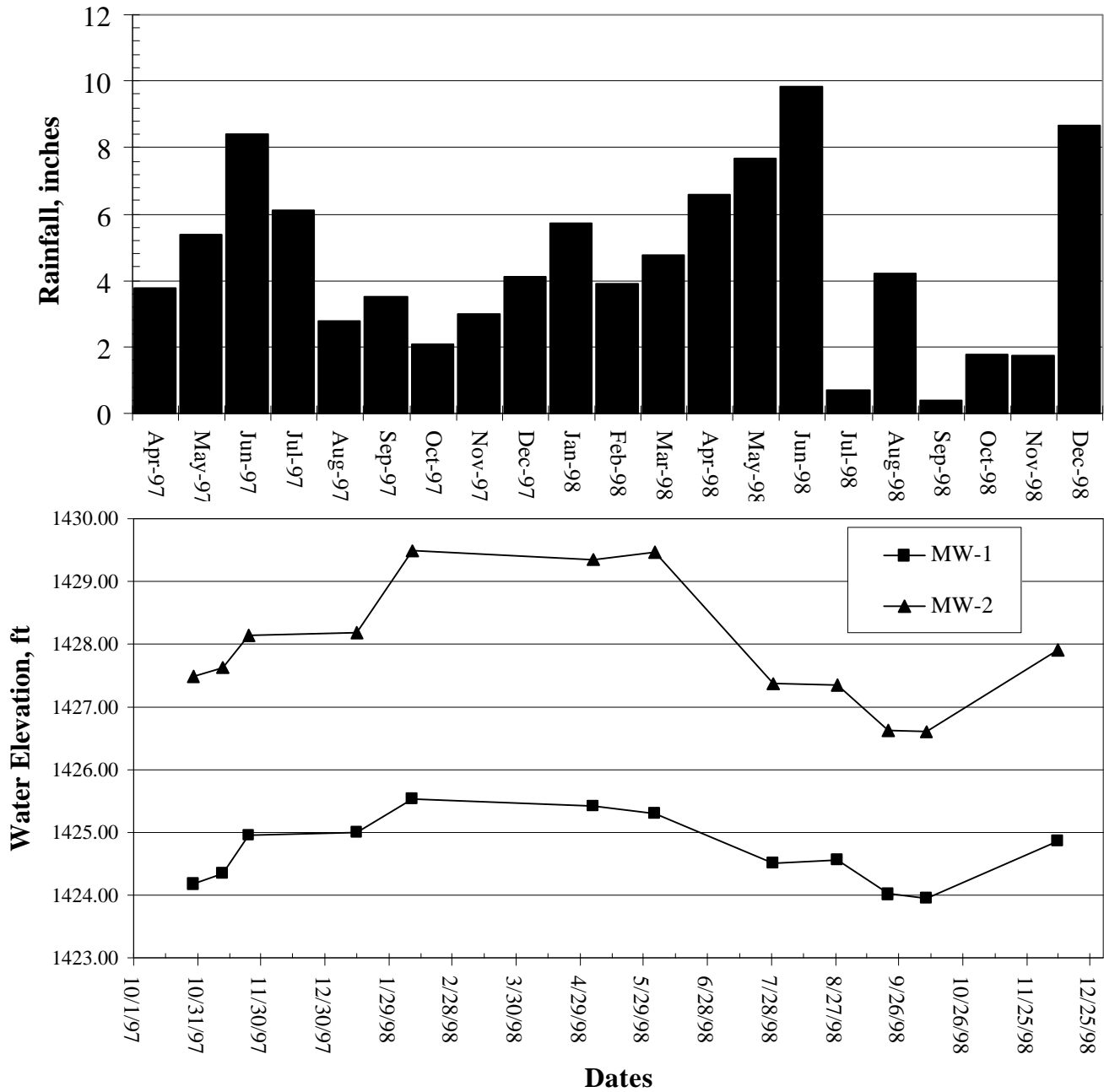


Figure 2.6: Water Level and Rainfall Comparisons for MW-1 and MW-2

Rainfall and Water Level Comparisons for P-2, P-15, and P-16

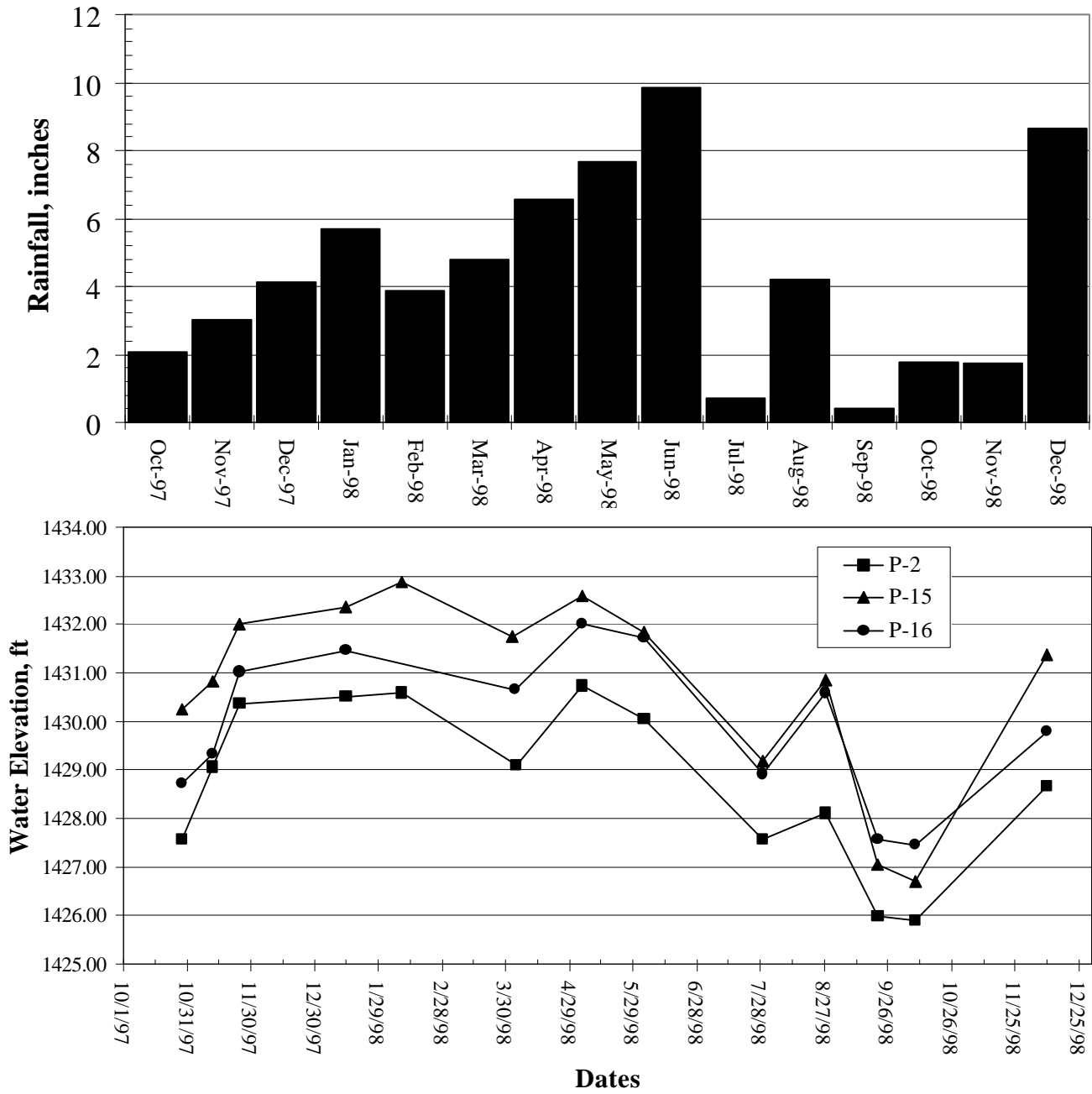


Figure 2.7: Rainfall and Water Level Comparisons for P-2, P-15, and P-16

Rainfall and Water Level Comparisons for P-6, P-7, P-8, and P-9

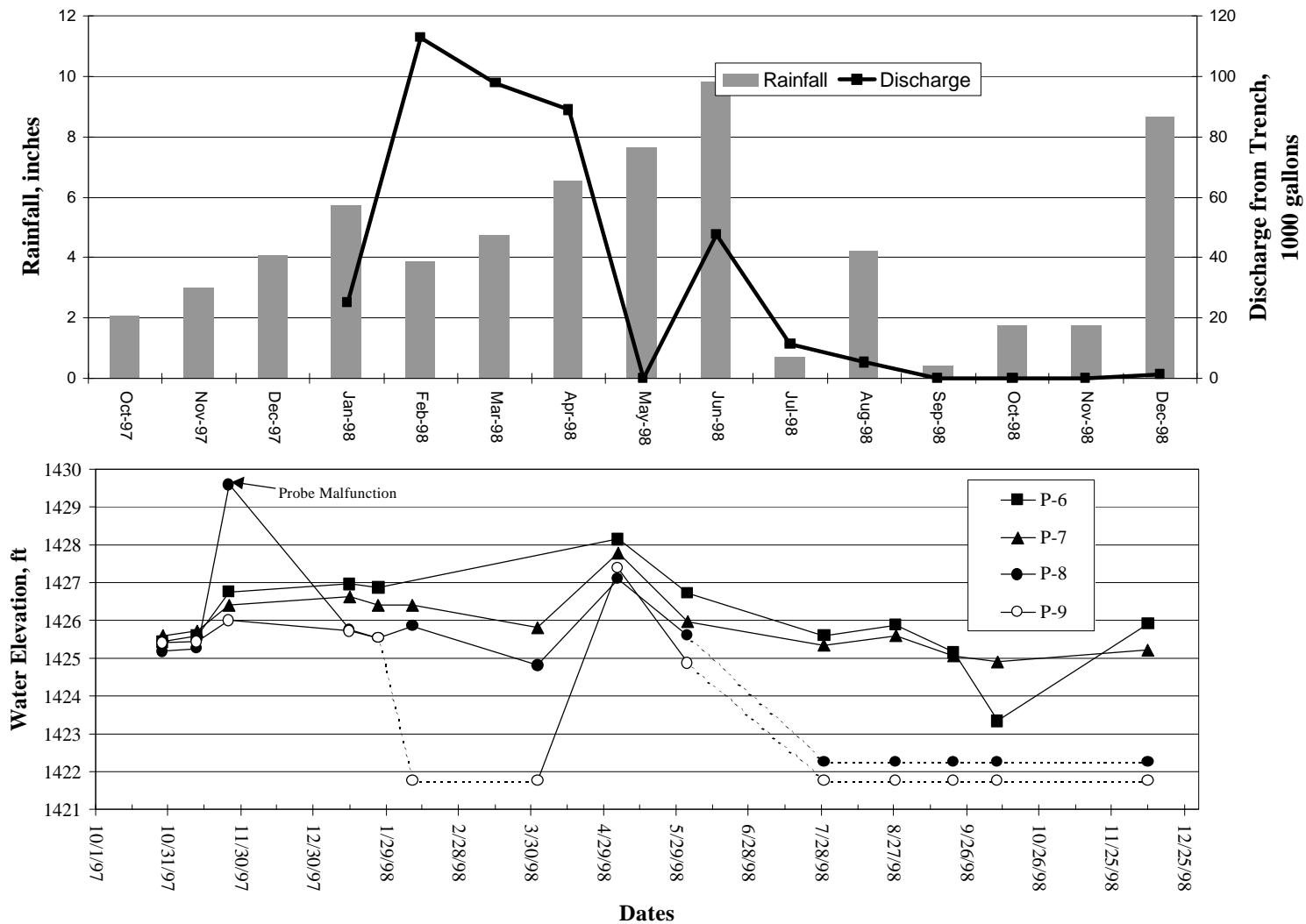


Figure 2.8: Rainfall and Water Level Comparisons for P-6, P-7, P-8, and P-9

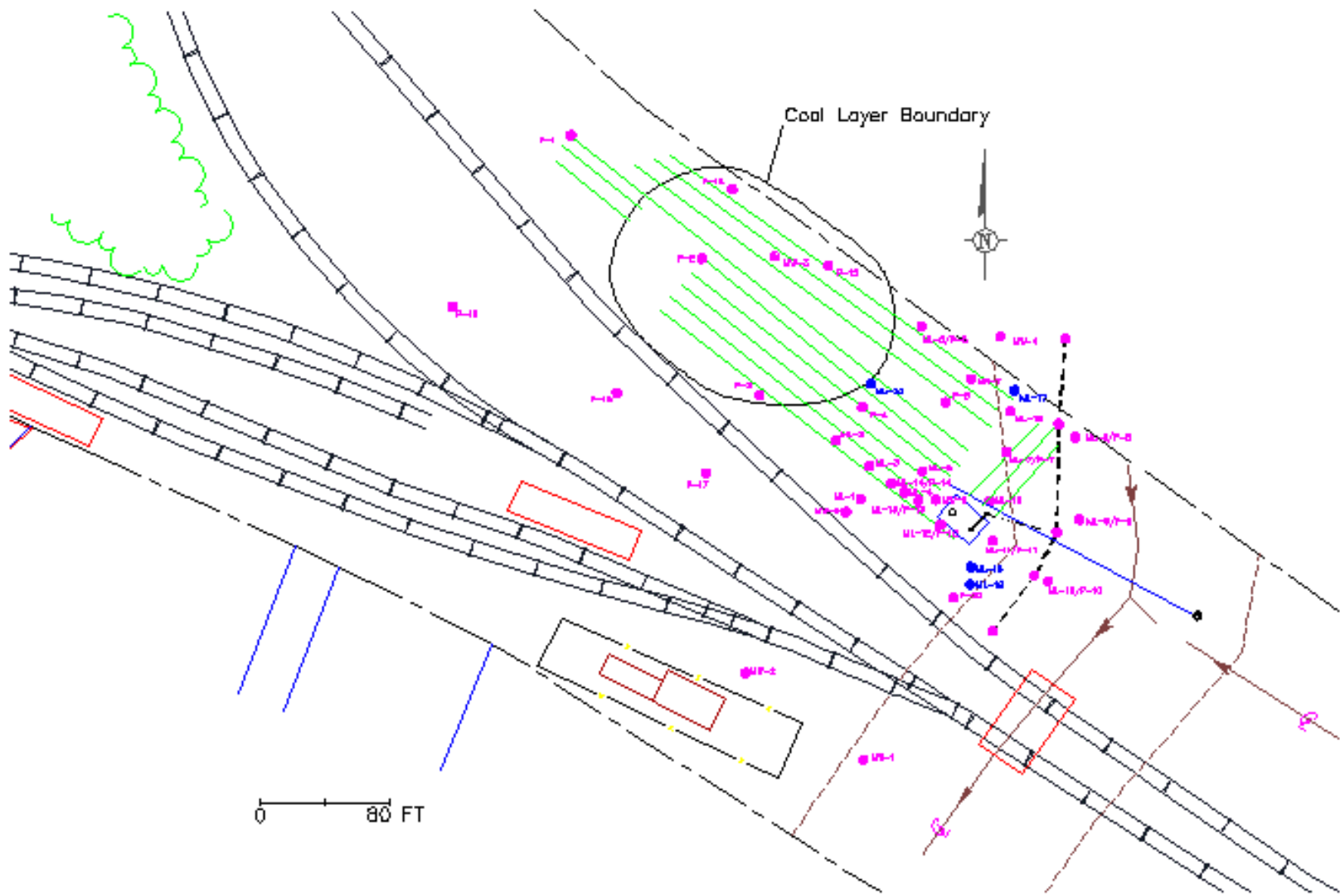


Figure 2.9: Estimated Location of the Coal Layer

Figure 2.8 is a plot of the water levels and rainfall for P-6, P-7, P-8, and P-9 and the volume of water discharged from the trench. In this plot, a dry piezometer or well is designated by a dashed line before that data point. In this case, the trench has more effect on the water elevations in P-8 and P-9 than in P-6 and P-7. From June 1998 to July 1998, the trench is in operation, and the water level dropped about 0.7 ft in piezometers P-6 and P-7. However, the water level dropped about 1.4 ft in P-8 and from 1425.25 ft to dry conditions in P-9. This was expected since the groundwater was intercepted before it could reach P-8 and P-9.

The analysis of the previously mentioned figures show that the phytoremediation and interception trench systems are affecting the hydraulic heads, thus affecting the groundwater flow. Here, the water levels change rapidly in response to rainfall events and trench operation, because the saturated thickness is relatively thin and the water table is close to the land surface. Additional water elevation and rainfall plots can be found in Appendix A.

2.2.2 Hydraulic Gradients

According to Darcy's Law ($q = kiA$), groundwater flow is directly proportional to hydraulic gradient. Therefore, knowing how the gradient reacts to stresses on the aquifer system also reveals the groundwater flow reaction. Two sets of hydraulic gradients were calculated using the triangulation method (see Appendix B) to represent base and remediation conditions. The December 1997 data was selected as the base condition because the trees were not in the growing season and the interception trench was not in operation. Thus, the hydraulic head was only affected by rainfall. August 1998 data were selected to represent the remediation condition because the trees were in the growing season and the trench was in operation. Additionally, the rainfall in August 1998 was similar to December 1997, which allows direct comparison between the two time periods. [Table 2.2](#) below contains the gradient magnitudes and directions for each triangle, along with the actual difference and percent difference from December 1997 to August 1998. [Figures 2.10 and 2.11](#) show the direction and magnitude of the gradient and the triangles used to calculate the gradients. The vectors are scaled relative to the calculated gradient to facilitate comparison.

Table 2.2: Gradient Summary

Triangle	Vertices	December-97		August-98		Difference in Gradient (Aug 98 - Dec 97)	% Difference
		Hydraulic Gradients (ft/ft)	Direction Angle*	Hydraulic Gradients (ft/ft)	Direction Angle*		
1	P-2, MW-3, P-16	0.017	61°	0.053	67°	0.036	209.7
2	P-7, P-4, P-5	0.021	151°	0.013	144°	-0.008	-38.2
3	P-1, P-18, P-19	0.003	211°	0.013	209°	0.010	284.3
4	P-3, P-18, P-17	0.038	228°	0.061	227°	0.023	60.7
5	P-12, P-4, MW-5	0.112	205°	0.079	204°	-0.033	-29.6
6	P-4, P-3, MW-3	0.034	170°	0.030	128°	-0.005	-13.3
Mean						0.004	78.9

*Measured counter-clockwise from 0° horizontal with the first vertice listed for each triangle as the origin

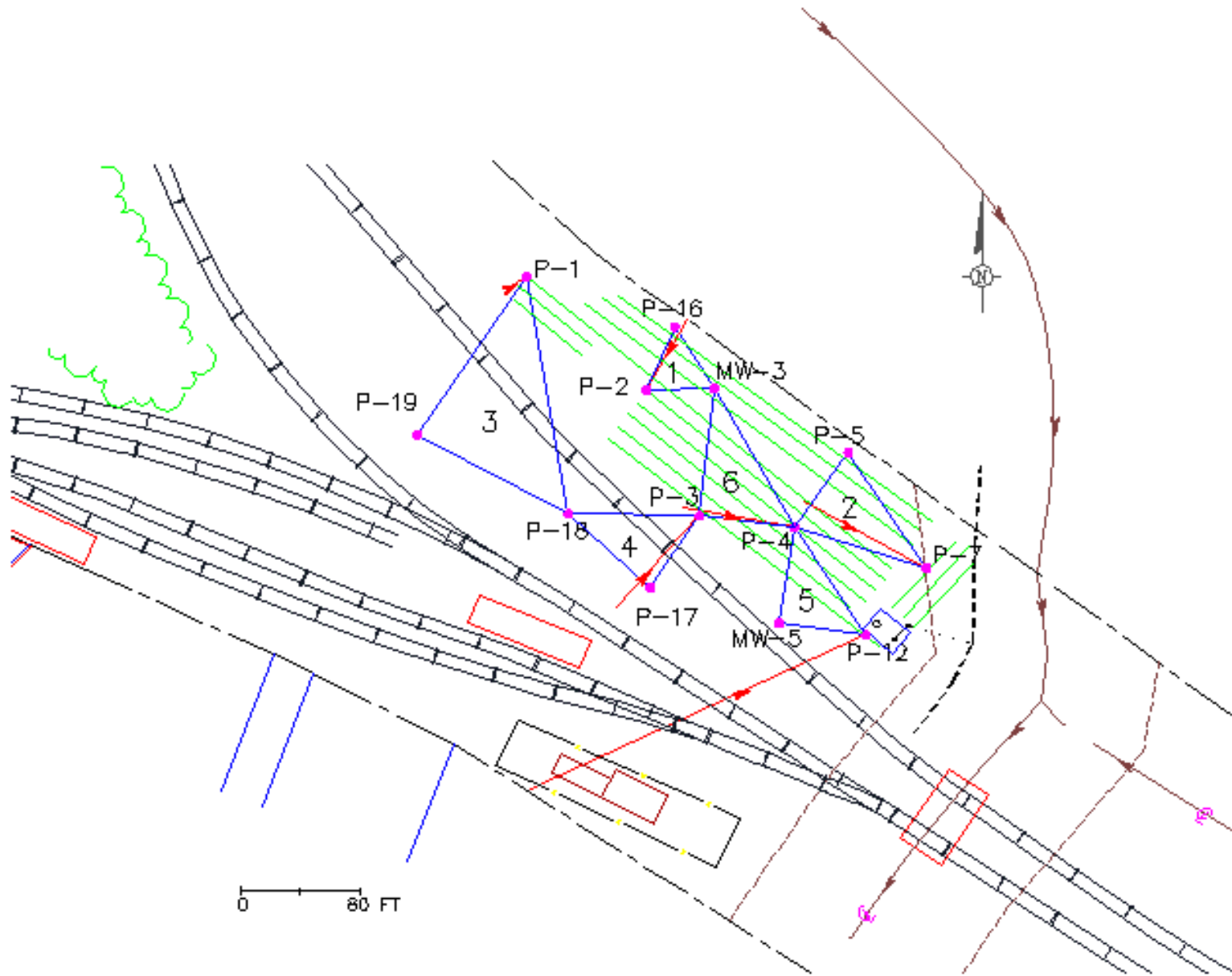


Figure 2.10: Gradient Directions and Magnitudes for December 1997 (modified drawing from Geraghty & Miller, Inc.)

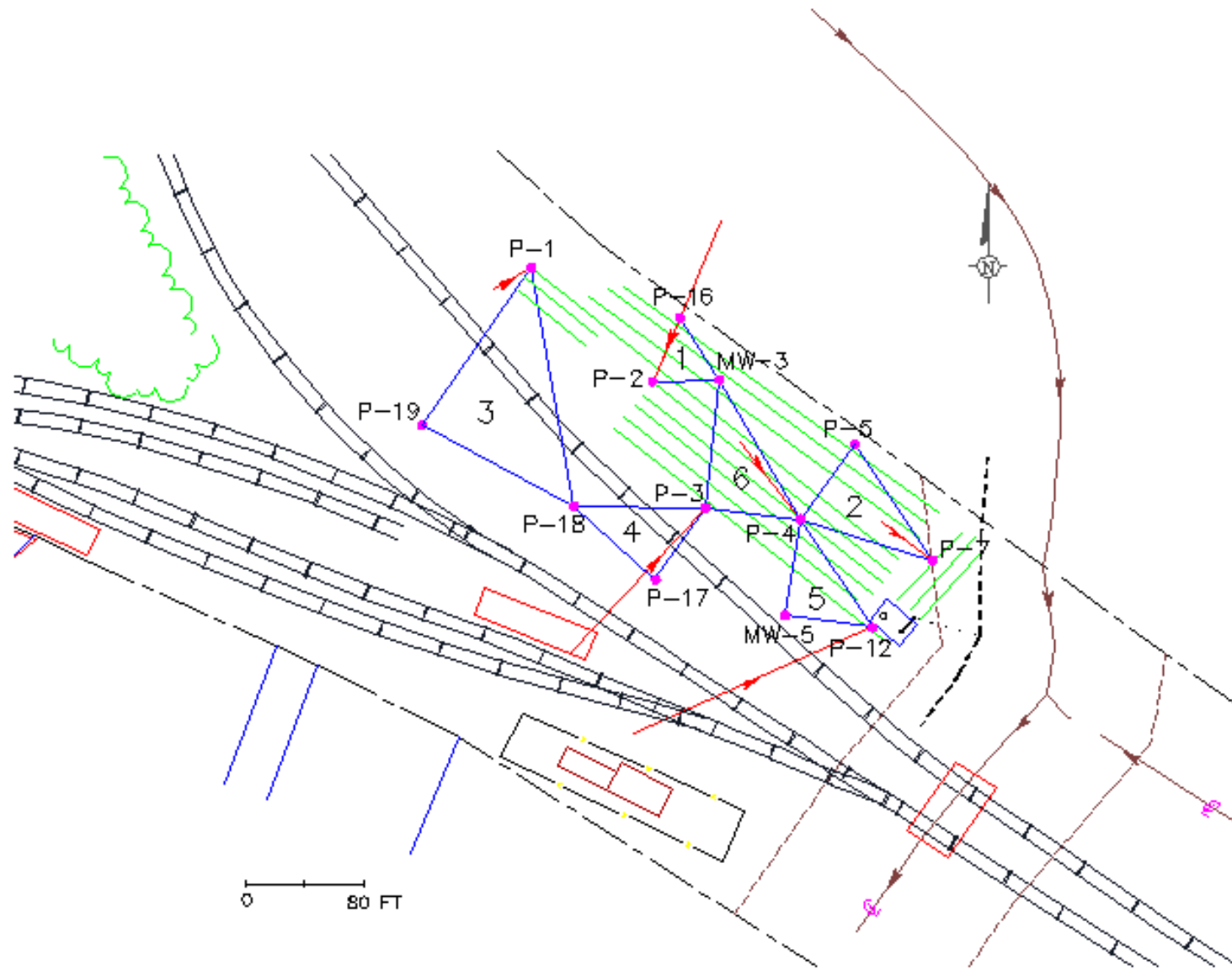


Figure 2.11: Gradient Directions and Magnitudes for August 1998 (modified drawing from Geraghty & Miller, Inc.)

From Table 2.2 and Figures 2.10 and 2.11, it can be determined that there were spatial and seasonal variation in the gradients. The greatest spatial variation occurs between triangles 3 and 5 of Figure 2.10. Here, triangle 5 has a gradient over 30 times larger than the gradient in triangle 3. Meanwhile, spatial variations also exist in the direction of the gradients. For example, in Figure 2.10 the gradients for triangle 2 and 3 were directed 151° and 211° to the horizontal, respectively. The spatial variation in direction was expected since the water should flow towards Pine Creek. In general, all of the gradients flow towards the creek, except for triangle 2, which flows away.

As far as seasonal variations, the magnitudes of the gradients increased an average of 0.004 ft/ft from December 1997 to August 1998. This increase was weighted heavily by the 210%, and 284% increases in the gradients for triangles 2 and 4, respectively. The reason behind the increases can be explained by examining Table 2.3, which contains the heads that were used in the gradient calculations.

Table 2.3: Hydraulic Heads used in Gradient Calculations

Triangle	Vertices	December 1997 Hydraulic Heads (ft)	August 1998 Hydraulic Heads (ft)	Difference August 1998 - December 1997 (ft)
1	P-2	1430.40	1428.12	-2.28
	MW-3	1430.80	1429.13	-1.67
	P-16	1431.20	1430.61	-0.59
2	P-4	1426.50	1425.60	-0.90
	P-5	1428.40	1426.55	-1.85
	P-7	1428.40	1426.84	-1.56
3	P-1	1432.60	1431.59	-1.01
	P-18	1432.80	1432.31	-0.49
	P-19	1433.00	1433.11	0.11
4	P-3	1430.60	1428.73	-1.87
	P-18	1432.80	1432.31	-0.49
	P-17	1432.80	1432.26	-0.54
5	P-12	1426.90	1425.66	-1.24
	P-4	1428.40	1426.84	-1.56
	MW-5	1432.50	1429.65	-2.85
6	P-4	1428.40	1426.84	-1.56
	P-3	1430.60	1428.73	-1.87
	MW-3	1430.80	1429.13	-1.67
Mean				-1.33

From Table 2.3, the heads at each of the vertices, except P-19, decrease from December 1997 to August 1998. There is no explanation for this occurrence at P-19, since P-18 decreased in head. One would expect the head to decrease similarly in both P-18 and P-

19 since they were both affected by rainfall only. The decrease in the other heads was expected since the poplars and the trench system were removing water from the system during August 1998.

In triangle 2, the water level in piezometer P-2 was also drastically lowered. This can be explained by the coal layer mentioned in the water level. The lack of recharge capability made it difficult for the aquifer around P-2 to recover from the drought in July 1998. Meanwhile, the areas around MW-3 and P-16 were able to accept more recharge, thus their water levels were not affected by the drought as much. With the greater decrease in head at P-2, the hydraulic gradient toward P-2 also increased.

As for triangle 4, the water level in piezometer P-1 was lowered about twice as much as P-18 and 9 times as much as P-19. The area around piezometer P-1 was probably affected by the trees, whereas piezometers P-19 and P-18 were not. This would explain the drastic gradient increase towards P-1.

Overall, the seasonal variations in the gradient magnitudes were caused by decreased recharge effects and potentially by evapotranspiration. For the most part, there were very little seasonal changes in the gradient directions, with the greatest change occurring in triangle 7.

2.2.3 Groundwater Velocity

The same seasonal and spatial variations in hydraulic gradient can be seen in the groundwater velocity. Table 2.4 below summarizes the velocities calculated using the gradients from Table 2.2. A constant hydraulic conductivity and effective porosity of 4 ft/day and 0.30, respectively, were assumed for the entire site. The hydraulic conductivity was the value from the calibrated model, which will be discussed later. Sample calculations of the velocities are in Appendix B.

Table 2.4: Calculated Velocities

Triangle	Darcy Velocity (ft/day)			Groundwater Velocity (ft/day)		
	Dec-97	Aug-98	Difference	Dec-97	Aug-98	Difference
1	0.069	0.213	0.144	0.229	0.708	0.480
2	0.086	0.053	-0.033	0.286	0.176	-0.109
3	0.013	0.052	0.038	0.045	0.173	0.128
4	0.151	0.243	0.092	0.503	0.808	0.305
5	0.449	0.316	-0.133	1.496	1.054	-0.442
6	0.137	0.119	-0.018	0.457	0.396	-0.061

Spatial variations in velocity definitely exist, and, in general, the groundwater velocities increased during the summer season. Since the velocities are directly related to the hydraulic gradients, the variations can be explained using the same reasoning as the hydraulic gradients.

3 Finite Difference Model

3.1 Objectives

The objective of the modeling effort was to predict water table response under the remediation strategy used at the site. To accomplish this, three steady state single layer models were constructed using the Groundwater Modeling System (GMS) MODFLOW software. With a single layer model, the site was simulated as one unconfined aquifer. The first model simulated the site without evapotranspiration from the poplars or discharge from the interception. This model was used as the base model and it was calibrated with actual field data. The second model simulated the site when the interception trench was in operation, while the third model simulated the site when the trees were in their growing season.

In order for the second model to be under steady state conditions, a constant trench discharge value is needed. However, the discharge data is not constant, thus this model simplifies the actual conditions during the trench operation. The third model would show how effective the phytoremediation strategy would be in reducing the groundwater flow. A typical growing season for the poplar trees is about 5 to 6 months, and a steady-state model would only be valid if steady state was reached in that period. For the third model, steady state is assumed to occur in that 5 to 6 month window.

3.2 Model Construction

There are two different approaches in constructing models using GMS. One is the conceptual approach, and the other is the grid approach. All of the models, in this case, were constructed using the conceptual approach in GMS. The GMS v2.1 Tutorial was also used as a guide in constructing the conceptual model. With the conceptual model approach, a background image is used as a guide to construct arcs and polygons that can be assigned certain aquifer properties. For example, a creek boundary can be constructed by drawing an arc over the entire creek image and then assigning the creek elevation and conductance parameters to the arc. A grid can then be created within the space surrounded by the boundaries, and the conceptual model parameters can be transferred into the MODFLOW input files. With the grid approach, the grid is constructed first and then the cells are assigned the parameter values and boundary conditions. With this

method, the MODFLOW input files are created directly. The advantage of the conceptual approach is that everything can be constructed using an image of the site. With the grid approach, scaling is required from a site map.

Once the conceptual image has been registered (see Appendix C), the boundary conditions were added to the model. This was done by creating arcs that were assigned a boundary type. [Figure 3.1](#) shows the location and the types boundaries that were constructed.

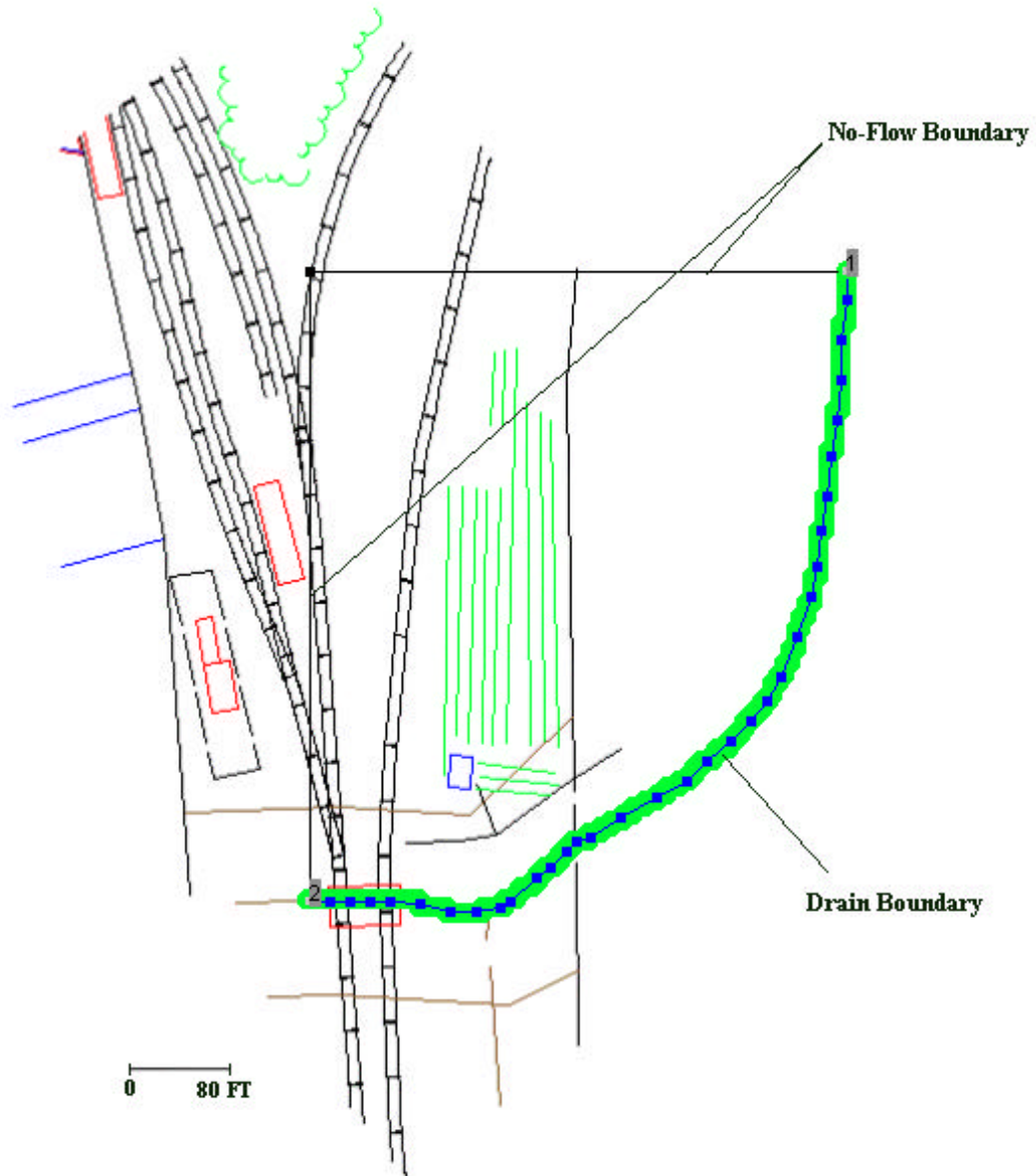


Figure 3.1: Location and Type of Boundary Arcs

The northern and western boundaries were set as no-flow boundaries, and Pine Creek was simulated with a drain boundary. The groundwater was assumed to flow perpendicular to Pine Creek, therefore the northern and western no-flow boundaries are streamlines. However, the gradient calculations show that there is a flux entering the site through the western boundary. There is a possibility that wells should be added in future modeling studies to both the northern and western boundaries to simulate the possible fluxes. In the models done for this study, the flux entering the west boundary was not simulated.

For the drain boundary, the conductance for each cell and the elevations for the beginning and ending nodes were required. Using this information, GMS assumes the drain elevation varies linearly in the cells in between. For the drain boundary conductance, it must be entered in terms of conductance per cell arc length (L) in the following form:

$$C_{arc} = \frac{k/t \cdot l \cdot w}{L} = \frac{k \cdot w}{t} \quad (\text{Department of Defense 1998})$$

where: k = hydraulic conductivity of the creek sediment (ft/day)

t = thickness of the sediment perpendicular with the flow (ft)

$l \cdot w$ = cross-sectional area perpendicular to the flow (ft²)

L = length of the arc in a particular cell (ft)

Figure 3.2 is a diagram showing the location of the above variables in a single cell.

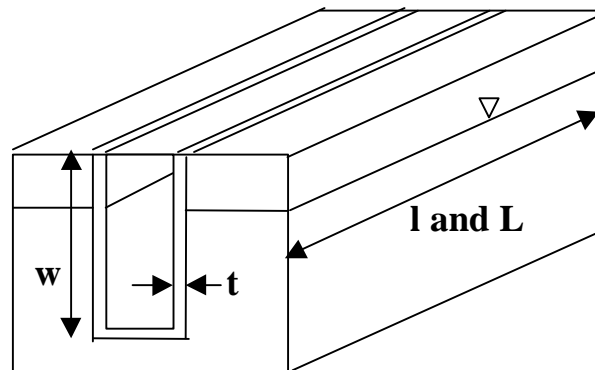


Figure 3.2: Drain Diagram

With the boundary conditions and drain elevations complete, a 100 by 100 (4.5 ft × 5.3 ft) single layer grid was placed on the image. Figure 3.3, below, shows the location

of the final grid and grid frame. The BCF file, which contains the IBOUND input, can be found in Appendix D.

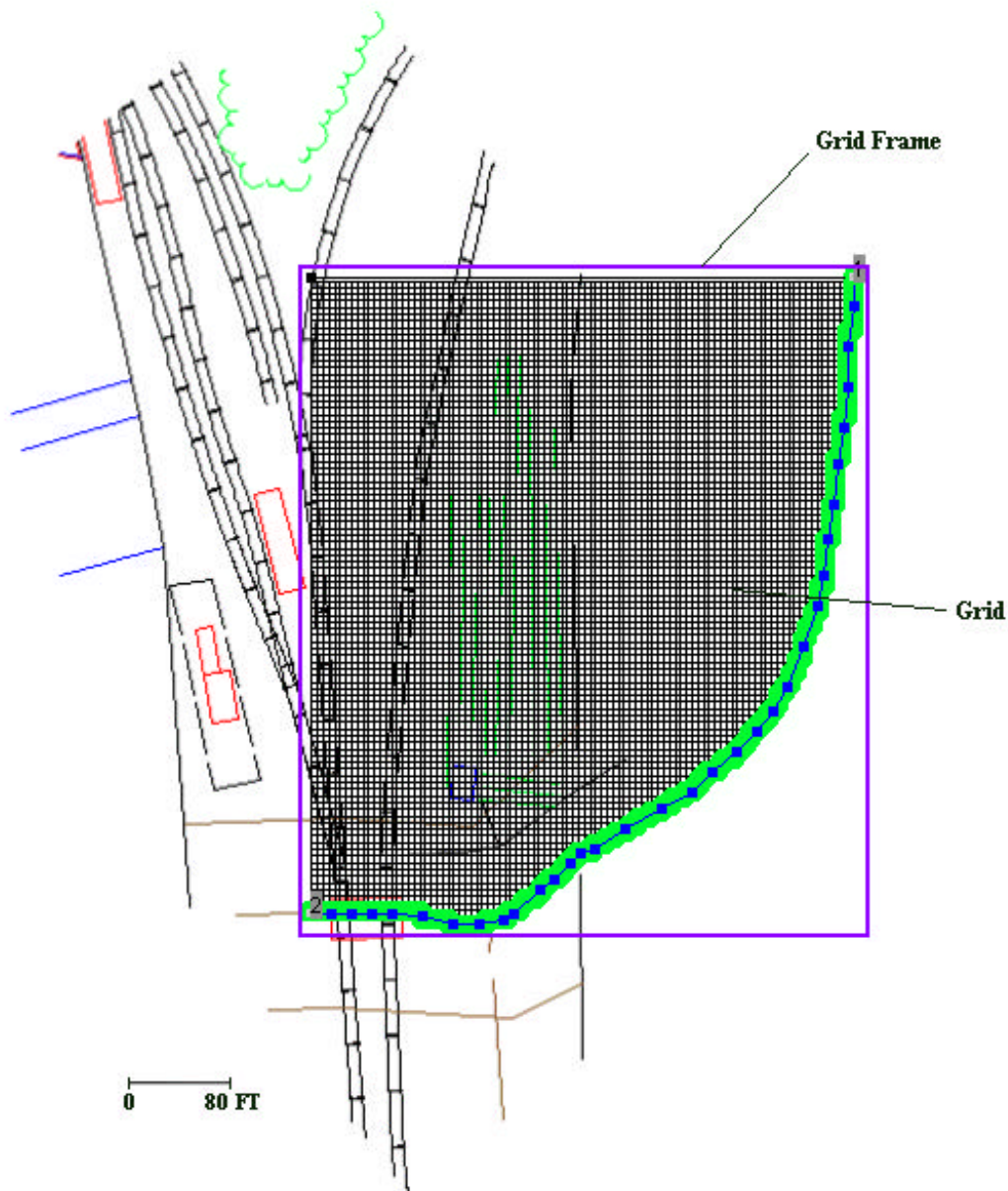


Figure 3.3: Grid Layout

For an unconfined aquifer model, the elevation of the bedrock must be defined. From the data in Table 2.1, a grid was created to define the bedrock elevation. The grid was interpolated using the nearest neighbor method in the 2D-scatter point module in GMS. The bedrock elevations compiled by the interpolation in the northern region of the site were extremely high. This was a result of not having bedrock data for the northern region. In order to correct this, a uniform bedrock elevation of 1426 ft was manually

entered for those cells. This uniform bedrock elevation is highly unlikely for the site. However, it was a valid assumption given the simplicity of the model. On a more detailed model of the site, additional bedrock data should be attained for the northern region. This will ensure results that are more realistic after the interpolation scheme is used. Figure 3.4 shows a contour map of the bedrock elevation, the actual values used for each cell can be found in the BCF file in Appendix D.

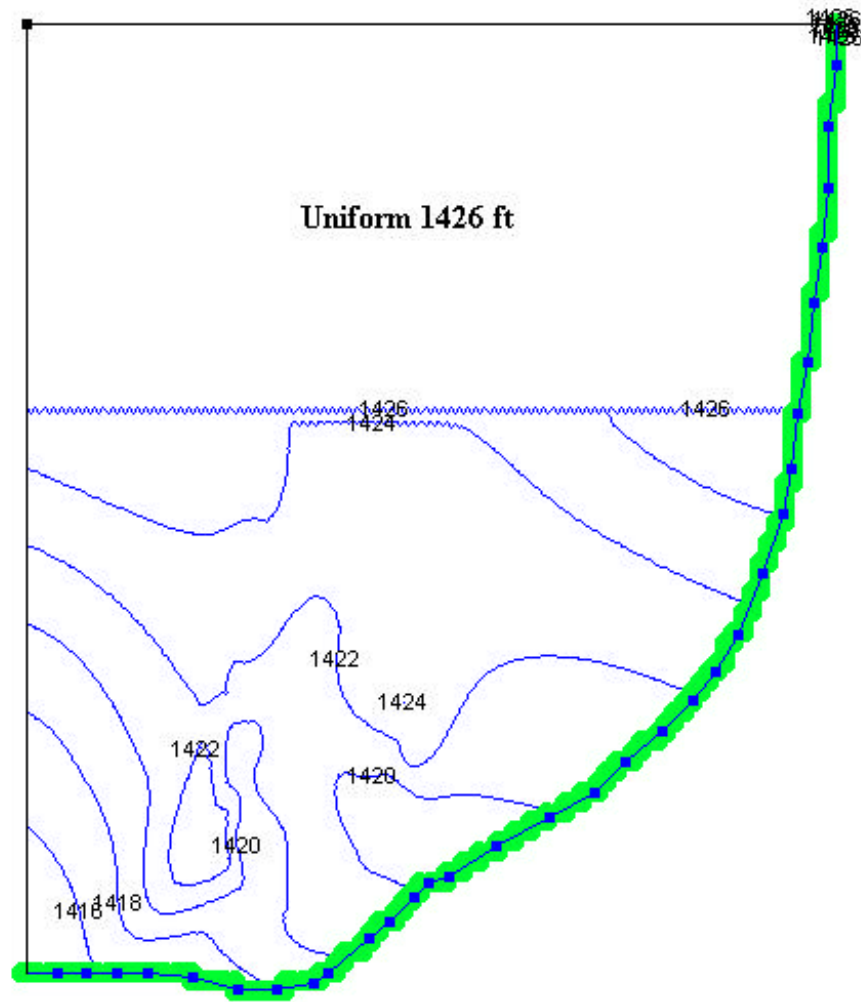


Figure 3.4: Bedrock Elevation

3.3 Calibration

The three unknown parameters for the simulation were recharge, hydraulic conductivity, and creek conductance. During the calibration process, the simulated heads were compared with observed head values from December 1997. The water levels were measured from the piezometers and monitoring wells shown in Figure 3.5.

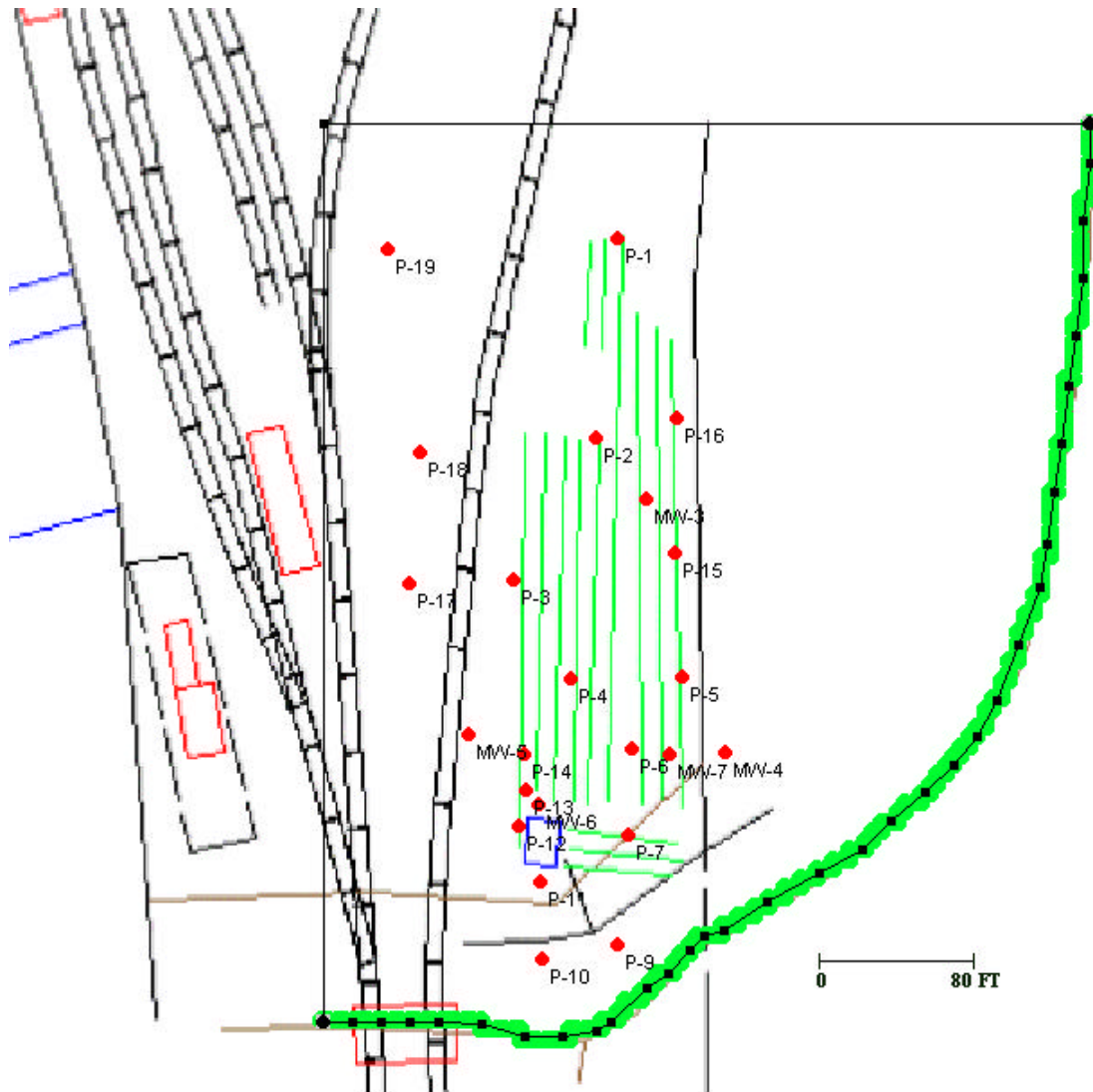


Figure 3.5: Observation Wells

For large adjustments in the hydraulic heads, the hydraulic conductivity and recharge were modified, while the creek conductance was modified when small changes in the head near the creek were needed. If the heads were lower than the observed values, the

creek conductance was decreased. Meanwhile, if the heads were higher than the observed values, the conductance was decreased.

The model was run using the strongly implicit (SIP) solution package with an acceleration parameter of 0.70 and a convergence criterion of 1×10^{-4} ft. After using different combinations of parameters, the best-fit scenario had a drain conductance of 3 ft^2/day per unit length, a uniform hydraulic conductivity of 4 ft/day , and a uniform recharge value of 0.0026 ft/day . Assuming that the creek bank (w) is 6 ft high, this could mean that the creek material is 0.5 ft thick (t) and has a hydraulic conductivity (k) of 1 ft/day . The actual values of these parameters were not measured at the site. The conductance values can be found in the drain file in Appendix D. The calibration results are summarized in Table 3.1, and the equations used for the statistical analysis can be found in Appendix B.

Table 3.1: Calibration Results

Well ID	Model Row	Model Column	Observed Heads, H_o (ft)	Calculated Heads, H_c (ft)	Residual, $H_c - H_o$ (ft)
MW-3	42	43	1430.80	1431.04	0.24
MW-4	68	53	1428.20	1428.01	-0.19
MW-5	67	20	1432.48	1428.64	-3.84
MW-6	74	29	1427.20	1427.64	0.44
MW-7	69	45	1427.40	1428.22	0.82
P-1	14	39	1432.60	1432.73	0.13
P-2	35	36	1430.40	1431.74	1.34
P-3	50	26	1430.60	1430.51	-0.09
P-4	60	33	1428.40	1429.36	0.96
P-5	60	47	1428.40	1429.23	0.83
P-6	68	41	1426.90	1428.26	1.36
P-7	77	40	1426.60	1427.00	0.40
P-9	89	39	1425.80	1425.10	-0.70
P-10	90	30	1425.90	1424.93	-0.97
P-11	82	29	1426.00	1426.42	0.42
P-12	76	27	1426.90	1427.31	0.41
P-13	73	28	1427.60	1427.83	0.23
P-14	69	27	1428.40	1428.40	0.00
P-15	47	46	1432.20	1430.53	-1.67
P-16	33	47	1431.20	1431.71	0.51
P-17	51	13	1432.80	1430.52	-2.28
P-18	37	15	1432.80	1431.87	-0.93
P-19	15	9	1433.00	1432.99	-0.01
Mean Error				-0.11	
Mean Absolute Error				0.82	
RMS				1.18	

As predicted by the majority of the gradients, the groundwater travels in a southeast direction towards Pine Creek. Figure 3.6 shows the resulting heads from this model.

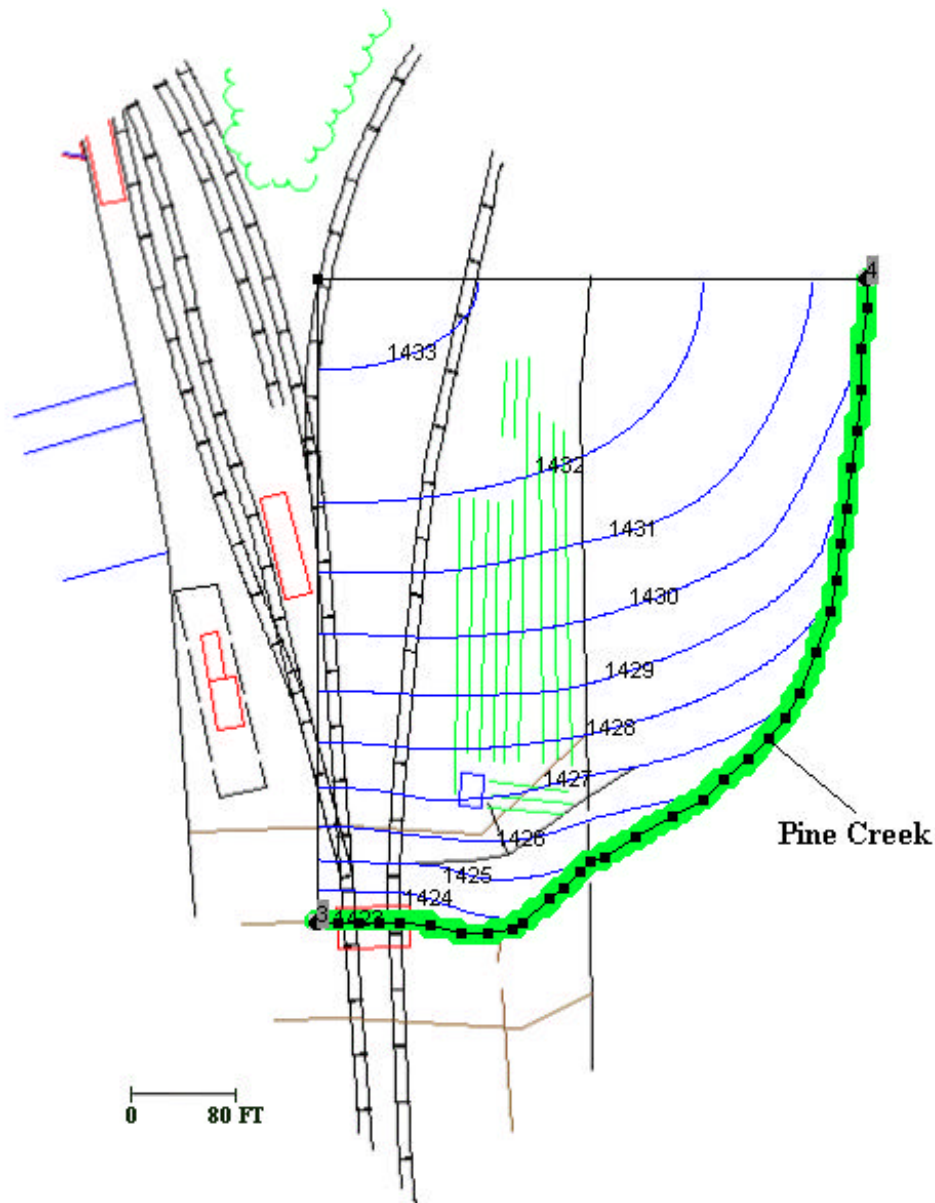


Figure 3.6: Calibrated Model Results

The model produced a mean error of -0.11 , a mean absolute error of 0.82 , and a root mean squared error (RMS) of 1.18 . Overall, the model matched the observed heads well, with the greatest difference occurring in MW-5, P-17, and P-15. With these observation points eliminated from the analysis the mean error raised to 0.26 , the mean absolute error decreased to 0.55 , and the RMS dropped to 0.68 . One possible reason why the calculated

heads at MW-5 and P-17 are lower has to do with the simulation not taking into account the flux that enters the west side of the model. This flux can be seen in triangles 6 and 7 of Figure 2.6. If the model had incorporated some wells along the west boundary, the calculated heads would have been closer to the observed values. The same reasoning could also be applied to P-15, because there is a strong flux entering the model (See triangle 2 of Figure 2.6) on the east boundary north of P-15. Figure 3.7 is a plot of the calculated heads versus the observed heads.

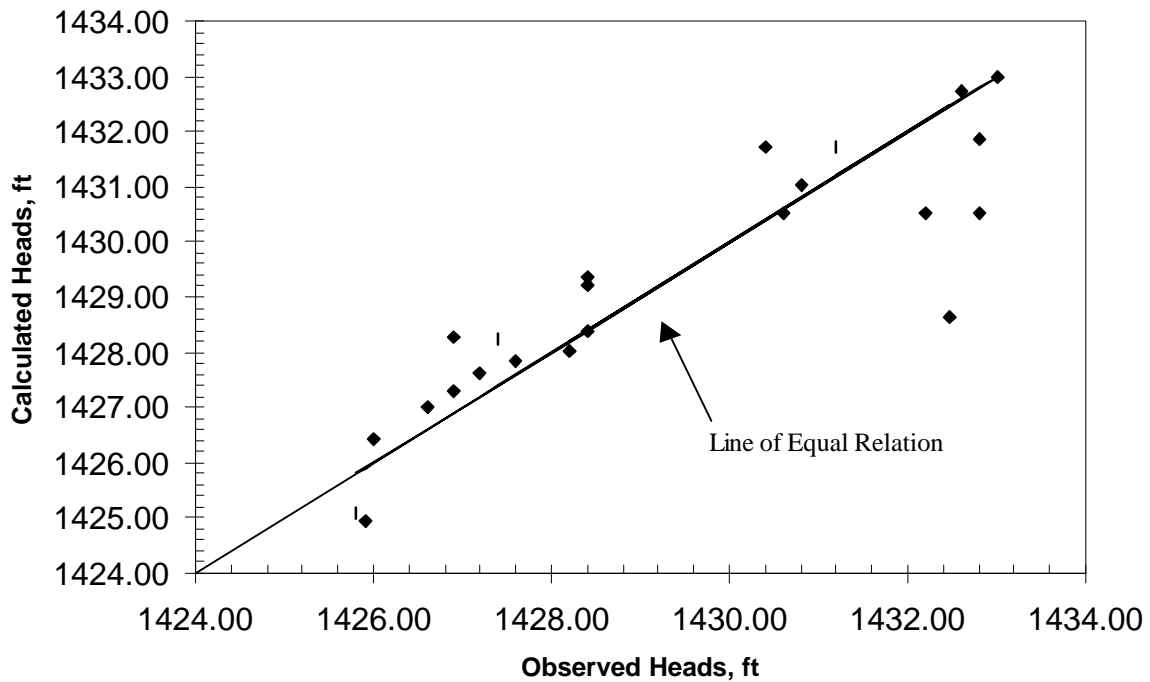


Figure 3.7: Comparison of the Observed and Calculated Heads

3.4 Water Balance Comparison

A comparison was done on the groundwater leaving the actual site and between the calibrated model. Table 3.2 contains the mass balance results from the calibrated model.

Table 3.2: Mass Balance for the Calibrated Model

Inflows	(ft ³ /day)	Outflows	(ft ³ /day)
Storage	0.00	Storage	0.00
Constant Head	0.00	Constant Head	0.00
Wells	0.00	Wells	0.00
Drains	0.00	Drains	485.11
Recharge	485.09	Recharge	0.00
ET	0.00	ET	0.00
Total	485.09	Total	485.11

Inflows-Outflows = -0.020691 ft³/day

Percent Discrepancy = 0.00

In the calibrated model, 485.09 ft³/day enters the model from recharge, and 485.11 ft³/day leaves the model by way of the drain (creek). A rough calculation (see Appendix B) of the flow leaving the site was done using the gradients calculated in section 2.2.2. With the length of the drain arc measured by GMS being 781 ft and using an assumed average saturated thickness of 6 ft, the flowrate was calculated to be 515.6 ft³/day. This value is slightly higher than the 487.11 ft³/day calculated by the model because of the spatially invariable gradient that was used in the calculation. For example, it is observed that in the northern portion of the drain arc that the gradient flows away from the creek, whereas the gradients used in the calculation flow towards the creek. Not accounting for the flux leaving the creek caused the calculated flowrate into the creek to be higher.

3.5 Non-Unique Solution

After calibrating the initial model, the solution was tested for uniqueness. In order to accomplish this, different values of hydraulic conductivity (k) and recharge (R) were used in the model, but the ratio of k/R was kept at $\frac{4 \text{ ft/day}}{0.0026 \text{ ft/day}} = 1515.2$. Table

3.3 summarizes the results of this test, with the originally calibrated model highlighted.

Table 3.3: Non-Unique Solution Results

Model #	k (ft/day)	R (ft/day)	C (ft ² /day per L)	Mean	Absolute Mean	RMS
5	1	6.60E-04	3	-0.22	0.80	1.20
1	4	0.0026	3	-0.11	0.82	1.18
2	10	0.0066	3	0.10	0.88	1.18
3	15	0.0099	3	0.28	0.96	1.21
4	20	0.0132	3	0.46	1.05	1.27

The simulations used hydraulic conductivities ranging from 1 to 20 ft/day and produced root mean squared errors ranging from 1.18 to 1.27. Widely varying values of k and R were used, and the RMS was relatively unchanged. This shows that as long as the ratio of hydraulic conductivity to recharge is maintained the model produces similar results. Ultimately this means that the value of hydraulic conductivity and recharge used in the original model could be incorrect. To obtain a more accurate model of the site, one of the two parameters needs to be measured in the field.

3.6 Sensitivity Analysis

A sensitivity analysis was done on the hydraulic conductivity, recharge, and creek conductance values. Sensitivity coefficients were calculated (see Appendix B for a sample calculation) using the following equation:

$$X_n = \frac{\partial RMS}{\partial a_n} \approx \frac{RMS(a_n + \Delta a_n) - RMS(a_n)}{\Delta a_n} \quad (\text{Widdowson 1998})$$

where: X_n = global sensitivity coefficient for the n^{th} parameter

$RMS(a_n)$ = RMS for the calibrated model

$RMS(a_n + \Delta a_n)$ = RMS for the perturbed-parameter simulation

Δa_n = amount of disturbance in the n^{th} parameter

a_n = n^{th} parameter value in the calibrated model

A positive value of X_n indicates that the RMS increases as the value of a_n increases.

When X_n is negative, the RMS decreases as the value of a_n increases. Table 3.4

contains the values of X_n for each parameter.

Table 3.4: Results of the Sensitivity Analysis

Model #	Parameter	Δa_n	a_n	$RMS(a_n + \Delta a_n)$	$RMS(a_n)$	X_n
6	k (ft/day)	2	4	1.62	1.18	0.88
7	R (ft/day)	0.0024	0.0026	1.35	1.18	0.18
8	C (ft ² /day per L)	5	3	1.29	1.18	0.07

From this analysis, hydraulic conductivity had the highest sensitivity with creek conductance having the least. Therefore, a slight change in hydraulic conductivity can

have large effects on the simulation results. The input files for the models can be found in Appendix D.

3.7 Model with the Interception Trench in Operation

Next, a steady state model was devised with only the interception trench in operation. In order to simulate the trench, pumping wells were placed along the length of the trench. Figure 3.8 shows the location of the wells.

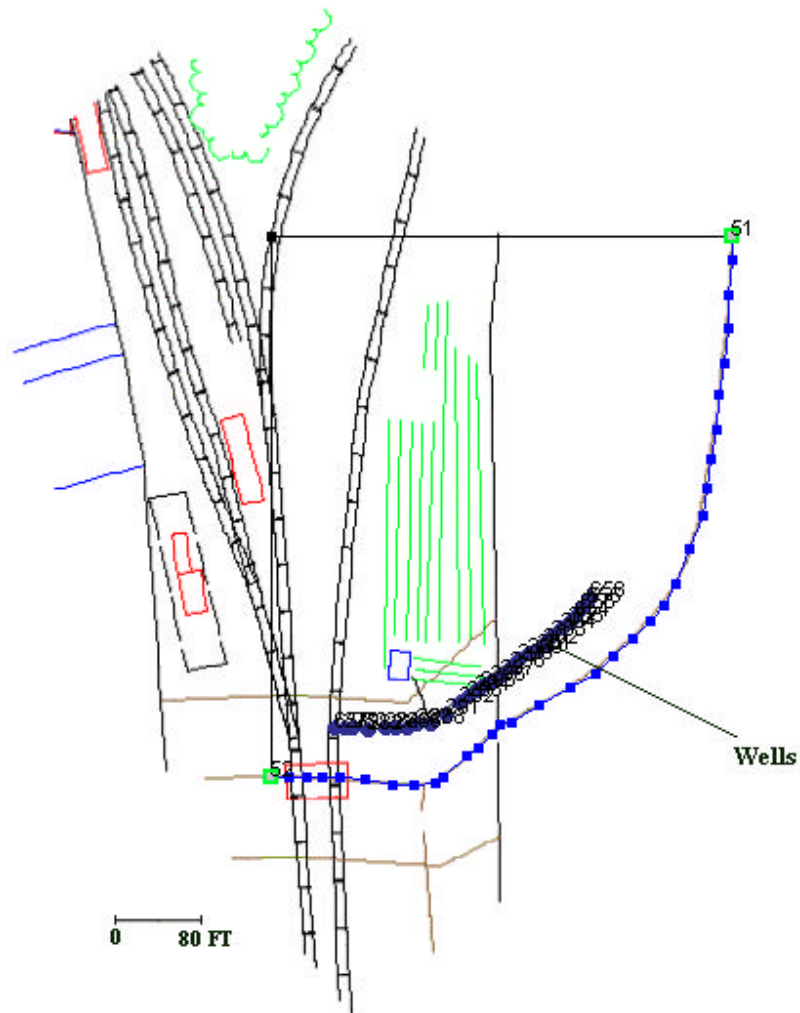


Figure 3.8: Location of the Interception Trench Wells

For the trench model, the average recharge and trench discharge for January, February, and March 1998 were used. In the original calibrated model, the recharge was equal to 20.7% of the average yearly rainfall. In January, February, and March 1998, the average precipitation was 0.162 in/day. This value was multiplied by 20.7% to get a recharge of 0.0028 ft/day. Notice that this value is similar to the recharge used in the initial model. Meanwhile, the average trench discharge for the 3 months was about 350 ft³/day. The only calibration done on this model was to vary the pumping rate of the wells until the water leaving through the trench was close to 350 ft³/day. The hydraulic heads and water balance for this simulation are shown in Figure 3.9 and Table 3.5, respectively.

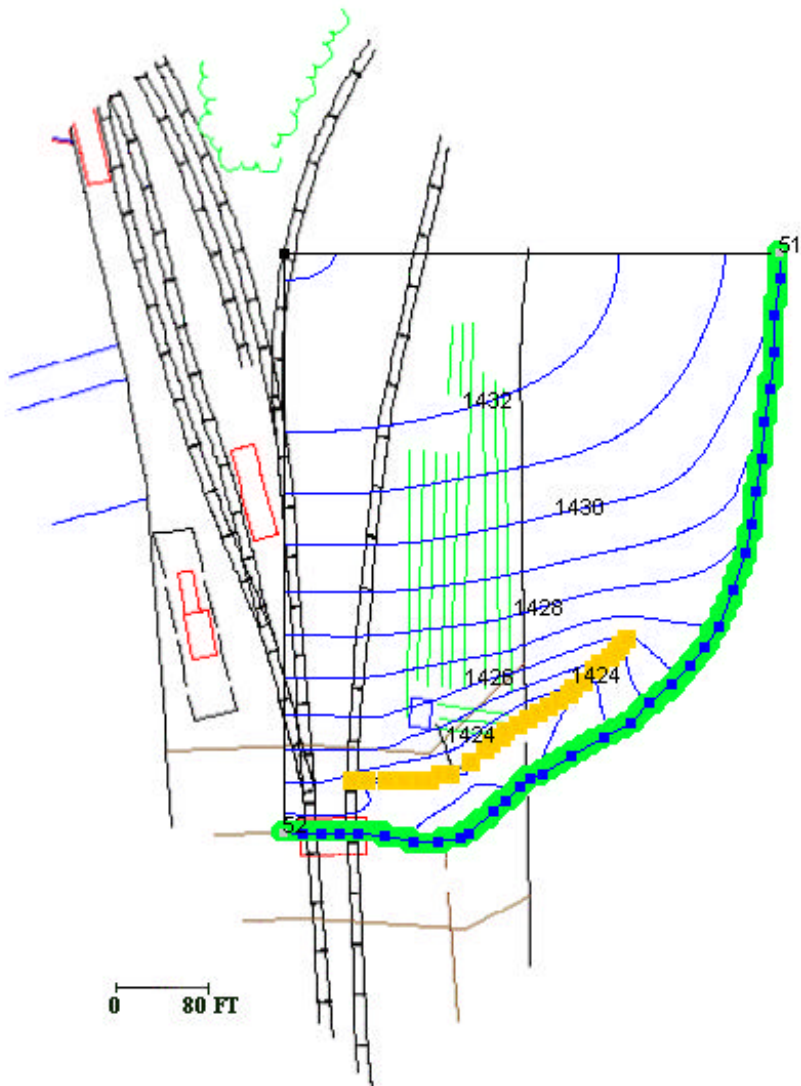


Figure 3.9: Results with the Interception Trench in Operation

Table 3.5: Mass Balance Results for the Trench Model

Inflows	(ft ³ /day)	Outflows	(ft ³ /day)
Storage	0.00	Storage	0.00
Constant H	0.00	Constant H	0.00
Wells	0.00	Wells	334.00
Drains	0.00	Drains	180.49
Recharge	514.46	Recharge	0.00
ET	0.00	ET	0.00
Total	514.46	Total	514.49

Inflows-Outflows = -0.034302 ft³/day

Percent Discrepancy = -0.01

The final pumping well calibration produced a net flow of 334 ft³/day, which was slightly less than the target rate of 350 ft³/day. Adding additional wells or increasing the pumping rate to reach the target rate resulted in dry cells. The dry cells were due to the system being over-stressed with the steady state requirements of the trench. The steady state pumping rates of the wells were more than what would be expected at the site. In reality, the single sump pump would not have the extreme range of influence that the line of wells have, nor would the discharges from the sump pump be constant. Because of this, the calculated heads (see Table 3.6) were an average of 0.63 ft lower than the observed heads.

The trench should be simulated with a transient model with a separate recharge and trench discharge for each time step. Then the observed heads at the end of the three month period considered (March 1998) would be closer to the calculated heads. However, the steady state model does show how the trench can affect the surrounding water levels.

Table 3.6: Trench Simulation Heads Compared with March 1998 Heads

Well ID	Model Row	Model Column	Observed Heads, H_0 (ft)	Calculated Heads, H_c (ft)	Residual, $H_c - H_0$ (ft)
MW-3	42	43	1430.20	1430.56	0.36
MW-4	68	53	1428.20	1426.12	-2.08
MW-5	67	20	1430.41	1427.76	-2.65
MW-6	74	29	1426.66	1426.30	-0.36
MW-7	69	45	1426.16	1426.72	0.56
P-1	14	39	1432.21	1432.57	0.36
P-2	35	36	1429.10	1431.40	2.30
P-3	50	26	1430.12	1429.94	-0.18
P-4	60	33	1427.78	1428.47	0.69
P-5	60	47	1427.21	1428.19	0.98
P-7	77	40	1425.82	1424.75	-1.07
P-8	83	48	1424.70	1422.80	-1.90
P-10	90	30	1424.87	1422.87	-2.00
P-11	92	29	1425.56	1424.60	-0.96
P-12	76	27	1426.11	1425.97	-0.14
P-13	73	28	1427.00	1426.59	-0.41
P-14	69	27	1427.58	1427.32	-0.26
P-15	47	46	1431.75	1429.93	-1.82
P-16	33	47	1430.66	1431.40	0.74
P-17	51	13	1433.10	1429.98	-3.12
P-18	37	15	1433.10	1431.54	-1.56
P-19	15	9	1433.50	1432.82	-0.68
P-20	83	20	1426.50	1425.12	-1.38
Mean Error				-0.63	
Mean Absolute Error				1.15	
RMS				1.43	

3.8 Model with Evapotranspiration by the Poplar Trees

According to Edward Gatliff, poplar trees have been found to transpire about 50-350 gallons of water per day (Fetterolf, 1998). Therefore, evapotranspiration (ET) is a powerful mechanism in the groundwater system. The final steady state model has the same parameters as the original model, but now considers the effects of ET from the poplar trees. The goal of this model was to find the minimum uptake rate for each tree that would produce dry cells over the majority of the site.

The ET package in GMS MODFLOW requires three parameters: ET rate, ET elevation, and extinction depth. ET rate has units ft/day and represents the volume of water per unit area that is transpired per day. The ET elevation is the elevation which the water table must exceed in order for maximum ET to occur. This value is usually the

land surface elevation. The extinction depth is the depth to which the water table must drop below in order for evapotranspiration to not occur. Between the ET elevation and the extinction depth, the MODFLOW assumes ET rate varies linearly.

The ET elevation and extinction depth were assumed to be 1430 ft and 1427 ft, respectively. A conservative extinction depth chosen was assuming that the major taproot could extract water up to 3 ft below the surface. A trial and error process was used to find the minimum ET value that would produce dry cells over the majority of the site.

The model was run using the SIP solution package with an acceleration parameter of 0.70 and a convergence criterion of 1×10^{-4} ft. The minimum ET rate that would produce dry cells over the majority of the site is 0.025 ft/day. This correlates to an uptake rate of 4.6 gallons per day per tree. Appendix B contains the uptake rate calculation and Figure 3.10 shows the extent of the dry cells.

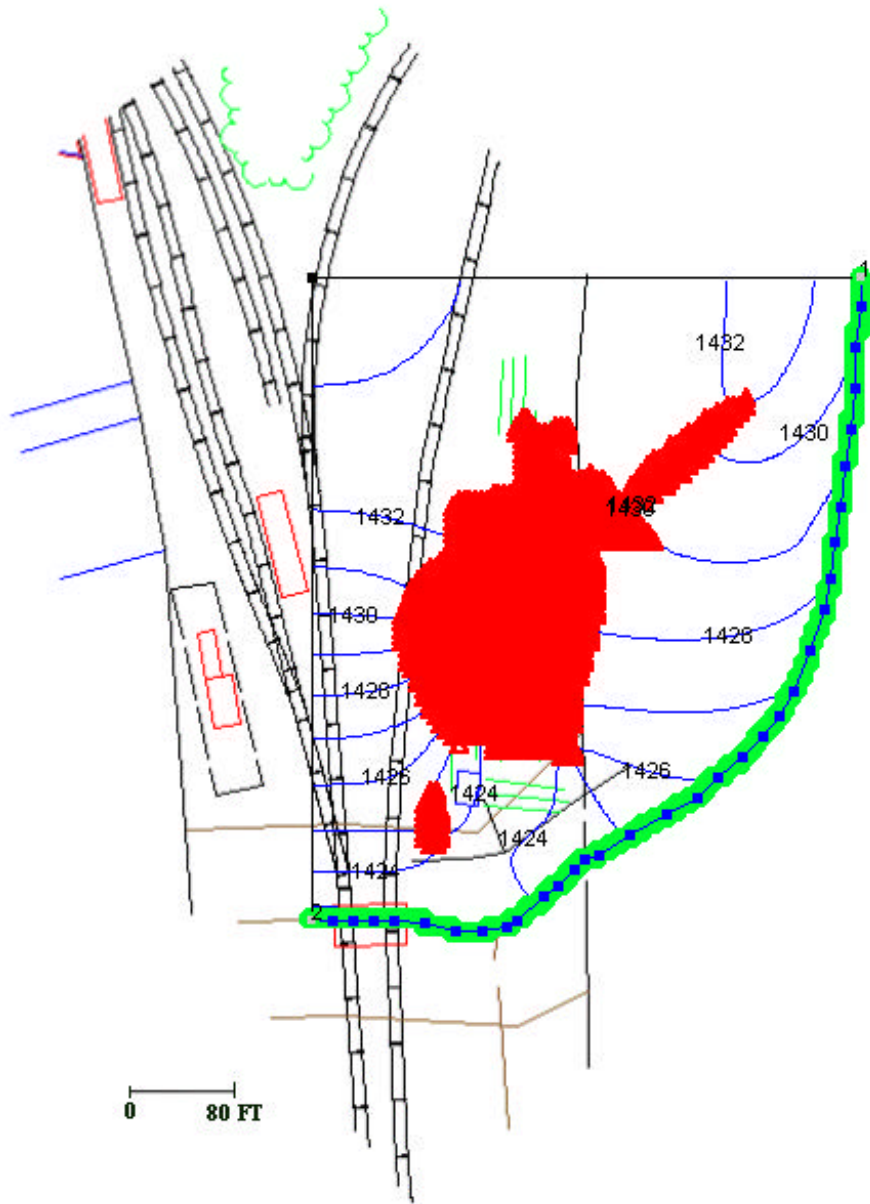


Figure 3.10: Results with a Water Uptake Rate of 4.6 gallons per day per tree

The evapotranspiration model favored dry cell conditions because a constant ET was assumed to occur the whole time. Over the entire growing season, this would not happen because the trees would not transpire the same amount of water. However, the model does not favor dry cells because it uses an uptake rate that is more than 10 times smaller than a minimum uptake rate seen in mature poplar trees. This means that if the trees perform up to one tenth of their ability throughout the growing season and steady state has been reached during the growing season, then the site will experience dry conditions shown in Figure 3.10.

4 Additional Data

4.1 Soil and Groundwater Data

Groundwater and soil samples were collected in order to monitor changes in the PAH concentration. In order to sample groundwater at discrete intervals, 20 multi-level samplers (MLS) were installed by Virginia Tech. A diagram of ML-1 is shown in Figure A11. Groundwater field data (i.e. dissolved oxygen, nitrate, iron (III), sulfate, and temperature) were collected on July 1997, March 98, and January 1999. Groundwater PAH concentration data were taken March 1998, June 1998, and January 1999. In the PAH analyses, 9 constituents of creosote were analyzed: Naphthalene, Acenaphthylene, Acenaphthene, Phenanthrene, Anthracene, Fluoranthene, Pyrene, and Chrysene. The sampling results and sampling ports can be found in Appendix A Tables A3-A7 and Table A8, respectively. The sampling ports can be converted in elevations using Table A9. With the groundwater data, concentration profiles along two transects were constructed using Surfer v.6.03. These profiles can be found in Figures A12-A29. Tables A12 and A13-A14 contains the interpolation parameters and sampling points used in Surfer, respectively.

Soil samples were collected on July 1997 and June 1998 and the can be found in Tables A10 and A11. Acenaphthene, Fluorene, Phenanthrene, Pyrene, and Chrysene were the constituents analyzed. Soil Concentration profiles (see Figures A30-A432) were also constructed for two transects using Surfer v.6.03. The Surfer parameters and sampling points can be found in Tables A12 and A15-A16, respectively.

4.2 Tree Heights

On March 23, 1999, the heights and distance between the trees were measured (see Table C17). In the future, these will be plotted in Surfer to see if there is a pattern between the tree growth and extent of the coal layer.

4.3 Tensiometers

In order to investigate the vertical flow that can be induced by the transpiration of the trees beneath the subsurface, 4 tensiometers were installed at depths of 1, 2, 3, and 4 feet around a poplar tree. In the field of agriculture a tensiometers is used to determine

the moisture content of soils and are sometimes used to regulate irrigation systems. A tensiometer consists of a plastic tube that has a ceramic tip, a vacuum gage, and water reservoir (see Figure A45 in Appendix A for a picture). When a tensiometer is inserted into a dry soil, the soil will want to extract water from the tube, thus a vacuum is pulled on the gage. In a wet soil the water will enter the ceramic tip, thus releasing the vacuum on the tube. With this information, the soil moisture content cannot be quantified but can be used for comparison. For example, if there is less of a vacuum on a tensiometer near a tree at a higher depth compared to a tensiometer at a lower depth, then there is more moisture in the soil near the tree. This could mean that the tree is pulling moisture up towards the land surface for transpiration. Thus, this a valuable tool in understanding the effects of the poplar trees on the aquifer system. (Note: No data has been taken from the tensiometers.)

5 Conclusions

The objectives of this report involved analyzing the hydrogeology of the Oneida, Tennessee site and organizing the collected data for the purpose of evaluating the impact of the phytoremediation and interception trench systems on the aquifer. The water level data was used to evaluate water level and hydraulic gradient changes due to evapotranspiration, rainfall, and groundwater extraction. It was obvious from the water level and rainfall comparison plots that the rainfall has a measurable effect on the water table elevation (i.e. groundwater flow). Some areas may be less affected because the coal layer has a tendency to decrease recharge. Meanwhile, the interception trench lowers the water level around the trench. The decrease in head occurs before and after the trench, thus the water level forms a “v-shape” at the trench. This “v-shape” lends to the notion that the hydraulic gradient also slopes towards the trench in both directions. As for the phytoremediation, there was not sufficient evidence to suggest that the water levels were being lowered by evapotranspiration. This was expected since the poplar trees were had only completed their second growing season.

GMS MODFLOW was used to predict the effects on the water table due to the phytoremediation and the interception trench systems. The calibrated model did an adequate job in simulating the site when the interception trench was not in operation and the trees were not in their growing season. By using variable recharge in some areas, the results are expected to improve. For example, it is important to know the location of the coal layer so this area can be given a lower recharge value than the other areas in the model. As for the trench model, the simulated heads were much lower than the observed heads, which emphasizes that using wells is not the best method to simulate the interception trench. In the future, a transient model should be used to simulate the site with the trench operation, and the drain package could be used to model the trench itself. Meanwhile, the ET model was a valuable simulation, because it illustrates how effective the poplar trees can be even under conservative conditions. With an assumed root zone of just 3 feet and a maximum potential evapotranspiration rate of 4.6 gallons per day per tree, the majority of the site will experience the dry conditions expected.

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Geraghty & Miller, Inc. 1997. Remediation Strategy Workshop.

Widdowson, A Mark. Fall 1998. Unpublished. Groundwater Flow and Transport Modeling Notes.

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APPENDICES

APPENDIX A: DATA FROM THE SITE

Table A1: Rainfall Amounts

Month	Precipitation (in)
April-97	3.78
May-97	5.36
June-97	8.42
July-97	6.1
August-97	2.76
September-97	3.49
October-97	2.07
November-97	2.99
December-97	4.11
January-98	5.71
February-98	3.88
March-98	4.78
April-98	6.57
May-98	7.66
June-98	9.84
July-98	0.71
August-98	4.21
September-98	0.4
October-98	1.77
November-98	1.74
December-98	8.67

Table A2: Water Levels

Well Number	Date Measured	Measuring Point Elevation (TOC) (ft, msl)	Depth to Water (ft)	Depth to Product (ft)	Product Thickness (ft)	Water-Level Elevation (ft, msl)	
MW-1	4/28/94	1433.64	8.91			1424.73	
	6/2/94		8.97			1424.67	
	2/23/95		8.92			1424.72	
	4/3/97		9.09			1424.55	
	10/29/97		9.45			1424.19	
	11/12/97		9.30			1424.34	
	11/24/97		8.68			1424.96	
	1/14/98		8.64			1425.00	
	2/9/98		8.10			1425.54	
	4/2/98		NM			NM	
	5/5/98		8.22			1425.42	
	6/3/98		8.33			1425.31	
	7/29/98		9.13			1424.51	
	8/28/98		9.09			1424.55	
	9/21/98		9.62			1424.02	
	10/9/98		9.68			1423.96	
	VT		11/8/98		NM		
			12/10/98		8.79		1424.85
	VT		1/16/99		NM		
VT	3/23/99		NM				
MW-2	4/28/94	1436.10	8.20			1427.90	
	6/2/94		7.84			1428.26	
	2/23/95		8.92			1427.18	
	4/3/97		8.50			1427.60	
	10/29/97		8.61			1427.49	
	11/12/97		8.48			1427.62	
	11/24/97		7.97			1428.13	
	1/14/98		7.91			1428.19	
	2/9/98		6.62			1429.48	
	4/2/98		NM			NM	
	5/5/98		6.76			1429.34	
	6/3/98		6.63			1429.47	
	7/29/98		8.73			1427.37	
	8/28/98		8.75			1427.35	
	9/21/98		9.48			1426.62	
	10/9/98		9.50			1426.60	
	VT		11/8/98		NM		
			12/10/98		8.20		1427.90
	VT		1/16/99		NM		
VT	3/23/99		NM				

ft - feet
msl - mean sea level
TOC - top of casing
NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
* - adjusted water level elevations
VT- measured by Virginia Tech relative to the land surface.

MW-3	4/28/94	1437.24	6.17	1431.07
	6/2/94		6.47	1430.77
	2/23/95		5.97	1431.27
	4/3/97		6.99	1430.25
	10/29/97		8.92	1428.32
	11/12/97		8.29	1428.95
	11/24/97		6.59	1430.65
	1/14/98		6.25	1430.99
	2/9/98		5.45	1431.79
	4/2/98		7.04	1430.20
	5/5/98		5.58	1431.66
	6/3/98		5.92	1431.32
	7/29/98		8.67	1428.57
	8/28/98		8.11	1429.13
	9/21/98		9.94	1427.30
	10/9/98		10.06	1427.18
VT	11/8/98		NM	
	12/10/98		7.55	1429.69
VT	1/16/99		NM	
VT	3/23/99		NM	
MW-4	4/28/94	1435.48	5.67	1429.81
	6/2/94		8.20	1427.28
	2/23/95		5.92	1429.56
	4/3/97		8.35	1427.13
	10/29/97		8.75	1426.73
	11/12/97		8.60	1426.88
	11/24/97		6.72	1428.76
	1/14/98		7.52	1427.96
	1/26/98		8.69	1426.79
	2/9/98		7.50	1427.98
	4/2/98		9.64	1425.84
	5/5/98		6.09	1429.39
	6/3/98		7.10	1428.38
	7/29/98		10.02	1425.46
	8/28/98		9.91	1425.57
	9/21/98		10.60	1424.88
	10/9/98		10.68	1424.80
VT	11/8/98		NM	
	12/10/98		8.88	1426.60
VT	1/16/99		NM	
VT	3/23/99		NM	

ft - feet
 msl - mean sea level
 TOC - top of casing
 NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
 * - adjusted water level elevations
 VT- measured by Virginia Tech relative to the land surface.

MW-5	4/28/94	1436.62	3.97	1432.65
	6/2/94		4.47	1432.15
	2/23/95		4.06	1432.56
	4/3/97		4.98	1431.64
	10/29/97		6.45	1430.17
	11/12/97		6.10	1430.52
	11/24/97		4.14	1432.48
	1/14/98		4.14	1432.48
	1/26/98		5.21	1431.41
	2/9/98		4.42	1432.20
	4/2/98		6.21	1430.41
	5/5/98		4.46	1432.16
	6/3/98		4.56	1432.06
	7/29/98		7.41	1429.21
	8/28/98		6.97	1429.65
	9/21/98		9.07	1427.55
	10/9/98		9.29	1427.33
	VT 11/8/98		NM	
	12/10/98		5.00	1431.62
	VT 1/16/99		NM	
VT 3/23/99	NM			
MW-6	11/12/97	1434.81	8.65	1426.16
	11/24/97		7.62	1427.19
	1/14/98		7.69	1427.12
	1/26/98		7.73	1427.08
	2/9/98		7.09	1427.72
	4/2/98		8.15	1426.66
	5/5/98		6.20	1428.61
	6/3/98		7.30	1427.51
	7/29/98		8.86	1425.95
	8/28/98		8.76	1426.05
	9/21/98		9.52	1425.29
	10/9/98		7.70	1427.11
	VT 11/8/98		NM	
	VT 1/16/99		NM	
	VT 3/23/99		NM	
MW-7	11/12/97	1434.69	8.85	1425.84
	11/24/97		6.84	1427.85
	1/14/98		7.50	1427.19
	1/26/98		7.49	1427.20
	2/9/98		6.13	1428.56
	4/2/98		8.53	1426.16
	5/5/98		5.06	1429.63
	6/3/98		6.67	1428.02
	7/29/98		9.01	1425.68
	8/28/98		8.83	1425.86
	9/21/98		9.56	1425.13
	10/9/98		9.72	1424.97
	VT 11/8/98		NM	
	12/10/98		7.68	1427.01
	VT 1/16/99		NM	
VT 3/23/99	NM			

ft - feet
msl - mean sea level
TOC - top of casing
NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
* - adjusted water level elevations
VT- measured by Virginia Tech relative to the land surface.

P-1	10/29/97	1435.90	6.95		1428.95
	11/12/97		6.40		1429.50
	11/25/97		3.33		1432.57
	1/14/98		3.21		1432.69
	2/9/98		2.28		1433.62
	4/2/98		3.69		1432.21
	5/5/98		3.03		1432.87
	6/3/98		3.24		1432.66
	7/29/98		5.08		1430.82
	8/28/98		4.31		1431.59
	9/21/98		6.64		1429.26
	10/9/98		<i>Dry</i>		—
	VT 11/8/98		<i>Dry</i>		
	12/10/98		4.86		1431.04
	VT 1/16/99		1.60		
VT 3/23/99	2.20				
P-2	10/29/97	1435.02	7.44		1427.58
	11/12/97		5.94		1429.08
	11/25/97		4.66		1430.36
	1/14/98		4.50		1430.52
	2/9/98		4.41		1430.61
	4/2/98		5.93		1429.09
	5/5/98		4.28		1430.74
	6/3/98		4.96		1430.06
	7/29/98		7.46		1427.56
	8/28/98		6.90		1428.12
	9/21/98		9.04		1425.98
	10/9/98		9.14		1425.88
	VT 11/8/98		<i>Dry</i>		
	12/10/98		6.35		1428.67
	VT 1/16/99		2.30		
VT 3/23/99	3.30				
P-3	10/29/97	1435.98	7.59		1428.39
	11/12/97		7.08		1428.90
	11/25/97		5.69		1430.29
	1/14/98		5.18	sheen	1430.80
	2/9/98		4.43		1431.55
	4/2/98		5.86		1430.12
	5/5/98		4.49		1431.49
	6/3/98		4.86		1431.12
	7/29/98		7.49		1428.49
	8/28/98		7.25		1428.73
	9/21/98		8.82		1427.16
	10/9/98		8.62		1427.36
	VT 11/8/98		<i>Dry</i>		
	12/10/98		6.16		1429.82
	VT 1/16/99		2.65		
VT 3/23/99	3.80				

ft - feet
msl - mean sea level
TOC - top of casing
NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
* - adjusted water level elevations

P-4	10/29/97	1435.04	8.52	6.49	0.01	1426.52
	11/12/97		8.22			1426.82
	11/25/97		6.90			1428.14
	1/14/98		6.50			1428.55*
	2/9/98		NF			—
	4/2/98		7.26			1427.78
	5/5/98		5.71			1429.33
	6/3/98		6.18			1428.86
	7/29/98		8.46			1426.58
	8/28/98		8.20			1426.84
	9/21/98		9.32			1425.72
	10/9/98		9.35			1425.69
	VT 11/8/98		Dry			
	12/10/98		7.35			1427.69
	VT 1/16/99		5.20			
	VT 3/23/99		6.60			
P-5	10/29/97	1434.65	8.36			1426.29
	11/12/97		8.05			1426.60
	11/25/97		6.36			1428.29
	1/14/98		6.23			1428.42
	2/9/98		4.92			1429.73
	4/2/98		7.44			1427.21
	5/5/98		4.50			1430.15
	6/3/98		5.12			1429.53
	7/29/98		8.44			1426.21
	8/28/98		8.10			1426.55
	9/21/98		9.20			1425.45
	10/9/98		Dry			—
	VT 11/8/98		Dry			
	12/10/98		6.47			1428.18
	VT 1/16/99		2.70			
	VT 3/23/99		5.50			
P-6	10/29/97	1434.17	8.73			1425.44
	11/12/97		8.57			1425.60
	11/25/97		7.41			1426.76
	1/14/98		7.19			1426.98
	1/26/98		7.31			1426.86
	2/9/98		NF			—
	4/2/98		NF			—
	5/5/98		6.02			1428.15
	6/3/98		7.44			1426.73
	7/29/98		8.59			1425.58
	8/28/98		8.28			1425.89
	9/21/98		9.00			1425.17
	10/9/98		Dry			—
	VT 11/8/98		Dry			
	12/10/98		8.26			1425.91
	VT 1/16/99		6.30			
VT 3/23/99	7.30					

ft - feet
msl - mean sea level
TOC - top of casing
NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
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VT- measured by Virginia Tech relative to the land surface.

P-7	10/29/97	1432.77	7.18			1425.59
	11/12/97		7.06			1425.71
	11/25/97		6.35			1426.42
	1/14/98		6.15			1426.62
	1/26/98		6.35			1426.42
	2/9/98		6.37			1426.40
	4/2/98		6.95			1425.82
	5/5/98		5.00			1427.77
	6/3/98		6.80			1425.97
	7/29/98		7.44			1425.33
	8/28/98		7.17			1425.60
	9/21/98		7.70			1425.07
	10/9/98		7.86			1424.91
	VT 11/8/98		7.90			
	12/10/98		7.56			1425.21
	VT 1/16/99		5.80			
	VT 3/23/99		6.45			
P-8	10/29/97	1432.14	6.95			1425.19
	11/12/97		6.90			1425.24
	11/25/97		6.18	1.35	4.83†	1429.58*
	1/14/98		6.40			1425.74
	1/26/98		6.62			1425.52
	2/9/98		6.30			1425.84
	4/2/98		7.34			1424.80
	5/5/98		5.05			1427.09
	6/3/98		6.54			1425.60
	7/29/98		Dry			—
	8/28/98		Dry			—
	9/21/98		Dry			—
	10/9/98		Dry			—
	VT 11/8/98		Dry			—
	12/10/98		Dry			—
	VT 1/16/99		Dry			—
	VT 3/23/99		Dry			—
P-9	10/29/97	1433.01	7.61			1425.40
	11/12/97		7.56			1425.45
	11/25/97		7.00			1426.01
	1/14/98		7.29			1425.72
	1/26/98		7.49			1425.52
	2/9/98		Dry			—
	4/2/98		Dry			—
	5/5/98		5.65			1427.36
	6/3/98		8.12			1424.89
	7/29/98		Dry			—
	8/28/98		Dry			—
	9/21/98		Dry			—
	10/9/98		Dry			—
	VT 11/8/98		Dry			—
	12/10/98		Dry			—
	VT 1/16/99		6.70			—
	VT 3/23/99		Dry			—

ft - feet
 msl - mean sea level
 TOC - top of casing
 NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
 * - adjusted water level elevations
 † - data suspect - likely probe malfunction
 VT- measured by Virginia Tech relative to the land surface.

P-10	10/29/97	1432.19	6.78	1425.41
	11/12/97		6.72	1425.47
	11/25/97		6.11	1426.08
	1/14/98		6.40	1425.79
	1/26/98		6.61	1425.58
	2/9/98		7.29	1424.90
	4/2/98		7.32	1424.87
	5/5/98		5.68	1426.51
	6/3/98		7.32	1424.87
	7/29/98		7.37	1424.82
	8/28/98		7.36	1424.83
	9/21/98		7.46	1424.73
	10/9/98		7.50	1424.69
	VT 11/8/98		<i>Dry</i>	
	12/10/98		7.31	1424.88
VT 1/16/99	7.20			
VT 3/23/99	7.30			
P-11	10/29/97	1432.74	7.26	1425.48
	11/12/97		7.20	1425.54
	11/25/97		6.55	1426.19
	1/14/98		6.81	1425.93
	1/26/98		6.91	1425.83
	2/9/98		6.98	1425.76
	4/2/98		7.18	1425.56
	5/5/98		5.11	1427.63
	6/3/98		6.80	1425.94
	7/29/98		7.38	1425.36
	8/28/98		7.35	1425.39
	9/21/98		7.70	1425.04
	10/9/98		7.54	1425.20
	VT 11/8/98		8.10	
	12/10/98		6.98	1425.76
VT 1/16/99	6.80			
VT 3/23/99	7.10			

P-12	10/29/97	1433.26	7.50	1425.76
	11/12/97		7.36	1425.90
	11/25/97		6.30	1426.96
	1/14/98		6.40	1426.86
	1/26/98		6.50	1426.76
	2/9/98		6.38	1426.88
	4/2/98		7.15	1426.11
	5/5/98		4.83	1428.43
	6/3/98		6.02	1427.24
	7/29/98		7.68	1425.58
	8/28/98		7.60	1425.66
	9/21/98		8.15	1425.11
	10/9/98		8.90	1424.36
	VT 11/8/98		8.30	
	12/10/98		6.34	1426.92
VT 1/16/99	5.55			
VT 3/23/99	6.90			
P-13	10/29/97	1434.68	8.44	1426.24
	11/12/97		8.26	1426.42
	11/25/97		7.20	1427.48
	1/14/98		7.02	1427.66
	1/26/98		7.10	1427.58
	2/9/98		6.53	1428.15
	4/2/98		7.73	1426.95
	5/5/98		5.81	1428.87
	6/3/98		6.69	1427.99
	7/29/98		8.61	1426.07
	8/28/98		8.46	1426.22
	9/21/98		9.41	1425.27
	10/9/98		9.11	1425.57
	VT 11/8/98		8.60	
	12/10/98		7.09	1427.59
VT 1/16/99	5.10			
VT 3/23/99	6.40			

P-14	10/29/97	1433.98	7.42	1426.56
	11/12/97		7.11	1426.87
	11/25/97		5.77	1428.21
	1/14/98		5.35	1428.63
	1/26/98		5.41	1428.57
	2/9/98		4.49	1429.49
	4/2/98		6.40	1427.58
	5/5/98		4.15	1429.83
	6/3/98		4.82	1429.16
	7/29/98		7.56	1426.42
	8/28/98		7.31	1426.67
	9/21/98		Dry	—
	10/9/98		Dry	—
	VT 11/8/98		Dry	
	12/10/98		5.27	1428.71
VT 1/16/99	3.55			
VT 3/23/99	5.65			
P-15	10/29/97	1434.63	4.38	1430.25
	11/12/97		3.80	1430.83
	11/25/97		2.63	1432.00
	1/14/98		2.27	1432.36
	2/9/98		1.75	1432.88
	4/2/98		2.88	1431.75
	5/5/98		2.04	1432.59
	6/3/98		2.79	1431.84
	7/29/98		5.45	1429.18
	8/28/98		3.78	1430.85
	9/21/98		7.57	1427.06
	10/9/98		7.94	1426.69
	VT 11/8/98		8.20	
	12/10/98		3.25	1431.38
	VT 1/16/99		1.30	
VT 3/23/99	2.20			

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 NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
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P-16	10/29/97	1436.01	7.28	1428.73
	11/12/97		6.69	1429.32
	11/25/97		4.98	1431.03
	1/14/98		4.56	1431.45
	2/9/98		NF	—
	4/2/98		5.35	1430.66
	5/5/98		3.99	1432.02
	6/3/98		4.28	1431.73
	7/29/98		7.10	1428.91
	8/28/98		5.40	1430.61
	9/21/98		8.43	1427.58
	10/9/98		8.55	1427.46
	VT 11/8/98		8.65	
	12/10/98		6.22	1429.79
	VT 1/16/99		3.70	
VT 3/23/99	4.80			
P-17	11/12/97	1437.20	5.70	1431.50
	11/25/97		4.36	1432.84
	1/14/98		4.38	1432.82
	2/9/98		3.97	1433.23
	4/2/98		NM	NM
	5/5/98		4.26	1432.94
	6/3/98		4.38	1432.82
	7/29/98		5.55	1431.65
	8/28/98		4.94	1432.26
	9/21/98		7.71	1429.49
	10/9/98		8.20	1429.00
	VT 11/8/98		<i>Dry</i>	
	12/10/98		5.26	1431.94
	VT 1/16/99		3.30	
	VT 3/23/99		NF-Construc.	
P-18	11/12/97	1437.17	5.11	1432.06
	11/25/97		4.30	1432.87
	1/14/98		4.31	1432.86
	2/9/98		3.86	1433.31
	4/2/98		NM	NM
	5/5/98		4.21	1432.96
	6/3/98		4.32	1432.85
	7/29/98		5.20	1431.97
	8/28/98		4.86	1432.31
	9/21/98		7.42	1429.75
	10/9/98		7.90	1429.27
	VT 11/8/98		<i>Dry</i>	
	12/10/98		4.96	1432.21
	VT 1/16/99		3.20	
	VT 3/23/99		3.80	

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P-19	11/12/97	1435.03	2.60	1432.43
	11/25/97		1.98	1433.05
	1/14/98		1.98	1433.05
	2/9/98		NF	—
	4/2/98		NM	NM
	5/5/98		1.33	1433.70
	6/3/98		1.32	1433.71
	7/29/98		2.19	1432.84
	8/28/98		1.92	1433.11
	9/21/98		<i>Dry</i>	—
	10/9/98		<i>Dry</i>	—
	VT 11/8/98		NM	
	12/10/98		2.12	1432.91
	VT 1/16/99		NM	
VT 3/23/99	<i>Dry</i>			
P-20	1/14/98	1434.80	7.20	1427.60
	2/9/98		6.28	1428.52
	4/2/98		8.30	1426.50
	5/5/98		4.80	1430.00
	6/3/98		5.10	1429.70
	7/29/98		<i>Dry</i>	—
	8/28/98		NF	—
	9/21/98		<i>Dry</i>	—
	10/9/98		<i>Dry</i>	—
	VT 11/8/98		NM	
	12/10/98		7.87	1426.93
	VT 1/16/99		NM	
	VT 3/23/99		<i>Dry</i>	

ft - feet
msl - mean sea level
TOC - top of casing
NF - not found on 2/9/98 due to snow cover, on 8/28/98 due to vegetation cover.
* - adjusted water level elevations
VT- measured by Virginia Tech relative to the land surface.

Rainfall and Water Level Comparisons for MW-1 and MW-2

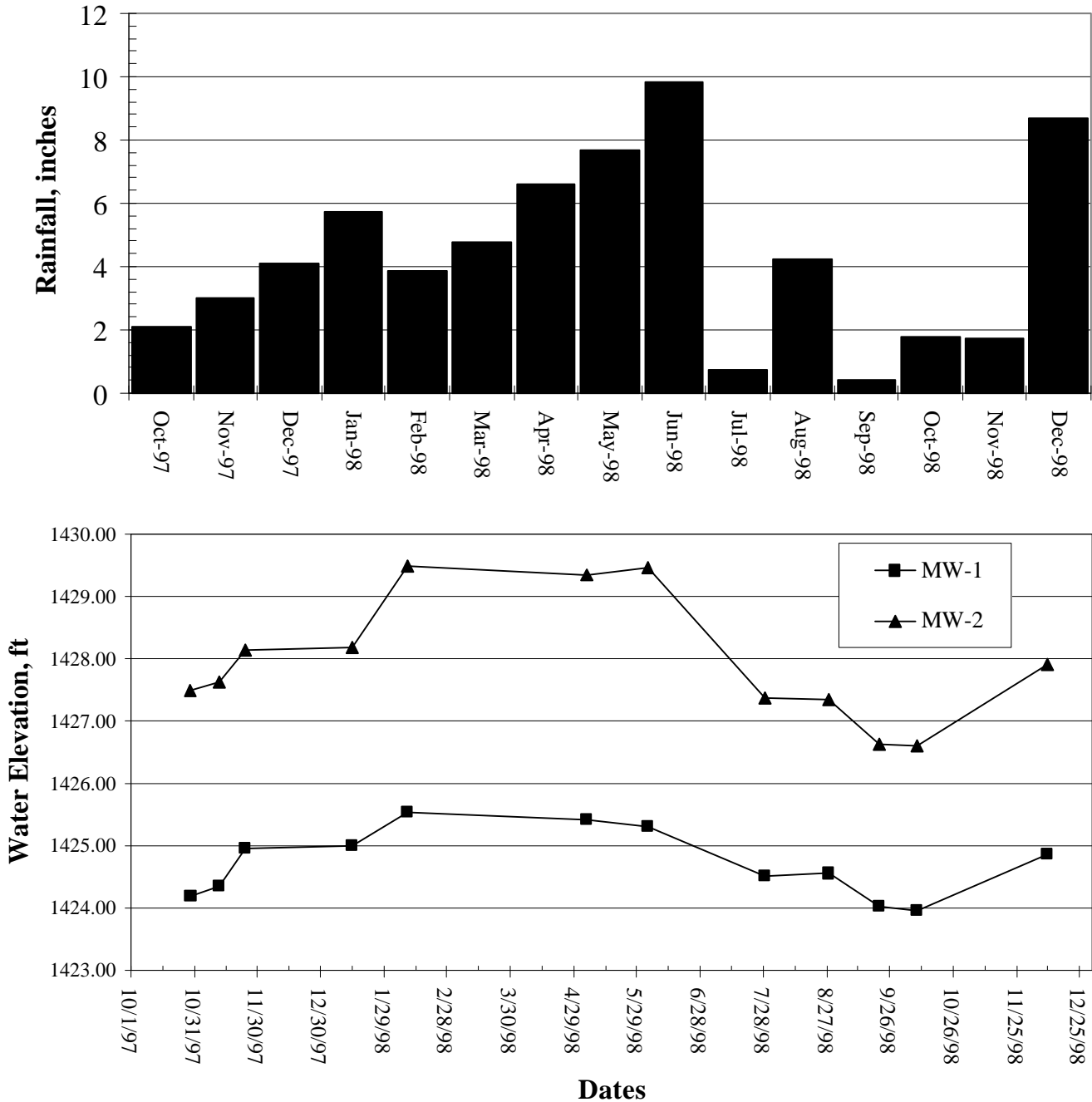


Figure A1: Rainfall and Water Level Comparisons for MW-1 and MW-2

Rainfall and Water Level Comparisons for MW-3, MW-4, and MW-7

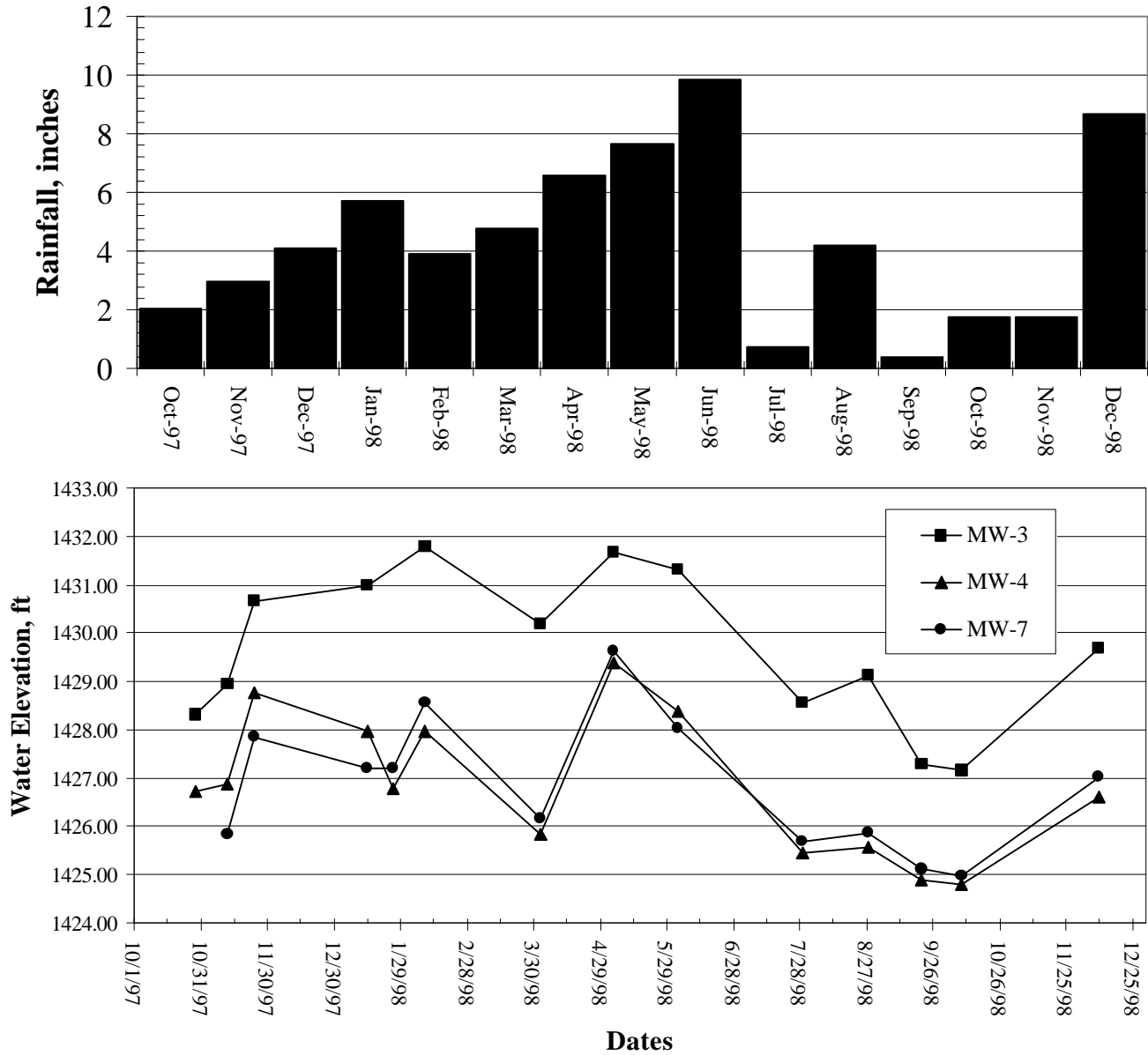


Figure A2: Rainfall and Water Level Comparisons for MW-3, MW-4, and MW-7

Rainfall and Water Level Comparisons for MW-5 and MW-6

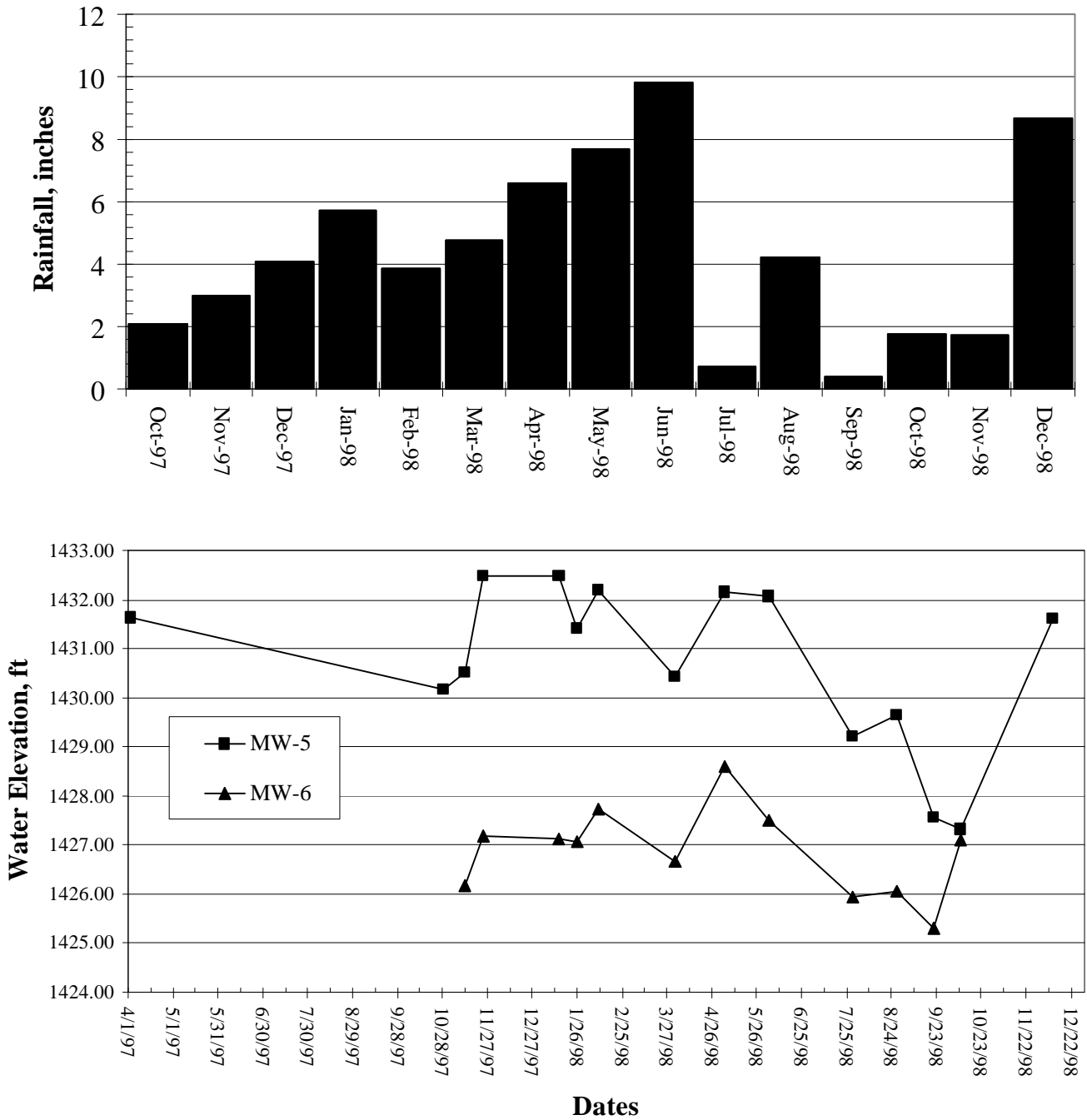


Figure A3: Rainfall and Water Level Comparisons for MW-5 and MW-6

Rainfall and Water Level Comparisons for P-1, P-4, and P-5

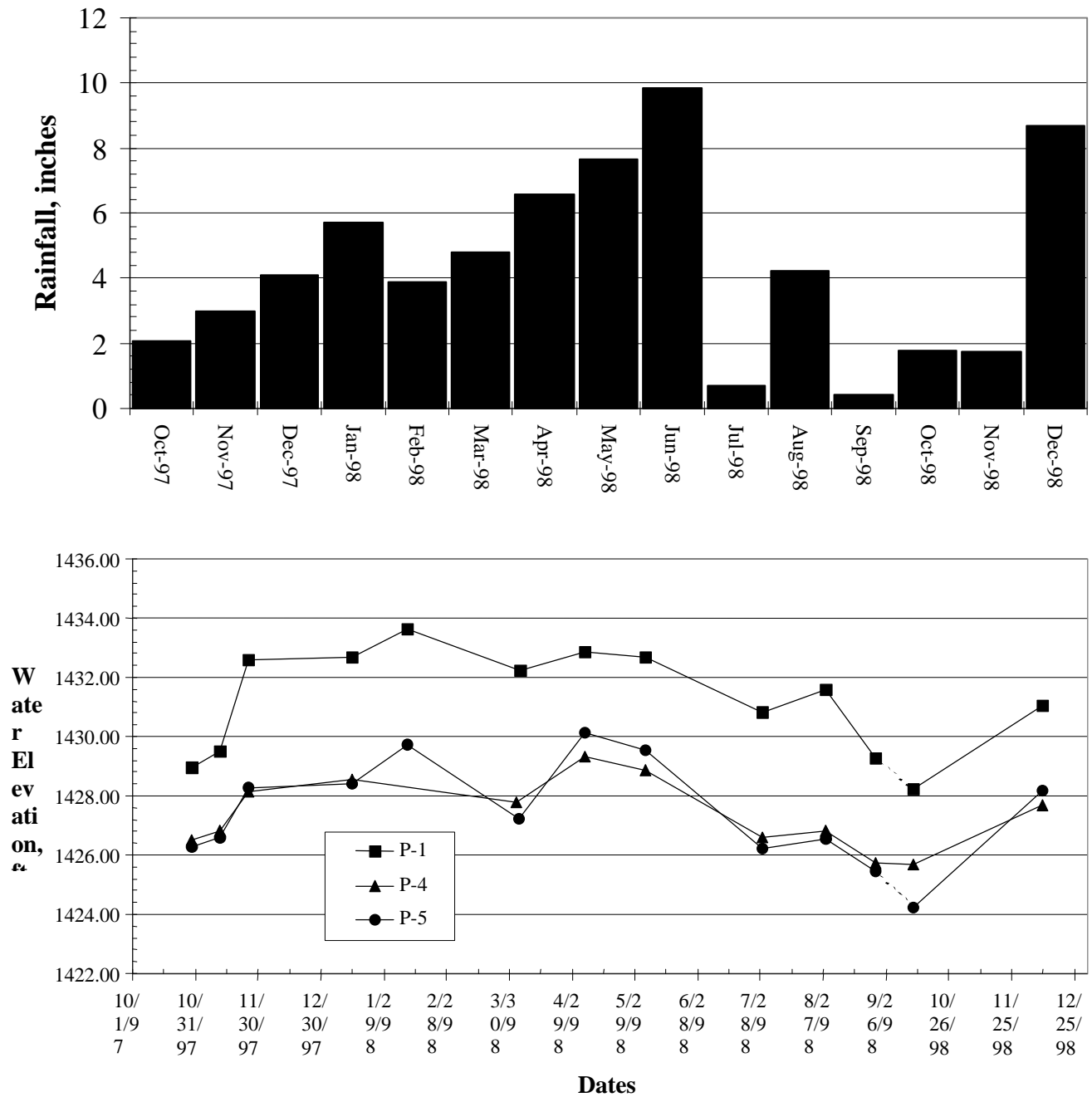


Figure A4: Rainfall and Water Level Comparisons for P-1, P-4, and P-5

Rainfall and Water Level Comparisons for P-2, P-15, and P-16

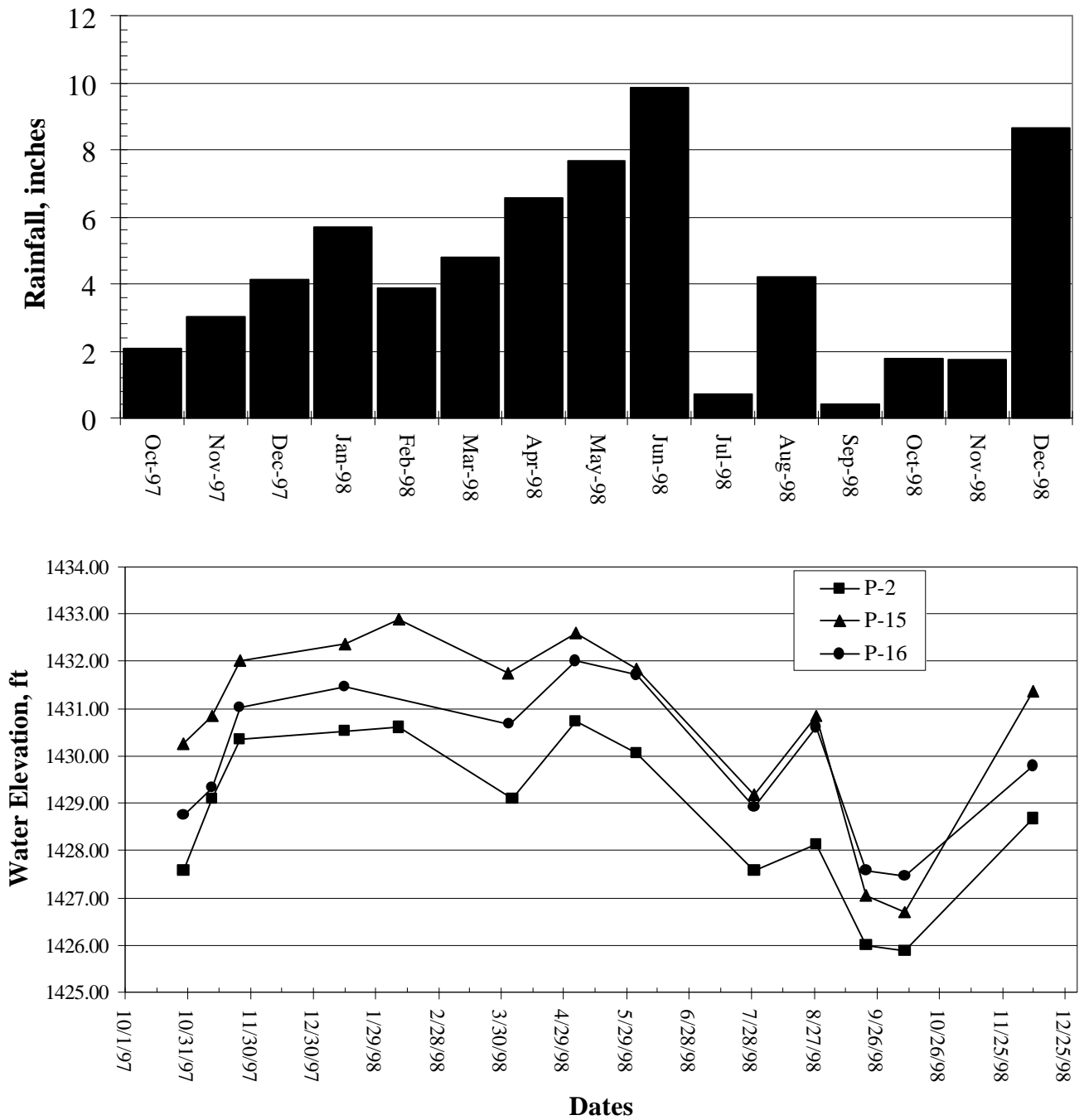


Figure A5: Rainfall and Water Level Comparisons for P-2, P-15, and P-16

Rainfall and Water Level Comparisons for P-3, P-17, P-18, and P-19

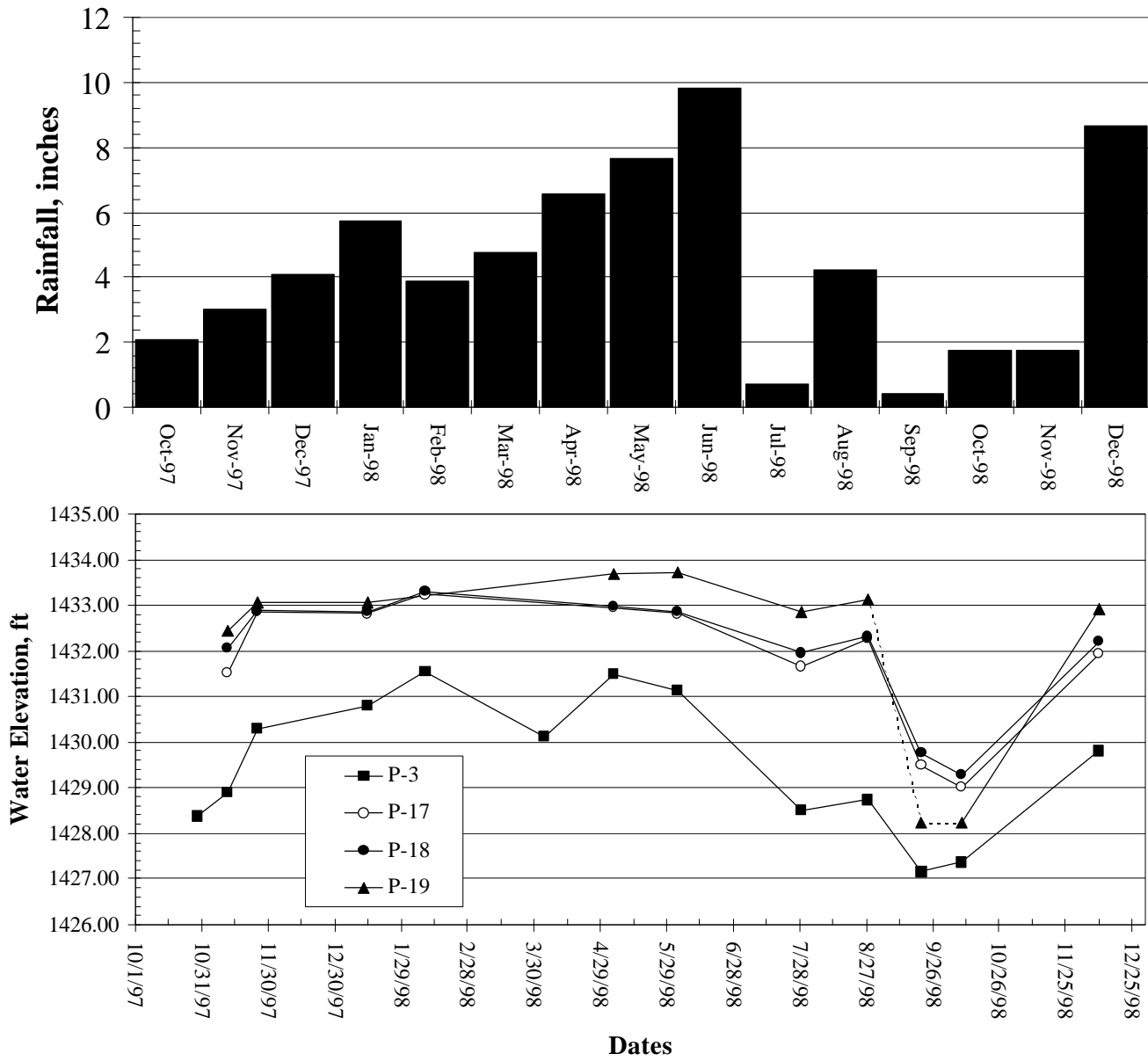


Figure A6: Rainfall and Water Level Comparisons for P-3, P-17, P-18, and P-19

Rainfall and Water Level Comparisons for P-6, P-7, P-8, and P-9

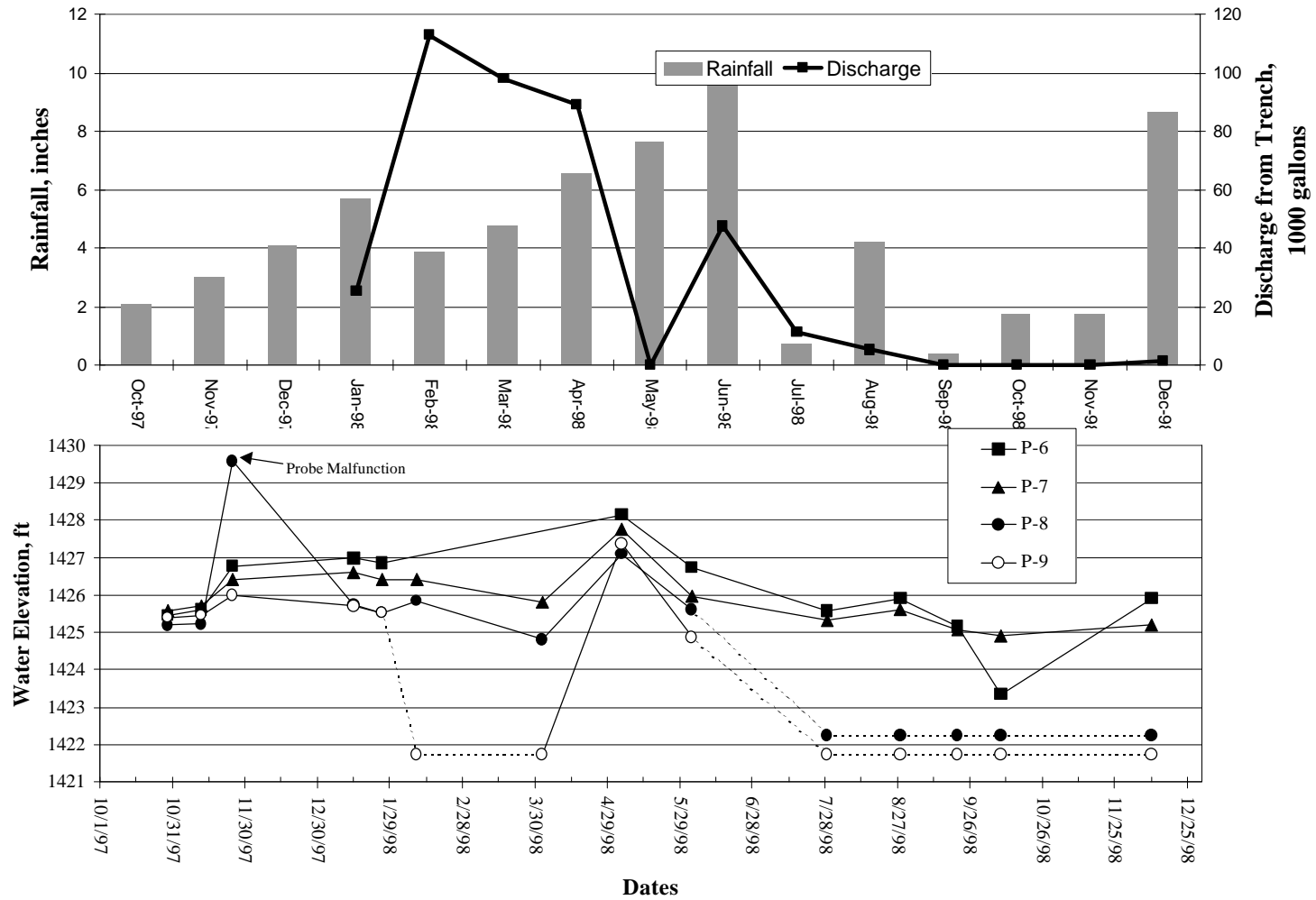


Figure A7: Rainfall and Water Level Comparisons for P-6, P-7, P-8, and P-9

Rainfall and Water Level Comparisons for P-10, P-11, and P-12

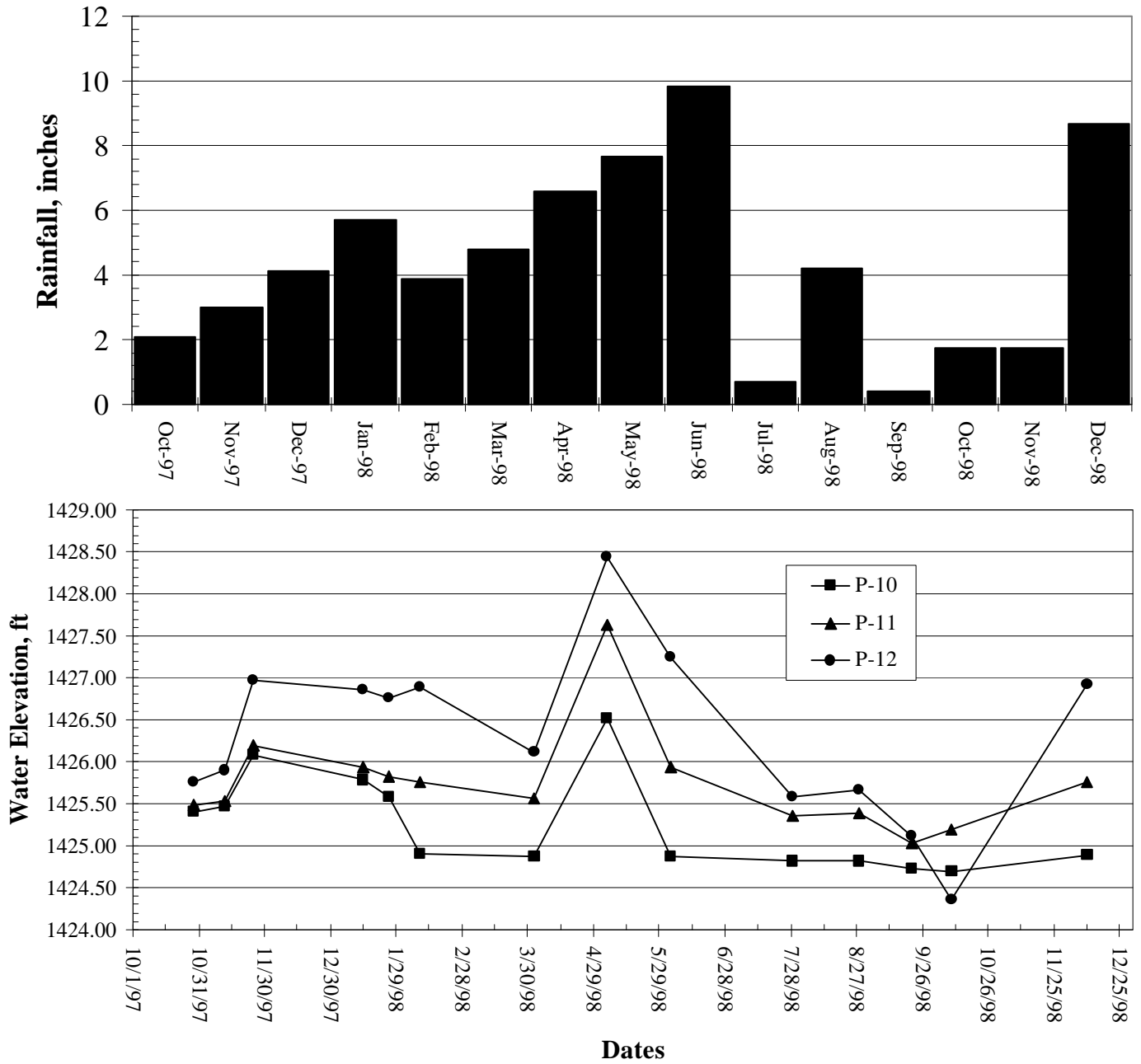


Figure A8: Rainfall and Water Level Comparisons for P-10, P-11, and P-12

Rainfall and Water Level Comparisons for P-13 and P-14

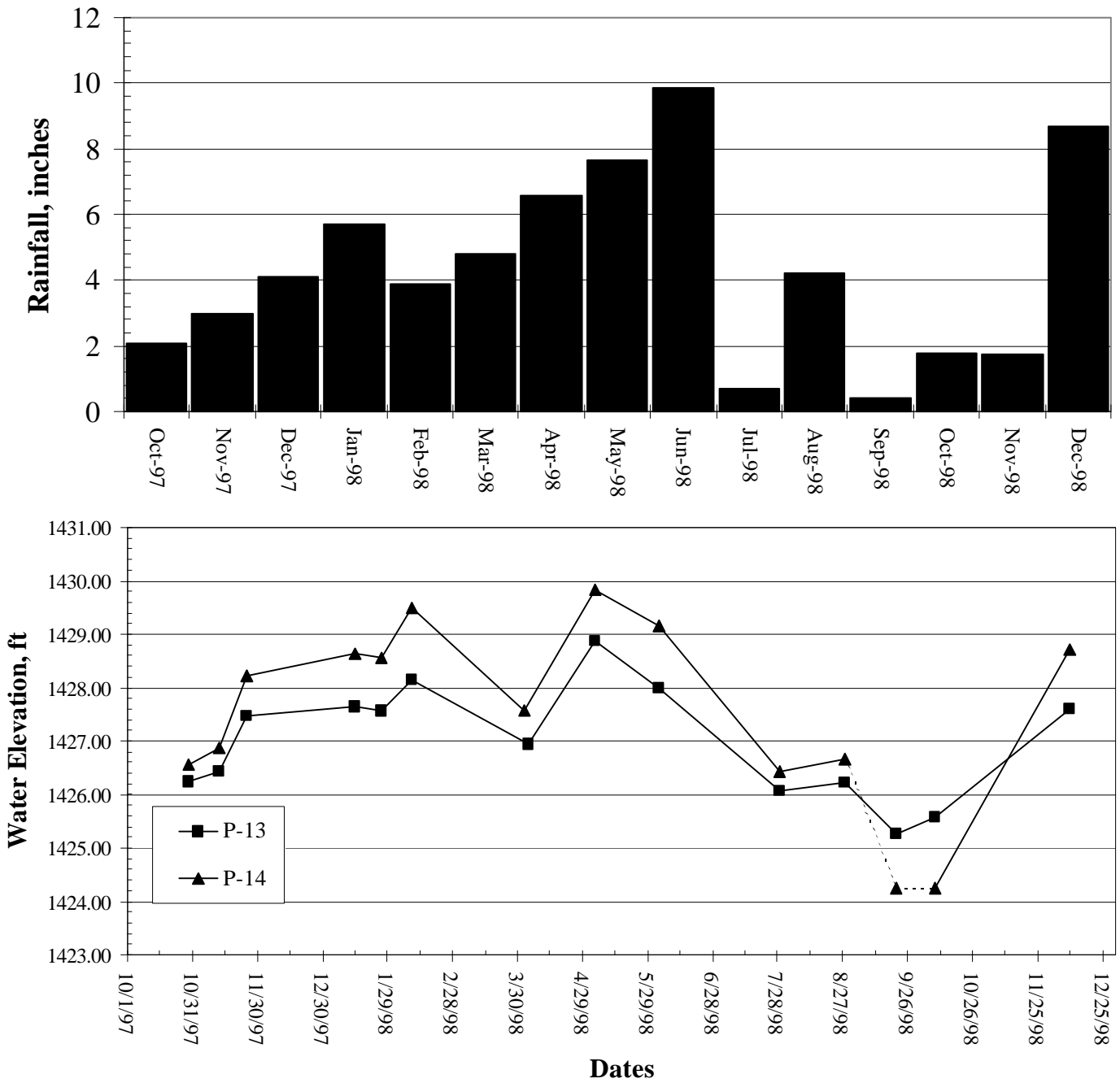


Figure A9: Rainfall and Water Level Comparisons for P-13 and P-14

Rainfall and Water Level Comparisons for P-20

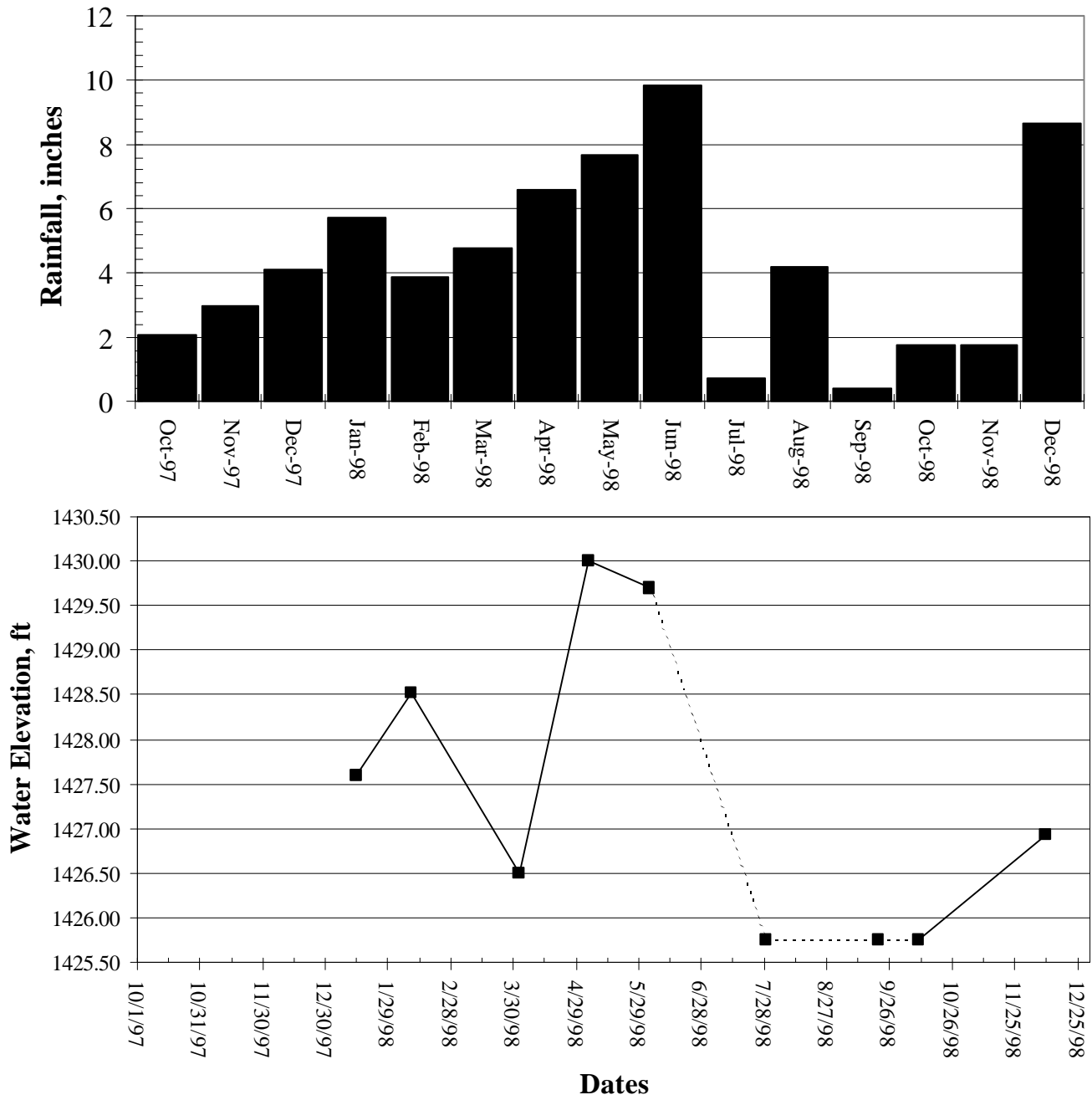


Figure A10: Rainfall and Water Level Comparison for P-20

Multi level Sampler 1

Elevation 1432.52 ft

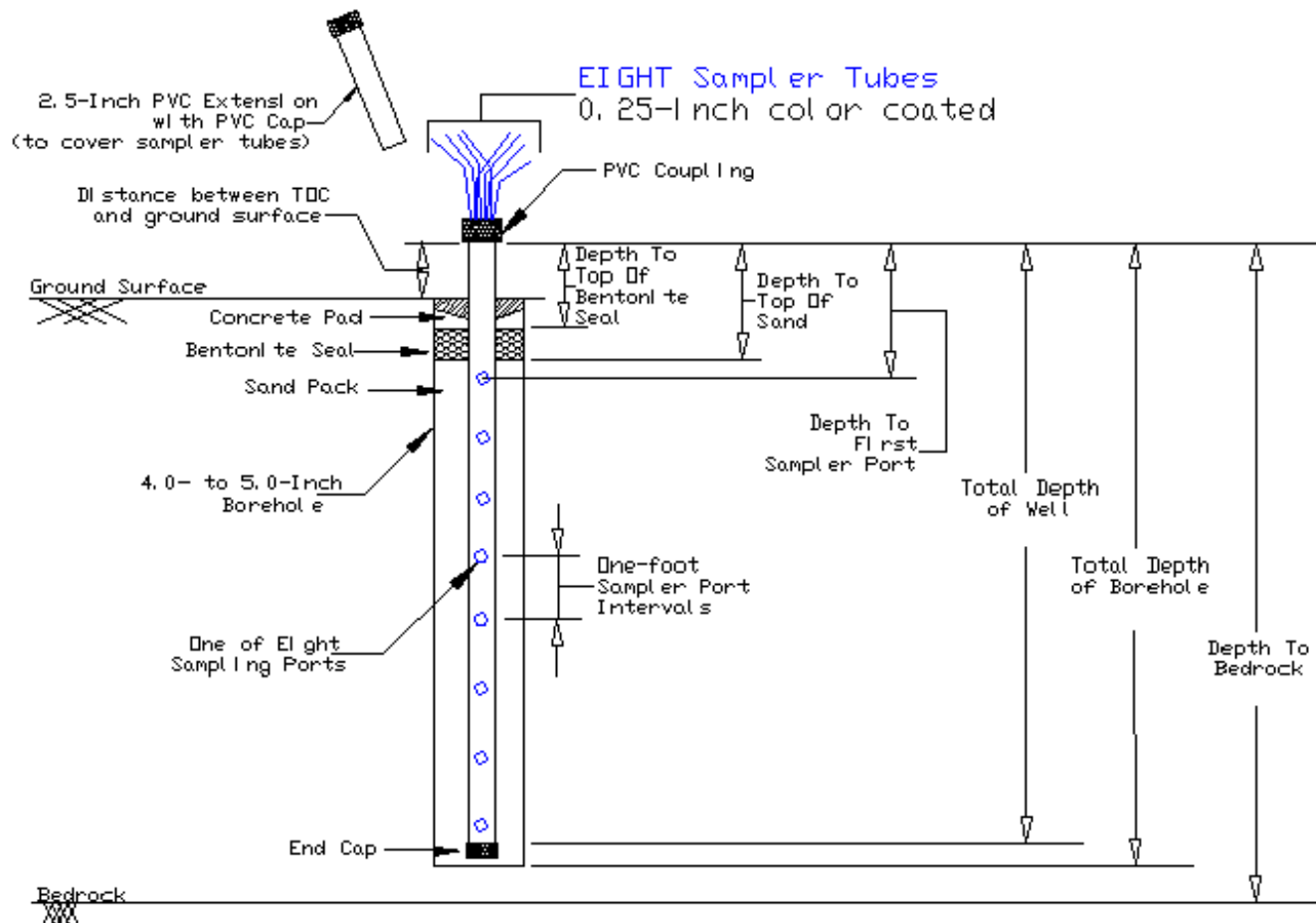


Figure A11: Diagram of a Multi-level Sampling Well

Table A3: November 1997 Groundwater Field Data

MLS #	Color Code	pH	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Iron(II) (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Chloride (mg/L)	Temperature (°C)	Notes
1	Blue		1.9	5.3	0.10	86				DO, NO3, Fe2, pH, Temp Data collected on 25Nov97 excepting MLS 5 & 9 collected on 24Nov. Samples for Cl/SO4 stored @ 4°C Nitrate filtered (Yellow)
	Green		2.2	7.2	0.13	112				
	Orange		1.7	7.4	0.08	89				
	Purple		3.3	7.5	0.19	98				
	Yellow		2.5	15.6	3.30	104				
4	Purple	4.11	1.0-1.4	4.1	3.30	312				
	Red	4.13	BD	1.1	2.68	176				
	Clear	4.71	ND	0.6	7.18	52				
8	Green	7.14	ND	2.5	0.43					First DO Measurement for the Yellow port = 7.5 mg/L Data Point rejected due to bubbles in collection and testing and remeasured @ 6.0
	Purple	6.93	6.3	3.2	0.28	62				
	Red	ND	6.35	3.3	0.60					
	Yellow	6.79	6	3.8	0.20	57				
	Clear	6.5	0.9	5.4	2.45	65				
7	Green	4.93	ND	2.1	32.75	404			14.3	Red and Purple port Iron(II) measurements >12.75 due to reading > 5.0 (range limit of DR/700) but less than reading off scale.
	Purple	4.84	BD	1.9	>12.75	419			15.2	
	Red	5.72	BD	3.5	>12.75	232			15.7	
	Yellow	ND	No Flow							
	Clear	ND	No Flow							
14	Orange	ND	1.7	10.2	0.48	455				
	Purple	ND	No Flow							
	Red	ND	No Flow							
	Yellow	ND	No Flow							
	Clear	ND	No Flow							
3	Purple	4.09	0.5	6.1	2.53	529				
	Yellow	4.00	BD	6.2	2.45	605				
2	Green	ND	ND	1.3	6.55	142				
	Orange	6.52	0.6	8.3	2.88	140				
5	Orange	3.88	4.9	0.7	4.15	480			11.8	1st MLS sampled 24Nov97
	Purple	3.66	2.4	2.3	5.50	505				
	Red	4.00	2.3	2.8	17.25	378	0.035			
	Yellow	ND								
	Clear	4.39	BD	BD	40.7	454	0.090			
9	Purple	7.36	6.5	ND	2.00	107				2nd MLS sampled 24Nov97

Comments: Iron (II) data for MLS 1, 4, and 8 was held 1-4 hours prior to measurement due to zero ND = No Data Collected
 Measurements of DO, NO3, Iron(II) conducted 24-25Nov97. Cl, SO4 conducted on 8Dec97 BD = Below Detection Limit

Table A4: March 1998 Groundwater Field Data

MLS #	Color Code	pH	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Iron(II) (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Chloride (mg/L)	Temperature (oC)	Notes
1	Blue		3.7	3.1	0.81		0.095			
	Green		1.15	2.1	0.09		0.114			
	Orange		1.2	2.2	0.15		0.064			
	Purple		1.0	2.6	0.25		0.066			
	Yellow		0.9	2.1	0.09		0.039			
	Red		0.7	2.1	0.08		0.022			
3	Green		0.9	2.3	2.93		0.016			
	Orange		0.4	2.8	3.51		0.026			
	Purple		BD	3	4.75		0.052			
	Red		BD	3.9	6.5		0.106			
	Yellow		BD	4.3	6.85		0.075			
	Clear		0.2	3.7	4.90		0.036			
4	Green		2	1.9	0.27		0.012			
	Orange		0.9	2.2	0.42		0.013			
	Purple		0.4	3.2	0.78		0.036			
	Red		0.5	5.4	4.75		0.104			
	Yellow		0.7	5.7	6.75		0.165			
	Clear		0.3	(Ion Sample composite of Yellow and Clear Ports)						
7	Blue	No Flow								
	Green	ND	BD	3.9	9.75		0.014			Green: Very low flow
	Orange	4.29	BD	3	13.3		0.167			Orange- Steady, Turbid
	Purple	4.37	ND	5.3	20.6		0.076			Purple - Very Turbid
	Red	4.33	BD	4.1	20.05					(Sulfide sample composite of Purple & Red)
8	Blue		10.7	7	3.41		0.118			Blue: Many bubbles while pumping
	Green		BD	3.9	2.13		0.4			
	Orange		0.2	3.3	2.55		0.206			
	Purple		BD	2.2	2.56		0.028			
	Red		BD	2.2	1.64		0.029			
	Yellow		0.2	2.7	7.8		0.084			
	Clear		BD	1.6	9.15		0.03			
9	Purple	6.39	6.9	3.3	0.04					
10	Green		2.3	4.5	2.69		0.064			
	Orange		ND	3.1	9.3		0.081			
	Purple		0.2	2.8	9.9		0.03			
	Red		ND	2.6	11.85		0.212			
11	Orange	5.29*	ND	6.3	8.05		ND			All ports turbid
	Purple	5.29*	BD	2.1	8.40		ND			(Orange "Filthy" - JTN)
	Clear	6.45	ND	5.3	4.85		ND			* pH composite (O+P)
12	Orange		BD	2.2	8.15		0.027			
	Purple		BD	3.5	8.7		0.028			
	Red		BD	3.2	7.3		0.026			
15	Red	6.38	0.3	ND	ND		ND			Trench Sample
16	Orange		0.7	0.9	13.7		0.011			
	Yellow		ND	2.5	27.2		0.073			
	Clear		ND	3.1	11.6		0.221			

Comments ND = No Data Collected

BD = Below Detection Limit

Table A5: January 1999 Groundwater Field Data

MLS #	Color Code	pH	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Iron(II) (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Chloride (mg/L)	Temperature (oC)	Notes
1	Blue		0.7							
	Green		0.6							
	Orange		1.2							
	Purple		0.7							
	Red		0							
	Yellow		0.1							
2	Blue		0							
	Green		0							
	Orange		0							
	Purple									
	Red									
	Yellow									
3	Blue		0.4							
	Green		0							
	Orange		0							
	Purple									
	Red									
	Yellow									
4	Blue									
	Green		1.8							
	Orange		0.8							
	Purple		0.1							
	Red		0							
5	Blue									
	Green		2.6							
	Orange		1							
	Purple		0.7							
	Red		0.3							
	Yellow		0							
	Clear									
6	Blue									
	Green									
	Orange									
	Purple									
	Yellow									
	Red									
7	Green		0							
	Orange		0							
	Purple		0							
	Red									
	Yellow									
	Clear									
8	Green		0.9							
	Orange		0							
	Purple		0							
	Red		0							
	Yellow									
	Clear									
9	Blue									
	Green									
	Orange									
	Purple									
	Yellow		ND							Very Turbid

MLS #	Color Code	pH	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Iron(II) (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Chloride (mg/L)	Temperature (oC)	Notes
10	Blue									
	Green									
	Orange		0							
	Purple		0							
	Red		ND							Turbid
	Yellow									
11	Blue									
	Green									
	Orange		0							
	Purple		ND							Turbid
	Red		ND							Turbid
	Yellow									
12	Green		0							
	Orange		0							
	Purple									
	Red									
	Yellow									
	Clear									
13	Blue		0.5							
	Green		0							
	Orange		0.8							
	Purple		0.1							
	Red		0							
	Yellow									
14	Blue		1.00							
	Green		2.2							
	Purple									
	Red									
	Yellow		2							
15	Blue									
	Green									
	Orange									
	Purple									
	Red									
	Yellow									
16	Green									
	Orange		3.3							
	Purple		0							Free Product
	Red									
	Yellow		ND							Turbid
	Clear		ND							Turbid
17	Green									
	Orange									
	Purple									
	Red		0							
	Yellow		0							
	Clear									

MLS #	Color Code	pH	Dissolved Oxygen (mg/L)	Nitrate (mg/L)	Iron(II) (mg/L)	Sulfate (mg/L)	Sulfide (mg/L)	Chloride (mg/L)	Temperature (oC)	Notes
18	Green									
	Orange									
	Purple		0							
	Red		ND							Turbid
	Yellow		ND							Turbid
	Clear									
19	Blue									
	Green									
	Orange									
	Purple									
	Red									
20	Blue									
	Green									
	Orange									
	Purple									
	Red									
	Yellow									
	Clear									

Comments:ND = No Data Collected BD = Below Detection Limit

Table A6: Groundwater PAH Concentrations for March 1998

Sample	Napthalene (ppb)	Acenaphthylene (ppb)	Acenaphthene (ppb)	Fluorene (ppb)	Phenanthrene (ppb)	Anthracene (ppb)	Fluoranthene (ppb)	Pyrene (ppb)	Chrysene (ppb)	Benzo(b) fluoranthene (ppb)
ML1-Blue	15.1	0.0	3.7	0.0	0.0	3.3	0.0	0.0	0.0	0.0
ML1-Gr	52.0	0.0	1.6	0.0	0.0	2.2	0.0	0.0	0.0	0.0
ML1-Or	37.8	0.0	1.4	0.0	0.0	2.5	0.0	0.0	0.0	0.0
ML1-Pur	9.9	0.0	0.0	0.0	0.0	2.1	0.0	0.0	0.0	0.0
ML1-Red	31.2	0.0	1.6	0.0	0.0	2.2	0.0	0.0	0.0	0.0
ML1-Yellow	7.8	0.0	0.0	0.0	0.0	2.2	0.0	0.0	0.0	0.0
ML3-Gr/Or	341.3	5.5	40.7	16.4	5.9	2.3	1.5	0.0	0.0	0.0
ML3-Pu/Rd	2071.9	20.3	144.4	68.0	50.9	10.0	6.0	3.5	0.0	0.0
ML3-Yel/Clr	3252.2	31.2	283.5	135.5	124.5	18.2	16.3	13.0	0.0	0.0
ML4-Pu/Or	18.3	3.0	31.0	12.7	3.1	1.7	2.8	2.7	0.0	0.0
ML4-Pu/Or-2	17.3	3.2	28.9	11.9	2.3	1.7	2.8	2.3	0.0	0.0
ML4-Pu/Rd	577.9	23.7	375.4	172.7	180.3	21.4	26.1	18.6	0.0	0.0
ML4-Yel/Clr	242.5	14.8	288.1	146.4	180.5	18.9	29.1	21.5	0.0	0.0
ML4-Yellow	3272.7	31.1	283.9	129.3	113.3	21.9	13.8	11.7	0.0	0.0
ML7-Or/Gr	12515.6	109.8	370.9	213.7	207.0	0.0	21.9	32.9	0.0	0.0
ML7-Or/Gr	8600.0	<200	370.0	<200	210.0	<200	<200	<200	<200	<200
ML7-Pu	36.0	<4	5.3	<4	<4	<4	<4	<4	<4	<4
ML7-Rd/Pu	11394.2	100.1	350.2	202.6	208.4	0.0	24.5	29.5	0.0	0.0
ML7-Rd/Pu-2	11076.3	107.3	482.6	194.6	391.7	0.0	31.4	24.5	0.0	0.0
ML7-Rd/Pu	<80	100.0	430.0	210.0	240.0	<80	<80	<80	<80	<80
ML7-Red/Yel	<4	13.0	87.0	36.0	<4	5.9	<4	<4	<4	<4
ML8-BL-2	190.0	18.5	78.4	17.4	5.0	0.0	14.3	0.0	0.0	0.0
ML8-BL	1.3	10.7	30.6	4.0	0.0	0.0	0.0	0.0	0.0	0.0
ML8-Gr	4997.5	68.2	410.9	176.8	45.0	0.0	20.8	18.3	0.0	0.0
ML8-Or	4874.1	56.1	319.7	129.6	43.6	0.0	18.2	16.8	0.0	0.0
ML8-Pu	2029.0	37.3	208.9	80.5	14.0	0.0	20.7	11.5	0.0	0.0
ML8-Pu-2	3498.6	46.9	254.2	102.0	44.8	0.0	20.1	13.0	0.0	0.0
ML8-Rd-2	3643.7	52.7	305.2	130.1	66.2	0.0	32.7	20.3	3.5	0.0
ML8-Red	1129.8	23.4	119.0	44.8	9.6	0.0	12.7	5.3	0.0	0.0
ML8-Yel	914.1	14.8	69.9	36.2	9.7	0.0	4.8	0.0	0.0	0.0
ML8-Clr	0.0	12.9	32.6	28.4	16.4	8.6	7.0	4.6	0.0	0.0
ML9-Pu	33.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML9-Yel	86.0	2.7	12.3	7.6	7.6	0.0	0.0	0.0	0.0	0.0
ML10-GR	8.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML10-OR	16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML10-Pur	23.8	0.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML10-Red-2	10.8	0.0	8.2	1.4	1.5	0.0	0.0	0.0	0.0	0.0
ML11-Or/Pu	3361.7	23.1	241.2	113.6	182.3	28.9	36.2	27.0	0.0	0.0
ML11-Or/Pu	<4	12.0	<4	<4	<4	21.0	48.0	33.0	<4	<4
ML11-Clr-Dup	3547.5	16.0	286.4	118.9	161.1	32.2	29.1	23.3	0.0	0.0
ML11-Clr	<4	8.7	<4	<4	<4	24.0	47.0	39.0	<4	<4
ML12-Pu/Or	64.5	15.5	262.1	118.7	57.2	12.6	22.2	17.8	0.0	0.0
ML12-Rd/Yel	805.9	43.2	578.1	297.2	359.3	54.5	110.0	82.8	78.9	2.2
ML15-Red	434.3	2.2	11.3	2.8	1.1	0.0	0.0	0.0	0.0	0.0
ML15-Red	<4	<4	28.0	7.0	<4	<4	<4	<4	<4	<4
ML16-OR	125.0	1.6	13.0	0.0	1.6	1.3	0.0	0.0	0.0	0.0
ML16-Yel	6856.5	107.7	768.6	354.5	381.8	44.2	39.6	32.4	5.0	0.0
ML16-Clr	4652.2	96.9	743.4	350.6	350.1	60.9	43.6	34.6	0.0	0.0

Comments:

Data was extracted by VT unless sample is boldfaced. **Boldfaced** = EnviroTech results

KEY: a (-2) indicates that the second 40 mL vial of GW was extracted, i.e. a duplicate extraction, not a duplicate injection.

0.0 equivalent to BDL (approx 1 ppb with this extr. Method/GC config.)

Table A7: Groundwater PAH Concentration Taken June 10, 1998

Sample	Naphthalene (ppb)	Acenaphthylene (ppb)	Acenaphthylene (ppb)	Fluorene (ppb)	Phenanthrene (ppb)	Anthracene (ppb)	Fluoranthene (ppb)	Pyrene (ppb)	Chrysene (ppb)
ML3-Black	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML3-BI	103.4	0.0	7.2	3.4	0.0	0.0	0.0	0.0	0.0
ML3-Gr	7.1	0.0	2.0	1.9	0.0	0.0	0.0	0.0	0.0
ML3-Or	128.7	0.0	8.0	4.7	0.0	0.0	0.0	0.0	0.0
ML3-Pur	80.7	0.0	5.8	3.3	1.4	0.0	0.0	0.0	0.0
ML3-Red	1427.3	13.6	89.0	43.6	37.7	5.2	4.5	2.8	0.0
ML3-Yel	1215.2	11.2	79.6	40.9	39.0	5.4	0.0	0.0	0.0
ML3-Clr	1426.1	20.9	181.5	110.3	153.0	15.7	24.7	17.6	0.0
ML4-Gr	365.7	15.4	262.9	142.0	183.8	18.5	32.6	22.5	0.0
ML4-Or	43.2	8.6	147.4	84.6	126.0	17.7	27.4	19.7	0.0
ML4-Pur	824.9	25.3	525.8	228.6	264.4	23.6	35.1	24.8	0.0
ML4-Red	253.7	12.7	226.7	102.2	100.2	12.0	17.7	13.2	0.0
ML4-Yel	71.3	2.5	32.9	15.0	4.8	2.2	1.6	2.3	0.0
ML4-Clr	186.2	0.0	8.1	4.2	2.2	0.0	0.0	0.0	0.0
ML7-Gr	3.6	2.6	8.6	5.9	1.7	0.0	1.9	2.4	0.0
ML7-Or	12254.2	105.5	476.3	251.5	246.5	0.0	35.4	35.8	0.0
ML7-Pur	13583.1	123.4	517.1	272.9	308.4	0.0	41.8	43.7	0.0
ML7-Red	13297.7	117.8	453.3	241.5	274.2	0.0	37.9	39.0	0.0
ML7-Red	12211.8	110.2	428.6	231.2	271.3	0.0	35.1	35.0	0.0
ML12-Gr	156.9	6.8	96.5	35.0	4.1	4.8	7.1	3.3	0.0
ML12-Gr	103.2	4.7	73.5	25.7	1.6	4.1	5.7	0.0	0.0
ML12-Or	130.3	22.1	339.8	149.9	52.8	18.0	34.5	24.3	0.0
ML12-Or	100.8	30.8	406.1	38.4	16.9	40.4	25.1	0.0	0.0
ML12-Pur	685.8	13.4	135.1	66.1	84.7	20.1	42.5	31.7	0.0
ML12-Pur	773.0	10.6	84.3	40.3	37.5	0.0	15.9	4.4	0.0
ML12-Red	768.8	35.8	542.9	2594.0	260.3	24.2	41.4	32.4	0.0
ML13-Blue	262.1	3.4	37.9	11.2	3.1	0.0	0.0	0.0	0.0
ML13-Or	189.7	10.9	145.6	78.8	75.8	10.1	16.0	13.2	0.0
ML13-Pur	84.5	11.5	165.7	88.6	86.8	14.3	48.3	38.5	0.0
ML14-Blue	1.9	0.0	10.4	4.2	1.5	0.0	0.0	0.0	0.0
ML14-Gr	95.8	0.0	7.9	3.2	1.5	0.0	0.0	0.0	0.0
ML14-Or	246.9	1.7	15.2	6.3	3.0	0.0	0.0	0.0	0.0

Analysis was performed on the Shimadzu.

0 is equivalent to below detection.

Concentrations for Benzo(b) were not included because all values were zero or BD.

Table A8: Groundwater PAH Concentration Taken January 15, 1999

Sample	Naphthalene (ppb)	Acenaphthylene (ppb)	Acenaphthene (ppb)	Fluorene (ppb)	Phenanthrene (ppb)	Anthracene (ppb)	Fluoranthene (ppb)	Pyrene (ppb)
ML1-Blue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML1-Gr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML1-Or	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML1-Pur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML1-Red	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML1-Yel	11.3	0.0	3.2	0.0	0.0	0.0	0.0	0.0
ML1-Clr	15.9	0.0	3.3	0.0	0.0	0.0	0.0	0.0
ML2-Blue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML2-Gr	61.4	0.0	10.4	3.9	0.0	0.0	0.0	0.0
ML2-Or	36.5	0.0	19.3	10.9	6.9	0.0	0.0	0.0
ML2-Yel/Red	1016.8	13.1	74.4	30.3	19.6	8.8	0.0	0.0
ML2-Clr	1847.4	21.1	112.4	45.3	39.3	24.0	0.0	0.0
ML3-Blue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML3-Gr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML3-Or	0.0	0.0	8.7	0.0	0.0	0.0	0.0	0.0
ML3-Pur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML3-Red	938.2	16.0	72.4	29.8	22.0	0.0	0.0	0.0
ML3-Yel	794.8	15.7	79.6	36.5	32.7	0.0	0.0	0.0
ML3-Yel/Clr	994.2	46.2	310.8	205.7	263.5	22.0	35.9	27.2
ML3-Clr	417.5	59.7	408.5	253.8	265.8	23.4	36.4	26.9
ML4-Gr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML4-Or	8.8	0.0	4.6	0.0	0.0	0.0	0.0	0.0
ML4-Pu	232.8	14.5	195.5	71.4	57.8	8.0	12.7	12.1
ML4-Red	375.6	25.5	362.6	178.5	216.7	21.1	29.8	25.5
ML4-Yel/Clr	30.5	14.7	188.2	121.5	169.1	20.8	34.6	28.0
ML5-Gr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML5-Gr/Or	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML5-Pur/Red	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML5-Clr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML6-Gr	16.3	24.4	16.3	0.0	0.0	0.0	0.0	0.0
ML7-Gr	5941.0	81.1	329.6	176.6	133.7	113.2	27.1	23.4
ML7-Or	12867.5	118.4	385.1	205.4	176.1	126.4	18.6	15.1
ML7-Pur	17161.6	160.2	487.3	258.2	238.8	170.1	26.1	22.8
ML7-Red	14444.8	137.6	412.0	240.0	234.8	138.8	29.6	20.1
ML8-Gr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML8-Or	0.0	0.0	20.6	0.0	0.0	0.0	0.0	0.0
ML8-Pur	464.9	12.6	61.8	27.9	20.9	0.0	5.2	0.0
ML8-Red	2280.9	27.9	115.7	48.1	51.3	11.0	7.4	0.0
ML8-Yel	0.0	0.0	18.9	8.7	9.4	0.0	0.0	0.0
ML8-Clr	13.7	13.4	101.4	59.3	63.8	9.2	0.0	0.0
ML9-Yel	11.6	0.0	3.5	0.0	0.0	0.0	0.0	0.0
ML10-Or	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML10-Pu	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML10-Rd	0.0	0.0	25.6	8.2	0.0	0.0	0.0	0.0
ML10-Yel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML11-Or	55.8	0.0	26.1	18.1	5.2	0.0	8.2	0.0
ML11-Pur	9499.8	60.1	377.6	161.3	212.2	54.2	39.0	31.8
ML11-Red	2467.8	27.7	193.5	112.6	175.7	25.7	32.1	27.1
ML12-Gr	7.9	0.0	26.8	8.3	0.0	0.0	0.0	0.0
ML12-Or	37.7	0.0	58.8	22.2	7.1	0.0	0.0	0.0
ML12-Pur	35.7	0.0	58.1	23.6	14.7	0.0	8.4	0.0
ML12-Red	53.9	13.3	173.7	117.8	244.4	22.0	38.1	31.4
ML12-Yel	2653.5	31.9	473.4	220.2	248.6	25.1	32.4	26.0
ML13-Blue	42.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML13-Gr	654.5	8.0	85.9	26.1	10.9	0.0	0.0	0.0
ML13-Or	347.7	5.9	57.3	24.0	18.8	0.0	0.0	0.0
ML13-Pur	62.4	0.0	59.5	26.2	18.4	0.0	7.5	0.0
ML14-Blue	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML14-Gr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML14-Or	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML14-Pur	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML14-Yel	0.0	0.0	5.1	0.0	0.0	0.0	0.0	0.0
ML16-Or	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML16-Pur	3.5	0.0	17.8	12.3	11.6	0.0	12.0	9.7
ML16-Yel/Clr	4831.9	127.2	624.7	300.9	286.0	13.6	31.0	24.6
ML17-Red	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML17-Yel	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML18-Pur	0.0	0.0	15.0	0.0	0.0	0.0	0.0	0.0
ML18-Red	0.0	0.0	75.3	27.0	0.0	0.0	7.9	0.0
ML19-Pur	362.5	0.0	6.2	0.0	0.0	0.0	0.0	0.0
ML19-Red	13.0	0.0	4.0	0.0	0.0	0.0	0.0	0.0
ML19-Yel	8.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ML20-Or/Pur	27.2	0.0	7.2	0.0	0.0	0.0	0.0	0.0
ML20-Red	45.3	0.0	11.5	0.0	0.0	0.0	0.0	0.0

These samples were collected on January 15, 1999.

All groundwater concentrations in ppb's. Analysis was performed on the HP GC, therefore the sensitivity is not quite as good as the Shimadzu.

NOTE: 0 is equivalent to below detection.

NOTE: Concentrations for Benzo(b) were not included because all values were zero or BD.

Table A9: Groundwater Sampling Elevations

MLS	Land Surface Elevation (ft)	Black (ft)	Blue (ft)	Green (ft)	Orange (ft)	Purple (ft)	Red (ft)	Yellow (ft)	Clear (ft)
1	1432.52	1429.60	1428.60	1427.60	1426.60	1425.60	1424.60	1423.60	1422.60
2	1434.23	1430.17	1429.17	1428.17	1427.17	1426.17	1425.17	1424.17	1423.17
3	1433.61	1429.30	1428.30	1427.30	1426.30	1425.30	1424.30	1423.30	1422.30
4	1433.83	1429.14	1428.14	1427.14	1426.14	1425.14	1424.14	1423.14	1422.14
5	1433.21	1429.57	1428.57	1427.57	1426.57	1425.57	1424.57	1423.57	1422.57
6	1433.29	1427.87	1426.87	1425.87	1424.87	1423.87	1422.87	1421.87	1420.87
7	1432.46	1427.21	1426.21	1425.21	1424.21	1423.21	1422.21	1421.21	1420.21
8	1430.86	1425.59	1424.59	1423.59	1422.59	1421.59	1420.59	1419.59	1418.59
9	1431.61	1428.74	1427.74	1426.74	1425.74	1424.74	1423.74	1422.74	1421.74
10	1431.92	1426.01	1425.01	1424.01	1423.01	1422.01	1421.01	1420.01	1419.01
11	1432.64	1425.61	1424.61	1423.61	1422.61	1421.61	1420.61	1419.61	1418.61
12	1432.91	1426.81	1425.81	1424.81	1423.81	1422.81	1421.81	1420.81	1419.81
13	1433.52	1426.46	1425.46	1424.46	1423.46	1422.46	1421.46	1420.46	1419.46
14	1433.54	1429.04	1428.04	1427.04	1426.04	1425.04	1424.04	1423.04	1422.04
15	1432.62	1428.43	1427.43	1426.43	1425.43	1424.43	1423.43	1422.43	1421.43
16	1431.5	1427.93	1426.93	1425.93	1424.93	1423.93	1422.93	1421.93	1420.93
17	1431.75	1430.70	1429.70	1428.70	1427.70	1426.70	1425.70	1424.70	1423.70
18	1432.5	1430.07	1429.07	1428.07	1427.07	1426.07	1425.07	1424.07	1423.07
19	1432.25	1430.98	1429.98	1428.98	1427.98	1426.98	1425.98	1424.98	1423.98
20	1433.5	1429.21	1428.21	1427.21	1426.21	1425.21	1424.21	1423.21	1422.21

Table A10: Soil PAH Concentration from July 1997

Sample	Depth (ft)	Acenaphthene (mg/kg)	Fluorene (mg/kg)	Phenanthrene (mg/kg)	Fluoranthene (mg/kg)	Pyrene (mg/kg)	Chrysene (mg/kg)	TPAH (mg/kg)
<u>Composite samples</u>								
SB-9	5.5-6'	169.55	218.40	683.31	351.66	287.79	83.44	1794.1
SB-9	6.5-7'	727.00	887.82	2000.65	819.60	664.73	219.57	5319.4
SB-9	7.5-8'	0.96	2.15	4.94	1.55	1.26	0	10.9
SB-9	8'-8.5'	9.22	17.51	47.12	21.10	16.97	5.69	117.6
SB-9	9.5'	630.12	602.25	1808.25	969.15	798.93	261.15	5069.8
SB-9	9.5'	532.79	499.31	1521.02	818.08	663.28	243.97	4278.4
SB-15	2-2.5'	115.14	113.84	350.18	217.50	188.58	51.94	1037.2
SB-18	2-2.5'	11.06	16.24	41.95	41.49	39.01	20.22	170.0
SB-18	5-5.5'	0	0	0	0.89	1.01	0.71	2.6
SB-18	9-10'	0.31	0.35	0.91	0.67	1.22	0	3.5
SB-14	6-6.5'	0	0	0	0.50	0	0	0.5
SB-14	9-9.5'	0	0	0	0	0	0	0.0
SB-14	9.5-10'	0.20	0	0.49	0.59	0	0.62	1.9
SB-5	8-9'	0	0	0	0.13	0	0	0.1
SB-5	9-10'	1.12	1.32	1.19	0.23	0.84	0	4.7
SB-13	7-7.5'	0	0	0	0	0	0	0.0
SB-13	8.5'	0.86	0.42	0	0	0	0	1.3
SB-13	8.5-9'	0.65	0.68	0.98	1.74	3.26	10.82	18.1
SB-13	9-9.5'	0.61	1.07	3.93	29.74	29.40	15.83	80.6
<u>Auger samples taken at exact intervals</u>								
SB-16	4	0	1.06	0	0	0.52	0	1.6
SB-16	5	0	0.82	0	0	0.34	0	1.2
SB-16	6	0.08	1.02	0	0	0	0	1.1
SB-16	7	0	0.69	0	0	0.31	0	1.0
SB-16	8	0.07	0.79	0	0	0.37	0	1.2
SB-16	9	0	0.62	0	0	0.27	0	0.9
SB-16	10	0	0.79	0	0	0.36	0	1.1
SB-16	11	0.07	0.75	0.23	0	0.35	0	1.4
SB-16 (BF	11' 8"	0	0.80	0	0	0.77	0	1.6
SB-8	3	0.07	0.35	0	0	0.51	0	0.9
SB-8	4	0.09	3.68	0	0	1.85	0	5.6
SB-8	5	0.06	0.80	0	0	0.33	0	1.2
SB-8	6	0	0.09	0	0	0.25	0	0.3
SB-8	7	0	0.95	0	0	0.43	0	1.4
SB-8	8	0	0.93	0	0	0.39	0	1.3
SB-8	9	0.10	0.93	0	0	0.46	0	1.5
SB-8 (BR)	10'10"	0.56	1.19	0.43	0	0.37	0	2.6
No SB ID	4	0	1.04	0	0	0.51	0	1.6
b/w SB-16	5	0	0.09	0	0	0.27	0	0.4
and SB-15	6	0	0.40	0	0	0.42	0	0.8
	7	0	0.34	0	0	0.34	0	0.7
	8	0	0.31	0	0	0.29	0	0.6
	9	0	0.55	0	0	0.50	0	1.1
	10	0.06	1.27	0	0	0.61	0	1.9
	11	0.15	1.65	0.0	0.0	0.72	0	2.5
BR	11' 9"	0.18	2.09	0.73	0.40	1.03	0	4.4
SB-17	3	0.80	0.63	0.80	0.42	0.59	0	3.2
SB-17	4	0.86	1.80	8.34	5.73	4.89	1.57	23.2
SB-17	5	0.09	0.15	0	0	0.45	0	0.7
SB-17	6	0	0.13	0	0	0.28	0	0.4
SB-17	7	0	0	0.13	0	0	0	0.1
SB-17	8	0	0.18	0.29	0.28	0.33	0	1.1
SB-17	9	0	0	0	0	0	0	0.0
SB-17	10	0.13	0.20	0.62	0.44	0.60	0	2.0
SB-17 (BF	10' 11"	0.78	1.19	3.07	1.35	0.78	0.43	7.6

Sample	Depth (ft)	Acenaphthene (mg/kg)	Fluorene (mg/kg)	Phenanthrene (mg/kg)	Fluoranthene (mg/kg)	Pyrene (mg/kg)	Chrysene (mg/kg)	TPAH (mg/kg)
ML-2	3	4.58	5.52	13.67	40.73	44.87	23.02	132.4
ML-2	4	0.60	0.33	0	0	0.72	0	1.6
ML-2	5	0.14	0.26	0	0	0.37	0	0.8
ML-2	6' 8 "	0.22	0.16	0.12	0	0.38	0	0.9
ML-2	7	1.26	0.50	0	0.35	1.87	0	4.0
ML-2	8	0.81	0.52	0	0	0.91	0	2.2
ML-2	9	3.31	0.86	1.02	0.22	1.55	0	7.0
ML-2	10	1.59	0.72	0	0.28	0.78	0	3.4
ML-2 (BR)	10' 9 "	1.08	0.59	0.48	0.32	1.27	0	3.7
SB-3	3	2.28	3.06	4.77	22.84	23.52	24.81	81.3
SB-3	4	4.32	4.87	12.13	19.05	20.02	18.54	78.9
SB-3	5	55.87	71.28	281.7	271.6	259.2	128.3	1068.0
SB-3	6	36.76	36.64	115.61	81.91	86.12	49.14	406.2
SB-3	7	2.80	2.70	7.57	20.31	18.77	7.27	59.4
SB-3	8	207.4	258.1	909.5	665.9	583.4	347.4	2971.8
SB-3 (BR)	9' 10 "	184.38	181.70	565.55	329.78	229.57	157.53	1648.5
SB-11	3	0	0	0	0	0	0	0.0
SB-11	4	0	0	0	0	0	0	0.0
SB-11	6	0.44	0.58	0.39	3.04	3.49	1.75	9.7
SB-11	7	3.30	6.77	29.70	19.92	16.45	5.04	81.2
SB-11	8	399.41	432.61	1119.61	583.20	488.28	166.34	3189.5
SB-1	3	0.43	1.73	2.69	10.15	13.29	21.56	49.9
SB-1	4	0	0.92	0	0	0.41	0	1.3
SB-1	5	0.08	1.11	0	0	0.83	0	2.0
SB-1	6	0	0.86	0	0	0.37	0	1.2
SB-1	7	0	1.07	0	0	0.51	0	1.6
SB-1	8	0.14	1.29	0	0	0.57	0	2.0
SB-1 (BR)	8' 2 "	0.13	1.02	0.58	2.14	2.07	0	5.9
P6	5	0	0.22	0	0	0.31	0	0.5
P6	6	0	0.21	0	0	0.29	0	0.5
P6	7	0	0.17	0	0	0.30	0	0.5
P6	8	0	0.25	0	0	0.33	0	0.6
P6	9	0.09	0.16	0.10	0.13	0.37	0	0.9
P6	10	0.21	0.24	0	0.15	0.47	0	1.1
P6 (BR)	10' 11 "	0.38	0.95	1.56	1.01	1.06	0.29	5.3
SB-2	4	0.17	0.18	0	0	0.39	0	0.7
SB-2	5	2.11	0.26	0	0.44	1.42	0	4.2
SB-2	6	0	0	0.12	0.21	0	0	0.3
SB-2	7	0.62	0.91	0.61	0.54	0.79	0	3.5
SB-2 (BR)	8'2"	1.06	1.55	1.59	1.00	0.81	0	6.0
SB-7	4	0.10	1.06	0	0	0.42	0	1.6
SB-7	5	0.08	1.08	0	0	0.46	0	1.6
SB-7	6	0	0.82	0	0	0.46	0	1.3
SB-7	7	0.08	0.93	0	0	0.36	0	1.4
SB-7	8	0	0.77	0	0	0.35	0	1.1
SB-7	9	0	0.99	0	0	0.50	0	1.5
SB-7	10	2.52	3.26	2.38	0.16	0.47	0	8.8
SB-7 (BR)	10' 6 "	0.56	1.13	0	0	0.74	0	2.4
SB-12	3	0	0.15	0	0.18	0.49	0	0.8
SB-12	4	0	0.13	0	0	0.22	0	0.4
SB-12	5	0	0.16	0	0	0.39	0	0.6
SB-12	6	0.13	0.33	0	0	0.55	0	1.0
SB-12	7	0	0.31	0	0	0.44	0	0.8
SB-12	8	0.12	0.17	0	0	0.58	0	0.9
SB-12	9	2.04	1.66	0.29	0	1.70	0	5.7
SB-12	10	557.83	1019.09	3191.00	1635.52	1363.29	510.16	8276.9
SB-12 (BF)	10' 3 "	17.01	42.09	161.43	101.09	82.73	47.93	452.3

Sample	Depth (ft)	Acenaphthene (mg/kg)	Fluorene (mg/kg)	Phenanthrene (mg/kg)	Fluoranthene (mg/kg)	Pyrene (mg/kg)	Chrysene (mg/kg)	TPAH (mg/kg)
SB-6	4	0	0	0	0	0	0	0.0
SB-6	5' 5 "	0	0	0	0	0	0	0.0
SB-6	6	0	0	0	0	0	0	0.0
SB-6	7	0.11	0.19	0	0	0	0	0.3
SB-6	8	0	0	0.18	0	0.10	0	0.3
SB-6	9	11.22	11.50	20.33	1.60	1.27	0	45.9
SB-6	10	0	0.14	0.25	0	0	0	0.4
SB-6 (BR)	10' 1 "	0.11	0.28	0.47	0.20	0.23	0.40	1.7
ML-14	3	0	0	0	0	0	0	0.0
ML-14	4	0	0	0	0	0	0	0.0
ML-14	5	0	0.70	0	0	0.34	0	1.0
ML-14	6	0	0.68	0	0	0.36	0	1.0
ML-14	7	0	0.54	0	0	0.33	0	0.9
ML-14	8	0	0	0	0	0	0	0.0
ML-14	9	0	0.10	0.13	0	0	0	0.2
ML-14	10	0.11	0.23	0.23	0	0	0	0.6
ML-14 (BR)	10' 10 "	0.11	0.30	0.50	0	0.11	0	1.0
ML-3	3	0	0.71	0	0	0.40	0	1.1
ML-3	4	0	1.40	0	0	1.41	0	2.8
ML-3	5	0	0.91	0	0	0.43	0	1.3
ML-3	6	0	1.02	0	0	0.50	0	1.5
ML-3	7	0	1.11	0	0	0.50	0	1.6
ML-3	8	0.11	0.78	0.26	0.20	0.47	0	1.8
ML-3	9	154.28	166.27	478.81	270.95	213.98	61.48	1345.8
ML-3	10	16.60	19.06	48.57	44.06	36.11	13.98	178.4
ML-3 (BR)	10' 1 "	1.70	2.04	4.56	8.01	6.65	1.95	24.9
ML-4	3	0.06	1.10	0	0	0.47	0	1.6
ML-4	4	0	0.85	0	0	0.38	0	1.2
ML-4	5	0	0.84	0	0	0.35	0	1.2
ML-4	6	0.34	1.07	0.71	8.08	11.82	9.18	31.2
ML-4	8' 2 "	0.18	1.46	3.56	2.94	1.70	0.23	10.1
ML-4	9	0.13	1.74	0	0.16	0.96	0	3.0
ML-4	10	2.38	2.05	3.53	6.44	6.09	1.84	22.3
ML-4 (BR)	10' 8 "	3.00	3.63	10.55	10.80	9.44	3.71	41.1
SB-4	3	0	0	0	0	0	0	0.0
SB-4	4	0	0	0	0	0	0	0.0
SB-4	5	0	0.20	0	0	0.35	0	0.5
SB-4	6	0.33	0.40	2.11	3.12	2.61	0	8.6
SB-4	7	14.26	21.35	89.89	61.50	53.11	20.18	260.3
SB-4	8	1.27	0.25	0.24	0.25	0.48	0	2.5
SB-4	9	0.81	0.66	2.19	2.05	1.79	0.40	7.9
SB-4	10	0	0.10	0.14	0.32	0.37	0	0.9
SB-4 (BR)	10' 10 "	10.23	7.59	3.95	4.62	3.43	0	29.8
SB-10	3	0.17	0.15	0	0	0.35	0	0.7
SB-10	4	0	0.14	0	0	0.33	0	0.5
SB-10	5	1.52	0.93	0.83	4.92	8.08	17.65	33.9
SB-10	6	470.34	553.00	1320.11	582.22	466.82	196.59	3589.1

Table A11: Soil PAH Concentration form June 1998

Sample	Depth (ft)	Acenaphthene (mg/kg)	Fluorene (mg/kg)	Phenanthrene (mg/kg)	Fluoranthene (mg/kg)	Pyrene (mg/kg)	Chrysene (mg/kg)	TPAH (mg/kg)
SB1	4	0.00	0.94	0.00	0.00	0.48	0.00	1.42
SB1	5	0.00	1.03	0.00	0.00	0.56	0.00	1.60
SB1	6	0.49	1.27	0.00	0.00	0.53	0.00	2.29
SB1	7	0.65	1.47	2.21	4.04	4.00	0.71	13.08
SB1	8	0.00	1.07	0.00	0.54	0.90	0.00	2.50
SB1	8.5	12.40	15.08	49.24	31.60	30.32	7.08	145.71
SB2	4	0.00	1.12	0.00	0.00	0.53	0.00	1.66
SB2	5	0.00	1.19	0.00	0.00	0.53	0.00	1.71
SB2	6	0.00	1.09	0.00	0.00	0.56	0.00	1.65
SB2	7	0.81	1.91	0.99	0.46	0.86	0.00	5.03
SB2	8	1.34	1.88	0.30	0.35	0.91	0.00	4.78
SB2	8.75	0.30	1.32	0.40	0.43	0.94	0.57	3.97
SB3	5	32.54	36.91	78.07	84.73	76.15	28.75	337.15
SB3	5'4"	22.79	25.62	55.34	61.32	55.41	22.57	243.05
SB3	5.5	0.00	1.35	0.40	3.07	2.96	0.29	8.06
SB3	6	0.00	1.36	0.00	1.80	0.00	0.00	3.16
SB3	7	0.75	1.90	1.25	1.22	1.51	0.28	6.92
SB3	8	0.00	1.16	0.32	0.55	0.00	0.00	2.03
SB3	9	548.65	495.38	1472.18	833.29	785.86	229.19	4364.55
SB3	10	390.02	368.18	1072.31	600.45	561.64	150.91	3143.51
SB4	3	0.00	0.97	0.00	0.00	0.44	0.00	1.41
SB4	4	0.00	1.09	0.00	0.00	0.50	0.00	1.60
SB4	5	0.00	1.16	0.00	0.00	0.65	0.00	1.81
SB4	6	12.07	14.38	63.32	39.91	32.80	8.21	170.68
SB4	7	7.03	8.54	26.96	16.20	15.16	2.87	76.76
SB4	8	1.55	2.84	6.49	3.60	3.52	0.55	18.55
SB4	9	0.78	2.11	2.81	1.50	1.78	0.00	8.99
SB4	10	25.58	27.46	26.00	9.72	8.33	0.00	97.09
SB5	3	0.00	1.17	0.00	0.00	0.50	0.00	1.68
SB5	4	0.00	1.40	0.00	0.00	0.66	0.00	2.06
SB5	5	0.00	1.36	0.00	0.00	0.61	0.00	1.96
SB5	6	0.00	1.21	0.00	0.66	1.34	0.58	3.80
SB5	7	0.00	1.11	0.00	0.00	0.56	0.00	1.67
SB5	8	0.00	1.10	0.00	0.00	0.53	0.00	1.64
SB5	9	0.00	1.15	0.00	0.00	0.57	0.00	1.72
SB5	10	0.60	1.33	0.33	0.00	0.53	0.00	2.78
SB6	3	0.00	1.07	0.00	0.00	0.49	0.00	1.57
SB6	4	0.00	1.10	0.00	0.00	0.51	0.00	1.61
SB6	5	0.00	1.10	0.00	0.00	0.52	0.00	1.62
SB6	6	0.00	1.31	0.00	0.00	0.60	0.00	1.91
SB6	7	0.00	2.10	0.00	0.00	1.02	0.00	3.12
SB6	8	5.72	6.33	6.79	0.77	1.12	0.00	20.72
SB6	9	0.51	1.42	0.80	0.00	0.67	0.00	3.40
SB7	4	0.00	1.02	0.00	0.00	0.36	0.00	1.38
SB7	5	0.00	1.80	0.00	0.00	0.69	0.00	2.49
SB7	6	0.00	1.16	0.00	0.00	0.43	0.00	1.59
SB7	7	0.00	0.99	0.00	0.00	0.36	0.00	1.34
SB7	8	0.00	1.19	0.00	0.00	0.53	0.00	1.73
SB7	9	0.00	1.32	0.00	0.00	0.48	0.00	1.80
SB10	3	0.00	1.27	0.56	0.30	0.78	0.00	2.90
SB10	4	0.31	1.28	0.39	2.36	2.83	1.77	8.95
SB10	5	0.90	1.89	1.18	1.32	2.65	5.15	13.10
SB10	6	1041.47	1148.18	2645.51	1094.11	940.65	213.73	7083.66
SB10	7	40.10	50.28	127.83	55.52	47.27	10.31	331.31
SB10	8	93.77	102.48	266.08	117.57	96.31	21.01	697.23
SB10	9	1858.48	1693.34	4860.92	2450.67	1987.18	712.68	13563.27

Sample	Depth (ft)	Acenaphthene (mg/kg)	Fluorene (mg/kg)	Phenanthrene (mg/kg)	Fluoranthene (mg/kg)	Pyrene (mg/kg)	Chrysene (mg/kg)	TPAH (mg/kg)
SB11	3	0.00	1.15	0.00	0.00	0.69	0.00	1.84
SB11	4	0.28	1.50	0.00	0.00	0.73	0.00	2.51
SB11	5	0.29	1.57	0.00	0.00	0.76	0.00	2.62
SB11	6	0.30	1.82	0.00	0.45	1.16	0.00	3.74
SB11	7	47.19	54.50	133.07	59.94	50.30	12.29	357.29
SB11	8	629.59	609.41	1583.64	765.53	739.30	159.13	4486.61
SB11	8	643.84	652.78	1709.35	823.55	861.06	173.50	4864.08
SB11	9	382.76	375.48	1037.38	511.51	459.86	136.47	2903.46
SB12	3	0.00	2.66	0.41	0.61	1.57	0.00	5.25
SB12	4	0.00	1.57	0.00	0.00	0.84	0.00	2.41
SB12	5	0.00	2.39	0.00	0.00	1.20	0.00	3.59
SB12	6	0.00	2.17	0.00	0.00	1.09	0.00	3.26
SB12	7	0.00	2.26	0.00	0.00	1.06	0.00	3.32
SB12	8	0.31	2.24	0.00	0.00	1.34	0.00	3.88
SB12	9	0.69	2.64	0.42	0.00	1.31	0.00	5.06
SB12	10	51.48	75.36	243.03	122.87	104.63	21.23	618.60
SB12	10.5	491.97	657.24	1646.65	781.02	684.09	131.82	4392.79
SB14	4	0.00	1.20	0.00	0.00	1.90	0.00	3.10
SB14	5	0.00	1.27	0.00	0.00	0.61	0.00	1.87
SB14	6	0.00	1.23	0.00	0.00	0.53	0.00	1.76
SB14	7	0.00	1.15	0.00	0.00	0.60	0.00	1.75
SB14	8	0.00	1.53	0.00	0.00	0.79	0.00	2.32
SB14	9	0.00	1.27	0.00	0.00	0.58	0.00	1.85
SB14	10	0.28	1.46	0.00	0.00	0.74	0.00	2.49
SB14	11	0.66	2.35	1.66	1.63	2.44	1.15	9.89
SB15	4	0.00	1.11	0.00	0.00	0.47	0.00	1.57
SB15	5	0.00	1.24	0.00	0.00	0.55	0.00	1.79
SB15	6	0.72	3.73	0.00	0.00	1.70	0.00	6.15
SB15	7	0.00	1.17	0.00	0.00	0.63	0.00	1.80
SB15	8	0.62	3.36	0.50	0.91	2.54	0.42	8.34
SB15	9	0.46	2.87	0.00	0.45	1.61	0.00	5.38
SB15	10	0.00	1.39	0.00	0.00	0.76	0.00	2.15
SB15	11	0.00	1.34	0.00	0.00	0.63	0.00	1.97
SB18	3	19.83	24.20	79.97	59.57	52.55	16.86	252.99
SB18	4	0.00	1.06	0.00	0.00	3.43	0.00	4.49
SB18	5	0.00	1.10	0.00	0.00	0.59	0.00	1.68
SB18	6	0.00	1.15	0.00	0.00	0.51	0.00	1.65
SB18	7	0.00	0.96	0.00	0.00	0.47	0.00	1.42
SB18	8	0.00	1.14	0.00	0.00	0.60	0.00	1.74
SB18	9	0.33	1.36	1.60	1.37	1.69	0.00	6.34
SB18	10	0.00	1.07	0.00	0.00	0.47	0.00	1.54
SB18	11	0.00	1.04	0.00	0.00	0.63	0.00	1.66
ML17	2	0.00	0.97	0.00	0.00	0.54	0.00	1.51
ML17	3	0.00	1.27	0.00	0.00	0.60	0.00	1.88
ML17	4	0.00	1.28	0.00	0.00	0.60	0.00	1.88
ML17	5	0.00	1.85	0.00	0.00	0.90	0.00	2.75
ML17	6	0.00	1.21	0.00	0.00	0.60	0.00	1.81
ML17	7	0.39	1.95	0.55	0.00	1.08	0.00	3.98
ML17	8	11.62	14.25	41.84	20.57	17.61	3.37	109.26
ML17	9	89.08	93.34	312.51	183.15	154.81	32.56	865.45
ML18	2	0.00	1.41	0.00	0.00	0.66	0.00	2.07
ML18	3	0.00	1.31	0.00	0.00	0.67	0.00	1.98
ML18	4	0.00	1.68	0.00	0.00	0.74	0.00	2.43
ML18	5	1.10	11.11	0.00	0.00	5.41	0.00	17.63
ML18	6	0.00	1.44	0.00	0.00	0.68	0.00	2.11
ML18	7	0.00	1.52	0.00	0.00	0.75	0.00	2.27
ML18	8	0.00	1.55	0.00	0.00	0.67	0.00	2.22

Table A12: Interpolation Methodology

Transect Number	Material Tested	Date Tested	X Nodes	Y Nodes	Interpolation Method
1	Groundwater	Mar-98	9	20	Kriging
1	Groundwater	Jan-99	9	24	Kriging
3	Groundwater	Mar-98	9	20	Kriging
3	Groundwater	Jan-99	9	20	Kriging
1	Soil	Jul-97	10	17	Kriging
1	Soil	Jun-98	10	17	Kriging
2	Soil	Jul-97	10	17	Kriging
2	Soil	Jun-98	10	17	Kriging

Table A13: Groundwater Surfer Data Points for Transect 1

March-98			January-99		
x (ft)	Elevation (ft)	Id	x	Elevation (ft)	Id
26.67	1427.30	ML3-Gr	0	1429.17	ML2-BI
26.67	1426.30	ML3-Or	0	1428.17	ML2-Gr
26.67	1425.30	ML3-Pu	0	1427.17	ML2-Or
26.67	1424.30	ML3-Rd	0	1424.67	ML2-Yel/Rd
26.67	1423.30	ML3-Yel	0	1423.17	ML2-Clr
26.67	1422.30	ML3-Clr	26.67	1428.30	ML3-BI
26.67	1426.80	ML3-Gr/Or	26.67	1427.30	ML3-Gr
26.67	1424.80	ML3-Pu/Rd	26.67	1426.30	ML3-Or
26.67	1422.80	ML3-Yel/Clr	26.67	1425.30	ML3-Pu
54.67	1427.14	ML4-Gr	26.67	1424.30	ML3-Rd
54.67	1426.14	ML4-Or	26.67	1423.30	ML3-Yel
54.67	1425.14	ML4-Pu	26.67	1422.80	ML3-Yel/Clr
54.67	1424.14	ML4-Rd	26.67	1422.30	ML3-Clr
54.67	1423.14	ML4-Yel	44	1428.04	ML14-BI
54.67	1422.14	ML4-Clr	44	1427.04	ML14-Gr
54.67	1425.64	ML4-Pu/Or	44	1426.04	ML14-Or
54.67	1424.64	ML4-Pu/Rd	44	1425.04	ML14-Pu
54.67	1422.64	ML4-Yel/Clr	44	1423.04	ML14-Yel
54.67	1423.14	ML4-Yellow	54.67	1427.14	ML4-Gr
85.33	1423.81	ML12-Or	54.67	1426.14	ML4-Or
85.33	1422.81	ML12-Pu	54.67	1425.14	ML4-Pu
85.33	1421.81	ML12-Rd	54.67	1424.14	ML4-Rd
85.33	1420.81	ML12-Yel	54.67	1422.64	ML4-Yel/Clr
85.33	1419.81	ML12-Clr	64	1425.46	ML13-BI
85.33	1423.31	ML12-Pu/Or	64	1424.46	ML13-Gr
85.33	1421.31	ML12-Rd/Yel	64	1423.46	ML13-Or
120	1421.61	ML11-Pu	64	1422.46	ML13-Pu
120	1422.11	ML11-Or/Pu	64	1421.46	ML13-Rd
120	1419.61	ML11-Rd	85.33	1424.81	ML12-Gr
120	1418.61	ML11-Clr-Dup	85.33	1423.81	ML12-Or
162.67	1424.01	ML10-Gr	85.33	1422.81	ML12-Pu
162.67	1422.01	ML10-Pur	85.33	1421.81	ML12-Rd
162.67	1421.01	ML10-Yel	85.33	1420.81	ML12-Yel
162.67	1420.01	ML10-Clr	120	1422.61	ML11-Or
162.67	1424.01	ML10-Gr	120	1421.61	ML11-Pu
162.67	1423.01	ML10-Or	120	1420.61	ML11-Rd
162.67	1422.01	ML10-Pur	162.67	1423.01	ML10-Or
162.67	1421.01	ML10-Red-2	162.67	1422.01	ML10-Pu
			162.67	1421.01	ML10-Rd
			162.67	1420.01	ML10-Yel

Table A14: Groundwater Surfer Data Points for Transect 3

March-98			January-99		
x (ft)	Elevation (ft)	Id	x (ft)	Elevation (ft)	Id
12	1424.93	ML16-Or	0	1425.70	ML17-Rd
12	1421.93	ML16-Yel	0	1424.70	ML17-Yel
12	1420.93	ML16-Clr	0	1423.70	ML17-Clr
38.67	1425.21	ML7-Gr	12	1424.93	ML16-Or
38.67	1424.21	ML7-Or	12	1423.93	ML16-Pu
38.67	1422.21	ML-7-Rd	12	1422.93	ML-16-Rd
38.67	1421.21	ML7-Yel	12	1421.93	ML16-Clr
38.67	1420.21	ML7-Clr	12	1421.43	ML16-Yel/Clr
38.67	1424.71	ML7-Or/Gr	38.67	1425.21	ML7-Gr
38.67	1422.71	ML7-Rd/Pu	38.67	1424.21	ML7-Or
70.67	1423.43	ML15-Red	38.67	1423.21	ML7-Pu
70.67	1422.43	ML15-Yel	38.67	1422.21	ML7-Rd
70.67	1421.43	ML15-Clr	38.67	1421.21	ML7-Yel
94.67	1422.11	ML11-Or/Pu	38.67	1420.21	ML7-Clr
94.67	1418.61	ML11-Clr-Dup	94.67	1422.61	ML 11-Or
94.67	1421.61	ML11-Pu	94.67	1421.61	ML 11-Pu
94.67	1420.61	ML11-Rd	94.67	1420.61	ML 11-Rd
94.67	1419.61	ML11-Yel	94.67	1419.61	ML11-Yel
94.67	1418.61	ML11-Clr	94.67	1418.61	ML11-Clr
			113.33	1426.07	ML18-Pu
			113.33	1425.07	ML18-Rd
			113.33	1424.07	ML18-Yel
			113.33	1423.07	ML18-Clr
			125.33	1426.98	ML19-Pu
			125.33	1425.98	ML19-Rd
			125.33	1424.98	ML19-Yel

Table A15: Soil Surfer Data Points for Transect 1

July-97						June-98		
x (ft)	Elevation (ft)	SB ID #	x (ft)	Elevation (ft)	SB ID #	x	Elevation (ft)	SB ID #
0	1431.5	SB-8	57.33	1425.05	SB-5	5.33	1430.4	SB-7
0	1430.5	SB-8	57.33	1424.05	SB-5	5.33	1429.4	SB-7
0	1429.5	SB-8	66.67	1430.83	ML-4	5.33	1428.4	SB-7
0	1428.5	SB-8	66.67	1429.83	ML-4	5.33	1427.4	SB-7
0	1427.5	SB-8	66.67	1428.83	ML-4	5.33	1426.4	SB-7
0	1426.5	SB-8	66.67	1427.83	ML-4	5.33	1425.4	SB-7
0	1425.5	SB-8	66.67	1425.6633	ML-4	49.33	1430.55	SB-6
0	1424.5	SB-8	66.67	1424.83	ML-4	49.33	1429.55	SB-6
5.33	1430.4	SB-7	66.67	1423.83	ML-4	49.33	1428.55	SB-6
5.33	1429.4	SB-7	66.67	1423.1633	ML-4	49.33	1427.55	SB-6
5.33	1428.4	SB-7	77.33	1430.55	SB-4	49.33	1426.55	SB-6
5.33	1427.4	SB-7	77.33	1429.55	SB-4	49.33	1425.55	SB-6
5.33	1426.4	SB-7	77.33	1428.55	SB-4	49.33	1424.55	SB-6
5.33	1425.4	SB-7	77.33	1427.55	SB-4	57.33	1430.55	SB-5
5.33	1424.4	SB-7	77.33	1426.55	SB-4	57.33	1429.55	SB-5
5.33	1423.9	SB-7	77.33	1425.55	SB-4	57.33	1428.55	SB-5
12	1431.23	ML-2	77.33	1424.55	SB-4	57.33	1427.55	SB-5
12	1430.23	ML-2	77.33	1423.55	SB-4	57.33	1426.55	SB-5
12	1429.23	ML-2	77.33	1422.7167	SB-4	57.33	1425.55	SB-5
12	1427.5633	ML-2	97.33	1429.95	SB-3	57.33	1424.55	SB-5
12	1427.23	ML-2	97.33	1428.95	SB-3	57.33	1423.55	SB-5
12	1426.23	ML-2	97.33	1427.95	SB-3	77.33	1430.55	SB-4
12	1425.23	ML-2	97.33	1426.95	SB-3	77.33	1429.55	SB-4
12	1424.23	ML-2	97.33	1425.95	SB-3	77.33	1428.55	SB-4
12	1423.48	ML-2	97.33	1424.95	SB-3	77.33	1427.55	SB-4
38.67	1430.61	ML-3	97.33	1423.1167	SB-3	77.33	1426.55	SB-4
38.67	1429.61	ML-3	109.33	1428.7	SB-2	77.33	1425.55	SB-4
38.67	1428.61	ML-3	109.33	1427.7	SB-2	77.33	1424.55	SB-4
38.67	1427.61	ML-3	109.33	1426.7	SB-2	77.33	1423.55	SB-4
38.67	1426.61	ML-3	109.33	1425.7	SB-2	97.33	1427.95	SB-3
38.67	1425.61	ML-3	109.33	1424.5333	SB-2	97.33	1427.45	SB-3
38.67	1424.61	ML-3	116	1429.6	SB-1	97.33	1426.95	SB-3
38.67	1423.61	ML-3	116	1428.6	SB-1	97.33	1425.95	SB-3
38.67	1423.5267	ML-3	116	1427.6	SB-1	97.33	1424.95	SB-3
49.33	1429.55	SB-6	116	1426.6	SB-1	97.33	1423.95	SB-3
49.33	1428.1333	SB-6	116	1425.6	SB-1	97.33	1422.95	SB-3
49.33	1427.55	SB-6	116	1424.6	SB-1	109.33	1428.7	SB-2
49.33	1426.55	SB-6	116	1424.4333	SB-1	109.33	1427.7	SB-2
49.33	1425.55	SB-6				109.33	1426.7	SB-2
49.33	1424.55	SB-6				109.33	1425.7	SB-2
49.33	1423.55	SB-6				109.33	1424.7	SB-2
49.33	1423.4667	SB-6				109.33	1423.95	SB-2
56	1430.54	ML-14				116	1428.6	SB-1
56	1429.54	ML-14				116	1427.6	SB-1
56	1428.54	ML-14				116	1426.6	SB-1
56	1427.54	ML-14				116	1425.6	SB-1
56	1426.54	ML-14				116	1424.6	SB-1
56	1425.54	ML-14				116	1424.1	SB-1
56	1424.54	ML-14				126.67	1430.5	ML-18
56	1423.54	ML-14				126.67	1429.5	ML-18
56	1422.7067	ML-14				126.67	1428.5	ML-18
						126.67	1427.5	ML-18
						126.67	1426.5	ML-18
						126.67	1425.5	ML-18
						126.67	1424.5	ML-18

Table A16: Soil Surfer Data Points for Transect 2

July-97						June-98		
x (ft)	Elevation (ft)	SB ID #	x (ft)	Elevation (ft)	SB ID #	x (ft)	Elevation (ft)	SB ID #
0	1430	SB-16	88	1429.45	SB-11	21.33	1429.5	SB-15
0	1429	SB-16	88	1428.45	SB-11	21.33	1428.5	SB-15
0	1428	SB-16	88	1426.45	SB-11	21.33	1427.5	SB-15
0	1427	SB-16	88	1425.45	SB-11	21.33	1426.5	SB-15
0	1426	SB-16	88	1424.45	SB-11	21.33	1425.5	SB-15
0	1425	SB-16	109.33	1429.45	SB-10	21.33	1424.5	SB-15
0	1424	SB-16	109.33	1428.45	SB-10	21.33	1423.5	SB-15
0	1423	SB-16	109.33	1427.45	SB-10	21.33	1422.5	SB-15
0	1422.3333	SB-16	109.33	1426.45	SB-10	40	1429.9	SB-18
12	1429.75	No SB ID	109.33	1425.45	SB-10	40	1428.9	SB-18
12	1428.75	b/w SB-16	109.33	1424.45	SB-10	40	1427.9	SB-18
12	1427.75	and SB-15	109.33	1423.45	SB-10	40	1426.9	SB-18
12	1426.75		109.33	1423.2833	SB-10	40	1425.9	SB-18
12	1425.75		112	1426.75	SB-9	40	1424.9	SB-18
12	1424.75		112	1425.75	SB-9	40	1423.9	SB-18
12	1423.75		112	1424.75	SB-9	40	1422.9	SB-18
12	1422.75		112	1424.25	SB-9	40	1421.9	SB-18
12	1422	BR	112	1423	SB-9	61.33	1428.8	SB-14
21.33	1431.25	SB-15				61.33	1427.8	SB-14
37.33	1429.85	SB-17				61.33	1426.8	SB-14
37.33	1428.85	SB-17				61.33	1425.8	SB-14
37.33	1427.85	SB-17				61.33	1424.8	SB-14
37.33	1426.85	SB-17				61.33	1423.8	SB-14
37.33	1425.85	SB-17				61.33	1422.8	SB-14
37.33	1424.85	SB-17				61.33	1421.8	SB-14
37.33	1423.85	SB-17				74.67	1429.6	SB-12
37.33	1422.85	SB-17				74.67	1428.6	SB-12
37.33	1421.9333	SB-17				74.67	1427.6	SB-12
40	1430.65	SB-18				74.67	1426.6	SB-12
40	1427.65	SB-18				74.67	1425.6	SB-12
40	1423.4	SB-18				74.67	1424.6	SB-12
61.33	1426.5	SB-14				74.67	1423.6	SB-12
61.33	1423.5	SB-14				74.67	1422.6	SB-12
61.33	1423	SB-14				74.67	1422.1	SB-12
61.33	1424	SB-14				88	1429.5	SB-11
61.33	1423.5	SB-14				88	1428.5	SB-11
74.67	1429.55	SB-12				88	1427.5	SB-11
74.67	1428.55	SB-12				88	1426.5	SB-11
74.67	1427.55	SB-12				88	1425.5	SB-11
74.67	1426.55	SB-12				88	1424.5	SB-11
74.67	1425.55	SB-12				88	1423.5	SB-11
74.67	1424.55	SB-12				109.33	1429.5	SB-10
74.67	1423.55	SB-12				109.33	1428.5	SB-10
74.67	1422.55	SB-12				109.33	1427.5	SB-10
74.67	1422.3	SB-12				109.33	1426.5	SB-10
						109.33	1425.5	SB-10
						109.33	1424.5	SB-10
						109.33	1423.5	SB-10

Transect 1: Groundwater Acenaphthene Concentration

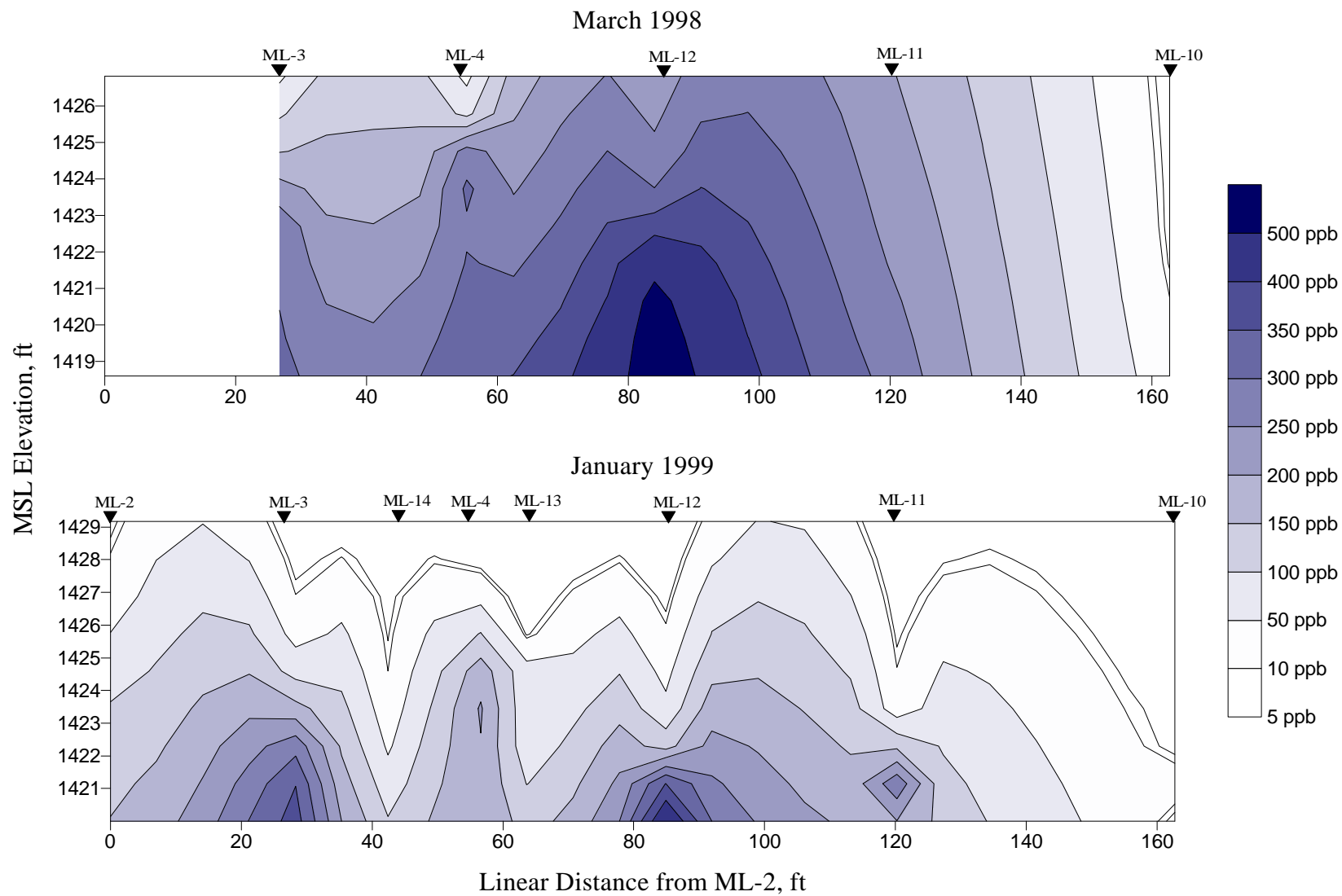


Figure A12: Transect 1 Groundwater Acenaphthene Concentration Profile

Transect 1: Groundwater Acenaphthylene Concentration

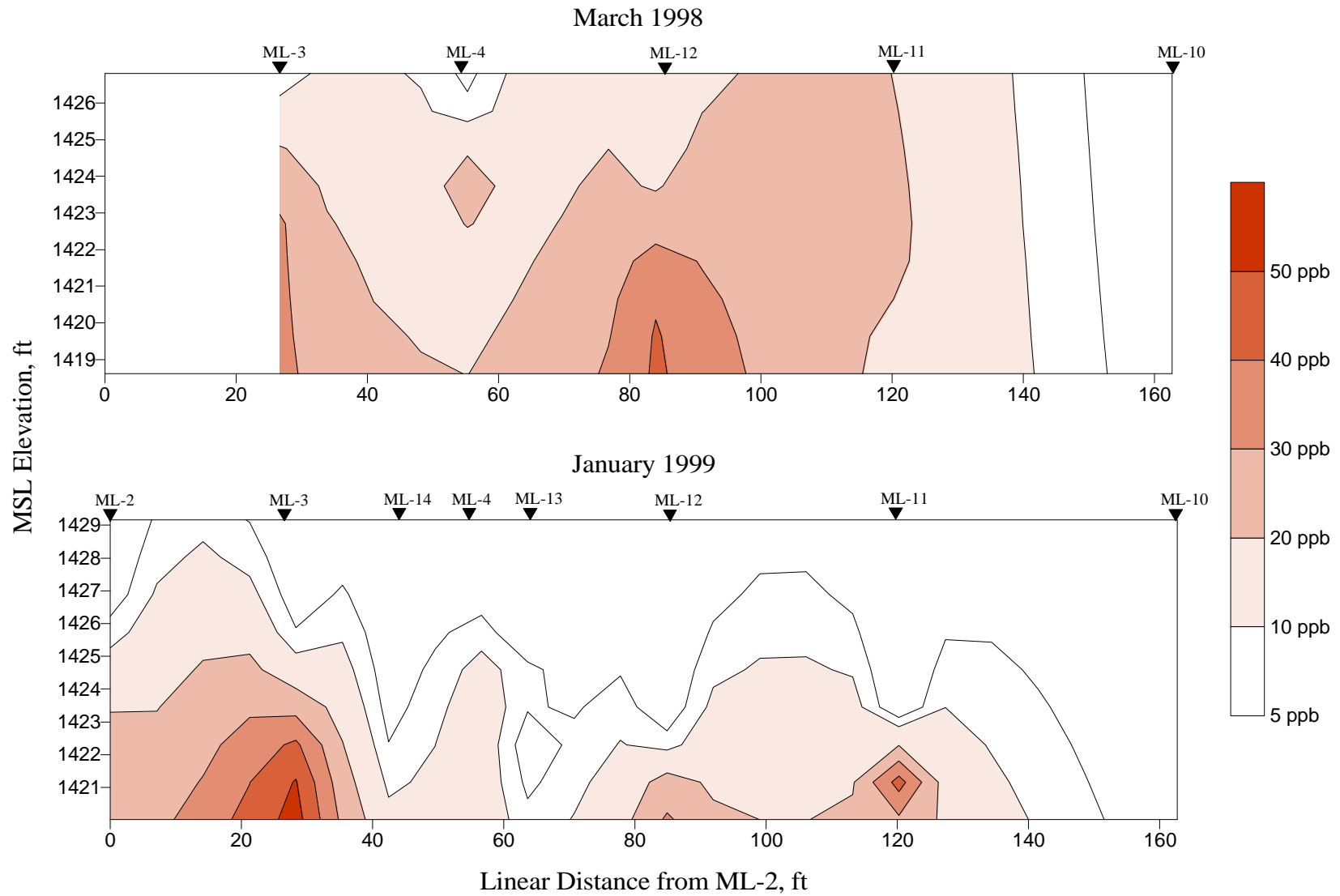


Figure A13: Transect 1 Acenaphthylene Groundwater Concentration Profile

Transect 1: Groundwater Anthracene Concentration

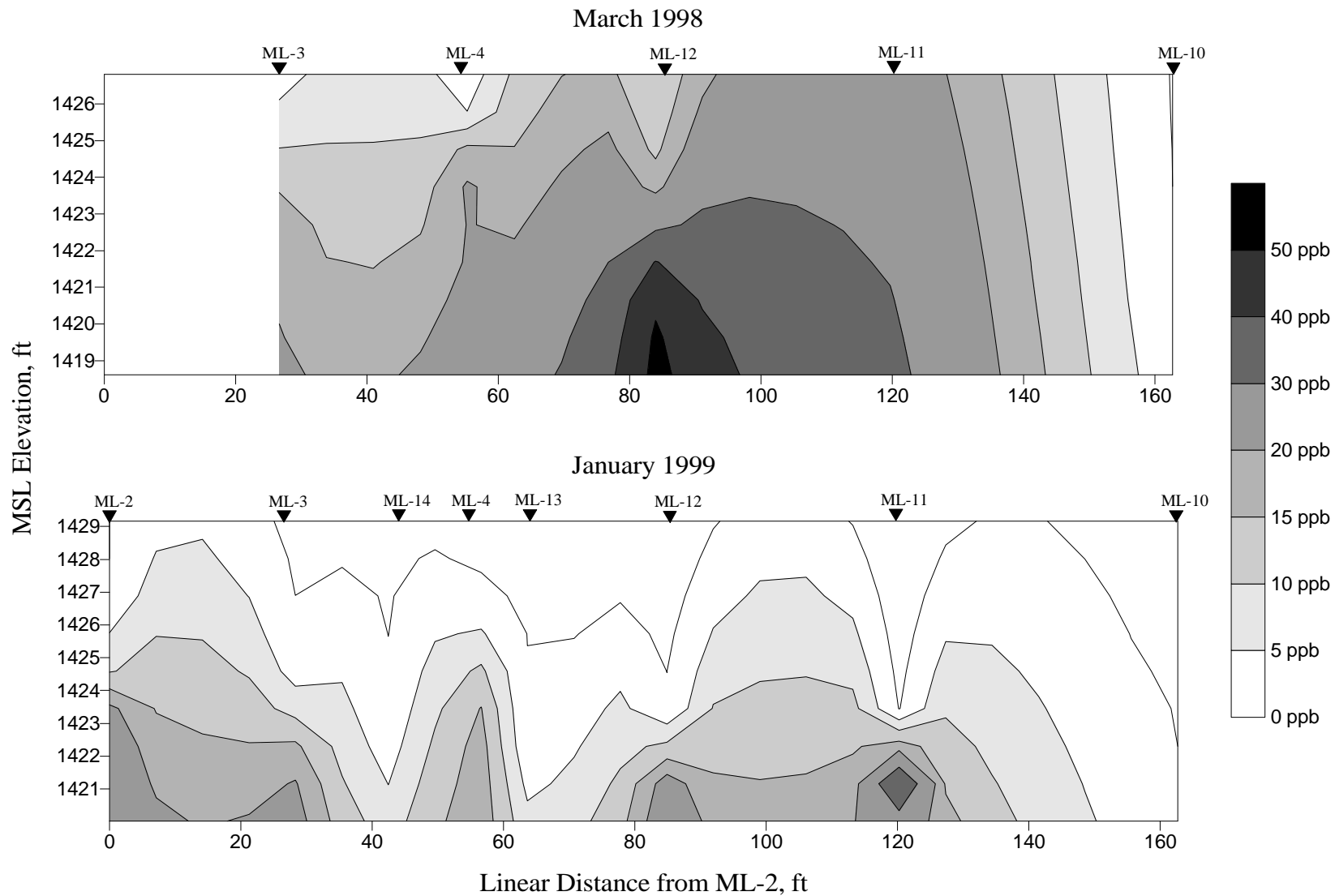


Figure A14: Transect 1 Anthracene Groundwater Concentration Profile

Transect 1: Groundwater Fluoranthene Concentration

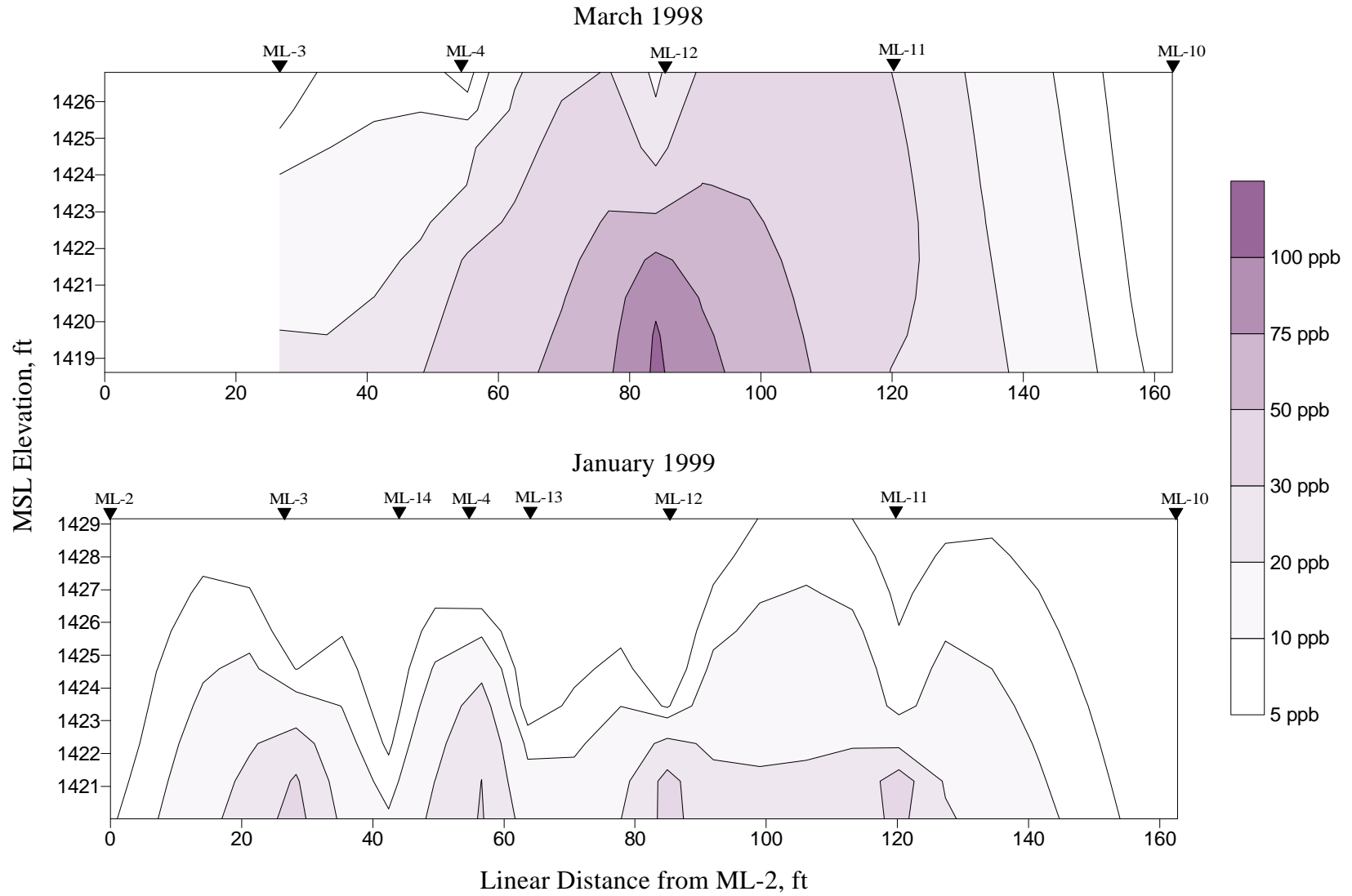


Figure A15: Transect 1 Groundwater Fluoranthene Concentration Profile

Transect 1: Groundwater Fluorene Concentration

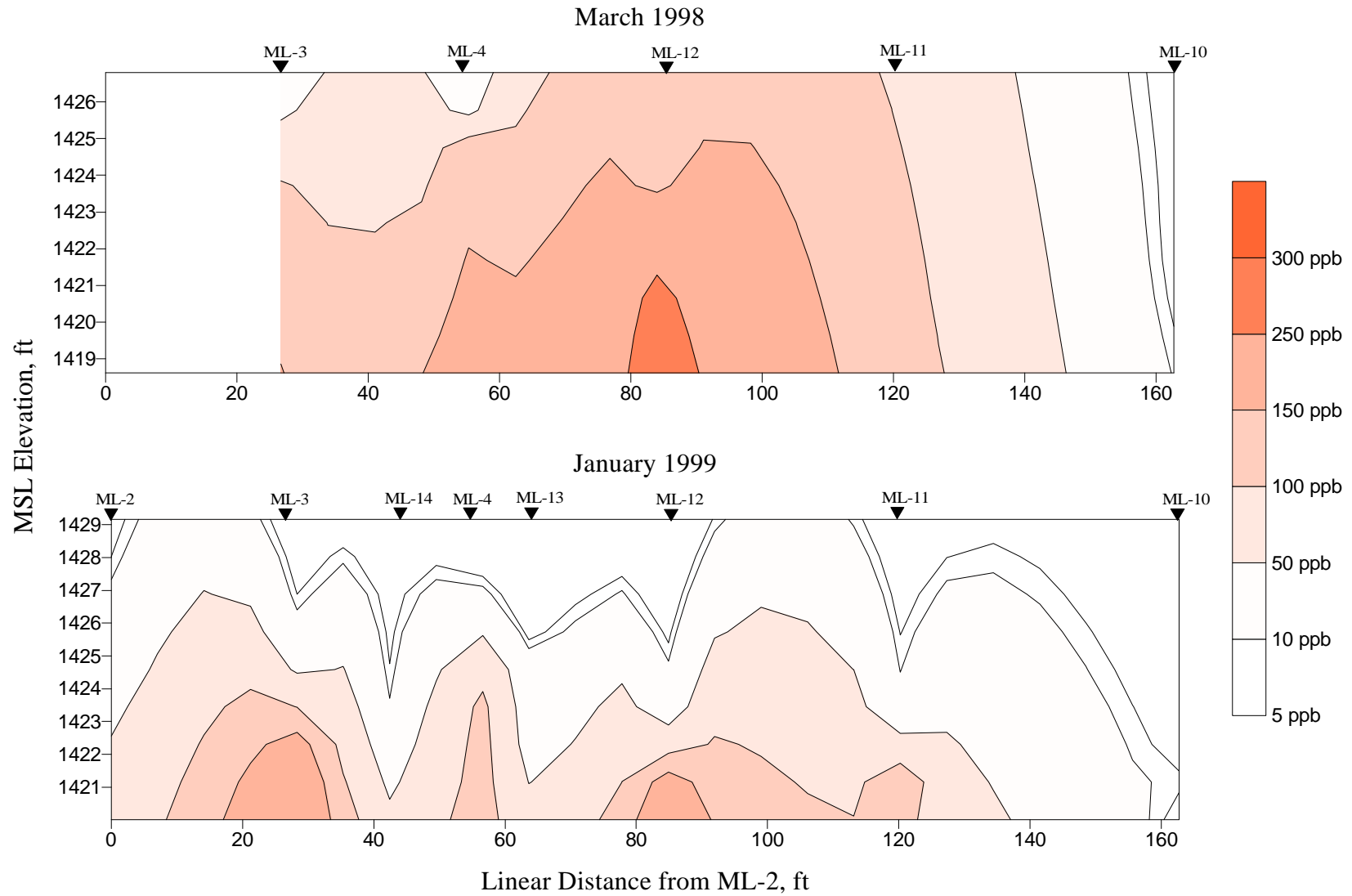


Figure A16: Transect 1 Groundwater Fluorene Concentration Profile

Transect 1: Groundwater Napthalene Concentration

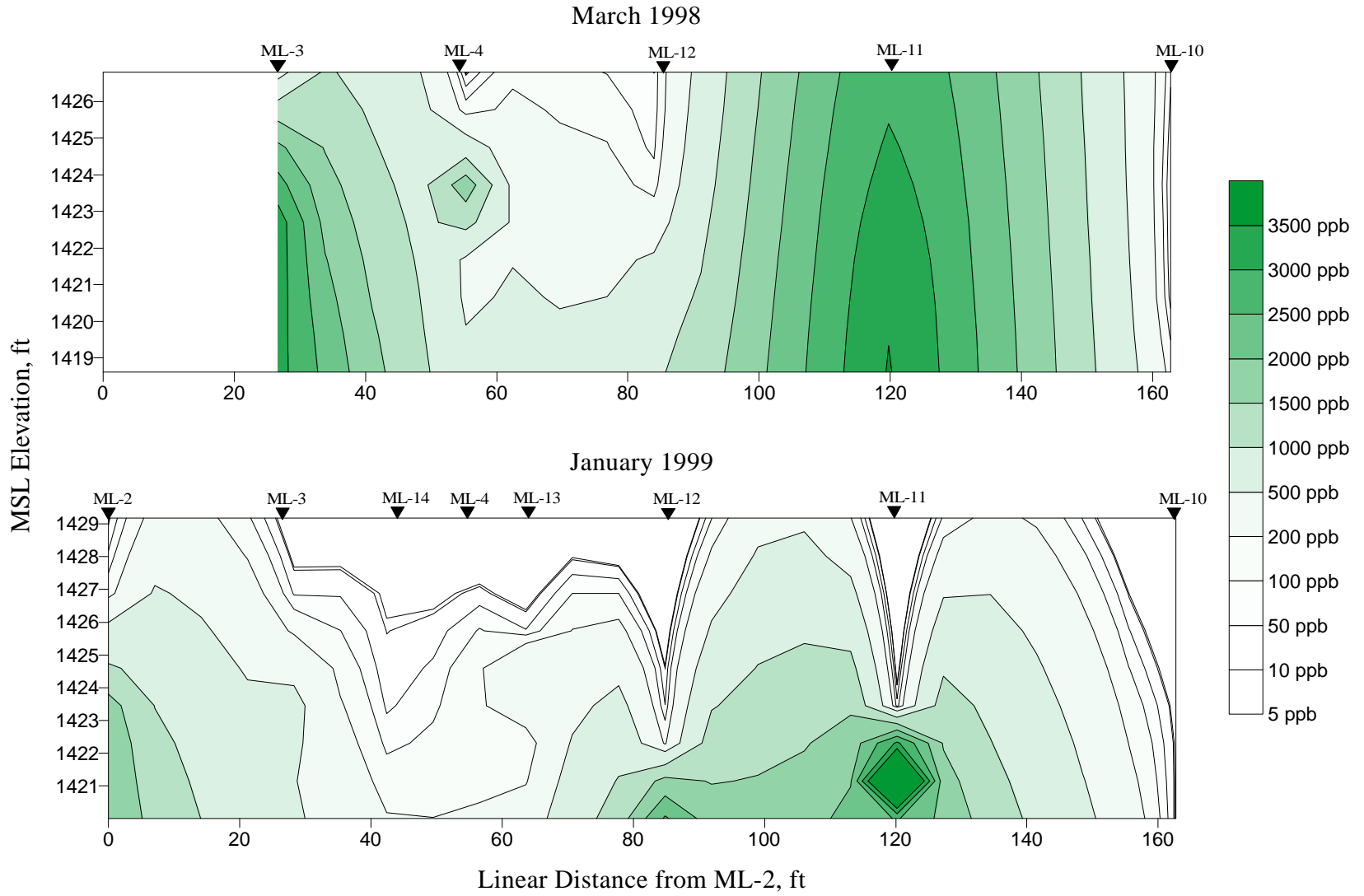


Figure A17: Transect 1 Groundwater Napthalene Concentration Profile

Transect 1: Groundwater Phenanthrene Concentration

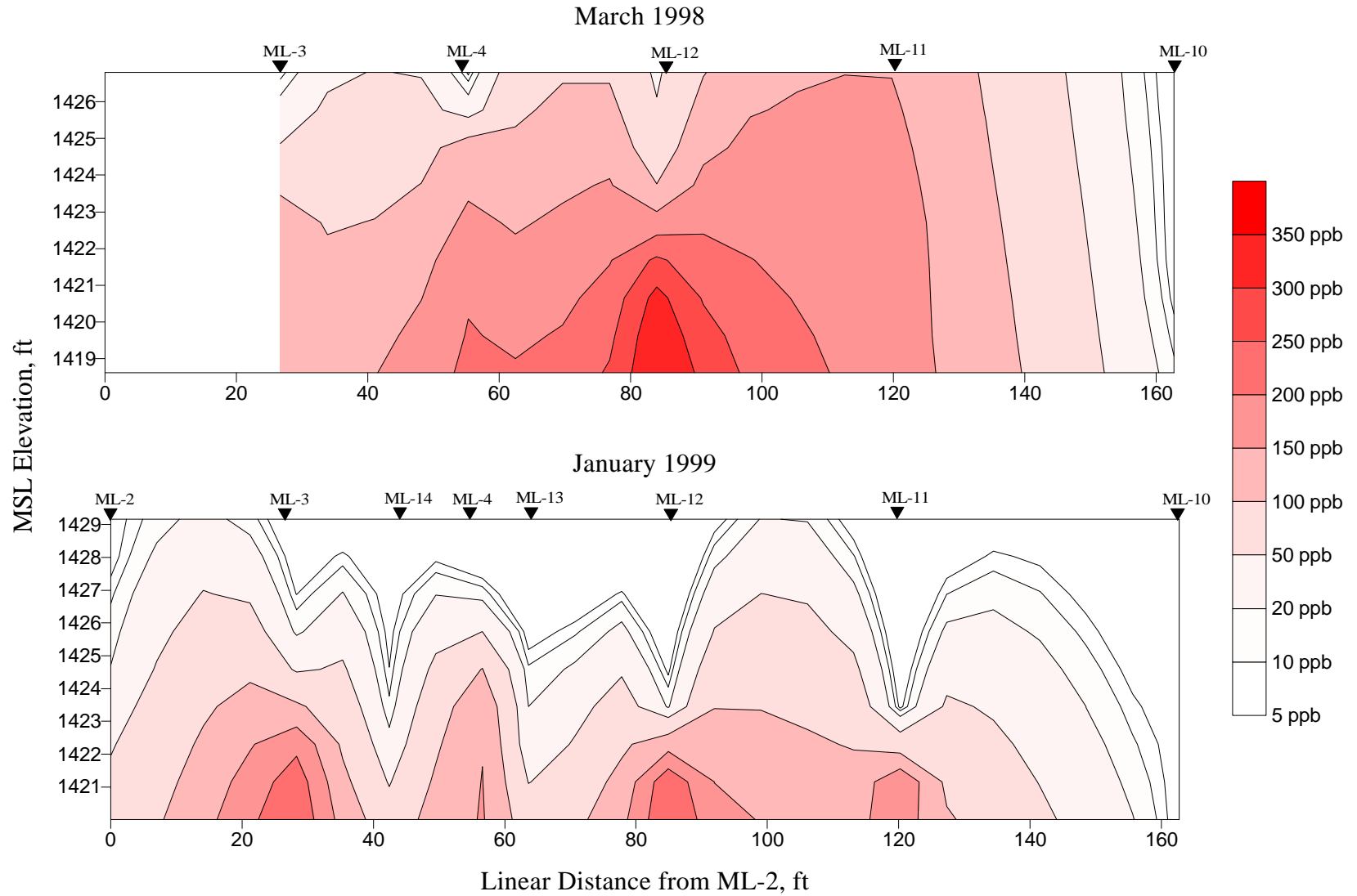


Figure A18: Transect 1 Groundwater Phenanthrene Concentration Profile

Transect 1: Groundwater Pyrene Concentration

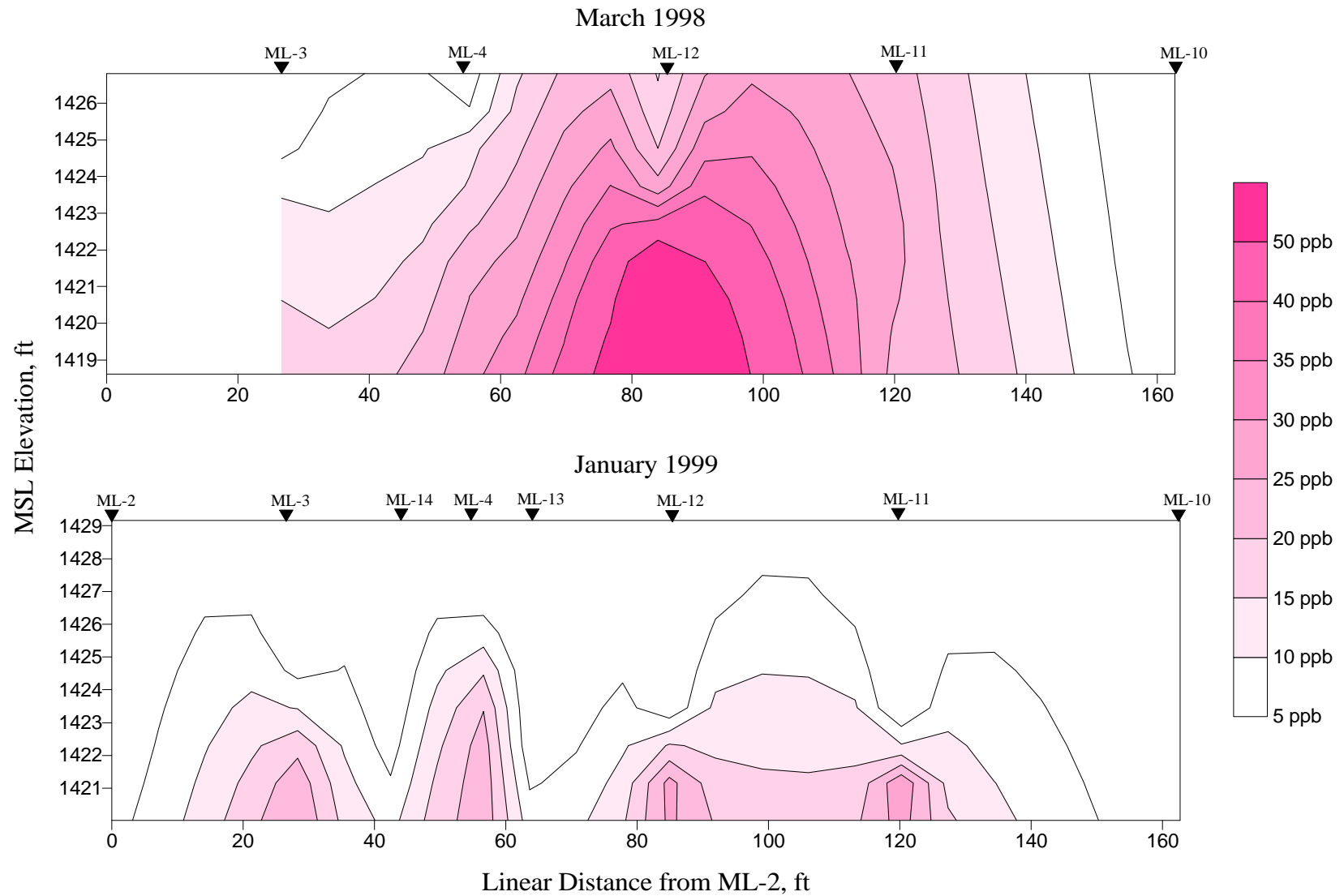


Figure A19: Transect 1 Groundwater Pyrene Concentration Profile

Transect 1: Groundwater Dissolved Oxygen Concentration

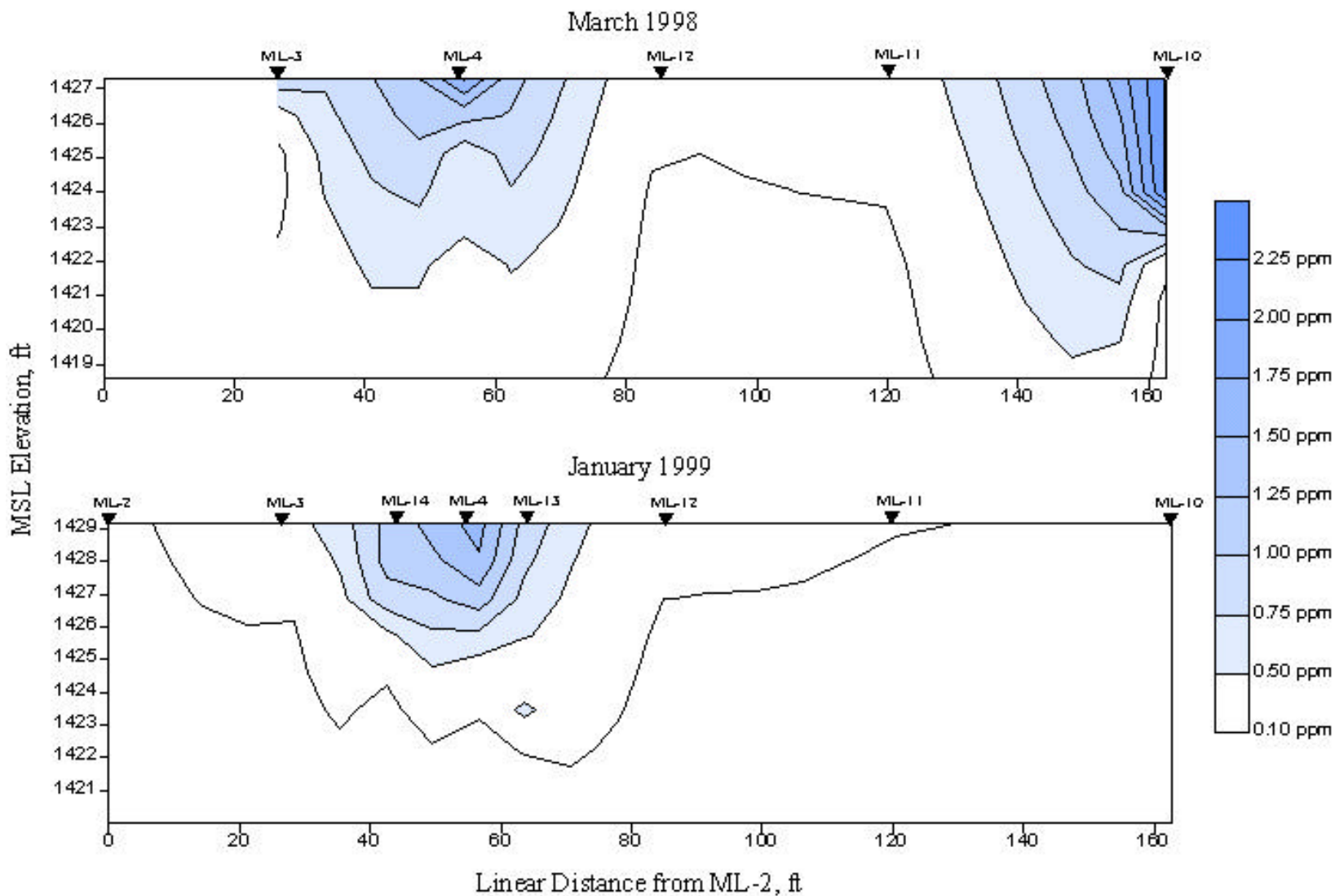


Figure A20: Transect 1 Groundwater Dissolved Oxygen Concentration Profile

Transect 3: Groundwater Acenaphthene Concentration

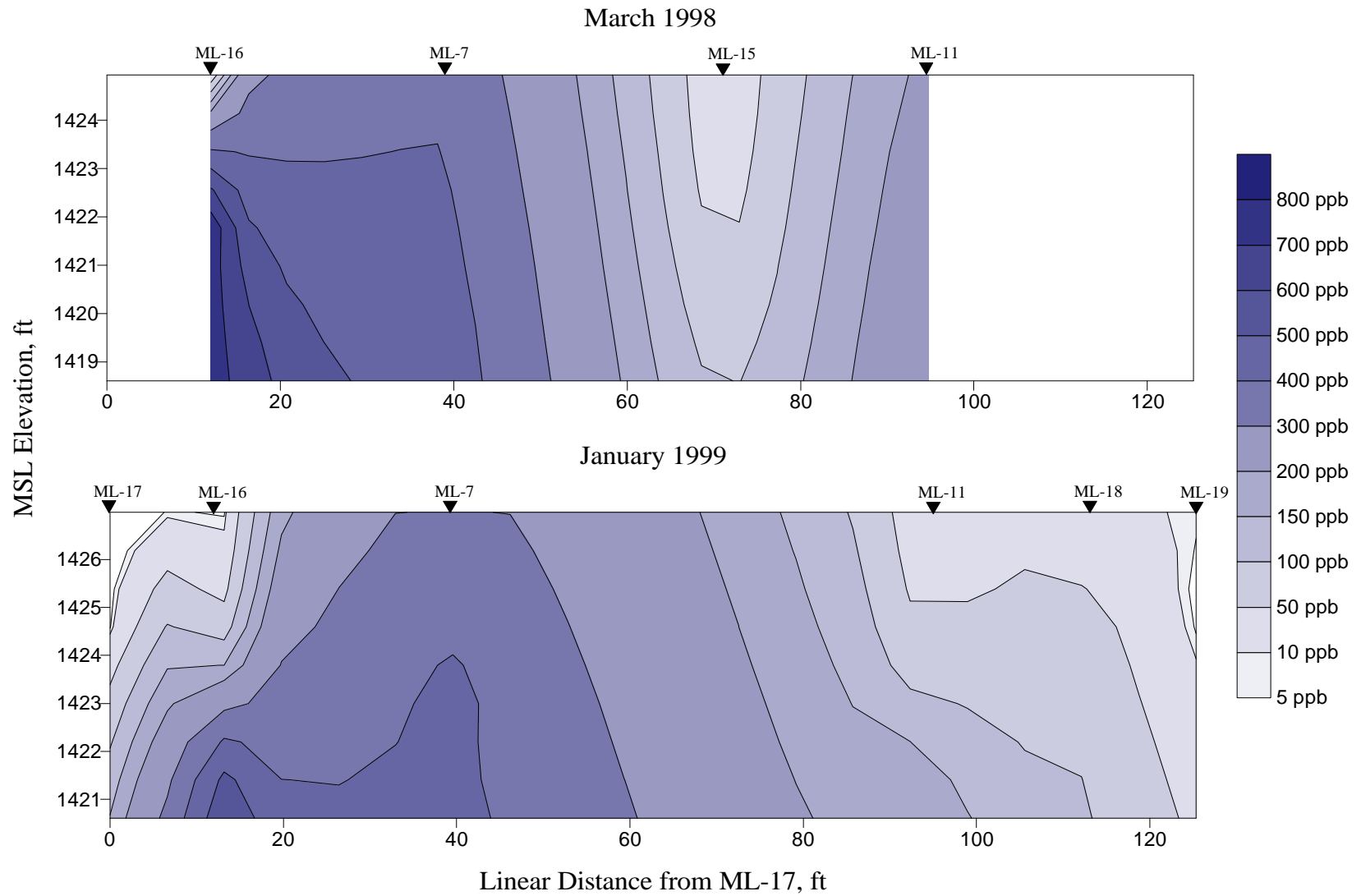


Figure A21: Transect 3 Groundwater Acenaphthene Concentration Profile

Transect 3: Groundwater Acenaphthylene Concentration

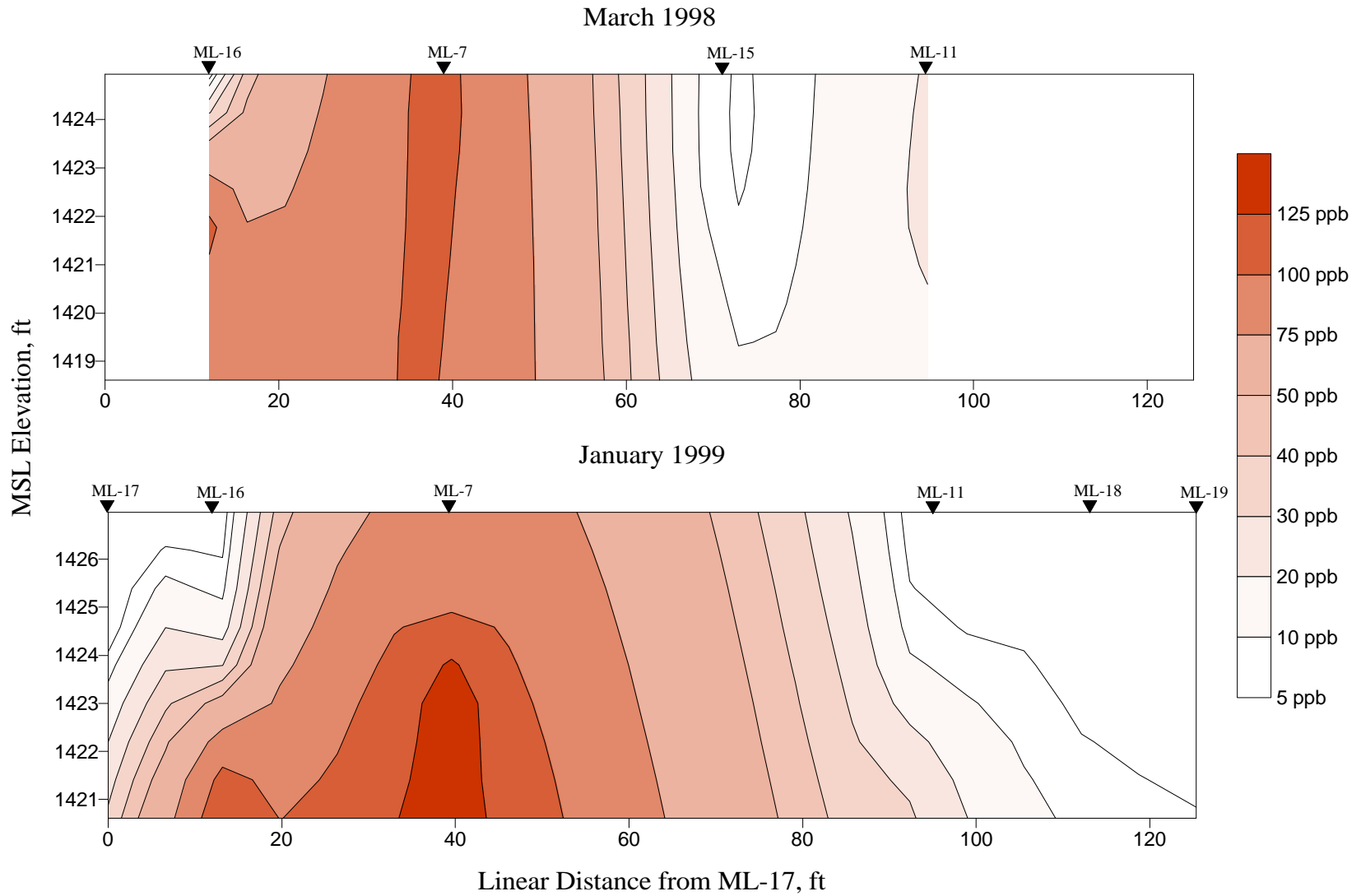


Figure A22: Transect 3 Groundwater Acenaphthylene Concentration

Transect 3: Groundwater Anthracene Concentration

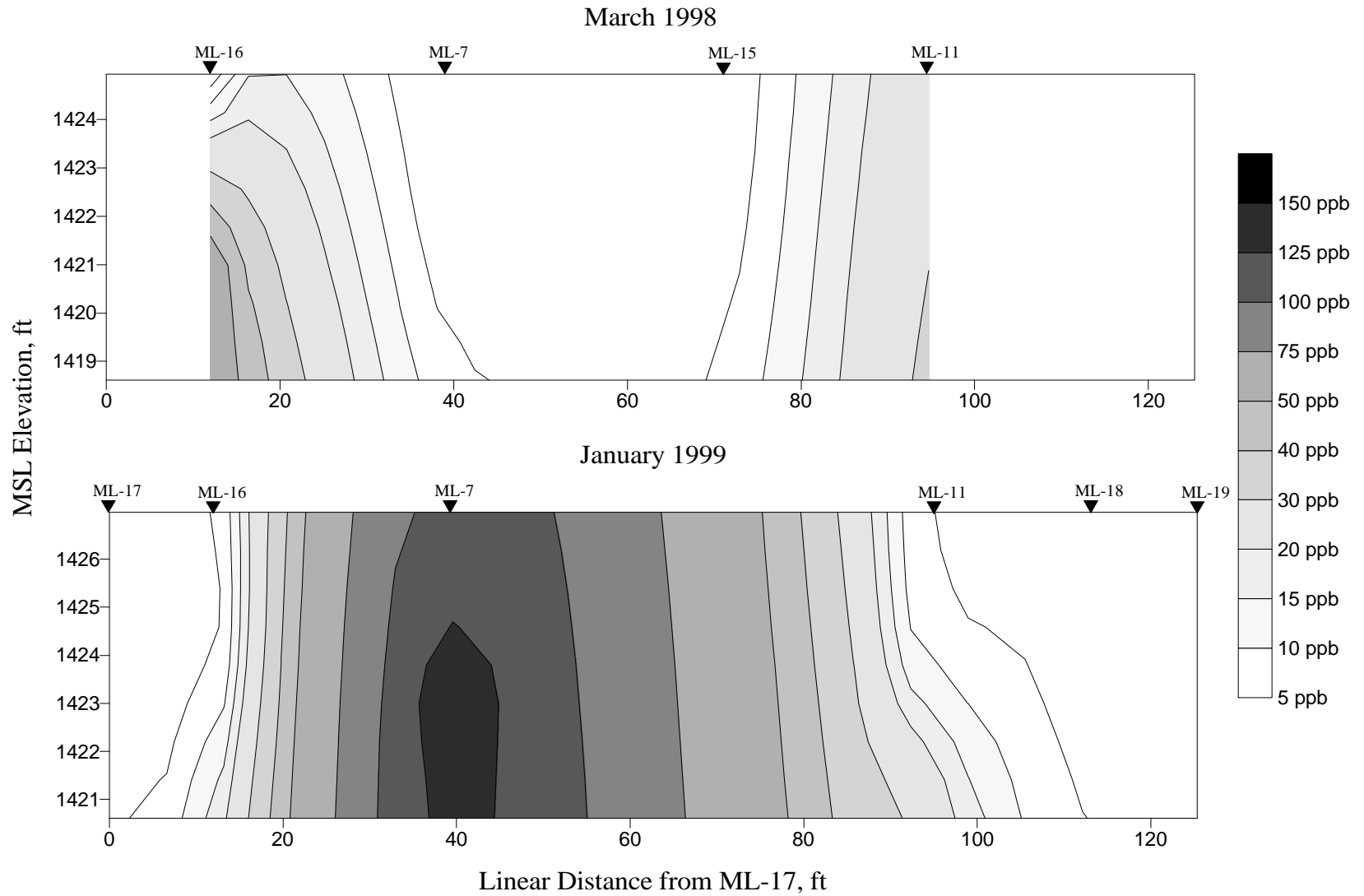


Figure A23: Transect 3 Groundwater Anthracene Concentration Profile

Transect 3: Groundwater Fluoranthene Concentration

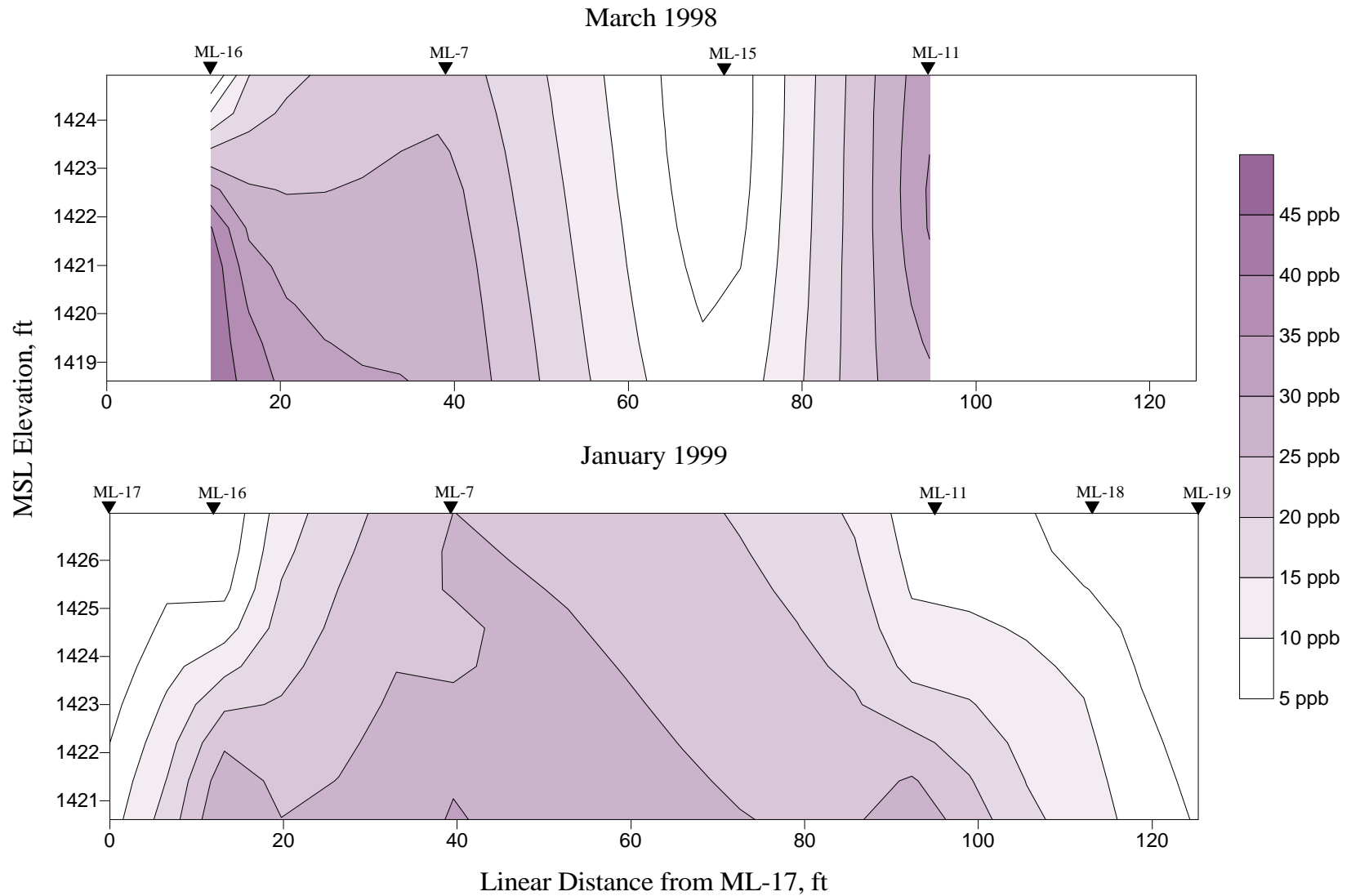


Figure A24: Transect 3 Groundwater Fluoranthene Concentration Profile

Transect 3: Groundwater Fluorene Concentration

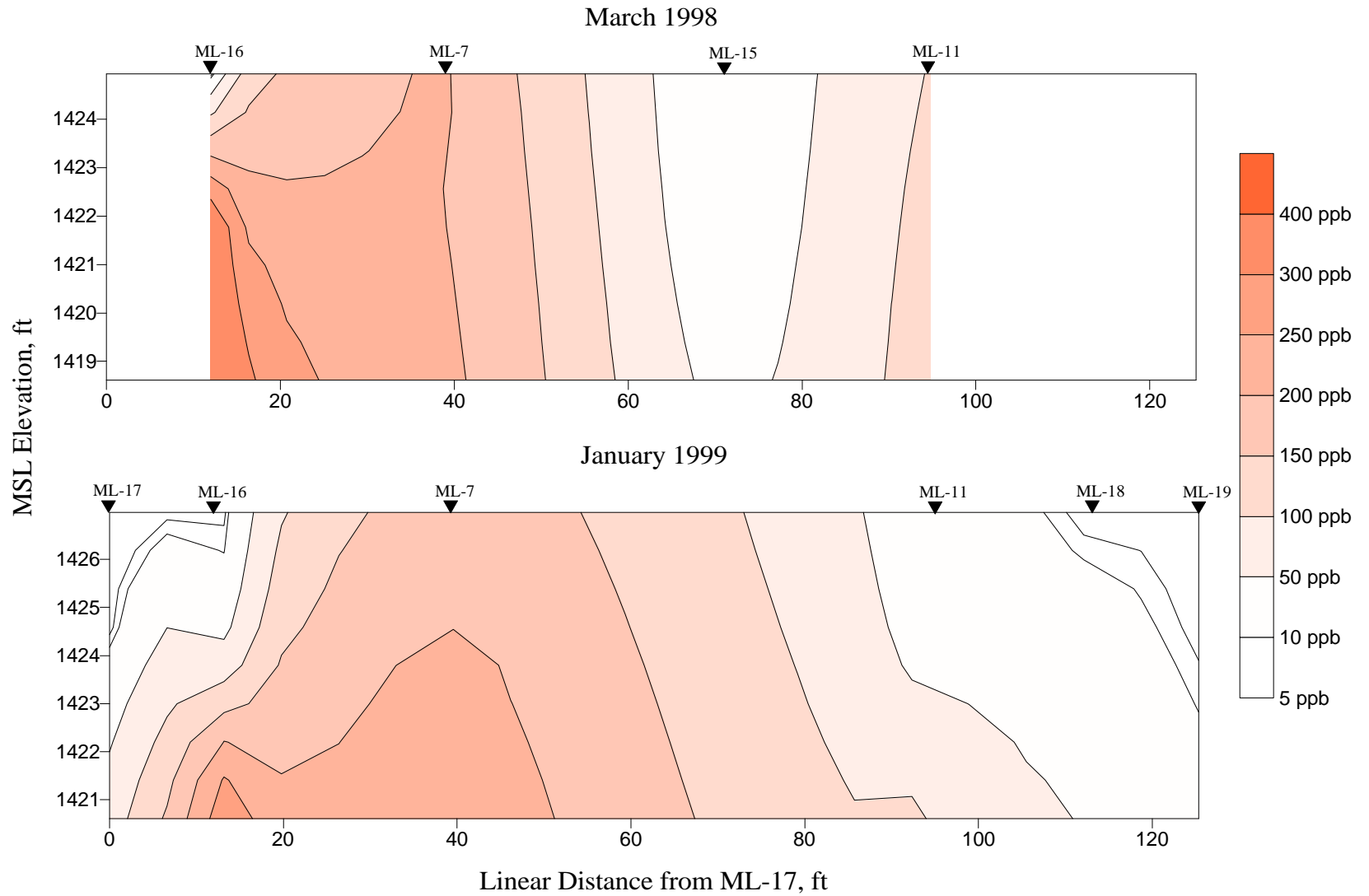


Figure A25: Transect 3 Groundwater Fluorene Concentration Profile

Transect 3: Groundwater Napthalene Concentration

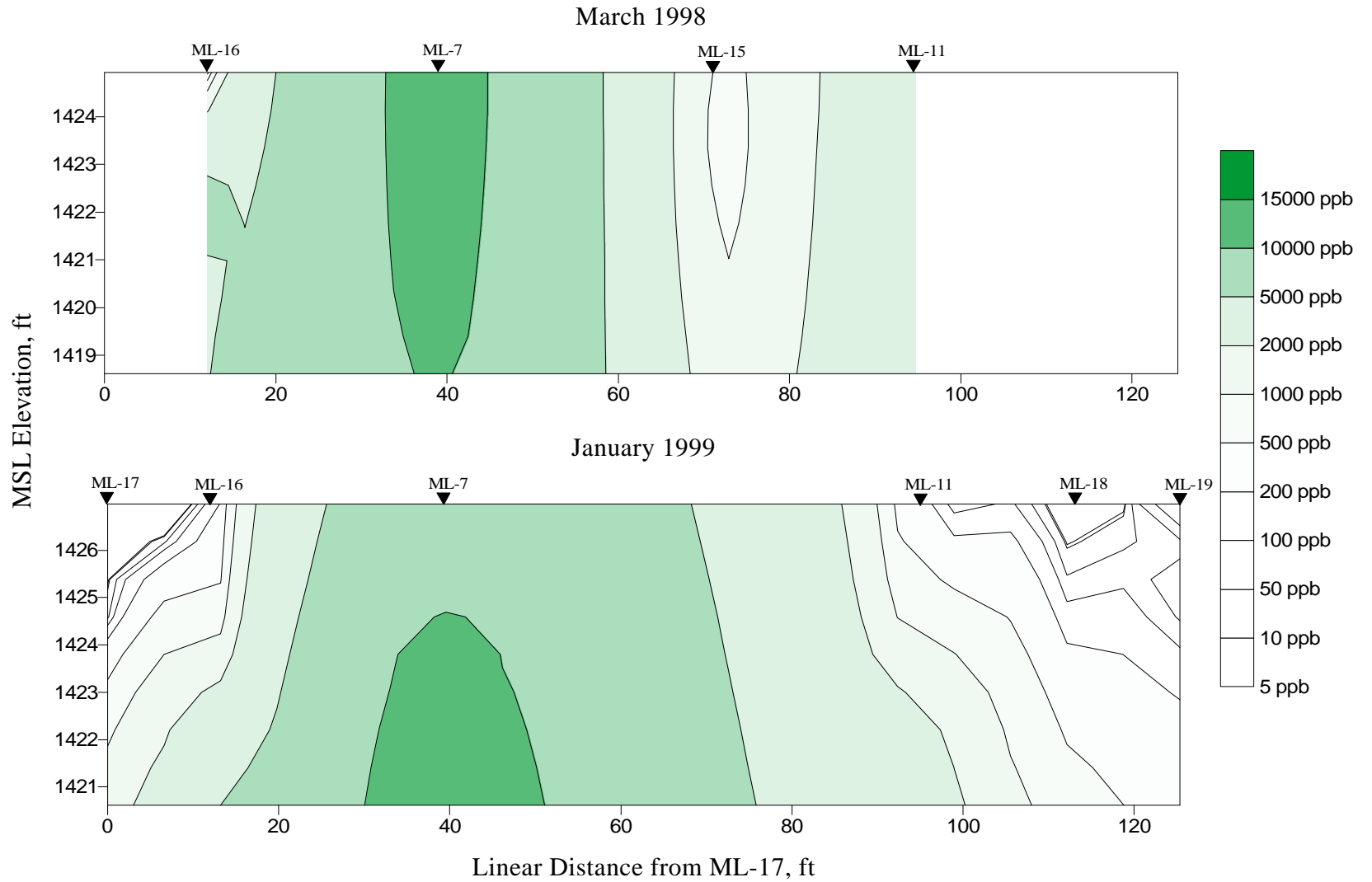


Figure A26: Transect 3 Groundwater Napthalene Concentration Profile

Transect 3: Groundwater Phenanthrene Concentration

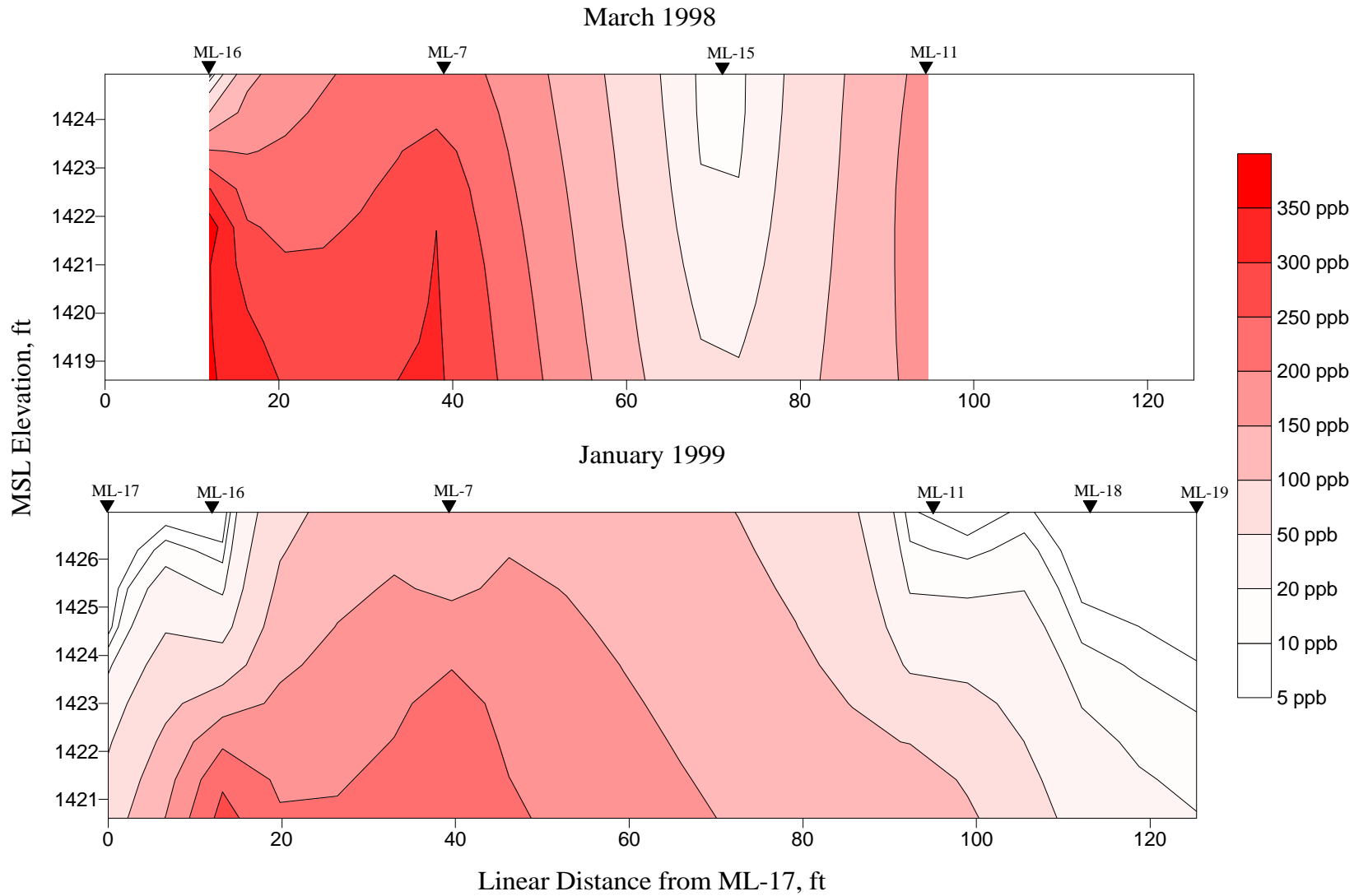


Figure A27: Transect 3 Groundwater Phenanthrene Concentration Profile

Transect 3: Groundwater Pyrene Concentration

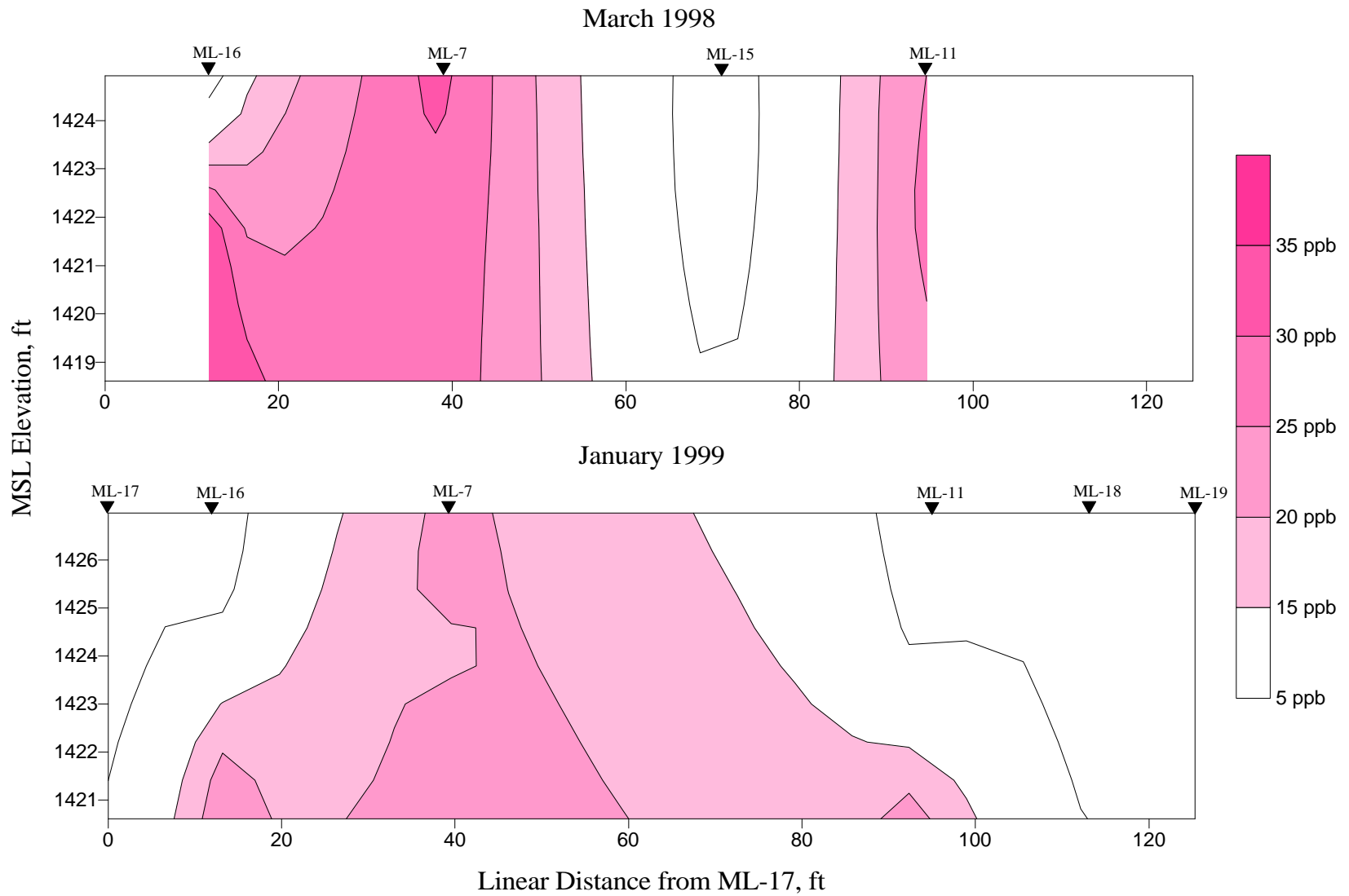


Figure A28: Transect 3 Groundwater Pyrene Concentration Profile

Transect 3: Groundwater Dissolved Oxygen Concentration

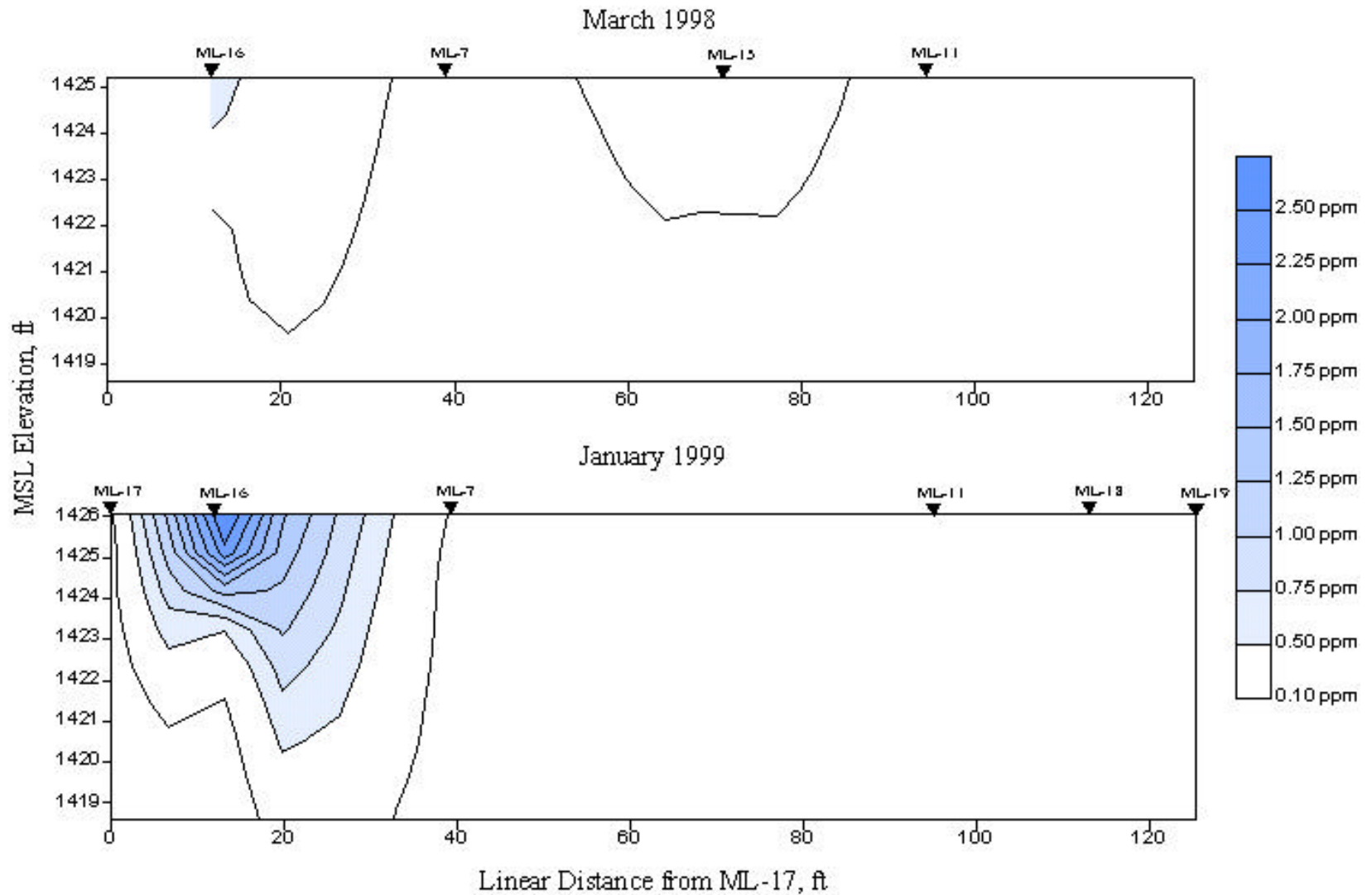


Figure A29: Transect 3 Groundwater Dissolved Oxygen Concentration Profile

Transect 1: Soil Acenaphthene Concentration

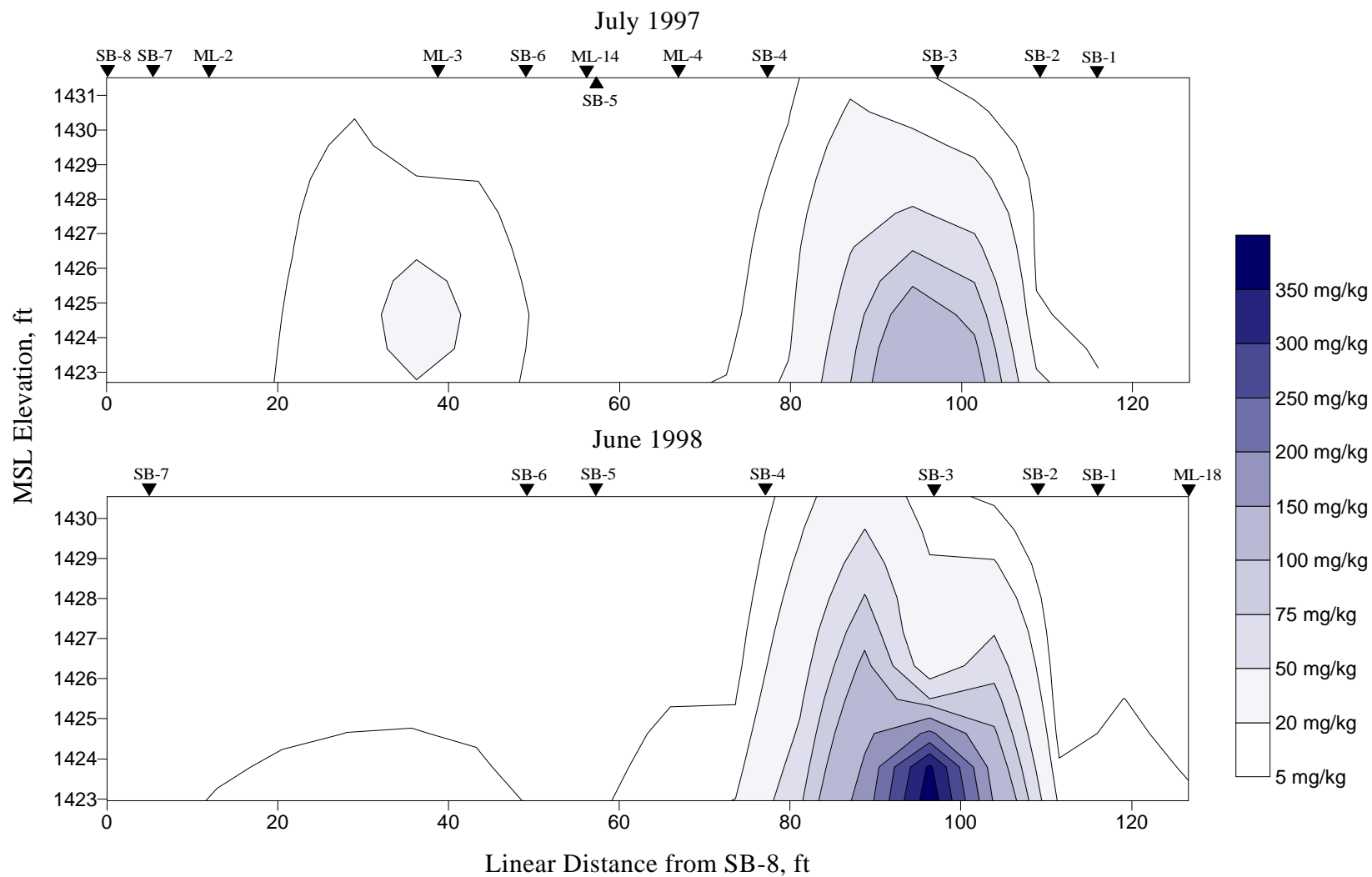


Figure A30: Transect 1 Soil Acenaphthene Concentration Profile

Transect 1: Soil Chrysene Concentration

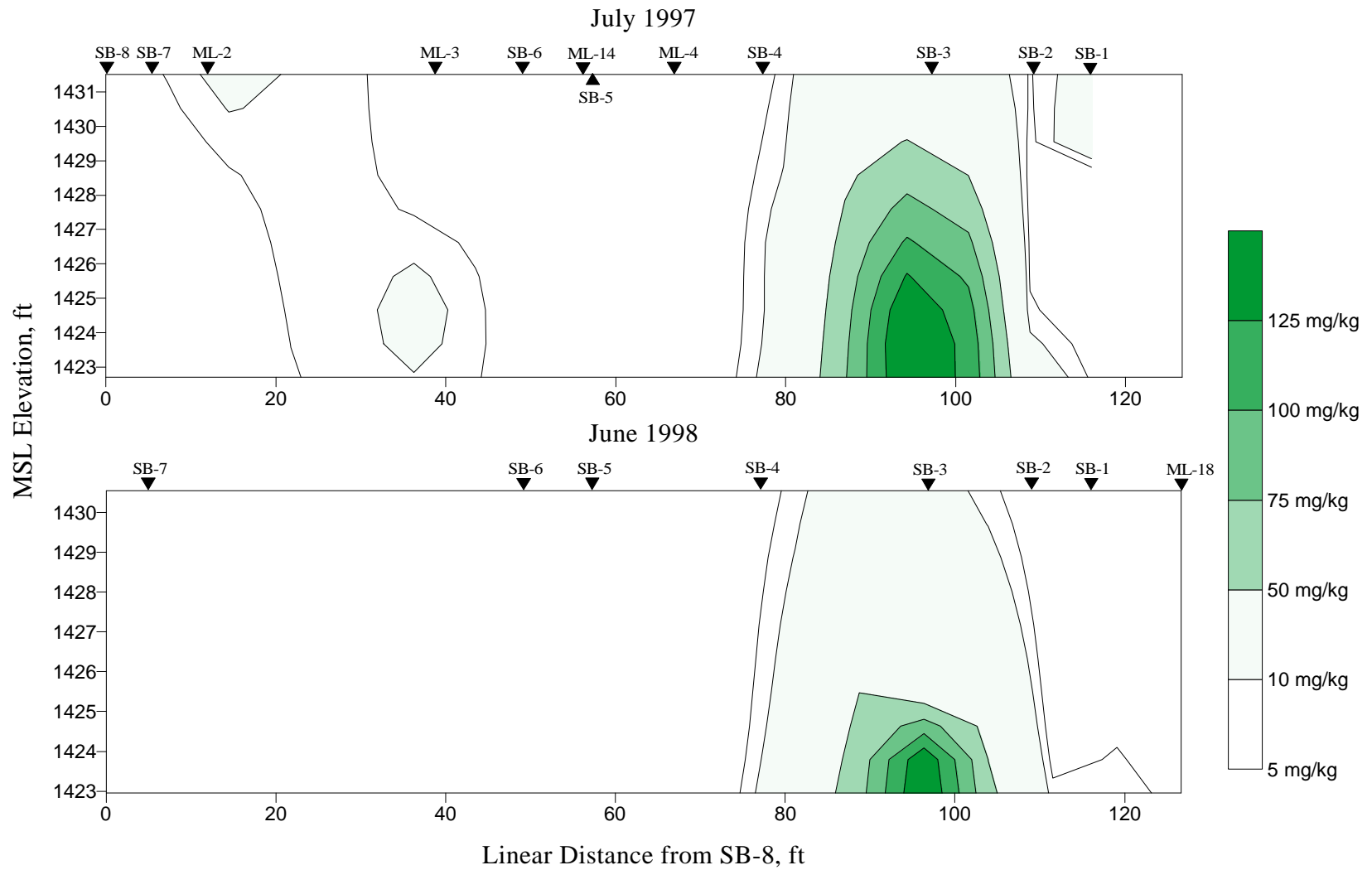


Figure A31: Transect 1 Soil Chrysene Concentration Profile

Transect 1: Soil Fluoranthene Concentration

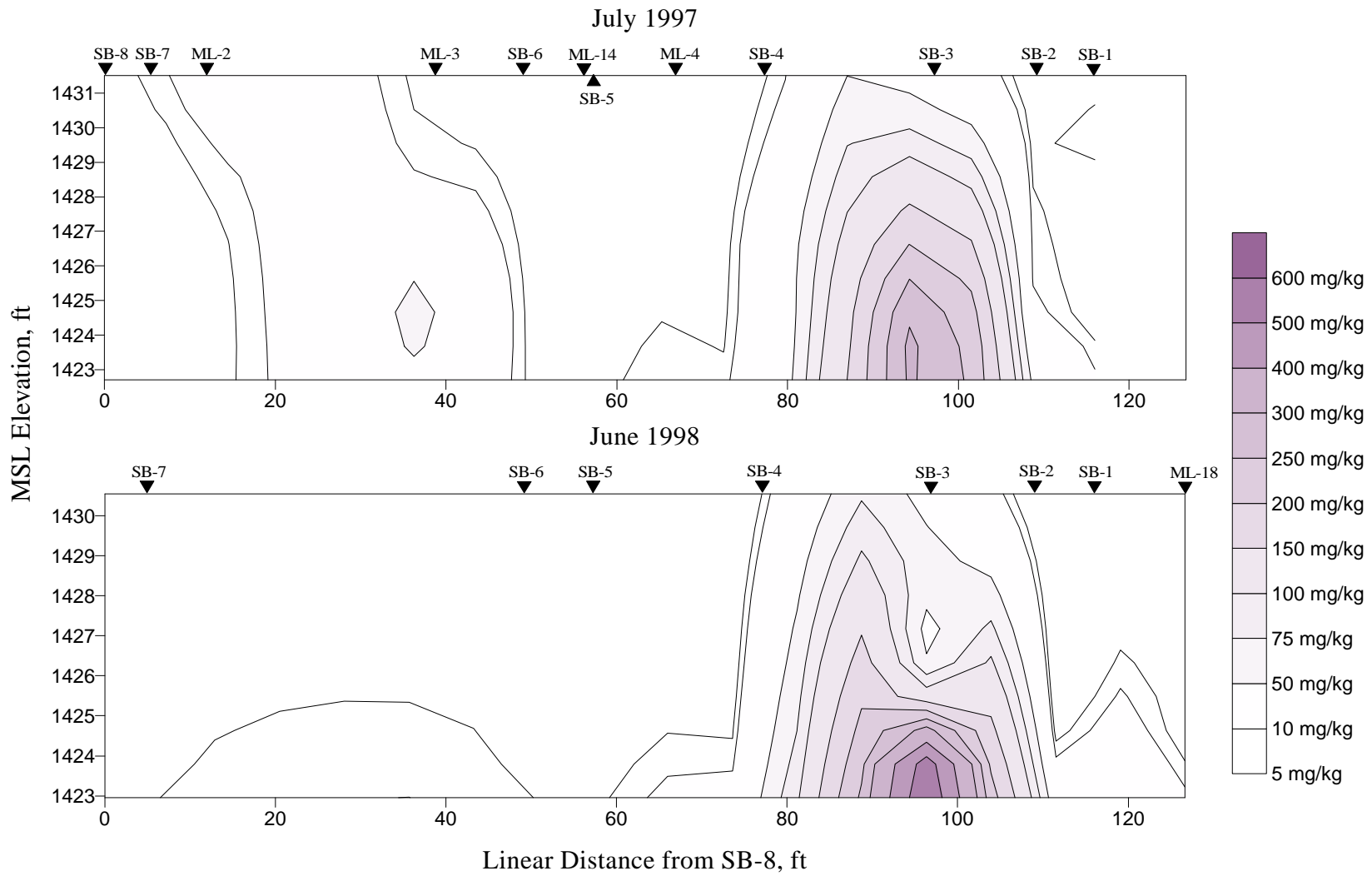


Figure A32: Transect 1 Soil Fluoranthene Concentration Profile

Transect 1: Soil Fluorene Concentration

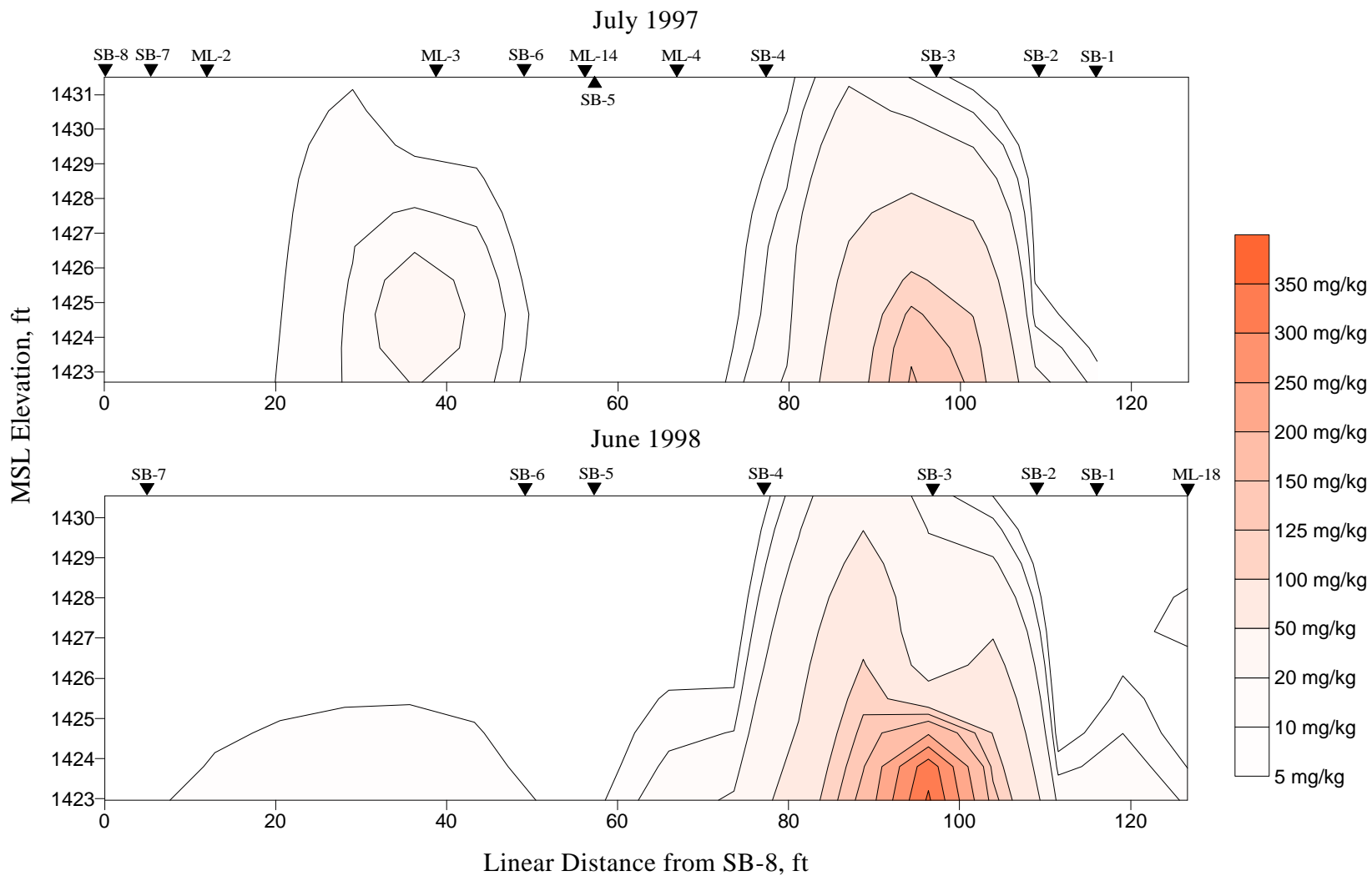


Figure A33: Transect 1 Soil Fluorene Concentration Profile

Transect 1: Soil Phenanthrene Concentration

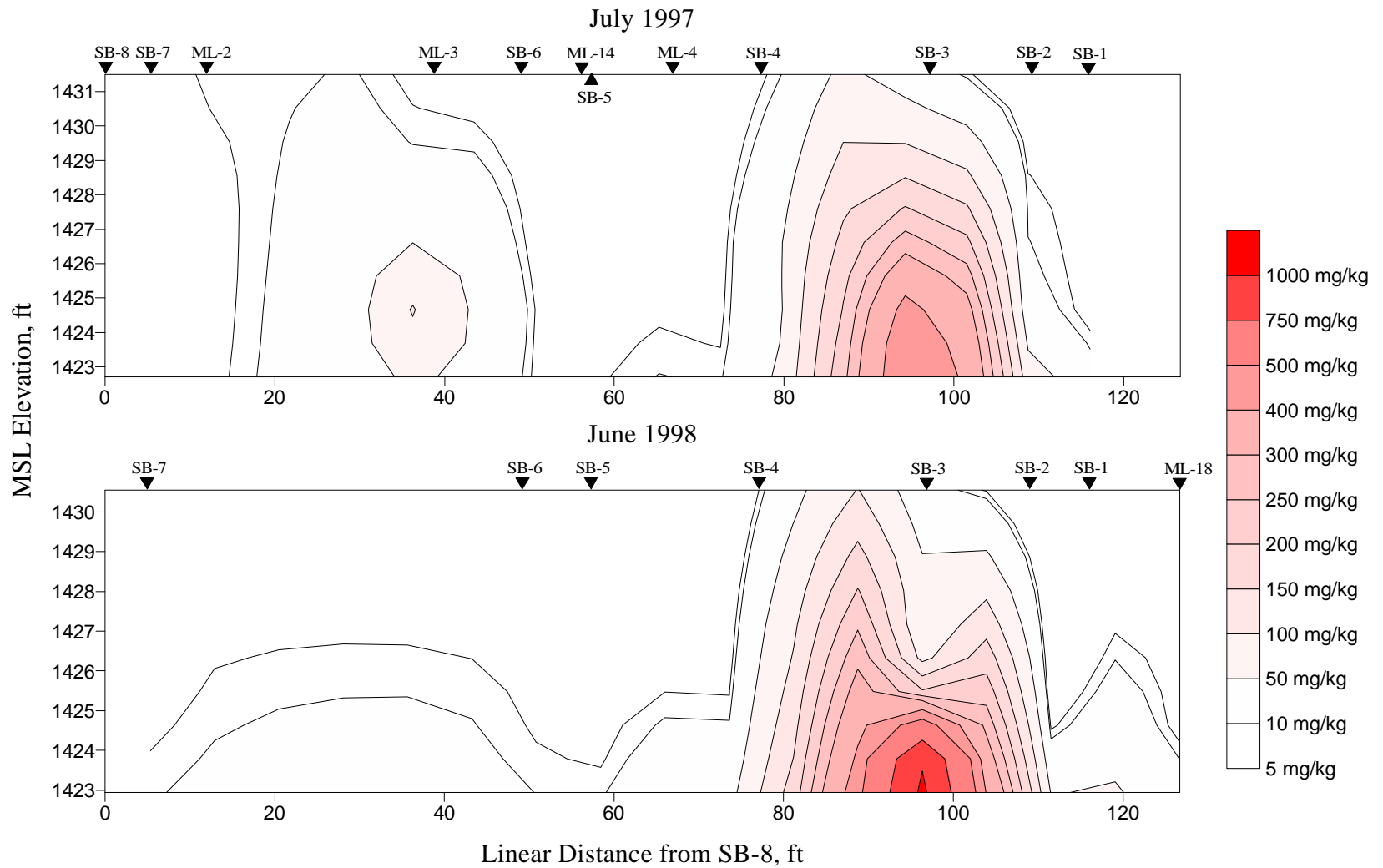


Figure A34: Transect 1 Soil Phenanthrene Concentration Profile

Transect 2: Soil Pyrene Concentration

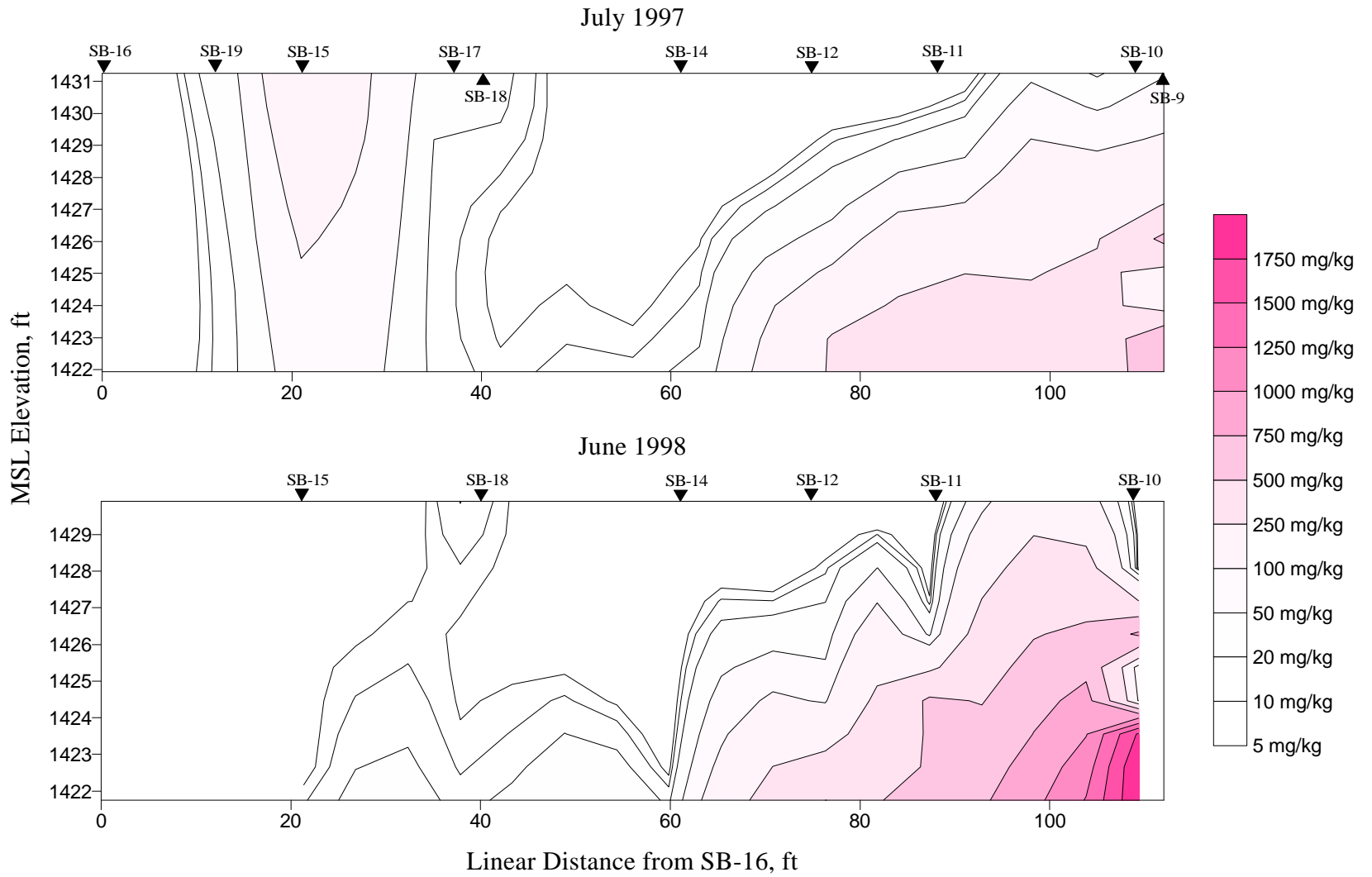


Figure A35: Transect 1 Soil Pyrene Concentration Profile

Transect 1: Soil Total PAH Concentration

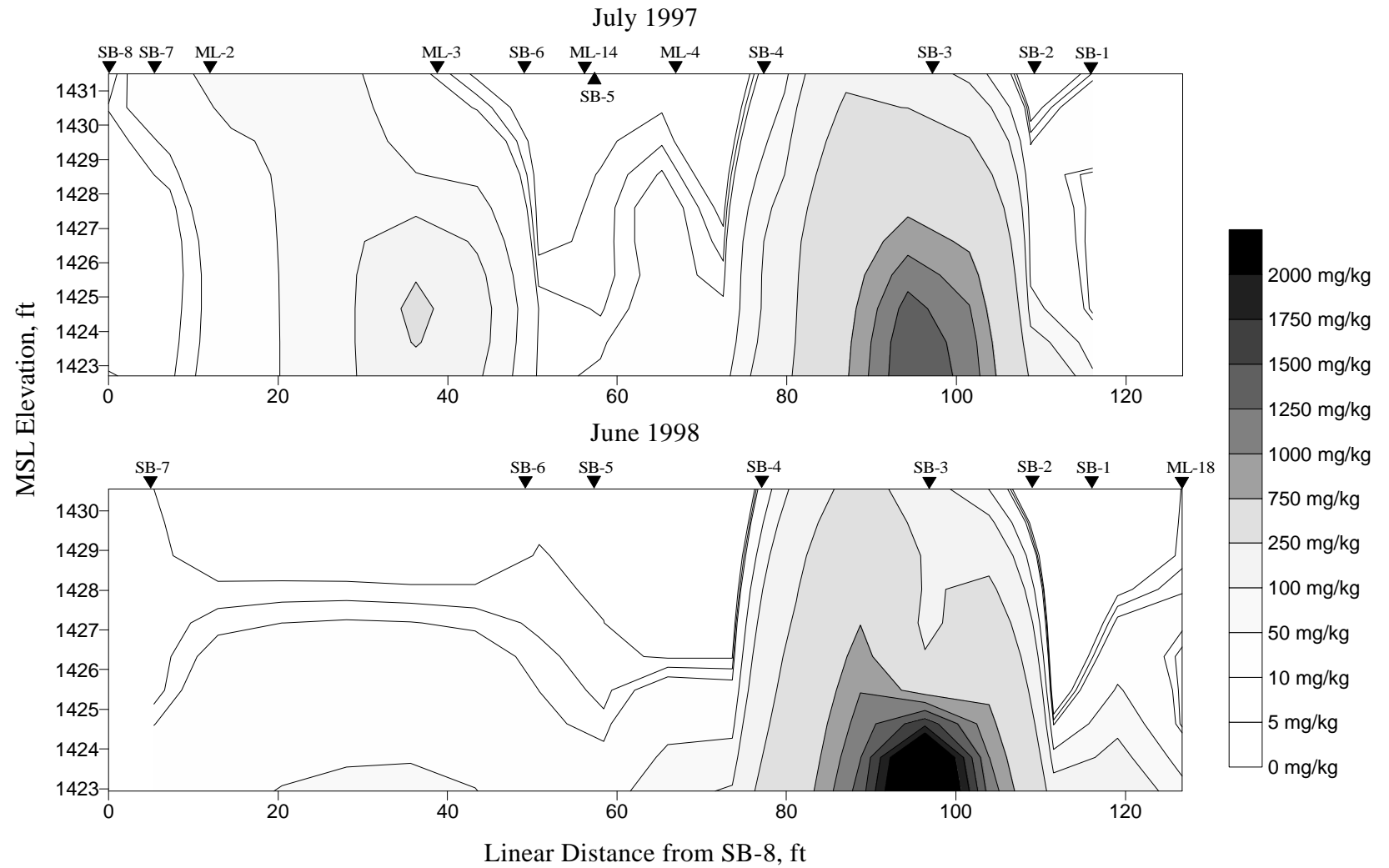


Figure A36: Transect 1 Soil Total PAH Concentration Profile

Transect 2: Soil Acenaphthene Concentration

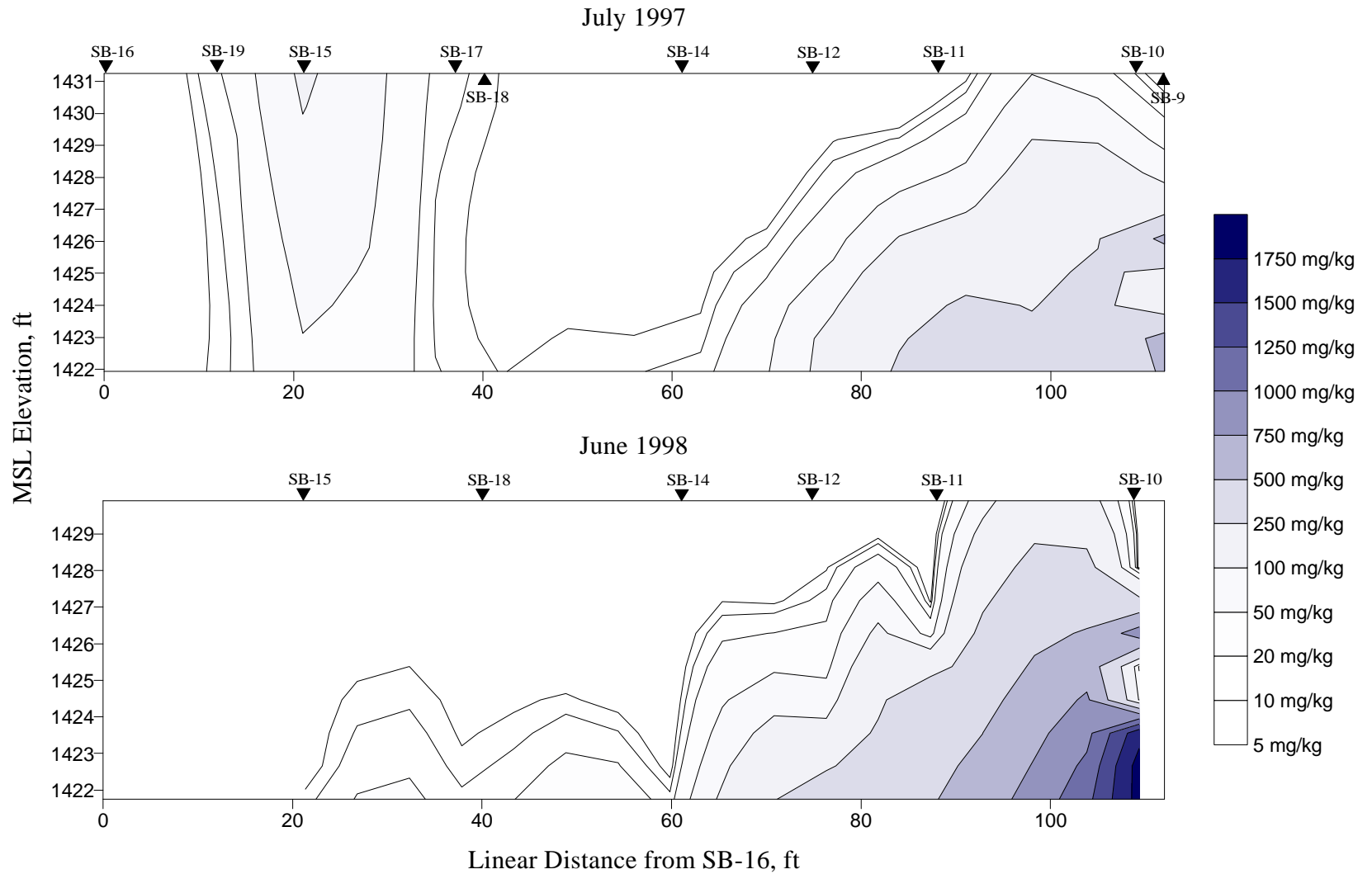


Figure A37: Transect 2 Soil Acenaphthene Concentration Profile

Transect 2: Soil Chrysene Concentration

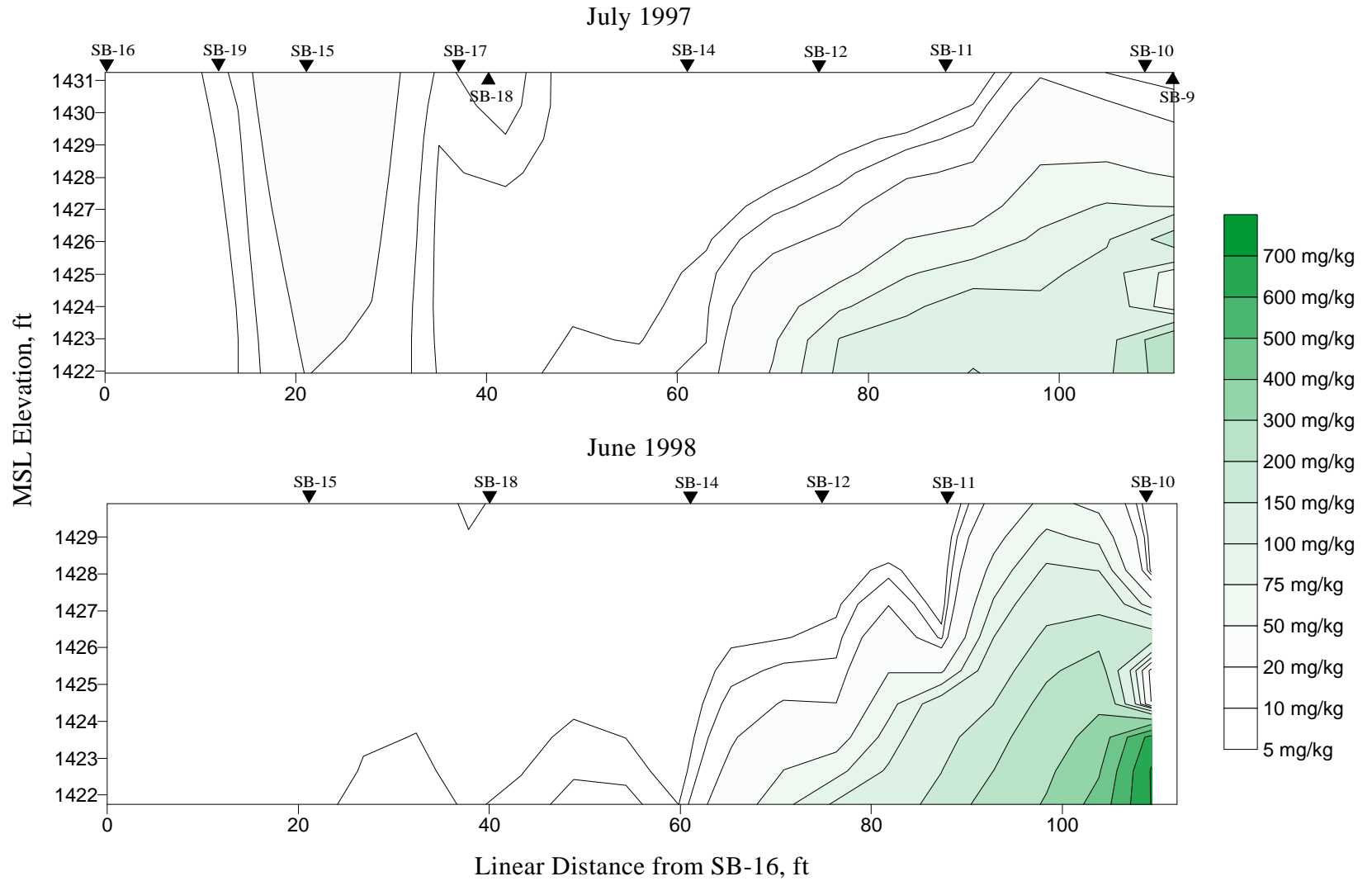


Figure A38: Transect 2 Soil Chrysene Concentration Profile

Transect 2: Soil Fluoranthene Concentration

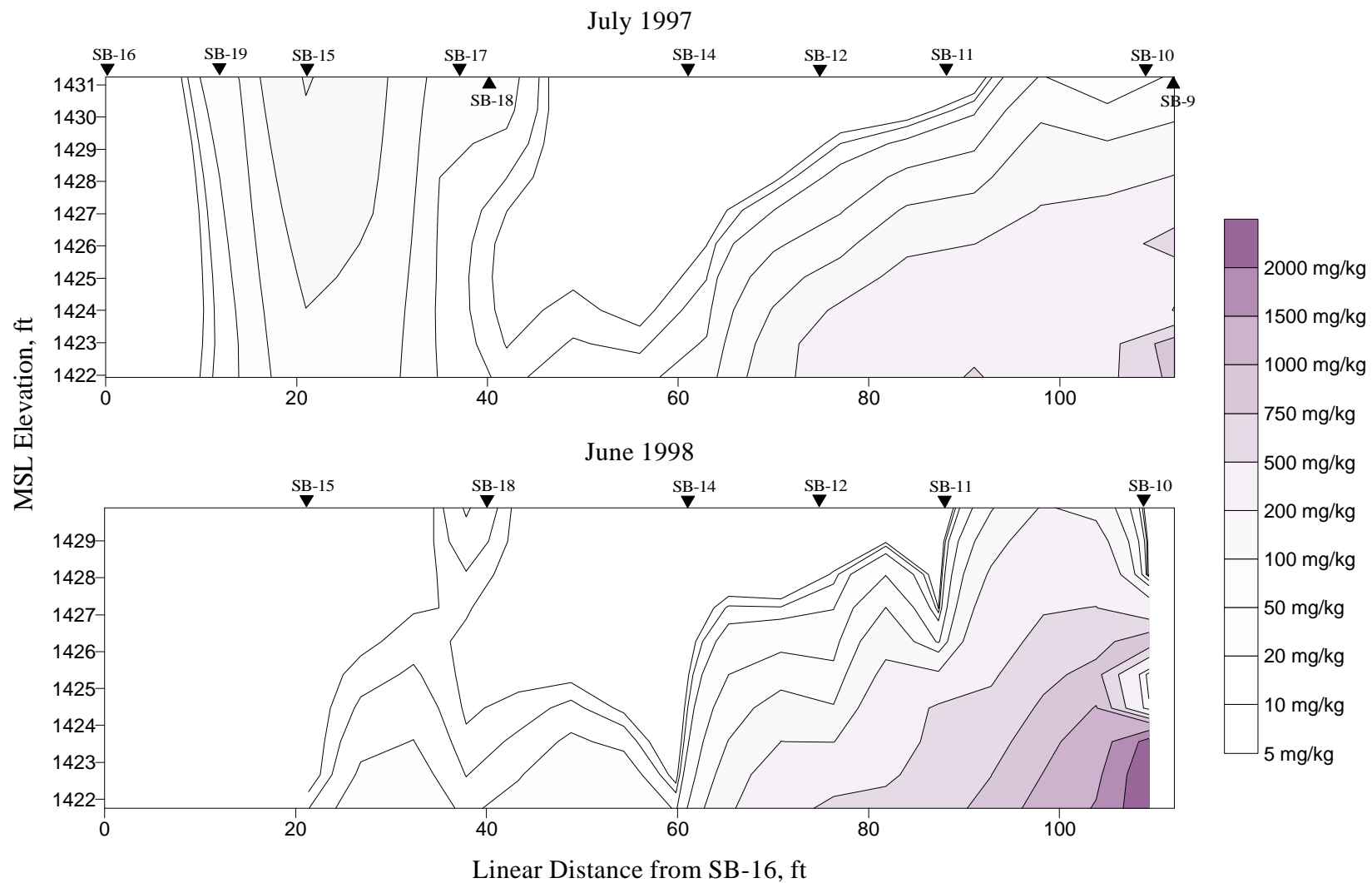


Figure A39: Transect 2 Soil Fluoranthene Concentration Profile

Transect 2: Soil Fluorene Concentration

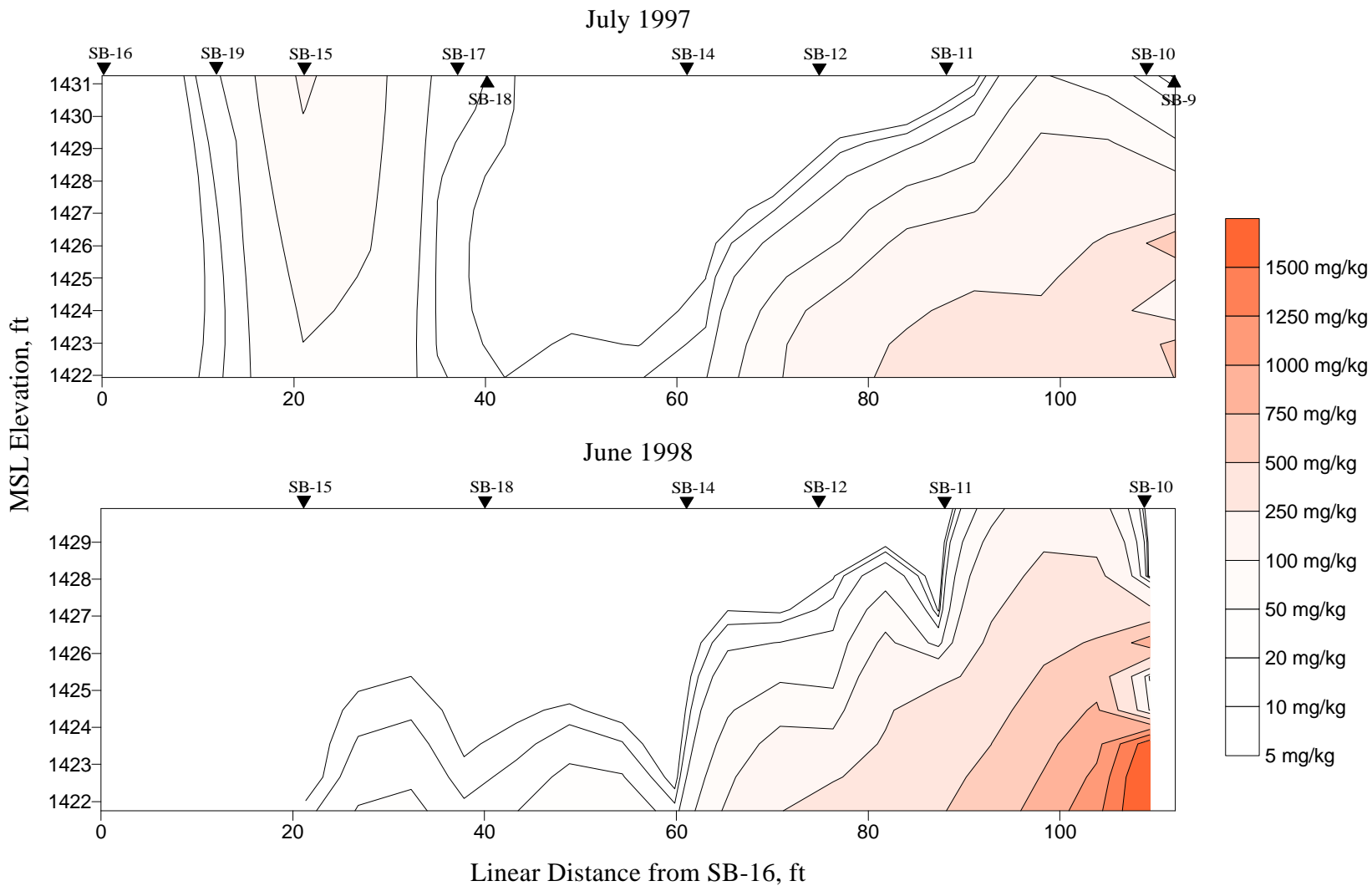


Figure A40: Transect 2 Soil Fluorene Concentration Profile

Transect 2: Soil Phenanthrene Concentration

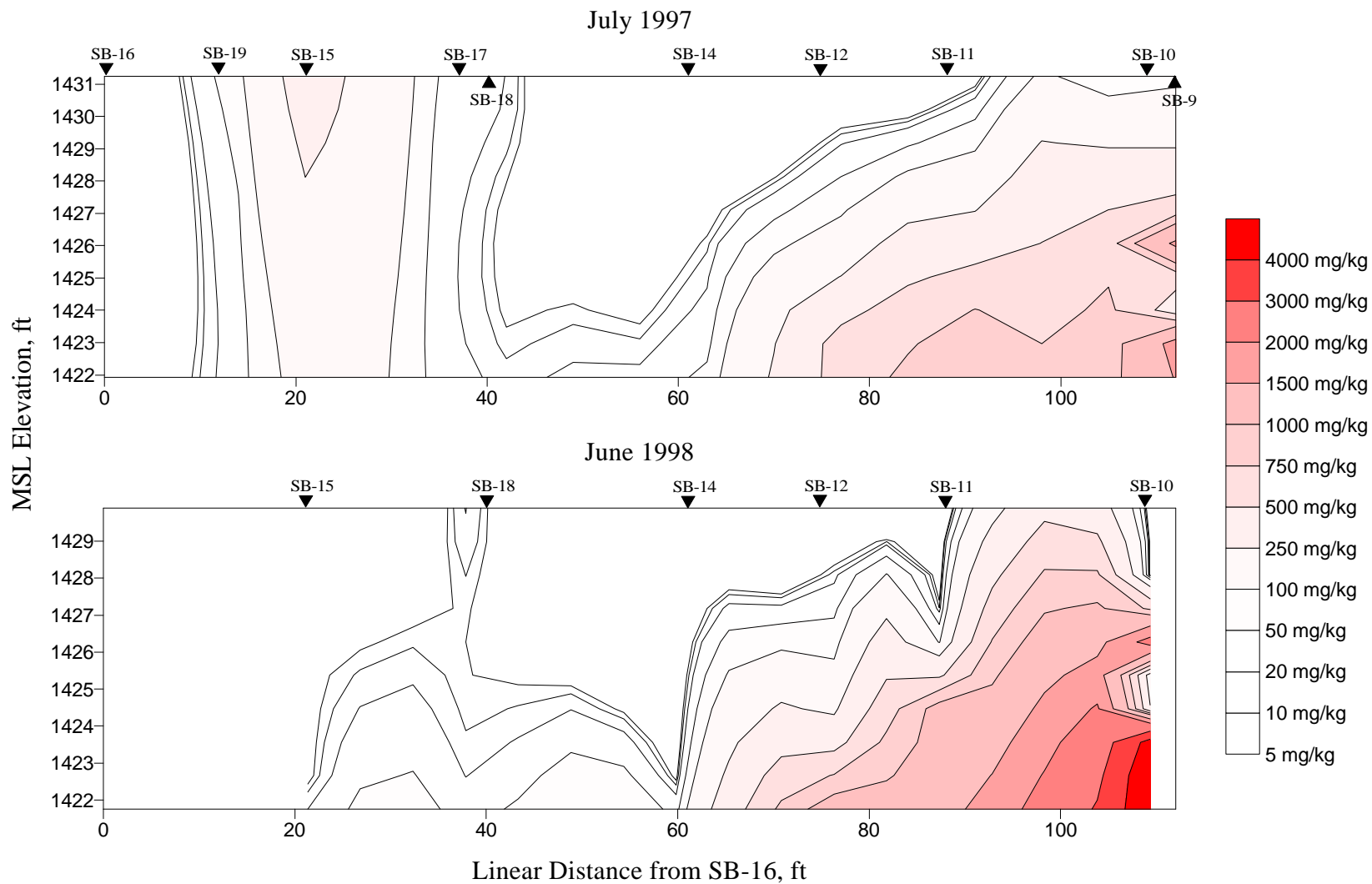


Figure A41: Transect 2 Soil Phenanthrene Concentration Profile

Transect 2: Soil Pyrene Concentration

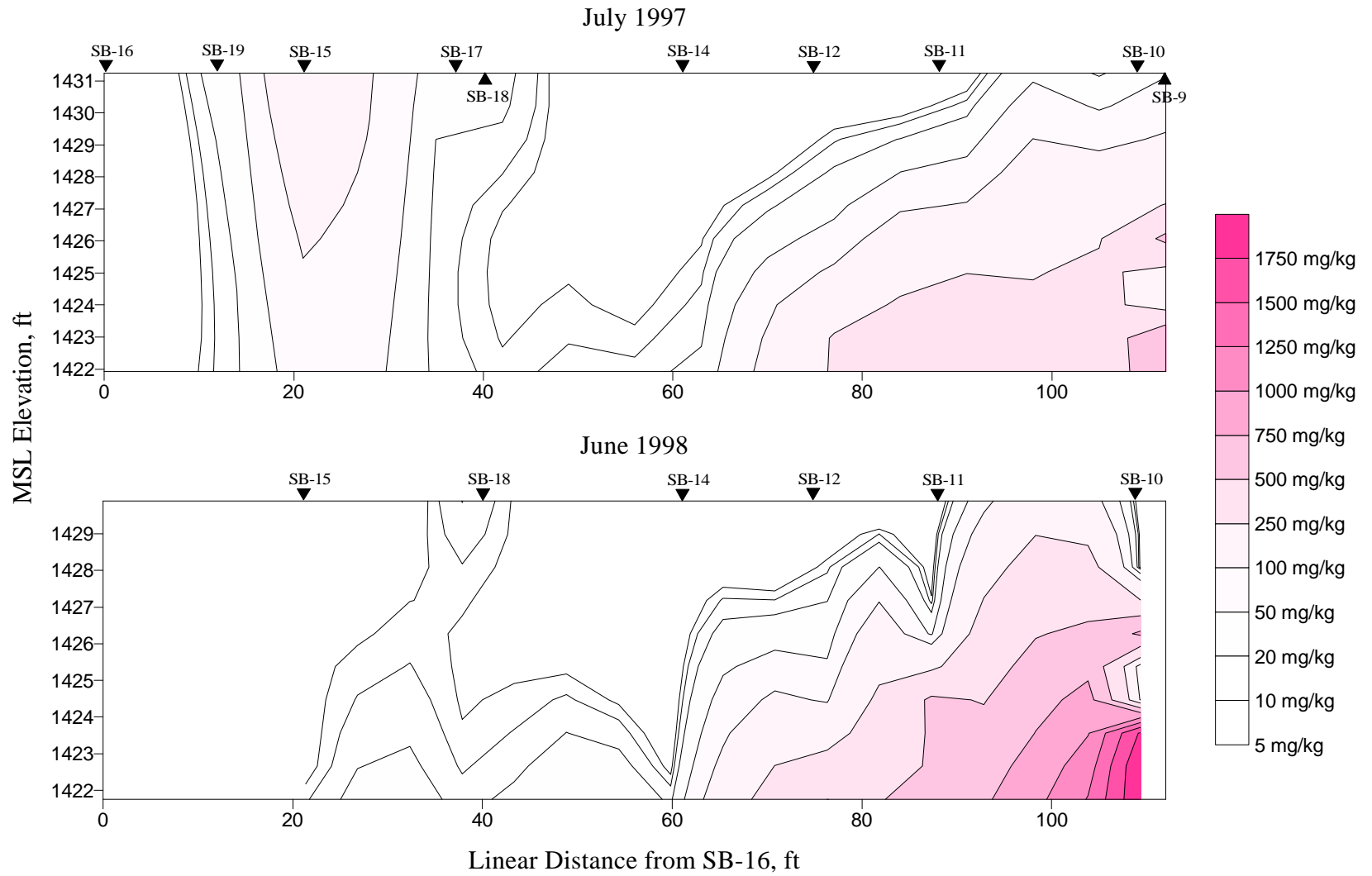


Figure A42: Transect 2 Soil Pyrene Concentration Profile

Transect 2: Soil Total PAH Concentration

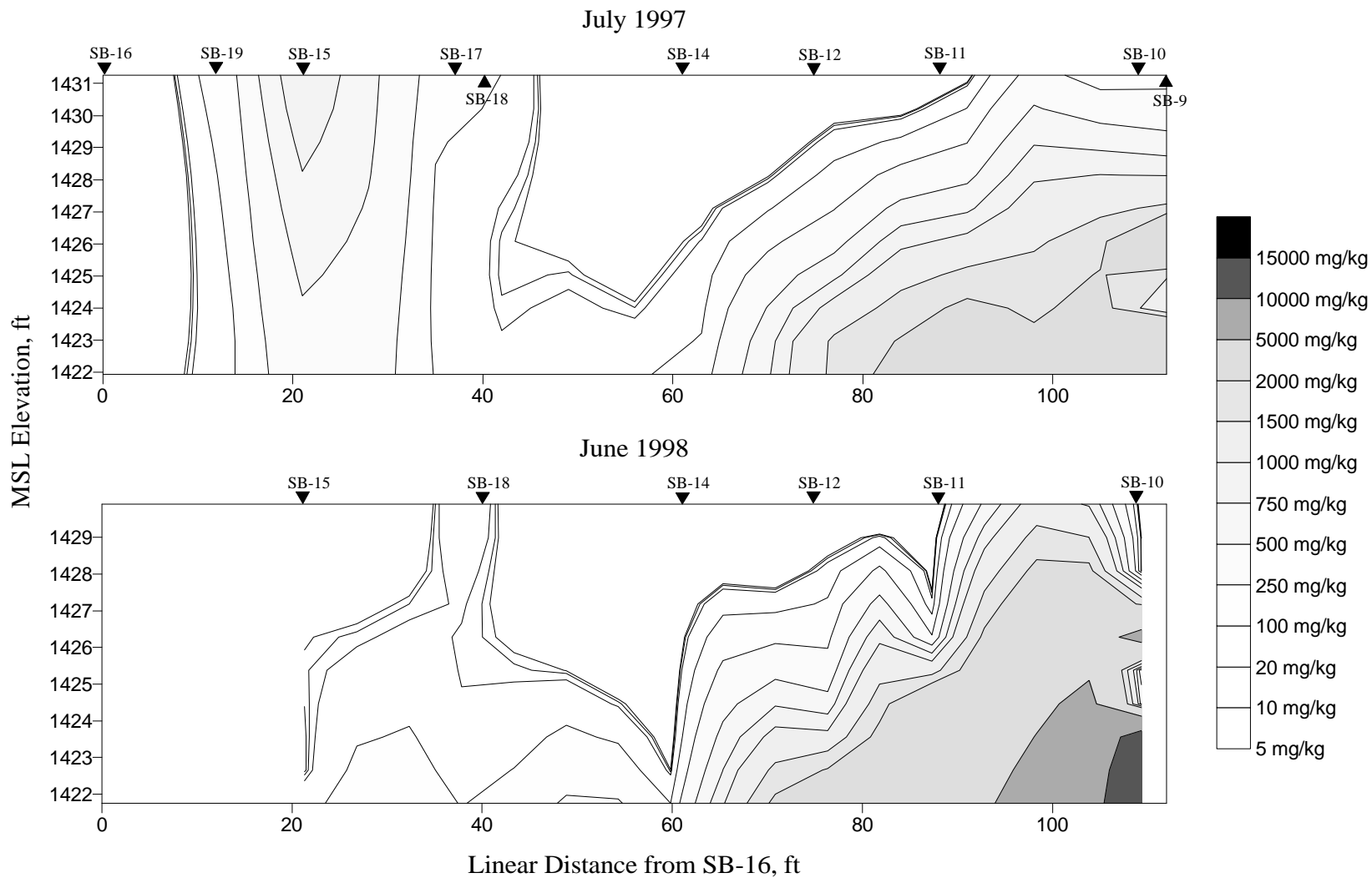


Figure A43: Transect 2 Soil Total PAH Concentration Profile

Multi-level Sampler 1

Elevation: 1432.52 ft

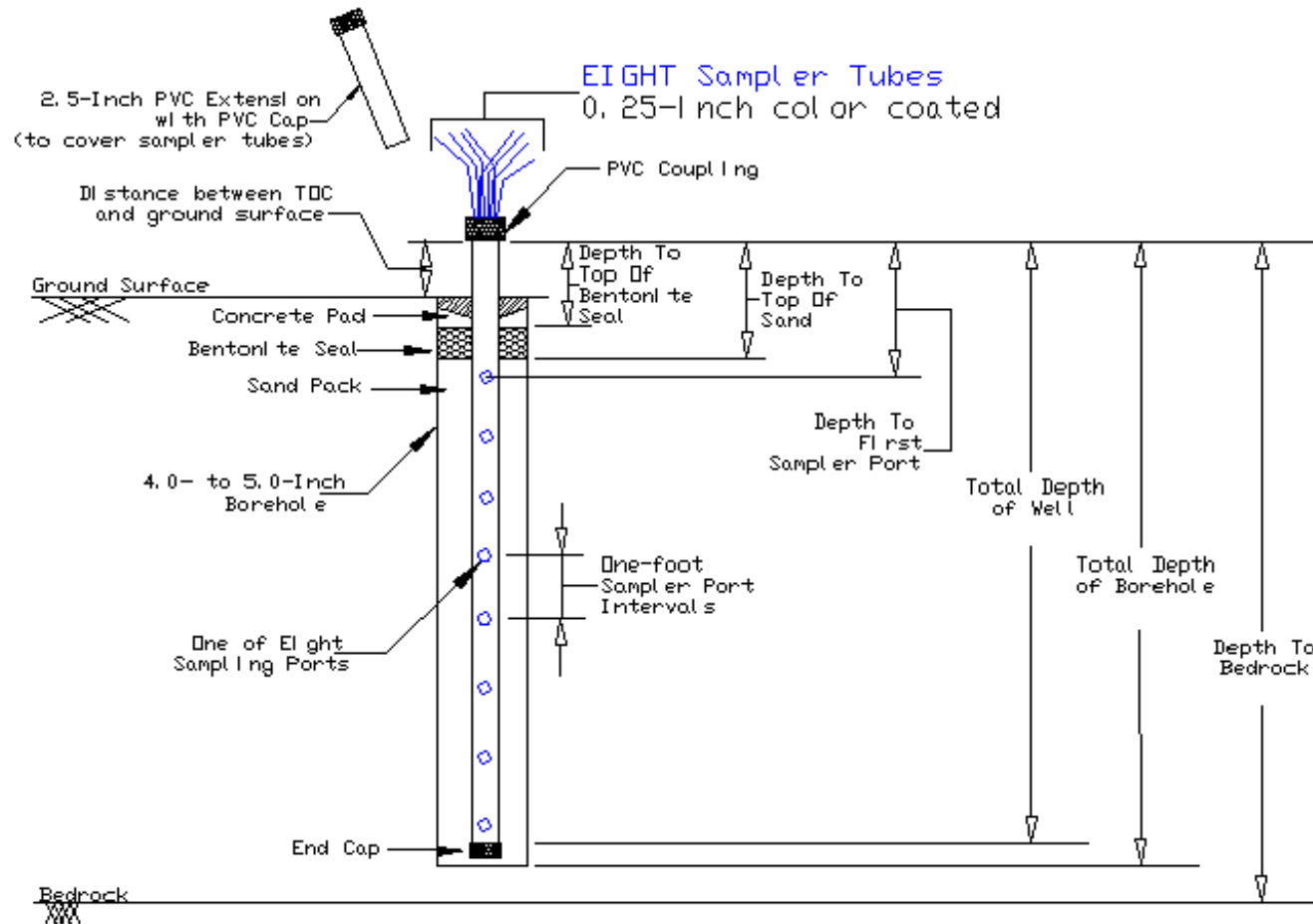


Figure A44: Diagram of a Multi-level Sampler

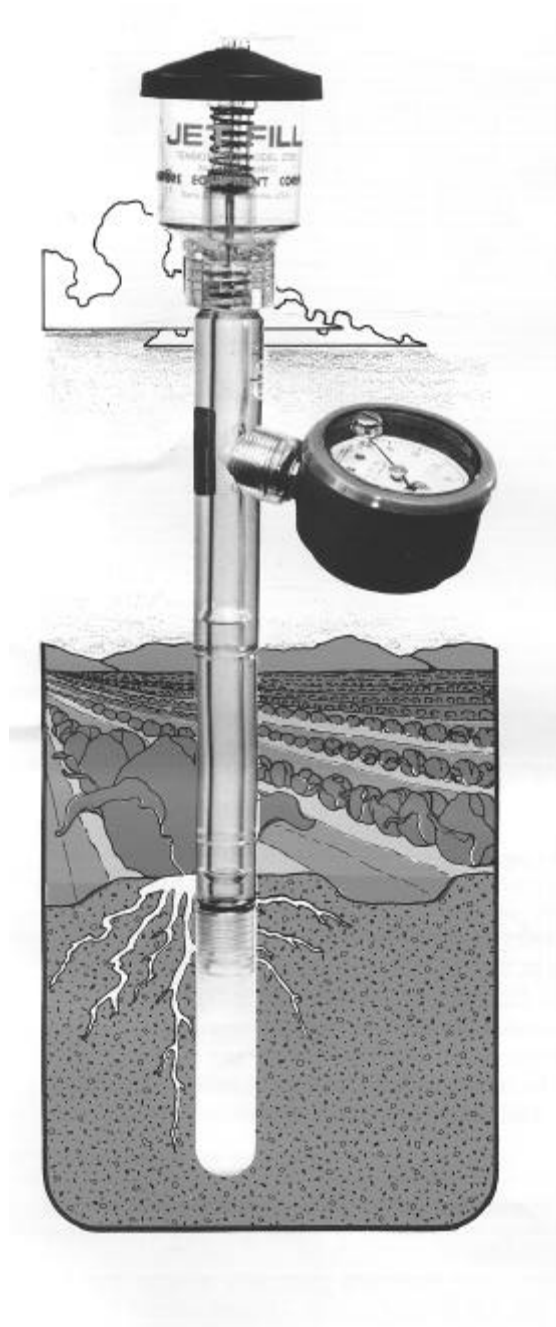


Figure A45: Tensiometer

Table A17: Tree Heights

Row 1

Tree Number	Position (feet)	Height (feet)	Marker	Tree Number	Position (feet)	Height (feet)	Marker
1	0	12.0		61	146.8	6.3	
2	2.7	9.5		62	150.1	3.8	
3	5	9.6		63	152.7	5.3	
4	7	11.3		64	158	5.0	
5	9.7	8.8		65	160.4	6.1	
6	14	10.8		66	162.8	6.9	
7	16.2	10.8		67	165.6	6.5	
8	18	10.2		68	169.1	7.0	
9	20	10.3		69	171.5	6.3	
10	22.2	12.0		70	173.8	6.8	
11	25.3	10.4		71	176.5	6.3	
12	27.5	11.1		72	178.9	6.5	
13	30	12.3	ml-13	73	184.4	7.2	
14	32.2	13.0	ml-13	74	186.6	7.5	
15	35	12.8		75	188.5	8.1	
16	37.3	12.0		76	191.7	7.8	
17	39.7	11.3		77	194.5	7.3	
18	42.4	8.5		78	197.5	6.9	
19	44.6	9.9		79	199.2	7.5	
20	46.6	10.3		80	201.9	5.3	
21	49	9.7		81	204.3	5.3	
22	50.8	9.2		82	206.5	5.3	
23	53.4	9.5		83	208.8	5.4	
24	55.5	9.1		84	210.9	5.1	
25	58	9.4		85	213.2	5.5	
26	60.1	11.2		86	215.1	7.5	
27	62.3	10.3		87	217.1	6.7	
28	64.2	9.1		88	219.3	6.3	
29	66.1	11.5		89	221.2	7.2	
30	68.4	8.0	ml3	90	223.6	7.7	
31	70.5	10.4		91	226	8.1	
32	73	6.3		92	228.1	8.3	
33	75.5	6.8		93	230.8	7.1	
34	78	7.3					
35	80.5	7.3					
36	82.5	7.3					
37	84.9	7.9					
38	87.5	9.3					
39	90	7.7					
40	92.2	8.8					
41	94.9	9.5					
42	97.2	8.3					
43	99.7	9.3					
44	102.4	8.1					
45	104.9	7.8					
46	107.9	9.2					
47	110.3	8.7					
48	113.4	8.4					
49	115.9	8.7					
50	118.2	8.5					
51	120.9	9.4					
52	123.1	8.6					
53	125.5	8.4					
54	128	7.9					
55	131	7.5					
56	133.1	7.8					
57	136	7.8					
58	138.8	8.3					
59	141.7	7.3					
60	144.7	7.6					

Row 2

Tree Number	Position (feet)	Height (feet)	Marker
1	0	13.0	#14 Row1
2	4.8	9.9	
3	9.2	10.2	
4	11.6	9.8	
5	13.5	9.8	
6	19	13.3	
7	21.7	12.8	
8	23.9	11.0	
9	26.2	12.7	
10	28.5	9.4	
11	30.9	10.0	ml3
12	33.7	9.8	
13	0	0.0	
14	0	0.0	
15	41.7	5.7	
16	43.9	8.4	
17	0	0.0	
18	48.7	7.2	
19	0	0.0	
20	52.3	8.3	
21	54.4	8.3	ml2
22	57.1	10.6	
23	59.7	9.1	
24	62.3	9.3	
25	65.3	8.2	
26	68.2	6.7	
27	70.6	9.0	
28	72.6	9.1	
29	75.2	9.7	
30	78.2	8.6	
31	80.8	7.3	
32	83.5	8.3	
33	86.5	8.0	
34	89.8	8.1	
35	93	9.0	
36	95.7	8.4	
37	98.2	6.2	
38	100.9	8.6	
39	103.6	8.3	
40	106.1	9.9	
41	109	7.6	
42	111.6	8.3	
43	114.2	8.1	
44	116.9	8.1	
45	119.1	8.3	
46	121.8	8.8	
47	124.2	7.1	
48	100.9	0.0	
49	129.5	5.3	
50	132.5	6.8	
51	135.3	6.4	
52	137.7	6.6	
53	139.8	8.3	
54	142.1	7.1	
55	144.6	8.3	
56	146.8	7.7	
57	148.6	8.3	
58	150.6	6.2	
59	153.4	8.6	
60	156.1	8.5	

Tree Number	Position (feet)	Height (feet)	Marker
61	158.9	7.8	
62	161.1	8.3	
63	164.4	8.3	
64	166.8	7.6	
65	171.6	6.1	
66	100.9	0.0	
67	176.4	5.8	
68	178.9	6.8	
69	181.3	7.1	
70	183.8	6.5	
71	186.4	7.1	
72	188.8	6.0	
73	100.9	0.0	
74	193.8	6.8	
75	196.5	7.0	
76	198.7	6.5	

Row 3

Tree Number	Position (feet)	Height (feet)	Marker
1	0	9.2	#12 Row1
2	3	15.0	
3	10.3	15.4	
4	13	15.3	
5	19.8	18.3	
6	24.5	17.1	
7	27.2	19.0	
8	29.4	19.4	
9	38.4	19.5	
10	40.7	10.2	
11	43	18.0	
12	45.8	16.0	
13	48.5	16.0	
14	50.8	12.0	
15	53.1	14.6	
16	55.3	13.7	
17	60.4	16.0	
18	64.9	10.4	
19	66.8	12.4	
20	69.2	14.4	
21	73.4	12.1	
22	75.6	13.1	
23	78.2	16.0	
24	80.6	14.3	
25	83	11.6	
26	95.5	14.5	
27	90.6	11.3	
28	92.4	8.7	
29	94.9	14.7	
30	97.7	13.6	
31	100.1	15.4	
32	102.1	16.3	
33	104.5	12.3	
34	106.5	10.4	
35	110.5	14.2	
36	113.1	14.6	
37	117.7	14.6	
38	120.3	14.2	
39	122.8	13.4	
40	124.8	13.3	
41	127.4	11.0	
42	132.2	14.3	
43	134.4	9.3	
44	138.7	11.5	
45	140.9	9.3	
46	143.5	12.6	
47	146.2	11.0	
48	148.5	9.9	
49	150.7	10.2	
50	153.2	10.2	
51	155.3	12.3	
52	157.9	8.9	
53	161.1	10.8	
54	165.6	9.0	
55	167.8	11.5	
56	169.9	10.4	
57	174.6	7.6	
58	176.7	8.8	
59	178.4	8.3	
60	180.2	10.4	
61	184.8	10.3	
62	186.7	9.5	
63	188.9	7.8	
64	191.4	10.0	
65	193.7	10.4	
66	195.8	8.2	
67	198.1	9.5	
68	204.1	10.3	

Row 4

Tree Number	Position (feet)	Height (feet)	Marker
1	0	10.0	
2	4.7	14.5	
3	10	3.6	
4	12	10.5	
5	20.2	16.5	
6	26.2	17.5	
7	30.8	5.0	
8	38.3	6.0	
9	40.5	17.0	
10	42.8	17.5	
11	47.8	17.0	
12	50.1	11.5	
13	52.6	15.5	
14	53.5	14.5	
15	60	17.0	
16	65.6	17.0	p4
17	70.3	18.5	p4
18	72.9	17.0	
19	75.2	18.0	
20	78.1	17.5	
21	80.8	17.3	
22	83.5	14.3	
23	85.5	14.0	
24	88.3	18.0	
25	90.6	18.3	
26	94	12.0	
27	96.4	15.5	
28	99.2	13.7	
29	101.5	14.0	
30	104.1	16.0	
31	107.1	12.2	
32	109.5	17.3	
33	111.8	12.2	
34	114.2	15.2	
35	116.8	16.2	
36	119.5	14.0	
37	122.8	17.0	
38	125.8	13.5	
39	128.1	12.5	
40	130.4	15.3	
41	134	10.0	
42	136.1	11.2	
43	139.1	11.0	
44	141.2	10.7	
45	143.3	9.5	
46	145.6	8.2	
47	147.7	8.0	
48	149.7	11.0	
49	151.9	9.5	
50	153.6	14.3	
51	158	13.3	
52	160.9	10.5	
53	163	13.3	
54	166.8	13.0	
55	169	8.5	
56	172	11.5	
57	174.7	11.0	
58	179	9.7	
59	186.7	8.3	
60	188.8	11.0	

Tree Number	Position (feet)	Height (feet)	Marker
61	193.6	7.3	
62	195.9	7.0	
63	198.5	9.0	
64	200.5	8.2	
65	253.7	9.3	
66	256.7	8.8	
67	259.6	8.5	
68	262.4	8.4	
69	265.1	7.5	
70	268.2	6.4	
71	271	8.0	
72	273.8	7.6	
73	276.9	6.6	
74	279.7	6.3	
75	282.1	7.7	
76	284.6	5.0	
77	287.3	8.0	
78	289.7	7.4	
79	292.1	6.7	
80	294.4	9.3	
81	297.1	8.6	
82	299.5	9.6	
83	301.9	8.8	
84	305	8.8	

Row 5

Tree Number	Position (feet)	Height (feet)	Marker
1	0	9.0	#12 Row1
2	5	12.5	
3	8.2	9.2	
4	10.8	12.6	
5	13.5	10.7	
6	18.5	14.1	
7	20.7	11.7	
8	25.5	16.0	
9	31.1	16.3	
10	33.5	13.7	
11	38	14.3	
12	40.2	16.0	
13	45.3	16.5	
14	52.7	14.3	
15	55	14.1	
16	57.5	12.3	
17	60.3	14.0	
18	63	14.0	
19	65.6	3.4	
20	71.1	15.6	
21	73.6	8.4	
22	78.1	17.1	
23	80.6	15.6	
24	82.9	15.0	
25	85.6	19.5	
26	88	16.5	
27	89.7	16.2	
28	92	16.3	
29	94.4	19.0	
30	96.9	17.1	
31	99.1	17.1	
32	101.6	18.0	
33	103.8	13.4	
34	106.3	15.3	
35	108	10.3	
36	110.8	16.3	
37	121	14.4	
38	126.8	15.0	
39	128.9	15.7	
40	133.7	13.6	
41	138.6	17.3	
42	141.6	12.8	
43	143.8	12.6	
44	146	11.7	
45	148.3	12.0	
46	150.9	11.3	
47	152.8	11.3	
48	155.7	13.3	
49	158.2	10.3	
50	160.2	12.0	
51	162.4	10.0	
52	164.2	11.3	
53	166.9	14.3	
54	172.6	12.3	
55	177.1	10.6	
56	185.8	8.0	
57	193.2	8.8	
58	196.2	9.2	
59	200.3	5.4	
60	203.2	10.8	

Tree Number	Position (feet)	Height (feet)
61	254.9	9.3
62	257.7	8.3
63	260.7	8.3
64	263.2	8.0
65	266	9.0
66	268.7	7.8
67	271.1	7.8
68	273.5	8.1
69	276	8.1
70	278.9	7.9
71	281.9	8.7
72	284.5	8.0
73	287	7.8
74	289.4	8.0
75	292.4	9.0
76	294.5	9.3
77	297.5	8.7
78	300	9.3
79	302.6	9.1
80	304.6	9.5
81	306.9	9.8
82	309.1	9.8
83	311.4	11.3
84	313.8	9.8
85	316.4	10.7

Row 6

Tree Number	Position (feet)	Height (feet)	Marker
1	0	10.2	#14 Row1
2	2.1	9.7	
3	12	10.8	
4	18.5	2.6	
5	20.5	7.4	
6	23.5	10.4	
7	26.3	10.0	
8	28.7	10.3	
9	31	9.8	
10	33.2	10.3	
11	36.2	11.0	
12	39.4	13.1	
13	43.2	14.2	
14	45.6	10.0	
15	48.3	10.8	
16	50.5	9.3	
17	53.2	11.8	
18	55.8	10.0	
19	58.2	9.4	
20	61.1	9.3	
21	64	10.5	
22	66.2	12.8	
23	68.8	11.8	
24	71.7	10.4	
25	86.6	13.1	
26	89.1	13.2	
27	91.8	13.7	
28	94.8	13.1	
29	97.4	11.7	
30	100.2	11.1	
31	103.5	12.4	
32	105.8	11.3	
33	108.6	10.3	
34	111.2	10.8	
35	113.8	10.9	
36	256.3	10.5	
37	119	10.4	
38	122.3	13.9	
39	124.7	10.3	
40	127.7	9.1	
41	130.7	8.1	
42	133.3	10.0	
43	135.9	8.8	
44	138.7	9.9	
45	142	11.3	
46	144.1	9.8	
47	146.6	9.8	
48	149.2	9.6	
49	152	9.4	
50	154.6	12.5	
51	157.1	8.5	
52	159.8	11.8	
53	162	9.9	
54	164.7	9.3	
55	167.4	6.8	
56	170.1	6.3	
57	173	6.4	
58	178.3	6.9	
59	181.9	6.7	
60	184.6	7.2	

Tree Number	Position (feet)	Height (feet)	Marker
61	186.9	7.3	
62	189.7	6.5	
63	192.3	8.0	
64	195.1	6.1	
65	197.7	6.8	
66	200.4	6.6	
67	203.2	7.6	
68	205.6	6.3	
69	208.2	7.1	
70	211	7.6	
71	214.1	7.8	
72	216.9	7.3	
73	219.1	5.4	
74	221.1	7.5	
75	223.7	7.9	
76	226.1	7.8	
77	228.5	8.2	
78	231.3	9.3	
79	233.7	8.6	
80	236.2	8.3	
81	238.7	8.7	
82	247.7	8.5	
83	250.3	8.3	
84	252.8	7.8	
85	255.4	8.2	
86	257.8	8.7	
87	260.4	7.7	
88	263	8.0	
89	265.3	8.3	
90	267.7	8.1	
91	270.1	7.8	
92	272.3	8.3	
93	274.3	8.1	
94	276.5	8.3	
95	279.2	7.6	
96	281.9	8.0	
97	284.1	7.3	
98	286.6	9.4	
99	288.8	9.9	
100	291.7	8.8	
101	294.4	10.3	
102	296.9	10.7	
103	299.7	10.3	
104	302.2	9.7	
105	304.4	8.5	
106	306.9	8.6	

Row 7

Tree Number	Position (feet)	Height (feet)	Marker
1	0	6.6	#11 row1
2	2.7	8.0	
3	5.4	11.7	
4	8	6.8	
5	15	16.5	nested piez
6	17.4	3.2	
7	23.2	13.5	
8	25.5	2.5	
9	30.1	11.3	
10	32.1	12.2	
11	34.2	9.1	
12	36.5	9.0	
13	38.9	9.1	
14	41	8.1	
15	43.2	10.9	
16	46.2	9.4	
17	48.5	10.3	
18	50.8	10.2	
19	53.2	10.4	
20	55.2	9.6	
21	57.7	9.1	
22	60.2	9.8	
23	63.9	9.3	
24	66	12.5	
25	68.2	8.3	
26	70.6	12.7	
27	73.5	11.2	
28	75.9	6.2	
29	78.3	15.2	edge of gp
30	82.9	9.5	edge of gp
31	84.8	7.5	
32	87.4	9.5	
33	89.5	9.8	
34	91.8	12.7	
35	94.1	10.2	
36	96.1	11.3	
37	104.4	5.3	
38	107.4	15.5	
39	112.3	12.8	
40	117	9.8	
41	119.2	11.6	
42	122.2	11.2	
43	126	14.7	
44	127.5	9.7	
45	139.8	6.1	
46	141.2	6.7	
47	143	9.7	
48	146.1	9.8	
49	147.9	9.2	
50	150.1	8.8	
51	152.3	9.3	
52	154.9	9.4	
53	157.2	9.5	
54	159.4	8.0	
55	162.2	9.7	
56	164.7	8.5	
57	167	8.1	
58	169.5	7.3	
59	172.1	8.4	edge of gp
60	174.2	7.7	

Tree Number	Position (feet)	Height (feet)	Marker
61	176.7	8.0	
62	178.7	7.0	
63	181.2	8.3	
64	184.7	8.9	
65	187.4	7.6	
66	189.6	7.7	
67	192.1	7.3	
68	194.6	8.3	
69	197	8.3	
70	199.1	7.2	
71	201.1	8.3	
72	204.3	8.4	
73	206.3	7.8	
74	208.4	7.8	
75	211.7	8.1	
76	213.6	6.7	
77	215.7	7.0	
78	218	7.2	
79	220.2	8.2	
80	223	8.2	
81	225.3	8.1	
82	227.9	8.6	
83	230	8.6	
84	231.9	7.8	
85	233.8	7.6	
86	235.9	7.5	
87	238.4	7.5	
88	240.8	7.8	
89	243.3	8.5	
90	245.8	8.4	
91	248.4	6.4	
92	250.9	8.5	
93	252.9	8.0	
94	255.6	9.1	
95	258.1	7.7	
96	261	8.2	
97	265.5	9.0	
98	267.7	9.0	
99	270.3	9.1	
100	273	8.2	
101	275.9	10.1	

Row 8

Tree Number	Position (feet)	Height (feet)	Marker
1	0	7.7	# 11 Row1
2	2.4	8.6	
3	5.4	10.3	
4	8.2	9.3	
5	10.6	14.0	
6	14.1	11.6	
7	16.9	12.8	
8	19.5	13.1	
9	21.8	13.3	
10	24.4	15.0	
11	27.1	16.5	
12	29.5	11.8	
13	31.9	10.1	
14	34.7	9.8	
15	37.2	9.1	
16	42.6	9.2	
17	45	8.7	
18	47.4	9.5	
19	49.5	9.0	
20	52.7	8.5	
21	58	8.5	
22	60.7	10.3	
23	64	5.4	
24	66.4	9.8	
25	69	7.8	
26	71.6	9.3	
27	74.5	9.0	
28	77.6	9.2	edge of gp
29	83.3	9.6	
30	85.9	10.6	
31	91.2	10.6	
32	93.7	11.2	
33	96.9	9.1	
34	100	8.8	
35	103	9.5	
36	105.1	5.7	
37	108.3	4.9	
38	111.4	7.4	
39	113.4	8.4	
40	116.3	8.1	
41	118.9	6.6	
42	122.6	5.0	
43	124	7.3	
44	125.6	5.8	
45	128	9.6	
46	130.7	9.3	
47	133	8.4	
48	135.3	9.7	
49	137.7	9.3	
50	140.2	8.9	
51	142.2	7.9	
52	144.9	8.9	
53	147.3	8.8	
54	149.6	7.1	
55	152.5	8.6	
56	154.4	7.6	
57	156.6	8.1	
58	158.9	8.8	
59	162.9	7.8	
60	165.3	7.7	mw3

Tree Number	Position (feet)	Height (feet)	Marker
61	178.8	9.1	edgeofgp
62	181.4	7.3	
63	184	9.0	
64	186.2	8.8	
65	188.8	9.2	
66	191.8	7.6	
67	194.9	9.0	
68	197.6	8.0	
69	199.9	8.8	
70	202.9	7.9	
71	205.2	9.4	
72	208	9.3	
73	210.1	9.1	
74	212.4	9.7	
75	215	9.1	
76	217.2	8.6	
77	219.5	7.5	
78	222.4	7.5	
79	224.7	8.0	
80	227.1	7.3	
81	230.8	8.8	
82	233.3	7.8	
83	236.2	7.7	
84	238.7	7.5	
85	240.8	6.8	
86	243.5	8.5	
87	246.1	9.8	
88	248.7	9.5	
89	251.7	7.7	
90	254.5	8.5	
91	260.7	7.5	
92	263.4	8.2	
93	266.1	8.0	
94	268.8	6.3	

Row 9

Tree Number	Position (feet)	Height (feet)	Marker
1	0	16.2	#12 Row1
2	2.6	8.4	
3	5.7	9.3	
4	8.4	9.7	
5	12	10.3	
6	14.3	3.0	
7	16.8	14.5	
8	19.7	16.4	
9	22	13.8	
10	24.1	15.1	
11	27.7	11.0	
12	30.4	8.3	
13	32.4	10.3	
14	35.3	9.9	
15	37.9	8.8	
16	40.4	10.0	
17	43.4	8.1	
18	45.8	8.8	
19	48	8.7	
20	50.4	10.3	
21	52.7	8.7	
22	55	9.6	
23	57.3	9.1	
24	60.1	10.3	
25	62.6	9.3	
26	64.7	9.0	
27	67.7	11.0	
28	73	4.9	
29	75.5	9.2	
30	80.8	8.4	
31	88.7	11.0	
32	91.5	7.3	
33	94.3	8.3	
34	96.9	8.0	
35	100	4.6	
36	102.7	7.8	
37	105.1	9.1	
38	107.6	13.2	
39	110.1	8.5	
40	113.2	9.4	
41	117	9.7	
42	121	9.3	
43	122.9	8.8	
44	125.6	8.1	
45	128.1	8.0	
46	133.4	8.8	
47	136.3	8.8	
48	138.7	8.7	
49	141.2	9.8	
50	143.2	7.6	
51	145.6	7.8	
52	150.6	8.0	
53	152.6	10.3	
54	155.5	8.5	
55	157.7	8.2	
56	160.6	7.5	
57	162.7	8.3	
58	165.1	5.0	
59	168.7	8.4	
60	172.1	9.0	

Tree Number	Position (feet)	Height (feet)	Marker
61	175	7.7	
62	177.7	7.0	
63	180.3	3.8	
64	183	8.8	
65	185.7	7.3	
66	188.3	7.6	
67	190.6	8.7	
68	193.3	9.0	
69	195.8	8.2	
70	198.3	8.3	
71	200.6	11.0	
72	202.4	7.8	
73	205.2	7.3	
74	207.2	7.3	
75	209.3	8.3	
76	211.8	8.1	
77	214.5	7.7	
78	217.2	8.4	
79	219.6	7.7	
80	221.7	8.4	
81	223.8	8.8	
82	227.2	13.2	
83	229.9	12.3	
84	232.5	11.6	
85	240.5	9.6	
86	246.4	9.8	
87	248.8	9.8	
88	251.6	8.7	
89	254.6	10.5	
90	257.3	7.1	

Row 10

Tree Number	Position (feet)	Height (feet)	Marker
1	0	7.8	#11 Row1
2	1.8	7.7	
3	5	8.4	
4	7.2	7.8	
5	9.3	8.3	
6	11.7	8.2	
7	14.4	7.8	
8	17.1	7.5	
9	19.4	8.3	
10	21.7	9.7	
11	24	10.0	
12	26.9	8.7	
13	29.7	10.1	
14	31.7	9.4	
15	34.2	9.3	
16	36.4	8.7	
17	38.5	8.1	
18	40.6	8.1	
19	43.2	7.2	
20	45.5	7.8	
21	47.9	7.8	
22	50.5	8.5	
23	53.1	7.7	
24	55.7	7.8	
25	58	8.3	
26	62.5	8.7	
27	65.4	8.1	
28	68	7.0	
29	70.8	8.7	
30	73.3	7.7	
31	75.4	7.8	
32	78	8.2	
33	80.7	7.7	
34	83.3	8.4	
35	85.5	8.0	
36	88.3	7.3	
37	91	9.8	

Row 11

Tree Number	Position (feet)	Height (feet)	Marker
1	0.0	10.8	
2	2.7	5.7	
3	6.1	9.8	
4	8.8	9.8	
5	11.7	9.0	
6	14.4	8.8	
7	18.1	7.8	
8	21.2	9.2	
9	23.6	10.7	
10	26.1	9.6	
11	31.0	9.0	
12	33.4	11.1	
13	36.4	10.0	
14	38.5	3.7	
15	40.9	8.5	
16	43.5	8.0	
17	45.9	7.2	
18	48.6	8.3	
19	51.2	8.1	
20	53.6	9.2	
21	58.6	8.8	
22	61.1	8.6	

Row 12

Tree Number	Position (feet)	Height (feet)	Marker
1	0	10.8	
2	2.7	8.8	ml15
3	11.6	9.1	
4	14.3	12.9	
5	17	9.6	
6	20	10.2	
7	22.8	12.5	
8	25.9	9.8	
9	29	9.9	
10	32	9.7	
11	34.5	9.6	
12	37	9.8	
13	39.4	9.6	
14	41.9	9.4	
15	44.5	9.5	
16	47.6	11.0	
17	50.4	10.0	
18	52.9	12.0	
19	56	12.5	
20	61.4	9.8	
21	64	9.0	

Row 13

Tree Number	Position (feet)	Height (feet)	Marker
1	0.0	12.3	
2	2.9	8.8	
3	6.5	8.8	
4	9.2	9.2	
5	11.7	10.3	
6	14.4	8.6	
7	16.7	9.3	
8	19.2	9.2	
9	21.7	7.4	
10	24.0	9.2	
11	26.7	8.4	
12	29.2	9.1	
13	31.8	7.9	
14	34.4	9.7	
15	37.3	10.2	
16	40.2	11.4	
17	43.1	8.6	
18	46.0	9.1	
19	48.3	10.2	
20	51.0	12.0	
21	52.0	9.0	
22	56.0	8.0	
23	58.0	6.2	

Row 14

Tree Number	Position (feet)	Height (feet)	Marker
1	0	8.4	
2	3.8	6.6	
3	6.5	8.2	
4	9.5	7.2	ml11
5	18.9	5.5	ml11
6	22.2	6.8	
7	24.8	6.6	
8	27.5	7.5	
9	30.4	6.2	
10	37.7	8.4	
11	39.7	7.3	
12	42.6	6.1	
13	45.9	7.1	
14	49	7.2	
15	51.6	6.3	
16	54.7	5.8	
17	58	5.9	
18	61.3	7.4	
19	64.1	7.3	
20	66.8	9.2	
21	69.6	8.3	
22	72.8	1.7	
23	75.8	4.8	
24	78.8	7.4	
25	82	7.3	
26	84.8	6.8	
27	87.7	6.8	
28	90.8	8.3	
29	93.9	6.5	

Row 15

Tree Number	Position (feet)	Height (feet)	Marker
1	0.0	8.7	
2	3.0	7.6	
3	6.0	7.1	
4	9.2	7.3	
5	12.8	8.6	
6	16.0	10.4	
7	18.8	9.3	
8	21.5	8.5	
9	24.6	6.2	
10	28.1	5.8	
11	31.0	7.6	
12	33.3	9.5	
13	39.7	6.7	
14	42.9	9.3	
15	45.8	7.0	
16	48.8	10.3	
17	52.1	8.2	
18	54.8	6.0	
19	58.1	5.1	
20	60.4	5.6	
21	63.2	7.4	
22	65.6	8.0	
23	69.0	8.2	
24	72.8	7.7	
25	75.0	7.5	
26	78.2	7.1	
27	81.1	6.3	
28	83.8	6.1	
29	86.7	8.2	

Row 16

Tree Number	Position (feet)	Height (feet)	Marker
1	0	7.3	
2	2.5	8.6	
3	6.9	8.4	
4	11.1	9.5	
5	14	9.7	
6	16.9	8.1	
7	20.3	9.3	
8	23.2	10.8	
9	26	11.0	
10	29.1	10.1	
11	31.5	10.0	
12	35.1	8.7	
13	38.1	8.8	4x4post
14	44.6	6.8	4x4post
15	47.3	6.3	
16	50.6	6.6	
17	53	6.8	
18	56	7.0	
19	59.4	6.8	weather st.
20	63	7.4	
21	66.2	7.1	
22	69	6.0	
23	72.1	6.4	
24	75	5.4	
25	77.8	6.3	
26	81.6	5.8	

Row 17

Tree Number	Position (feet)	Height (feet)	Marker
1	0	5.5	
2	2.5	7.6	
3	5.5	10.2	
4	9.2	10.0	
5	11.8	7.3	
6	14.6	9.4	
7	18.2	5.7	
8	21.6	6.2	
9	24.3	6.1	
10	27.3	7.5	
11	30.2	9.5	
12	33	10.1	
13	54.6	5.5	
14	57.2	6.4	
15	60.5	8.3	
16	63.2	6.6	
17	65.9	6.8	
18	68.6	6.4	
19	72.3	6.8	

Row 18

Tree Number	Position (feet)	Height (feet)	Marker
1	0	7.0	
2	3.3	7.2	
3	6.3	6.8	
4	9.3	3.6	
5	12.6	10.3	
6	15.4	11.8	ml10
7	17.6	6.7	
8	21.2	5.4	
9	24.2	4.6	
10	27.9	6.2	
11	30.4	7.3	
12	33.5	6.2	
13	36.6	9.1	
14	39.3	6.7	
15	42.3	6.8	
16	45.3	6.1	
17	48.4	5.3	

APPENDIX B: SAMPLE CALCULATIONS

December 1997 Triangle 1 Gradient Magnitude and Direction

Triangle 1		P-9, P-10, P-11		
Piezometer	Priority	Heads (ft)	X (ft)	Y (ft)
P-9	H-1	1425.80	1004.278213	363.5914667
P-10	H-2	1425.80	962.0046935	355.8906134
P-11	H-3	1426.10	961.1869335	398.4645067

Let $h_1 \leq h_2 \leq h_3$, so P-9, P-10, and P-11 were assigned to be h_1 , h_2 , and h_3 , respectively.

The following diagram and equations (Widdowson 1999) were then used:

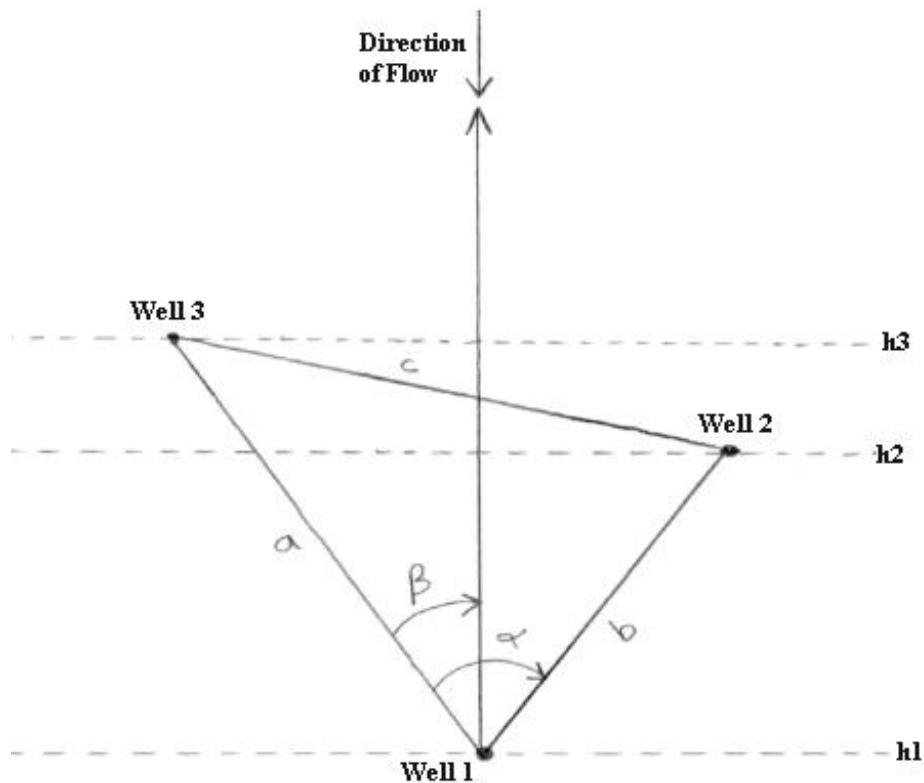


Figure B1: Diagram for Calculating the Gradient Magnitude and Direction

$$\text{Distance between two points} = \sqrt{(y_2 - y_1)^2 + (x_2 - x_1)^2}$$

$$a = \sqrt{(398.464 - 363.591)^2 + (961.187 - 1004.278)^2} = 55.43 \text{ ft}$$

$$b = \sqrt{(355.891 - 363.591)^2 + (962.005 - 1004.278)^2} = 42.97 \text{ ft}$$

$$c = \sqrt{(961.187 - 962.005)^2 + (398.464 - 355.891)^2} = 42.58 \text{ ft}$$

$$a = \cos^{-1} \left[\frac{a^2 + b^2 - c^2}{2ab} \right] = \cos^{-1} \left[\frac{55.43^2 + 42.97^2 - 42.58^2}{2 \cdot 55.43 \cdot 42.97} \right] = 49.3^\circ$$

$$b = \tan^{-1} \left\{ \frac{1}{\sin a} \left[\frac{(h_2 - h_1)a}{(h_3 - h_1)b} - \cos a \right] \right\}$$

$$= \tan^{-1} \left\{ \frac{1}{\sin 49.3^\circ} \left[\frac{(1425.80 \text{ ft} - 1425.80 \text{ ft}) \cdot 55.43 \text{ ft}}{(1426.10 \text{ ft} - 1425.80 \text{ ft}) \cdot 42.97 \text{ ft}} - \cos 49.3^\circ \right] \right\} = -40.69^\circ$$

$$i = \frac{h_3 - h_1}{a \cos b} = \frac{1426.10 \text{ ft} - 1425.80 \text{ ft}}{55.43 \text{ ft} \cdot \cos 49.3^\circ} = 0.007 \text{ ft / ft}$$

December 1997 Triangle 1 Velocity

$$q = ki = (4 \text{ ft / day}) (0.00713756 \text{ ft / ft}) = 0.02855 \text{ ft / day} \cong 0.029 \text{ ft / day}$$

where q = Darcy velocity (ft/day)

k = hydraulic conductivity (ft/day)

i = hydraulic gradient (ft/ft)

$$v = \frac{q}{n_e} = \frac{0.02855 \text{ ft / day}}{0.3} = 0.095167 \text{ ft / day} \cong 0.095 \text{ ft / day}$$

where v = groundwater velocity (ft/day)

n_e = effective porosity

Statistical Calculations for the Calibrated Model (Widdowson 1998)

$$\text{Mean Error} = \frac{1}{n} \sum_{i=1}^n (h_m - h_s)_i$$

$$\text{Mean Absolute Error} = \frac{1}{n} \sum_{i=1}^n |(h_m - h_s)_i|$$

$$\text{Root Mean Squared Error, RMS} = \sqrt{\frac{1}{n} \sum_{i=1}^n (h_m - h_s)_i^2}$$

where n = number of observation points
 h_m = measure hydraulic head (ft)
 h_s = simulated hydraulic head (ft)

Flowrate Leaving the Site

$$Q = k \cdot i \cdot A = \left(4 \frac{ft}{day} \right) \left(\frac{0.021 \frac{ft}{ft} + 0.034 \frac{ft}{ft}}{2} \right) (781 ft \cdot 6 ft) = 515.46 \frac{ft^3}{day}$$

where Q = flowrate leaving the site by way of the creek (ft³/day)
 k = hydraulic conductivity of the calibrated model (ft/day)
 i = average gradient of triangles 3 and 7 (ft/ft)
 A = length of the drain arc × average saturated thickness (ft²)

Sensitivity Analysis for Hydraulic Conductivity

$$X_n = \frac{\partial RMS}{\partial a_n / a_n} \approx \frac{RMS(a_n + Da_n) - RMS(a_n)}{Da_n / a_n} = \frac{1.62 - 1.18}{2/4} = 0.88 \text{ (Widdowson 1998)}$$

Poplar Uptake Rate

Once the ET rate was found, it was multiplied by the total area that the trees occupy. This area was found by constructing polygons around each group of trees using the map module in GIS. These polygons are shown in Figure A2. After the polygons were constructed, GIS gave the area of each. The product of the ET rate and tree area represented the total uptake in units ft³/day. This number was then divided by the total number of trees, which gave the individual uptake for each tree.

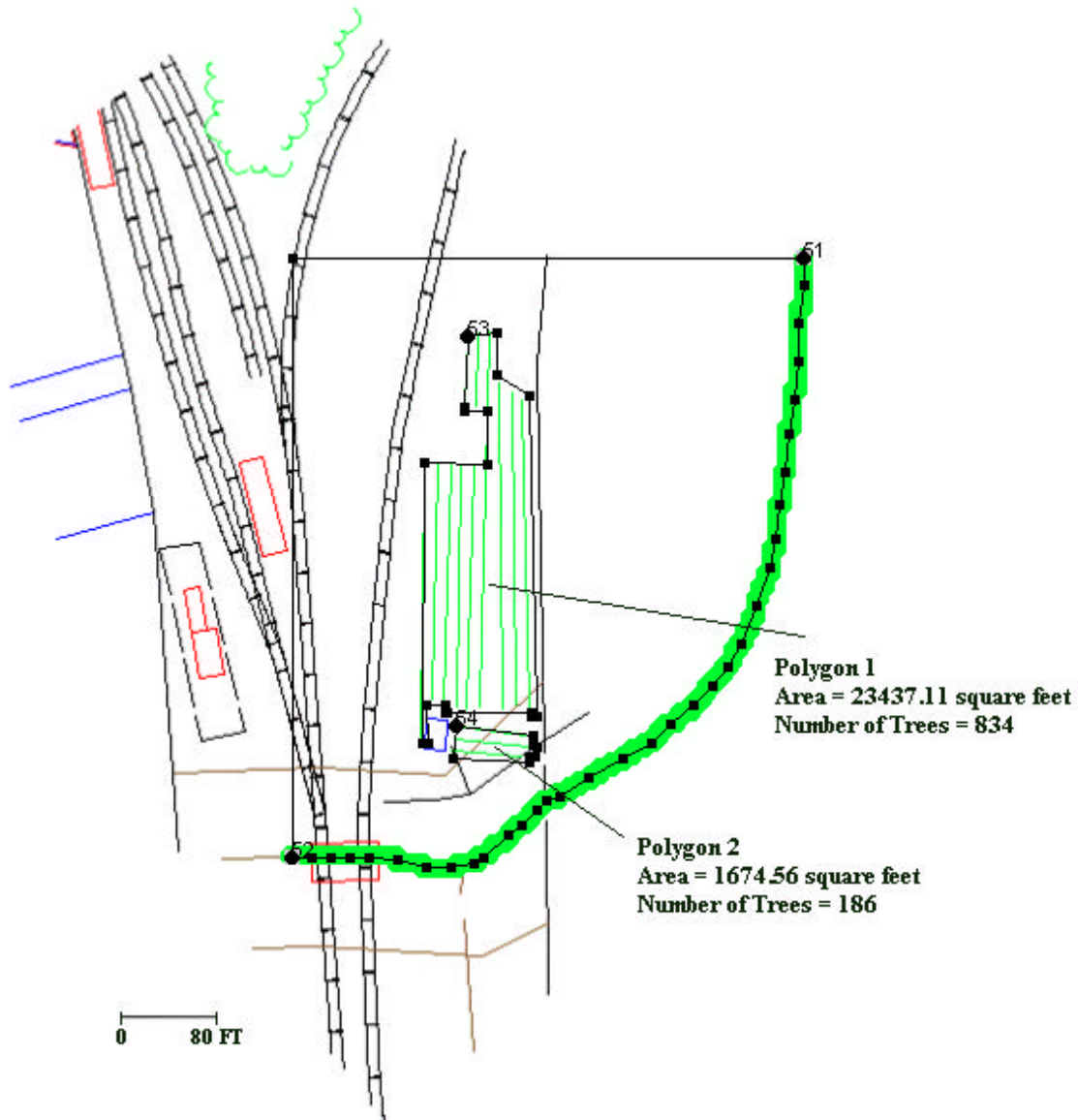


Figure B2: Location and Area of the ET Polygons

$$\text{Uptake Rate} = \frac{(\text{ET}) \cdot (\text{PA})}{\text{TR}}$$

where ET = evapotranspiration rate (ft/day)

PA = total area of Polygons 1 and 2 (ft²)

TR = total number of trees

$$= \frac{(0.025\text{ft/day})(23437.11\text{ft}^2 + 1674.56\text{ft}^2)}{(834\text{trees} + 186\text{trees})} \times \frac{7.48\text{gal}}{\text{ft}^3} = 4.6 \frac{\text{gal}}{\text{day}} \text{ per tree}$$

APPENDIX C: REGISTERING THE CONCEPTUAL IMAGE

The image used to construct the conceptual model for the Oneida Railroad site was created with an AutoCAD drawing provided by Geraghty & Miller, Inc. The AutoCAD drawing was first exported in the Drawing Exchange Format (DXF) extension. The DXF image was then imported into GMS and exported as a Tags Image File Format (TIF) image. The TIF image was then imported and registered with a global coordinate system. The coordinate system was set up using the coordinates from the rotated site drawing. [Figure B1](#), below, shows the location and values of the coordinates used.

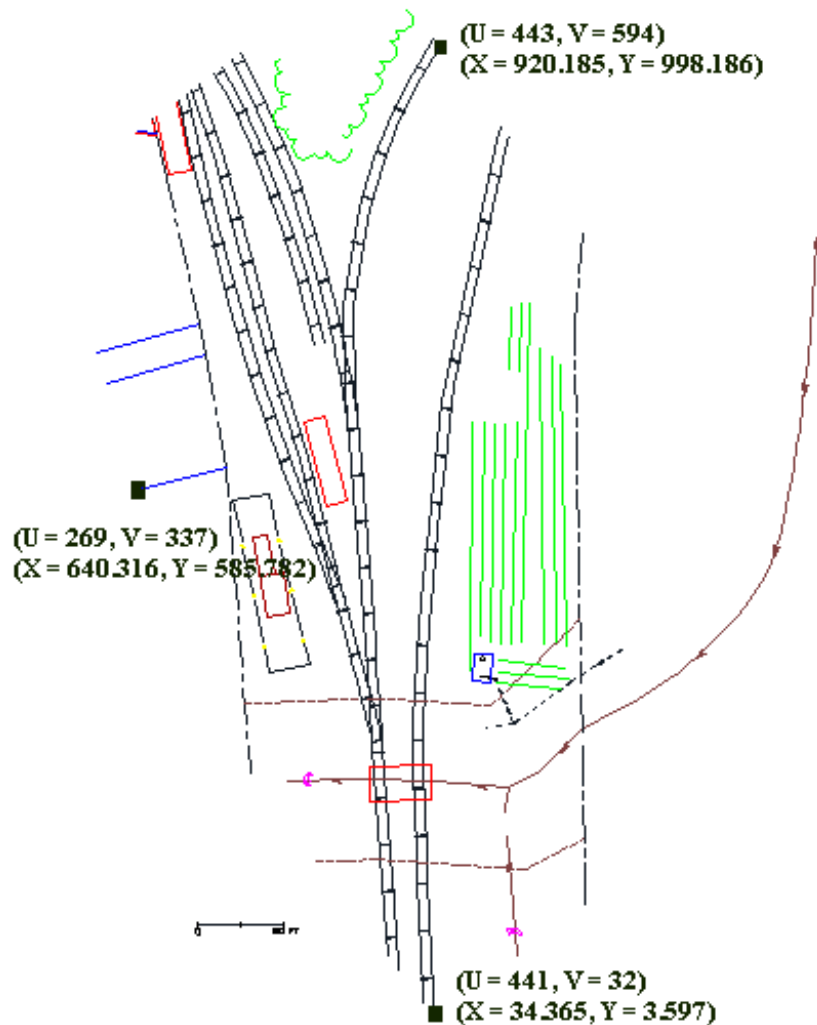


Figure 3.1: Location and Value of Coordinates to Register the Image

Figure C1: Location and Value of the Coordinates Used to Register the Conceptual Image

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1426.935303 1427.030029 1427.120117 1427.205200 1427.285278 1427.360107 1427.429810 1427.494141 1427.553223 1427.606934
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0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1414.859985	1414.976685	1415.117432	1415.284668	1415.482178	1415.715576	1415.994019	1416.332153
1416.748413	1417.213745	1417.694092	1418.162598	1418.592896	1418.959473	1419.234009	1419.375977	1419.306152	1419.107544
1418.895752	1418.691406	1418.512329	1418.382446	1418.340454	1418.386475	1418.506836	1418.682007	1418.894043	1419.136841
1419.454346	1419.773438	1420.065674	1420.325073	1420.549805	1420.740234	1420.859131	1420.909058	1420.925781	1420.917603
1420.888306	1420.840576	1420.776855	1420.699707	1420.611206	1420.513550	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1414.772095	1414.887817	1415.027588	1415.194214	1415.392212	1415.628784	1415.915283	1416.268677
1416.674316	1417.097412	1417.512695	1417.894897	1418.219482	1418.461426	1418.590820	1418.564697	1418.394043	1418.221436
1418.082764	1418.010620	1418.007813	1418.068970	1418.184570	1418.342407	1418.530151	1418.736938	1418.955322	1419.183472
1419.442017	1419.713257	1419.963257	1420.189453	1420.390503	1420.543945	1420.625000	1420.670288	1420.691162	1420.692383
1420.676514	1420.645874	1420.602051	1420.546997	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1414.690552	1414.805176	1414.943726	1415.109741	1415.308716	1415.549438	1415.845581	1416.193604
1416.559570	1416.919922	1417.251099	1417.530273	1417.735596	1417.845459	1417.838501	1417.721069	1417.625244	1417.583374
1417.594971	1417.656738	1417.762573	1417.904297	1418.073364	1418.261841	1418.462524	1418.670044	1418.881104	1419.095093
1419.319458	1419.559326	1419.783813	1419.990356	1420.169189	1420.279053	1420.348877	1420.393677	1420.419556	1420.429810
1420.426392	1420.411133	1420.385498	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1414.614990	1414.728394	1414.865723	1415.031128	1415.231567	1415.477539	1415.771484	1416.082886
1416.389771	1416.670532	1416.904541	1417.073853	1417.164307	1417.175903	1417.134521	1417.108032	1417.124268	1417.181396
1417.275269	1417.400757	1417.551758	1417.722290	1417.906982	1418.100952	1418.300293	1418.502075	1418.704590	1418.907471
1419.114014	1419.330444	1419.537964	1419.731201	1419.869507	1419.962036	1420.027588	1420.074341	1420.106201	1420.125610
1420.134521	1420.134033	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1414.545166	1414.656982	1414.792969	1414.958252	1415.161011	1415.405762	1415.666870	1415.923828
1416.157104	1416.349365	1416.484131	1416.560913	1416.602295	1416.612549	1416.628540	1416.678223	1416.759033	1416.867432
1416.999146	1417.150146	1417.316162	1417.493530	1417.678833	1417.869141	1418.062256	1418.256348	1418.450317	1418.643921
1418.838623	1419.038574	1419.233643	1419.398682	1419.512939	1419.597534	1419.662354	1419.712646	1419.751465	1419.780640
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000	0.000000

Drain Package for all Models

196	40			
196				
1	97	2	1422.0027	1.4611583
1	97	3	1422.0298	13.504382
1	97	4	1422.0788	13.504382
1	97	5	1422.1278	13.504382
1	97	6	1422.1768	13.504382
1	97	7	1422.2258	13.504382
1	97	8	1422.2747	13.504382
1	97	9	1422.3237	13.504382
1	97	10	1422.3727	13.504382
1	97	11	1422.4217	13.504382
1	97	12	1422.4707	13.504382
1	97	13	1422.5197	13.504382
1	97	14	1422.5687	13.504382
1	97	15	1422.6177	13.504382
1	97	16	1422.6667	13.504382
1	97	17	1422.7157	13.529037
1	97	18	1422.7648	13.534359
1	97	19	1422.8139	13.534359
1	97	20	1422.8630	13.534359
1	97	21	1422.9121	13.534359
1	97	22	1422.9532	9.1080823
1	98	22	1422.9781	4.6319265
1	98	23	1423.0118	13.976292
1	98	24	1423.0625	13.976292
1	98	25	1423.1132	13.976292
1	98	26	1423.1640	13.976292
1	98	27	1423.1915	1.2331252
1	99	27	1423.2168	12.692107
1	99	28	1423.2643	13.504382
1	99	29	1423.3133	13.504382
1	99	30	1423.3623	13.504382
1	99	31	1423.4113	13.504382
1	99	32	1423.4604	13.591064
1	99	33	1423.5055	11.231443
1	98	33	1423.5303	2.4592155
1	98	34	1423.5596	13.690658
1	98	35	1423.6093	13.690658
1	98	36	1423.6596	14.060335

1	98	37	1423.7123	14.982115
1	97	37	1423.7408	0.7665655
1	97	38	1423.7727	16.784492
1	97	39	1423.8184	8.4039478
1	96	39	1423.8517	9.9742759
1	96	40	1423.8943	13.490778
1	95	40	1423.9276	4.8874460
1	95	41	1423.9698	18.378224
1	95	42	1424.0035	0.1993839
1	94	42	1424.0368	18.178840
1	94	43	1424.0796	5.4049309
1	93	43	1424.1105	11.634431
1	93	44	1424.1602	15.748283
1	92	44	1424.1903	0.8473010
1	92	45	1424.2231	17.223850
1	92	46	1424.2666	6.8005789
1	91	46	1424.3013	12.297501
1	91	47	1424.3421	10.210951
1	90	47	1424.3768	8.8871298
1	90	48	1424.4176	13.621322
1	89	48	1424.4522	5.4767582
1	89	49	1424.4930	17.031694
1	88	49	1424.5277	2.0663866
1	88	50	1424.5605	16.024663
1	88	51	1424.6150	14.044769
1	88	52	1424.6601	10.769550
1	87	52	1424.6860	3.5116851
1	87	53	1424.7218	16.230247
1	87	54	1424.7691	9.8369437
1	86	54	1424.7985	6.3933036
1	86	55	1424.8395	16.230247
1	86	56	1424.8800	6.0692079
1	85	56	1424.9094	10.161039
1	85	57	1424.9573	16.230247
1	85	58	1424.9909	2.3014721
1	84	58	1425.0193	13.341608
1	84	59	1425.0715	15.448458
1	84	60	1425.1063	3.7354596
1	83	60	1425.1343	11.712999
1	83	61	1425.1836	15.448458
1	83	62	1425.2218	5.6113440
1	82	62	1425.2498	9.8371142

1	82	63	1425.2957	15.448458
1	82	64	1425.3373	7.4872284
1	81	64	1425.3652	7.9149559
1	81	65	1425.4073	15.304966
1	81	66	1425.4541	10.506008
1	80	66	1425.4819	4.7989587
1	80	67	1425.5184	15.304966
1	80	68	1425.5710	13.717318
1	79	68	1425.5988	1.5876485
1	79	69	1425.6294	15.304966
1	79	70	1425.6779	11.443638
1	78	70	1425.7123	7.5229792
1	78	71	1425.7532	14.985473
1	77	71	1425.7878	4.1126075
1	77	72	1425.8286	18.395844
1	76	72	1425.8633	0.7022359
1	76	73	1425.8981	18.499603
1	76	74	1425.9396	4.3761343
1	75	74	1425.9715	13.202632
1	75	75	1426.0166	11.658766
1	74	75	1426.0485	5.9199999
1	74	76	1426.0911	17.578766
1	74	77	1426.1255	1.3626319
1	73	77	1426.1576	16.380522
1	73	78	1426.2009	7.4826562
1	72	78	1426.2356	11.615424
1	72	79	1426.2764	10.893028
1	71	79	1426.3110	8.2050525
1	71	80	1426.3519	14.303399
1	70	80	1426.3865	4.7946808
1	70	81	1426.4258	16.876184
1	69	81	1426.4629	3.5742770
1	69	82	1426.4999	16.807993
1	68	82	1426.5391	4.8095659
1	68	83	1426.5761	15.572704
1	67	83	1426.6153	6.0448549
1	67	84	1426.6509	13.625997
1	66	84	1426.6966	11.514551
1	66	85	1426.7300	6.9113206
1	65	85	1426.7759	18.425871
1	64	85	1426.8120	1.4640754
1	64	86	1426.8454	16.961796

1	63	86	1426.8972	11.556778
1	63	87	1426.9289	5.9353150
1	62	87	1426.9707	17.141926
1	61	87	1427.0259	13.284420
1	61	88	1427.0570	3.8575060
1	60	88	1427.0951	17.141926
1	59	88	1427.1541	15.362229
1	59	89	1427.1852	1.7796969
1	58	89	1427.2195	17.141926
1	57	89	1427.2813	16.955690
1	56	89	1427.3156	1.9411069
1	56	90	1427.3462	14.921465
1	55	90	1427.4039	16.862571
1	54	90	1427.4509	9.0949248
1	54	91	1427.4815	7.7676467
1	53	91	1427.5262	16.862571
1	52	91	1427.5863	16.248743
1	52	92	1427.6169	0.6138287
1	51	92	1427.6479	16.479847
1	50	92	1427.7072	16.231076
1	49	92	1427.7661	16.231076
1	48	92	1427.8215	14.336366
1	48	93	1427.8510	1.8947091
1	47	93	1427.8838	16.217909
1	46	93	1427.9423	16.013824
1	45	93	1428.0004	16.013824
1	44	93	1428.0585	16.013824
1	43	93	1428.1166	16.013824
1	42	93	1428.1747	16.013824
1	41	93	1428.2203	9.1657701
1	41	94	1428.2495	6.9377388
1	40	94	1428.2914	16.161804
1	39	94	1428.3501	16.161804
1	38	94	1428.4087	16.161804
1	37	94	1428.4673	16.161804
1	36	94	1428.5078	6.1223045
1	36	95	1428.5369	9.9637979
1	35	95	1428.5840	15.995260
1	34	95	1428.6420	15.995260
1	33	95	1428.7001	15.995260
1	32	95	1428.7581	15.995260
1	31	95	1428.8161	15.995260

1	30	95	1428.8743	16.050474
1	29	95	1428.9292	14.266328
1	29	96	1428.9585	1.8690907
1	28	96	1428.9912	16.135419
1	27	96	1429.0497	16.135419
1	26	96	1429.1082	16.135419
1	25	96	1429.1668	16.135419
1	24	96	1429.2251	16.003755
1	23	96	1429.2711	9.3526683
1	23	97	1429.3001	6.6425921
1	22	97	1429.3411	15.995260
1	21	97	1429.3992	15.995260
1	20	97	1429.4572	15.995260
1	19	97	1429.5152	15.995260
1	18	97	1429.5731	15.925501
1	17	97	1429.6309	15.915879
1	16	97	1429.6886	15.915879
1	15	97	1429.7464	15.915879
1	14	97	1429.8041	15.915879
1	13	97	1429.8618	15.915879
1	12	97	1429.9198	16.061563
1	11	97	1429.9782	16.093937
1	10	97	1430.0311	13.101305
1	10	98	1430.0603	2.9926312
1	9	98	1430.0949	16.093937
1	8	98	1430.1533	16.093937
1	7	98	1430.2117	16.093937
1	6	98	1430.2698	15.959044
1	5	98	1430.3277	15.915879
1	4	98	1430.3854	15.915879
1	3	98	1430.4431	15.915879
1	2	98	1430.4860	7.7167843

Well Package for the Trench Model

28	40	
28		
1	89	18 -10.00000
1	89	19 -10.00000
1	89	23 -10.00000
1	89	26 -10.00000
1	89	29 -10.00000
1	89	31 -10.00000
1	88	33 -10.00000
1	88	35 -10.00000
1	86	39 -10.00000
1	84	42 -13.00000
1	83	43 -13.00000
1	82	45 -13.00000
1	81	46 -13.00000
1	80	48 -13.00000
1	79	50 -13.00000
1	78	52 -13.00000
1	77	54 -13.00000
1	76	56 -13.00000
1	75	58 -13.00000
1	74	59 -13.00000
1	73	61 -13.00000
1	71	63 -13.00000
1	70	64 -13.00000
1	69	66 -13.00000
1	68	67 -13.00000
1	67	68 -13.00000
1	89	16 -10.00000
1	66	69 -13.00000

0 5 -999.00 -999.00 1433.16 1433.16 1433.16 1433.16 1433.16 1433.16 1433.16 1433.16 1433.15 1433.15 1433.14 1433.14 1433.14 1433.13
 1433.12 1433.12 1433.11 1433.11 1433.10 1433.09 1433.08 1433.07 1433.06 1433.05 1433.04 1433.03 1433.02 1433.01 1433.00
 1432.98 1432.97 1432.96 1432.94 1432.93 1432.91 1432.90 1432.88 1432.86 1432.84 1432.83 1432.81 1432.79 1432.77 1432.75
 1432.72 1432.70 1432.68 1432.66 1432.63 1432.61 1432.58 1432.55 1432.53 1432.50 1432.47 1432.44 1432.41 1432.38 1432.34
 1432.31 1432.28 1432.24 1432.21 1432.17 1432.13 1432.09 1432.05 1432.01 1431.97 1431.93 1431.88 1431.84 1431.79 1431.74
 1431.69 1431.64 1431.59 1431.54 1431.48 1431.43 1431.37 1431.32 1431.26 1431.20 1431.14 1431.08 1431.01 1430.95 1430.89
 1430.82 1430.76 1430.70 1430.63 1430.57 1430.51 1430.45 1430.40 -999.00 -999.00
 0 6 -999.00 -999.00 1433.16 1433.16 1433.16 1433.16 1433.15 1433.15 1433.15 1433.15 1433.15 1433.14 1433.14 1433.13 1433.13 1433.12
 1433.12 1433.11 1433.11 1433.10 1433.09 1433.08 1433.08 1433.07 1433.06 1433.05 1433.04 1433.03 1433.02 1433.00 1432.99
 1432.98 1432.96 1432.95 1432.94 1432.92 1432.91 1432.89 1432.87 1432.86 1432.84 1432.82 1432.80 1432.78 1432.76 1432.74
 1432.72 1432.70 1432.67 1432.65 1432.63 1432.60 1432.57 1432.55 1432.52 1432.49 1432.46 1432.43 1432.40 1432.37 1432.34
 1432.31 1432.27 1432.24 1432.20 1432.16 1432.13 1432.09 1432.05 1432.01 1431.96 1431.92 1431.88 1431.83 1431.78 1431.74
 1431.69 1431.64 1431.58 1431.53 1431.48 1431.42 1431.37 1431.31 1431.25 1431.19 1431.13 1431.06 1431.00 1430.94 1430.87
 1430.81 1430.74 1430.68 1430.61 1430.55 1430.48 1430.42 1430.35 -999.00 -999.00
 0 7 -999.00 -999.00 1433.15 1433.15 1433.15 1433.15 1433.15 1433.14 1433.14 1433.14 1433.13 1433.13 1433.13 1433.12 1433.12
 1433.11 1433.10 1433.10 1433.09 1433.08 1433.08 1433.07 1433.06 1433.05 1433.04 1433.03 1433.02 1433.01 1433.00 1432.98
 1432.97 1432.96 1432.94 1432.93 1432.91 1432.90 1432.88 1432.87 1432.85 1432.83 1432.81 1432.79 1432.77 1432.75 1432.73
 1432.71 1432.69 1432.67 1432.64 1432.62 1432.59 1432.57 1432.54 1432.51 1432.48 1432.46 1432.43 1432.40 1432.36 1432.33
 1432.30 1432.26 1432.23 1432.19 1432.16 1432.12 1432.08 1432.04 1432.00 1431.96 1431.91 1431.87 1431.82 1431.77 1431.73
 1431.68 1431.63 1431.57 1431.52 1431.47 1431.41 1431.35 1431.30 1431.24 1431.18 1431.11 1431.05 1430.99 1430.92 1430.85
 1430.79 1430.72 1430.65 1430.58 1430.51 1430.44 1430.37 1430.30 -999.00 -999.00
 0 8 -999.00 -999.00 1433.14 1433.14 1433.14 1433.14 1433.14 1433.13 1433.13 1433.13 1433.12 1433.12 1433.12 1433.11 1433.11
 1433.10 1433.09 1433.09 1433.08 1433.07 1433.07 1433.06 1433.05 1433.04 1433.03 1433.02 1433.01 1433.00 1432.99 1432.97
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0HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 1, STRESS PERIOD 1

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VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

0	CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
	IN:		IN:	
	---		---	
	STORAGE = 0.0000		STORAGE = 0.0000	
	CONSTANT HEAD = 0.0000		CONSTANT HEAD = 0.0000	
	WELLS = 0.0000		WELLS = 0.0000	
	DRAINS = 0.0000		DRAINS = 0.0000	
	RECHARGE = 485.09		RECHARGE = 485.09	
	ET = 0.0000		ET = 0.0000	
0	TOTAL IN = 485.09		TOTAL IN = 485.09	
0	OUT:		OUT:	
	----		----	
	STORAGE = 0.0000		STORAGE = 0.0000	
	CONSTANT HEAD = 0.0000		CONSTANT HEAD = 0.0000	
	WELLS = 0.0000		WELLS = 0.0000	
	DRAINS = 485.11		DRAINS = 485.11	
	RECHARGE = 0.0000		RECHARGE = 0.0000	

	ET = 0.0000		ET = 0.0000	
0	TOTAL OUT = 485.11		TOTAL OUT = 485.11	
0	IN - OUT = -0.20813E-01		IN - OUT = -0.20813E-01	
0	PERCENT DISCREPANCY =	0.00	PERCENT DISCREPANCY =	0.00

0

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS

TIME STEP LENGTH	86400.0	1440.00	24.0000	1.00000	0.273785E-02
STRESS PERIOD TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02
TOTAL SIMULATION TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02

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 1432.84 1432.83 1432.81 1432.80 1432.78 1432.77 1432.75 1432.74 1432.72 1432.71 1432.69 1432.67 1432.65 1432.63 1432.61
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 1430.77 1430.71 1430.65 1430.59 1430.53 1430.47 1430.42 1430.36 -999.00 -999.00
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0HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 1, STRESS PERIOD 1

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VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

0	CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
	IN:		IN:	
	---		---	
	STORAGE = 0.0000		STORAGE = 0.0000	
	CONSTANT HEAD = 0.0000		CONSTANT HEAD = 0.0000	
	WELLS = 0.0000		WELLS = 0.0000	
	DRAINS = 0.0000		DRAINS = 0.0000	
	RECHARGE = 514.46		RECHARGE = 514.46	
	ET = 0.0000		ET = 0.0000	
0	TOTAL IN = 514.46		TOTAL IN = 514.46	
0	OUT:		OUT:	
	----		----	
	STORAGE = 0.0000		STORAGE = 0.0000	
	CONSTANT HEAD = 0.0000		CONSTANT HEAD = 0.0000	
	WELLS = 334.00		WELLS = 334.00	
	DRAINS = 180.49		DRAINS = 180.49	
	RECHARGE = 0.0000		RECHARGE = 0.0000	

	ET = 0.0000		ET = 0.0000	
0	TOTAL OUT = 514.49		TOTAL OUT = 514.49	
0	IN - OUT = -0.34241E-01		IN - OUT = -0.34241E-01	
0	PERCENT DISCREPANCY =	-0.01	PERCENT DISCREPANCY =	-0.01

0

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS

TIME STEP LENGTH	86400.0	1440.00	24.0000	1.00000	0.273785E-02
STRESS PERIOD TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02
TOTAL SIMULATION TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02

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0HEAD WILL BE SAVED ON UNIT 30 AT END OF TIME STEP 1, STRESS PERIOD 1

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VOLUMETRIC BUDGET FOR ENTIRE MODEL AT END OF TIME STEP 1 IN STRESS PERIOD 1

0	CUMULATIVE VOLUMES	L**3	RATES FOR THIS TIME STEP	L**3/T
	IN:		IN:	
	---		---	
	STORAGE = 0.0000		STORAGE = 0.0000	
	CONSTANT HEAD = 0.0000		CONSTANT HEAD = 0.0000	
	WELLS = 0.0000		WELLS = 0.0000	
	DRAINS = 0.0000		DRAINS = 0.0000	
	RECHARGE = 398.40		RECHARGE = 398.40	
	ET = 0.0000		ET = 0.0000	
0	TOTAL IN = 398.40		TOTAL IN = 398.40	
0	OUT:		OUT:	
	----		----	
	STORAGE = 0.0000		STORAGE = 0.0000	
	CONSTANT HEAD = 0.0000		CONSTANT HEAD = 0.0000	
	WELLS = 0.0000		WELLS = 0.0000	
	DRAINS = 245.33		DRAINS = 245.33	
	RECHARGE = 0.0000		RECHARGE = 0.0000	

	ET = 153.03		ET = 153.03	
0	TOTAL OUT = 398.35		TOTAL OUT = 398.35	
0	IN - OUT = 0.49316E-01		IN - OUT = 0.49316E-01	
0	PERCENT DISCREPANCY =	0.01	PERCENT DISCREPANCY =	0.01

0

TIME SUMMARY AT END OF TIME STEP 1 IN STRESS PERIOD 1

	SECONDS	MINUTES	HOURS	DAYS	YEARS

TIME STEP LENGTH	86400.0	1440.00	24.0000	1.00000	0.273785E-02
STRESS PERIOD TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02
TOTAL SIMULATION TIME	86400.0	1440.00	24.0000	1.00000	0.273785E-02

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VITA

David R. Loftis was born on November 24, 1975, in Halifax, Virginia. He attended Halifax County High School. In June 1993, he graduated and began his career at Virginia Polytechnic Institute and State University in August 1993. In May 1997, he graduated from Virginia Polytechnic and State University with a B.S. in Civil/Environmental Engineering. In August 1997, he began work on a Master's Degree in Civil Engineering. In June 1999, he will begin work with S & ME, Inc. in Greensboro, North Carolina, as a staff engineer.