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Phase I Groundwater Investigation

Jackson County Landfill

Jackson County, North Carolina

Prepared For:
Jackson County
401 Grindstaff Cove Road
Sylva, North Carolina 28779

March 4, 1999

Prepared By:
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THE FLETCHER GROUP
Engineering and Environmental Solutions

March 4, 1999

Mr. Mark Poindexter
Department of Environment and Natural Resources
Division of Waste Management
401 Oberlin Road; Suite 150
Raleigh, North Carolina 27065

Subject: Jackson County Landfill
Phase I Groundwater Investigation

Dear Mr. Poindexter:

On February 10, 1999 The Fletcher Group submitted a preliminary Phase I report. I stated at the time that additional laboratory data had not been received. That data has been received and evaluated. Enclosed please find the final Phase I Groundwater Investigation report.

We anticipate submitting a workplan for the Phase II Groundwater Investigation on March 11, 1999. We would like to discuss that plan with you prior to beginning the field activities. I will call you on March 5, 1999 to discuss your availability for a telephone meeting on March 11 or 12, 1999.

Thank you for your assistance with this project.

Sincerely,

James S. McElduff, P.E.
Project Engineer

enclosure

cc: Mr. Jay Denton/Jackson County

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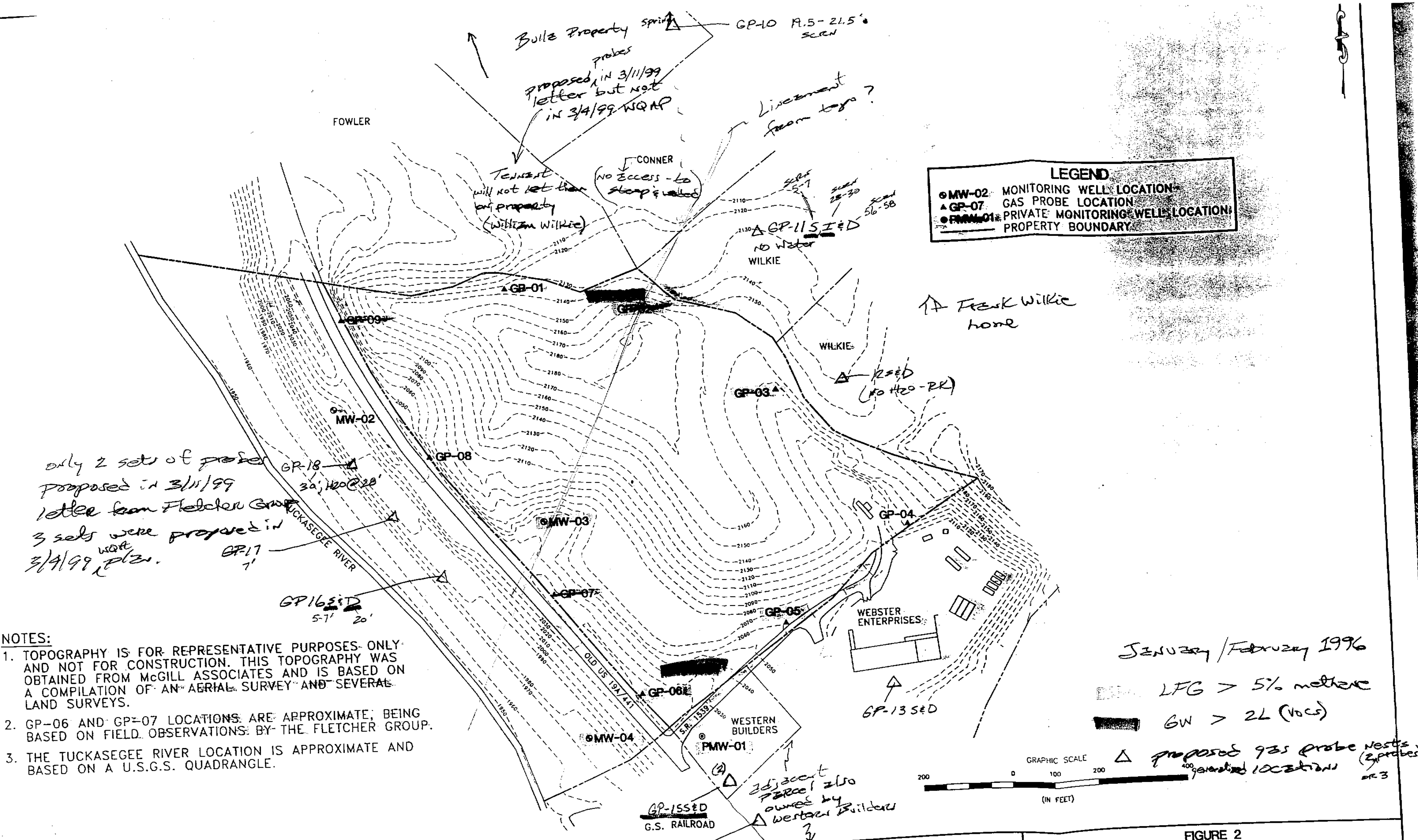

NOTES:

1. TOPOGRAPHY IS FOR REPRESENTATIVE PURPOSES ONLY AND NOT FOR CONSTRUCTION. THIS TOPOGRAPHY WAS OBTAINED FROM McGILL ASSOCIATES AND IS BASED ON A COMPILATION OF AN AERIAL SURVEY AND SEVERAL LAND SURVEYS.
2. GP-06 AND GP-07 LOCATIONS ARE APPROXIMATE, BEING BASED ON FIELD OBSERVATIONS BY THE FLETCHER GROUP.
3. THE TUCKASEGEE RIVER LOCATION IS APPROXIMATE AND BASED ON A U.S.G.S. QUADRANGLE.

THE FLETCHER GROUP Engineering and Environmental Solutions ASHEVILLE, NORTH CAROLINA	FIGURE 2 MONITORING WELL AND METHANE PROBE LOCATION MAP JACKSON COUNTY LANDFILL JACKSON COUNTY, NORTH CAROLINA

DRAWN BY: JOHNC. PROJ MAN: CDE DATE: 02-11-99 CADD FILENAME: P:\OASHVIL\JACKSON CO.040\LANDFILL.01\204001F2.DWG

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1.0 Introduction

In January, 1999 Jackson County (County) retained The Fletcher Group to develop a response plan and implement a program to meet North Carolina Department of Environment and Natural Resources (DENR) groundwater investigation requirements. DENR requested that the results of the initial investigation (Phase I) be submitted on February 10, 1999. The request by DENR for the investigation was based on previously identified groundwater contamination.

On February 10, 1999 The Fletcher Group provided a letter report to DENR. The letter report contained the Phase I findings along with related conclusions and recommendations. As described in that letter, additional data had not been received from the laboratory at that time. Since February 10, 1999, these additional data have been received and evaluated by The Fletcher Group. This report updates the February 10, 1999 letter with the complete Phase I findings, conclusions, and recommendations.

This report provides information on four subjects:

- Background information that describes the regulatory requirements associated with the investigation.
- The purpose of the Phase I investigation.
- A description of the Phase I site characterization activities, findings, and conclusions.
- Recommendations for additional investigation, in accordance with DENR requirements.

1.1 Background

Jackson County (County) owns a closed Municipal Solid Waste Landfill located near Dillsboro, North Carolina. The landfill location is shown on Figure 1. Four groundwater monitoring wells were installed near the perimeter of the landfill in 1992 and a fifth monitoring well was drilled in 1994. The monitoring well locations are shown on Figure 2. In November 1992, the County initiated a *detection* groundwater monitoring program as required by the North Carolina Solid Waste Management Rules; 15A North Carolina Administrative Code (NCAC) 13B. The detection monitoring program included laboratory analysis of the suite of chemicals referred to as Appendix I.

By approximately April, 1996, results of the groundwater monitoring program showed specific Appendix I constituents at concentrations that were determined to be greater than background. As required by the Solid Waste Rules, the County implemented an *assessment* groundwater monitoring program. This latter monitoring program is based on an expanded suite of constituents known as the Appendix II list. In correspondence from DENR to Jackson County dated March 13, 1998, DENR required the County to conduct additional investigation as a result of the presence of compounds included on the Appendix II list. This investigation must be conducted in accordance with the Title 15A NCAC 13B regulations.

1.2 Purpose

The Phase I activities, and others that will be conducted subsequently, comprise a series of related tasks that are being completed to characterize the nature and extent of the groundwater contamination. Phase I focused on accomplishing the following three goals:

- Determining whether groundwater contamination at the landfill poses an immediate risk to the local residents.
- Assessing the likelihood that landfill gas has an adverse affect on groundwater quality.
- Evaluating onsite and nearby hydrogeology.

Finally, the results of Phase I have been used to define the scope of additional tasks that will further evaluate the horizontal and vertical extent of groundwater contamination.

The following remaining sections of this Phase I report describe four aspects of the completed investigation:

Phase I Tasks: Summarizes the tasks that were completed during January and February, 1999.

Risk Characterization: Details the new technical information related to the landfill and nearby properties.

Conclusions: Details the current understanding of groundwater conditions at the landfill.

Recommendations: Discusses the final goals of this project and outlines the next step required by DENR.

2.0 PHASE I TASKS

Six Phase I tasks have been completed. Each is described in one of the following sections. The findings that resulted from the Phase I tasks are described in Section 3 of this report.

2.1 Community Meeting

A community meeting was held on January 19, 1999 to inform residents of the landfill area of the operational status of the landfill and the pending groundwater investigation. During the meeting, Mr. Jay Denton, Jackson County Manager, assured the residents that the County is committed to addressing the environmental issues associated with the landfill. Representatives of The Fletcher Group discussed the historical groundwater quality data and presented the plan for the Phase I investigation. Approximately 12 local residents attended the meeting.

2.2 Water Use Survey

A door to door survey was completed to identify local groundwater users within one-quarter mile of the landfill boundary. The goal of the survey was to identify the location and use of wells or springs in the area. The water use survey included a review of available well construction logs to evaluate local hydrogeologic conditions.

2.3 Analyze Samples from Local Domestic Wells and Springs

As requested by DENR, a sample was collected from each of the identified domestic wells and springs located within one-quarter mile of the landfill boundary. Twenty-one samples were collected. Each sample was analyzed for volatile organic compounds (VOCs) using US EPA method 524.2. Use of this drinking water analytical method was requested by DENR. The method has a reporting limit of 0.5 micrograms per liter (µg/l). The samples were also analyzed for Total and Fecal Coliform.

Where possible, The Fletcher Group has used Test America as the analytical laboratory for all sampling. Test America, formerly known as Hydrologic, has provided analytical services for groundwater samples collected at the landfill for approximately three years. In the interests of analytical continuity and consistency, it is generally preferable to minimize the number of laboratories providing services at a single location.

2.4 Notify Owners of Water Quality Results

A copy of the analytical results has been mailed or hand-delivered to each owner of a sampled well or spring. The owners were also given a letter that described the sampling procedures and explained the analytical results. An example letter is included in Appendix A.

2.5 Landfill Gas Evaluation

The presence of landfill gas was evaluated to determine whether the gas could be contributing to the groundwater contamination observed in the monitoring wells at the site. The landfill gas evaluation utilized nine existing gas monitoring probes and five onsite monitoring wells. The locations of these probes and wells are shown on Figure 2. Other points were also monitored. These additional points included offsite wells, onsite and offsite structures, and one offsite spring. Prior to monitoring the probes and wells, each one was fitted with a cap designed to facilitate measurement of gas concentrations without mixing the gas with ambient air. The presence and concentration of landfill gas was measured using a GasTech landfill gas meter (Model GA-90). The meter measures percent methane, oxygen, and carbon dioxide by volume; and the percent lower explosive limit (LEL) of combustible gases.

Two discrete measurements were made at each probe and well. The data were used develop a profile of the area affected by landfill gas. The first round of measurements was recorded on January 27, 1999. The second was recorded on February 3, 1999. A comparison was then made between the locations where landfill gas was detected and the areas where groundwater contamination has been found. The purpose of the comparison was to evaluate whether there is a correlation between the occurrence of gas and groundwater contamination.

In addition to measuring gas concentrations in the wells, two samples of landfill gas were collected and submitted for laboratory analysis of VOCs. These samples were analyzed to determine whether the gas contains the same VOCs as those detected in groundwater. One gas sample was collected from monitoring well MW-1, and one was collected from gas probe GP-6. Gas probe GP-6 is located near MW-5. It was not possible to collect a gas sample from MW-5 itself because the well is screened entirely below the water table and does not allow gas in the vadose zone to freely enter the well.

2.6 Evaluate the Interconnection of Domestic Wells and Onsite Wells and Assess Onsite Geology

This task was conducted to evaluate the interconnection between onsite groundwater monitoring wells and the closest domestic water supply wells. Boring logs prepared by S&ME, Inc. for onsite monitoring wells MW-1 and MW-2 indicate that both wells are screened entirely in fractured bedrock. In order for the contamination identified in MW-1 to migrate to MW-2, or to an offsite domestic well drilled into bedrock, the fracture(s) in which MW-1 is completed must be connected to the fractures in the other wells. An understanding of the interconnection of the fracture system is necessary in order to design an efficient Phase II groundwater investigation program.

To evaluate the interconnection of the fractures, the water levels in monitoring wells MW-1, MW-2 and MW-5 were measured while, on separate days, nearby domestic wells on the Jack Bulla and Frank Wilkie properties were pumped and then allowed to recharge. To accomplish this task, electronic water level data recorders were temporarily installed in wells MW-1, MW-2, and MW-5. From January 28 through 31, 1999 "background" water levels were measured. During this period, local domestic wells were operated normally.

Then, on February 1, 1999, the pump in the Bulla well was started and allowed to run for approximately two hours at a rate of approximately 6 gallons per minute (gpm) while the data loggers continued to measure water levels in the monitoring wells. The pump was shut off after only two hours because the water became turbid. On February 2, 1999, the Bulla well was again pumped at a rate of 6 gpm, this time for five and one half hours. At that time, the Bulla pump began to draw air and was turned off. The Bulla pump is set at approximately 60 feet below ground surface and the total depth of the well is approximately 220 feet. During both episodes, the data loggers measured water levels in the monitoring wells MW-1, MW-2 and MW-5.

On February 3, 1999, the Bulla well was operated normally and the Frank Wilkie well was pumped for 11 hours while the data loggers measured water levels in the monitoring wells MW-1, MW-2 and MW-5. The Wilkie well is approximately 165 feet deep. The depth of the pump is unknown. It was not possible to measure the static or dynamic water level in either domestic well without disassembling the piping and disrupting water use in the households. As a result, these water levels were not measured. At the end of the test period, the water level data were evaluated to determine whether there was evidence of interconnection. Those findings are discussed in Section 3.5.

Also, as part of this task, The Fletcher Group reviewed the available geologic mapping of fracture occurrence and orientation. The purpose of this review was to evaluate whether the level of understanding is sufficient to support the Phase II investigation.

3.0 PHASE I RISK CHARACTERIZATION

3.1 Water Use Survey

With the assistance of local residents, the door to door survey identified 15 wells and 6 springs on the east side of the Tuckaseegee River, within a quarter mile of the landfill boundary. Individuals in 17 residences were contacted. A list of these residences is included in Table 1. The locations of the wells and springs are shown on Figure 3. As shown on Table 1, 18 residences use groundwater from wells and four residents use water from springs as their primary domestic supply. Four wells and one spring are shared between multiple residences. Two of the identified springs are used for domestic water supply. Four of the identified springs are not used for domestic purposes.

A public water supply system is located on Dillsboro Road. However, the water main terminates near the south boundary of the landfill. A portion of the residents south of the landfill are connected to the public water supply. The two properties located closest to the landfill (Western Builders and Webster Enterprises) are connected to the public water supply.

3.2 Analyze Samples from Local Domestic Wells and Springs

Laboratory analyses by US EPA method 524.2 did not detect VOCs in any water sample collected from water supply wells or springs. Neither Total nor Fecal Coliform were detected in any well water sample. However, Total Coliform was detected in all six spring water samples. Fecal Coliform was detected in one spring water sample (Old Wilkey Spring No. 2). The spring containing Fecal Coliform is not used for domestic water supply. It is, however, located in a cow pasture. These results are shown in Table 1.

3.3 Landfill Gas Evaluation

On January 27, 1999 landfill gas monitoring detected gas in four monitoring wells (MW-1, MW-3, MW-4 and MW-5). The concentration of methane (a primary component of landfill gas) in these four wells ranged from 0.1% in MW-5 to 64.6% in well MW-3. Methane was also detected in four of nine gas probes (GP-2, GP-3, GP-5, and GP-6) on January 27, 1999. The concentration of methane in these gas probes ranged from 23.3% in probe GP-5 to 63.5% in probe GP-2. The concentration of methane in the two offsite locations was measured as 0% in the Bulla Spring and 26.6% in the offsite Western Builder's monitoring well. These measurements are summarized on Table 2.

The gas measurements collected on February 3, 1999 varied from those collected on January 27, 1999. These data are also summarized in Table 2. Lower methane concentrations were measured in the onsite monitoring well MW-1and gas probes GP-3, GP-5, and GP-6. Higher gas concentrations were measured in the onsite monitoring wells MW-3 and MW-4, the offsite monitoring well on the Western Builders property, and gas probe GP-2.

The decrease at well MW-1 is attributed to the fact that the well was not capped while the pumping test was underway. As a result, the well was allowed to vent freely. The reason for the decreased methane concentration in the gas probes and increased concentrations in MW-3, MW-4 and the Western Builders well is not known. However, a major rain event occurred between January 27 and February 3. The associated infiltration of rainwater and fluctuations in temperature and barometric pressure may have affected the distribution of landfill gas.

An evaluation of the gas measurements indicates that, in the area of MW-1 and GP-2, gas is present both near the ground surface and at a depth of approximately 90 feet below the ground surface. Landfill gas was also found near the ground surface and at a depth of approximately 20 feet below ground in wells and probes near the southern portion of the landfill. These data suggest that the unsaturated zone of saprolite has been impacted by landfill gas both north and south of the landfill.

A comparison of landfill gas data with groundwater quality results shows a strong correlation between the occurrence of gas and the detection of VOCs in groundwater. The groundwater quality impacts detected to date occur north, south, and southwest of the landfill in MW-1, MW-4 and MW-5, and MW-3, respectively. The highest concentrations of landfill gas were also measured to the north, south, and southwest of the landfill. In addition, water samples collected from monitoring well MW-2, which is located west of the landfill, have historically been free of contaminants. Gas monitoring determined that the three gas probes closest to MW-2 were free of gas. Taken together, these data suggest that the gas may be a source of groundwater contamination.

To evaluate the hypothesis that gas may be a source of groundwater contamination, two samples of landfill gas were collected and submitted for laboratory analysis of VOCs. These samples were analyzed to determine whether the gas contains the same suite of VOCs as detected in groundwater. One gas sample was collected from groundwater monitoring well MW-1 and one was collected from gas probe GP-6. Gas probe GP-6 is in proximate to groundwater monitoring well MW-5.

Results of the gas analyses are summarized in Table 3 with the results of the most recent VOC water quality data for monitoring wells MW-1 and MW-5. As shown, there is excellent correlation between the specific VOCs detected in the groundwater and those detected in the gas collected from MW-1. A total of 13 VOCs were detected in groundwater and 13 VOCs were also detected in the gas sample. Eleven of these VOCs were detected in both the groundwater and the gas. One compound, methylene chloride, was detected in groundwater but not in gas. Similarly, one compound, chloromethane, was detected in gas but not groundwater. The compound 1,4 Dichlorobenzene was detected in groundwater but was not analyzed in the gas and 1,2,4 trimethylbenzene was detected in gas but was not analyzed in the groundwater. In every instance, the respective VOC concentration was higher in gas than in groundwater.

Comparatively, the correlation between VOCs in groundwater from MW-5 and gas from GP-6 was relatively poor. Six VOCs were detected in groundwater from MW-5 and six VOCs were also detected in the gas from GP-6. However, only two VOCs (1,1 dichloroethane and total xylenes) were detected in both the groundwater and gas samples. In general, the concentration of VOCs was higher in the gas than in groundwater.

To further evaluate whether the VOCs in gas could be a source of groundwater contamination, the equilibrium concentration for each detected VOC was calculated. The equilibrium concentrations are shown in Table 4. As shown, the concentration of each VOC detected in gas was less than the calculated gas equilibrium concentration. This indicates that the VOCs in groundwater and gas are not at equilibrium and, at the concentrations detected, most VOCs would tend to move from the groundwater to the gas.

3.4 Evaluate The Interconnection of Domestic Wells and Onsite Wells and Assess OnSite Geology

The pumping test data were downloaded from the field computer for evaluation with water level data for wells MW-1, MW-2, and MW-5. Ten plots of the data were created and each is included in Appendix B. The first plot shows the background water level data for the three onsite monitoring wells in a single chart. To create this chart, the raw data for wells MW-1 and MW-2 were adjusted so that the plots for all three wells could be compared on the same chart. These adjustments did not affect the relative water level fluctuations of the individual data sets. The overall magnitude of change and water level trend for each well is actual.

The next three plots show water level fluctuations for the individual wells over the duration of the test. The remaining plots show water level trends in individual wells MW-1 and MW-5 during the two Bulla well tests and the single Wilkie test. The vertical axis on each plot shows the length of the water column over the data logger. The horizontal axis shows the total elapsed time in minutes for the particular data set being plotted.

An evaluation of the background data plot shows a good correlation between the water level trends in wells MW-1 and MW-5 but a very dissimilar trend in MW-2. As indicated on the plot, a precipitation event occurred while background data were being collected. During the background period, wells MW-1 and MW-5 both show daily fluctuations in water level and a slight increase in water level near the end of the test; at about 4,000 minutes. The cause for the daily fluctuations in unknown, but the increasing water levels are likely to be a response to precipitation.

Comparatively, the plot for MW-2 shows a stable water level during the first 3,000 minutes. The periodic fluctuations noted in wells MW-1 and MW-5 are not observed in MW-2. After 3,000 minutes the water level in well MW-2 begins to rise rapidly. The magnitude of the water level increase in MW-2 is much greater than that in wells MW-1 and MW-5. The rise in water level corresponds with the precipitation event. The similarities between the plots for wells MW-1 and MW-5 indicate that the wells were completed in the same hydrogeologic unit. The dissimilar plot for well MW-2 suggests that this well was completed in a separate hydrogeologic unit. Given the duration of the test, it is not possible to quantify the degree of interconnection between the two units. However, the data suggest that the units are not well connected.

The second, third, and fourth plots provide longer term water level data for the three monitoring wells. The plots of these data are used to evaluate the response in each well to pumping stresses imposed at the Bulla and Wilkie wells. Each plot incorporates the background data, as well as the data collected during the three pumping tests (first and second Bulla tests and the Wilkie test). The duration of the individual pumping tests are indicated by the horizontal thickness of the blue bars.

An overview of all three plots again shows a very good correlation between the water level fluctuations in wells MW-1 and MW-5, and a distinct lack of correlation with the water level trend in well MW-2. The maximum relative water level fluctuation in wells MW-1 and MW-5 was less than 0.20 feet. The water level in MW-2 varied by 0.80 feet. All three wells show a response to precipitation beginning between 3,000 and 4,000 minutes. However, the response noted in MW-1 and MW-5 appears to be dampened by periodic fluctuations from a routine stress on the aquifer. The long-term plots support the conclusion that wells MW-1 and MW-5 are completed in a different aquifer unit than MW-2.

An evaluation of the plots for MW-1 and MW-5 indicate that a stress is applied to the aquifer twice a day on a regular basis. Both plots show a water level decrease each day starting between 4:00 a.m. and 5:00 a.m. and lasting until approximately 9:00 a.m. At around 4:00 p.m. each day, another water level decrease is noted and this drawdown lasts until between 8:00 p.m. and 9:00 p.m. During the background period, the magnitude of drawdown and recovery appears to be relatively uniform. The cause of the periodic stress is unknown. The stress could be related to diurnal effects due to pumping at an offsite well.

The Bulla well appeared to have an influence on the water levels in wells MW-1 and MW-5. The first Bulla test (Bulla #1) was started at 12:53 p.m. on Monday, February 1. The aquifer was apparently experiencing recharge from precipitation when the test was started. Neither well MW-1 or MW-5 showed an immediate response due to the Bulla well stress, however, the water level in each well began decreasing at about the same time as the Bulla pump was turned off (approximately 3:00 p.m.). This drawdown response began about one hour earlier than would be expected if the drawdown were due only to the regional "background" stress which occurs each day at approximately 4:00 pm. Further evaluation of the data plots suggest that the typical 4:00 p.m. stress occurred as the slope of both drawdown plots changed just after 4:00 p.m. This suggests that the wells respond to the elimination of the Bulla well stress (i.e., the rate of drawdown decreased), but both wells were still under the influence of the periodic regional stress. The remainder of the Bulla #1 plots show that both wells began recovering from the regional stress at approximately 10:00 p.m. and were again influenced by the regional stress beginning at 5:00 a.m. the next day.

The Bulla #2 test also appeared to have had an impact on wells MW-1 and MW-5. A review of the plots for the Bulla #2 test shows that both wells were recovering during the entire pumping portion of the test, except for a brief drawdown that occurred approximately 90 minutes after the pump was started. The water level in each well begins increasing at approximately 9:30 a.m. The increase may be in response to elimination of the periodic regional stress which typically stops at about 9:00 a.m. At about the same time as the Bulla pump was turned off, both wells MW-1 and MW-5 began to drawdown. The rate of drawdown increased just after 4:00 p.m. It is likely that the initial drawdown observed from 3:00 p.m. to 4:00 p.m. was in response to the Bulla well stress and the later drawdown was a response to both the Bulla stress and the periodic regional stress. However, the regional stress appears to be of greater significance than the stress imposed by the Bulla well.

A review of the water level plots for the wells MW-1 and MW-5 during the Wilkie well test period show a pattern similar to that which occurred during the second Bulla test. The water level in both wells was increasing during the first five hours of the test and then the water levels in both wells began to decrease. The rate of drawdown increased at approximately 4:00 p.m. when the periodic regional stress began. The water levels began to recover at approximately 7:30 p.m. even though the Wilkie well was still being pumped. This is probably because the regional stress stopped at about this time. However, the rate of water level recovery increased significantly about 60 minutes after the Wilkie well was shutoff, indicating that the Wilkie well was influencing the hydrogeologic unit in which MW-1 and MW-5 are completed.

During the test period, both domestic wells were pumped for a longer duration than they would be under normal operating conditions. Under typical pumping conditions, the domestic wells would have less impact on MW-1 and MW-5 than was observed during the test period. If the groundwater gradient in the hydrogeologic unit in which wells MW-1 and MW-5 are completed is toward the west-northwest, then the Bulla and Wilkie domestic wells are located upgradient, or possibly, cross gradient of wells MW-1 and MW-5. Considering the data collected during the pumping tests, it is unlikely that the stresses imposed by either the Bulla or Wilkie well would be sufficient to overcome the regional gradient. To draw contaminated groundwater from near the wells MW-1 or MW-5 toward these domestic wells, pumping would have to exceed typical domestic pumping rates. However, the periodic stress caused by the unidentified source could influence the direction or rate of contaminant migration if the source of the stress is located downgradient of MW-1 or MW-5. What if MW-1 is across GW divide?

? South-SW

As part of this task, The Fletcher Group reviewed the structural mapping completed by Law Engineering in 1994. Representatives of Law Engineering field mapped 35 open joint surfaces and 10 interbedded bedrock foliations. These features were plotted on Schmidt Equal Area Projections and Rose Diagrams to demonstrate the general orientation of structural features in the landfill area. Results of the fracture trace analyses indicate two primary joint orientations. The joints in one set are oriented N30°-50°W; dipping 50°-80° SW. A second set is oriented 40°-50°E; dipping 60°-80°SE. The Fletcher Group did not field verify the work completed by Law. However, the completed to date appears adequate to support the next phase of the groundwater quality investigation.

4.0 PHASE I CONCLUSIONS

The following conclusions are based upon the data collected during the Phase I work.

- The private drinking water wells and springs that were tested are not contaminated with VOCs. As a result, groundwater contamination detected at the landfill does not appear to present a current risk to local consumers of groundwater.

- Landfill gas is prevalent along significant portions of the landfill boundaries.

- The specific VOCs in groundwater and gas from monitoring well MW-1 correlate very well. This correlation suggests a relationship between the VOCs in soil gas and groundwater contamination.

- The concentrations of VOCs in the gas and groundwater are not in equilibrium. The data collected indicate that, at the concentrations detected, VOCs would tend to move from groundwater to gas in the soil, above the water table. These data suggest that the VOCs detected in groundwater may be caused in part by liquids leaching from the landfilled area or direct contact between groundwater and waste material. VOCs in the landfill gas may be contributing to the groundwater contamination identified in the monitoring wells. However, landfill gas may not be the sole source of groundwater contamination.

- The data indicate that in areas where VOCs have been identified in soil gas, nearby groundwater is also contaminated.

- Because there is good correlation between VOCs in groundwater and VOCs in soil gas, it is expected that monitoring for total hydrocarbons and VOCs in soil gas would provide a cost effective method for estimating the horizontal distribution of groundwater contamination.

- The water level data indicate that wells MW-1 and MW-5 behave very similarly and are completed in the same hydrogeologic unit. Well MW-2 behaves very differently from wells MW-1 and MW-5 and may be completed in a different unit; or, MW-2 may be significantly influenced by the Tuckaseegee River.

- The water level data from the background monitoring period as well as that collected during the three pumping tests concur and indicate that a periodic stress is applied to the aquifer in which MW-1 and MW-5 are completed. The source of this stress is unknown. The source of this stress should be identified, if possible, before the groundwater monitoring well network is expanded so that any new wells can be sited appropriately.

- The pumping test data indicate that pumping the Bulla and Wilkie domestic wells influences the water levels in wells MW-1 and MW-5. However, an unknown periodic stress affects the aquifer more than pumping from either the Bulla or Wilkie well. It is unlikely that, under typical domestic pumping conditions, groundwater contamination in wells MW-1 or MW-5 would be drawn to either the Bulla or Wilkie well.

- The structural mapping completed to date is adequate to support the next phase of work and additional mapping is not required at this time.

5.0 RECOMMENDATIONS

DENR is requiring Jackson County to define the horizontal and vertical extent of groundwater contamination. As a start to complying with that requirement, the Phase I activities were conducted to accomplishing the three goals:

- Determining whether groundwater contamination at the landfill poses an immediate risk to the local residents.
- Assessing the likelihood that landfill gas has an adverse affect on groundwater quality.
- Evaluating onsite and nearby hydrogeology.

The next step in this process is to use the landfill gas and groundwater quality data to install permanent monitoring wells. The wells will be used to document for DENR where groundwater is contaminated.

The data collected to date indicate a strong correlation between the occurrence of landfill gas and the detection of groundwater contaminants. This correlation provides Jackson County a cost-effective method on which to base the number and locations of future wells.

As a result, The Fletcher Group recommends that Phase II tasks focus on evaluating the extent of VOCs in soil gas in order to estimate the horizontal extent of groundwater contamination. After the extent of landfill gas has been determined, a monitoring well network can be designed to monitor water quality near the perimeters of the gas plume. Knowledge of gas distribution will provide a cost effective mechanism by which the locations of future groundwater monitoring wells can be established. It is expected that this approach will reduce the overall costs of determining the extent and magnitude of groundwater contamination.

The following tasks are recommended for Phase II.

TASK 1: Install up to four sets of gas probes north and east of the landfill using the GeoProbe direct push method.

The saprolite is unsaturated in the vicinity of MW-1 near the top of the ridge east of the landfill. The depth to bedrock in MW-1 is approximately 83 feet below the ground surface and the depth to groundwater is approximately 92 feet. In this area, landfill gas has been detected just below the ground surface and in the bedrock fractures. This indicates that landfill gas occurs throughout the entire thickness of saprolite in that area.

The Fletcher Group recommends installing sets of probes on offsite property owned by Mr. Frank Wilkie and Mr. Johnny Connor. Three probes should be installed at each location. The first probe should be screened just above the saprolite - bedrock interface at an estimated depth of approximately 80 to 82 feet; the second at a midpoint depth of approximately 40 to 42 feet; and, the third near the ground surface from approximately from 5 to 7 feet below the ground surface. The exact screen depths will be determined during field activities.

Available data indicates that groundwater occurs in bedrock north of the landfill. This being the case, groundwater sampling using a direct push probe will not be possible in that area. However, if groundwater is encountered in saprolite during installation of the deeper probes, a one-time groundwater sample should be collected and analyzed for VOCs using a method approved by DENR.

TASK 2: Install up to six sets of gas probes south and west of the landfill.

According to a well log prepared by Greene Brothers Drilling Company, the depth to bedrock in MW-5 is greater than approximately 60 feet below the ground surface. The depth to groundwater in MW-5 is approximately 46 feet below the ground surface. This indicates that the most significant portion of landfill gas is migrating through the saprolite. To estimate and evaluate the extent of VOCs in soil gas, six sets of nested gas probes should be installed around the southern portion of the landfill. One set should be installed on the Webster Enterprise property, one on the Western Builders property, and one on the G.S. Railroad property. Up to three sets should be installed on Jackson County property west of Dillsboro Road. Each nest should consist of two gas probes; one screened from depths of 5 to 7 feet and the second screened near the water table. It is anticipated that groundwater will occur in saprolite in these areas and, if so, a one-time groundwater sample should be collected during the installation of each deeper probe. The groundwater sample should be analyzed for VOCs using a method approved by DENR.

TASK 3: Measure the concentration of landfill gas in each probe and plot the location of the gas data on a base map.

Each new gas probe should be monitored using a landfill gas meter. Gas readings should also be collected from existing gas probes and monitoring wells. The locations of the new probes should be identified on a map of the site. If the deeper gas probes are screened across the water table, the location and elevation of these probes should be surveyed so water level data collected from the probes can be used to calculate the groundwater gradient.

TASK 4: Evaluate the gas monitoring data and estimate the extent of groundwater impacts.

The results of gas monitoring should be evaluated to determine the horizontal and vertical distribution of landfill gas. The results of the first three tasks will be used to map the distribution of gas. Any new groundwater quality results will also be used to minimize the number of permanent monitoring wells that would be required by DENR to identify the vertical and horizontal extent of groundwater contamination.

TASK 5: Select the appropriate location for additional groundwater monitoring wells.

Utilize the results of the gas monitoring program and the groundwater quality sampling to select the number and locations of additional required monitoring wells. Currently, The Fletcher Group anticipates that one additional bedrock monitoring well will be required north of the landfill and at least two saprolite monitoring wells will be required to the south and southwest.

Table 1

JACKSON COUNTY LANDFILL
Beneficial Use Survey
Well and Spring Analytical Results

Location Number	Owner of Record	Tax Lot Number	Well	Spring	Shared Water / With Whom	Bacteria Detected / Type	VOCs Detected	Notified	Comments
1	Jack Bulla	7621-98-3612	●			no	no	2/4/99	
2	Bulla Spring	7621-98-3612		●		total = yes fecal = no	no	2/4/99	Notified Jack Bulla about the Bulla Spring
3	John Connor	7621-98-6421	●		Sister who lives across Joe Wilkey	no	no	2/4/99	
4	Staffelbach	7621-98-7788	●			no	no	2/4/99	
5	Geneva Wall	7621-98-9484	●			no	no	2/22/99	
6	Dennis Wilkey	7631-08-7452	●			no	no	2/4/99	
7	Frank Wilkie	7631-07-2955	●		Shares water with Mrs. Wilkey	no	no	2/11/99	
8	Old Wilkey Spring	7631-07-2955		●		total = yes fecal = no	—	2/11/99	Notified Frank Wilkie about the Old Wilkey Spring #1
9	Old Wilkey Spring # 2	7631-07-2955		●		total = yes fecal = yes	no	2/11/99	Notified Frank Wilkie about the Old Wilkey Spring #2
10	Mrs. Wilkey Spring	??6845		●	Gets water from Frank Wilkie's well	total = yes fecal = no	—		
11	Roger Brooks	7631-18-3297	●		Shares water with tax lot number 4413	no	no	2/22/99	
12	Edwin Wilkey	7631-18-3532	●			no	no	2/23/99	
13	Charlie Ashe	7621-99-118	●		Margaret and Ronald Russel	total = yes fecal = no	no	2/22/99	Notified Ronald and Margaret Russell on 2/22/99
14	A.G. Sutton Spring	7621-99-1118		●	Gets water from spring on Russel	total = yes fecal = no	no	2/22/99	
15	William Wilkey	7621-88-8239	●			total = yes fecal = no	no	2/17/99	
16	Perry Sutton		●			no	no	2/4/99	
17	Pullium Spring			●	Ray Buchanan Nancy Decker	total = yes fecal = no	no	2/22/99	Notified Buchanan and Decker on 2/22/99
18	Lucille Lambert		●			no	no	2/22/99	

Table 1

JACKSON COUNTY LANDFILL
Beneficial Use Survey
Well and Spring Analytical Results

Location Number	Owner of Record	Tax Lot Number	Well	Spring	Shared Water / With Whom	Bacteria Detected / Type	VOCs Detected	Notified	Comments
19	Ellis Stiles		●			no	no	3/2/99	
20	Eddie Bingham		●			no	no	3/2/99	
21	Western Builders		●			total = yes fecal = no	no	3/2/99	former domestic water supply well - not currently used
Note	Locations are shown on Figure 3								

Table 2

Regulatory limits → LEL, or, 5% methane @ property line
→ 25% of LEL in Buildings

Jackson County Landfill

Landfill Gas Measurements

Well	Date	Time	LEL Meter % LEL	% Methane	% CO2	% O2	Atmospheric Pressure ("H20)	Notes
MW-1	1/27/99	11:50	[redacted] ok	1.1	1.4	20.4	378	
	1/27/99	14:35	[redacted] ok	1	1	19.4	376	
	2/3/99	14:45	0	0	0	20.4	374	No cap due to pumping test
MW-2	1/27/99	16:30	0	0	0	20.8	378	
	2/3/99	13:46	0	0	0	19.8	377	
[redacted]	1/27/99	16:10	>1000	[redacted]	26.6	0.6	377	
	2/3/99	13:53	>1000	[redacted]	27.7	0	376	
[redacted]	1/27/99	16:35	34	1.7	2.4	19.5	378	
	2/3/99	15:50	286	[redacted]	17	12.1	376	
MW-5	1/27/99	15:40	2	0.1	0.2	20.3	378	Screened entirely below the water table
	1/27/99	17:10	2	0.1	0.1	20.5	378	
	2/3/99	14:24	0	0	0	21	376	No cap due to pumping test
Gas Probe 1	1/27/99	14:20	0	0	8.4	3.1	377	
	2/3/99	14:51	0	0	5.8	10.6	374	
[redacted]	1/27/99	14:50	>1000	[redacted]	39.8	0	376	
	2/3/99	15:00	>1000	[redacted]	40.6	0	373	
[redacted]	1/27/99	15:00	766	[redacted]	29.8	0	376	
	2/3/99	15:07	282	[redacted]	9.5	13.8	374	

Table 2

Jackson County Landfill

Landfill Gas Measurements

Well	Date	Time	LEL Meter % LEL	% Methane	% CO2	% O2	Atmospheric Pressure ("H20)	Notes
Gas Probe 4	1/27/99	15:10	0	0	0.5	20	376	
	2/3/99	15:15	0	0	0.6	19.8	375	
Gas Probe 5	1/27/99	15:20	480	[redacted]	6.4	4.7	378	
	2/3/99	14:27	50	3.4	0.7	19	376	
Gas Probe 6	1/27/99	16:00	>1000	[redacted]	25.2	1.9	378	
	2/3/99	14:07	562	[redacted]	23.1	1.7	376	
Gas Probe 7	1/27/99	16:05	0	0	0.9	19.8	378	
	2/3/99	14:00	0	0	1	18.6	376	
Gas Probe 8	1/27/99	16:15	0	0	1.4	19.3	378	
	2/3/99	13:37	0	0	2.4	15.6	377	
Gas Probe 9	1/27/99	16:25	0	0	0	20.4	378	
	2/3/99	13:33	0	0	0.1	20.3	377	
W. Builders Monitoring Well	1/27/99	15:50	586	[redacted]	11.5	13.6	378	Loose Cap
	2/3/99	14:18	950	[redacted]	23.9	6.7	376	Tight Cap
Bulla Spring	1/27/99	13:50	0	0	0	20.2	379	
Underneath the Scale House	2/3/99	15:20	0	0	0	20.9	375	
Underneath the Scale	2/3/99	15:25	0	0	0	21.2	375	
Webster Enterprise Outside	2/3/99	16:00	0	0	0	20.8	375	

Table 2

Jackson County Landfill

Landfill Gas Measurements

Well	Date	Time	LEL Meter % LEL	% Methane	% CO2	% O2	Atmospheric Pressure ("H20)	Notes
Webster Enterprise Inside	2/3/99	16:05	0	0	0	20.8	375	
Mr. Johnny Conner (under house)	2/3/99	15:40	0	0	0	21.1	376	
Frank Wilkie's Well	2/3/99	16:20	0	0	0	21	374	
Frank Wilkie's Basement	2/3/99	16:15	0	0	0	20.7	375	
Frank Wilkie's Garage	2/3/99	16:15	0	0	0	20.7	375	

Table 3

JACKSON COUNTY LANDFILL
Landfill Gas Evaluation
Comparison of VOCs in Groundwater and LFG

COMPOUND	MW-1 Groundwater (µg/l)	MW-1 Gas (ppbv)	MW-5 Groundwater (µg/l)	Probe 6 Gas (ppbv)
22				
Acetone	ND		ND	
Acetonitrile	ND		ND	
Acrolein	ND		ND	
Acrylonitrile	ND		ND	
Allyl chloride	ND		ND	
Benzene 1	6.8	27	2.4	ND
Bromochloromethane	ND		ND	
Bromoform	ND		ND	
Bromomethane	ND		ND	
2-Butanone	ND		ND	
Carbon disulfide	ND		ND	
Carbon tetrachloride	ND		ND	
Chlorobenzene 50	ND		4.4	ND
Chloroethane 2800P	14.4	85	ND	50
Chloroform	ND		ND	
Chloromethane 2.6 GWPS	ND	17	ND	
Chloroprene	ND		ND	
1,2-Dibromo-3-chloropropane	ND		ND	
Dibromochloromethane	ND		ND	
Dibromomethane	ND		ND	
1,4-Dichloro-2-butene	ND		ND	
1,2-Dichlorobenzene	ND		ND	
1,3-Dichlorobenzene	ND		ND	
1,4-Dichlorbenzene 75	2.6	NA	13.2	NA
Dichlorodifluoromethane 1400	ND		ND	250
1,1-Dichloroethane	30	83	2.7	11
1,2-Dichloroethane	ND		ND	
1,1-Dichloroethene	ND		ND	
cis-1,2-Dichloroethene 700	6.8	34	54.7	ND
trans-1,2-Dichloroethene	ND		ND	
1,2-Dichloropropane	ND		ND	
1,3-Dichloropropane	ND		ND	
2,2-Dichloropropane	ND		ND	
1,1-Dichloropropene	ND		ND	
cis-1,3-Dichloropropene	ND		ND	
trans-1,3-Dichloropropene	ND		ND	
Ethylbenzene 29	1.5	16	ND	
Ethyl methacrylate	ND		ND	
2-Hexanone	ND		ND	
Iodomethane	ND		ND	
Isobutyl alcohol	ND		ND	
Methacrylonitrile	ND		ND	
Methyl methacrylate	ND		ND	
4-Methyl-2-pentanone	ND		ND	
Methylene chloride 5	88.7		ND	
Propionitrile	ND		ND	

Table 3

JACKSON COUNTY LANDFILL
Landfill Gas Evaluation
Comparison of VOCs in Groundwater and LFG

COMPOUND 2L	MW-1 Groundwater (µg/l)	MW-1 Gas (ppbv)	MW-5 Groundwater (µg/l)	Probe 6 Gas (ppbv)
Styrene	ND		ND	
1,1,1,2-Tetrachloroethane	ND		ND	
1,1,2,2-Tetrachloroethane	ND		ND	
Tetrachloroethene 0.7	3	16	ND	
Toluene 1000	3.1	420	ND	4.5
1,1,1-Trichloroethane 200	3	12	ND	
1,1,2-Trichloroethane	ND		ND	
Trichloroethene 2.8	3.2	12	ND	
1,2,3-Trichloropropane	ND		ND	
Vinyl acetate	ND		ND	
Vinyl chloride 0.015	2.3	21	ND	
Xylenes 530	28.4	127	2.6	3.4
Bromodichloromethane	ND		ND	
Trichlorofluoromethane	ND		ND	
Ethylene Dibromide	ND		ND	
1,2-Dibromo-3-chloropropane	ND		ND	
Dichlorotetrafluoroethane - F114	NA	ND	ND	230
1,2,4 Trimethylbenzene	NA	8	NA	ND
THC as Gas	NA	13,000	NA	79000

Note: VOCs in water in µg/L (micrograms per liter or parts per billion)
VOCs in gas in ppbv (nanomoles analyte per mole air)
ppbv and µg/L are not directly comparable

Table 4

JACKSON COUNTY LANDFILL
Landfill Gas Evaluation
Calculated Gas Equalibrium Concentrations

COMPOUND	MW-1 Groundwater - Measured (µg/l)	MW-1 Gas - Measured (ppbv)	MW-1 Gas - Calculated Equalibrium Concentration (ppbv)	MW-5 Groundwater - Measured (µg/l)	Probe 6 Gas - Measured (ppbv)	Probe 6 Gas - Calculated Equalibrium Concentration (ppbv)
Benzene	6.8	27	483	2.4	ND	
Chlorobenzene	ND			4.4	ND	
Chloroethane	14.4	85	2450	ND	50	
Chloromethane	ND	17		ND		
1,4-Dichlorbenzene	2.6	NA		13.2	NA	
Dichlorodifluoromethane	ND			ND	250	
1,1-Dichloroethane	30	83	1774	2.7	11	160
cis-1,2-Dichloroethene	6.8	34	517	54.7	ND	
Ethylbenzene	1.5	16	115	ND		
Methylene chloride	88.7	.		ND		
Tetrachloroethene	3	16	487	ND		
Toluene	3.1	420	6.09	ND	4.5	
1,1,1-Trichloroethane	3	12	487	ND		
Trichloroethene	3.2	12	282	ND		
Vinyl chloride	2.3	21	824	ND		
Xylenes	28.4	127	1813	2.6	3.4	166
Dichlorotetrafluoroethane - F114	NA	ND		ND	230	
1,2,4 Trimethylbenzene	NA	8		NA	ND	
THC as Gas	NA	13,000		NA	79000	

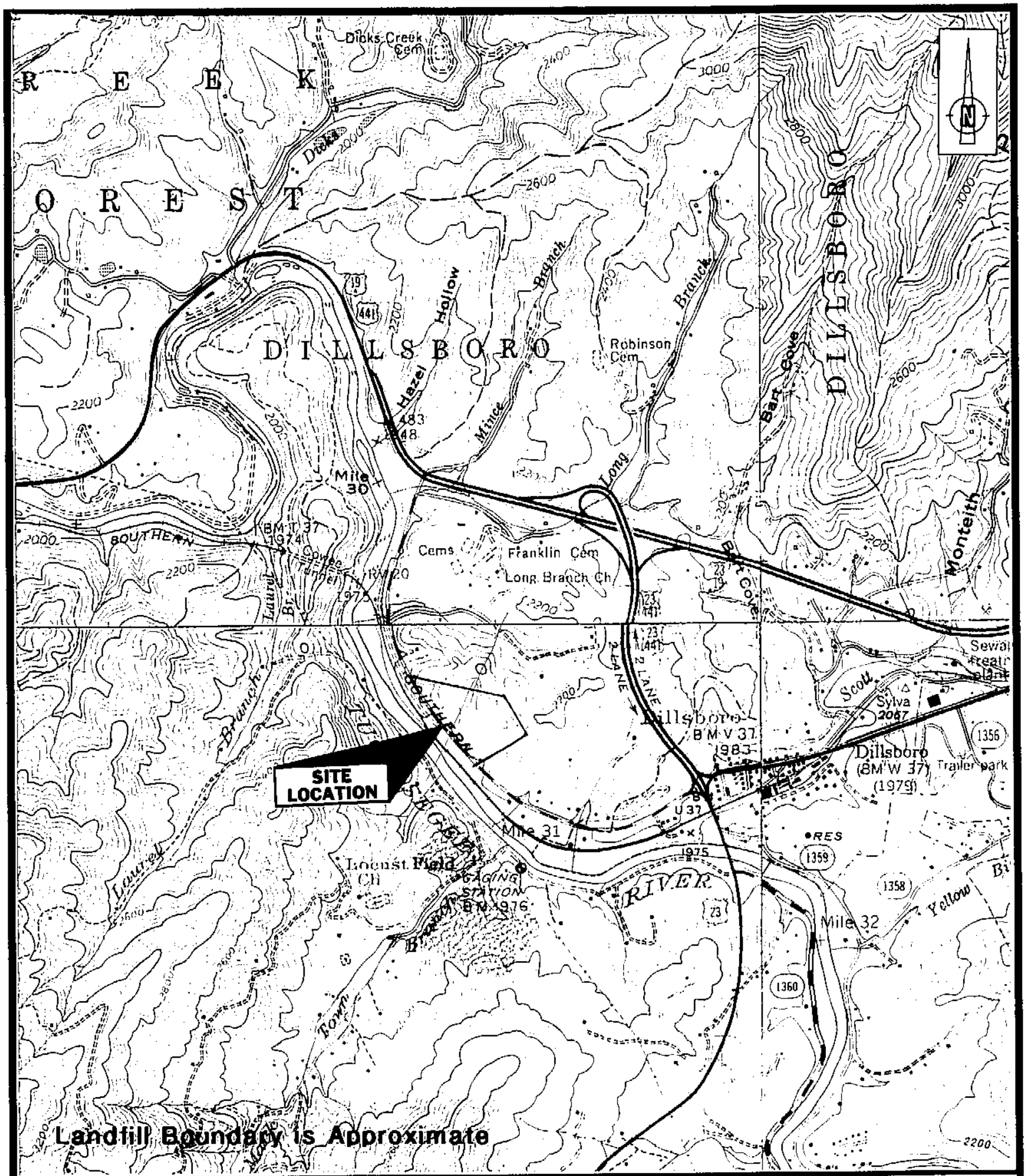
Note: H[atm-ppbv/(mg/m3)]=H[atm-m3/mol]*$10^9/(10^3$*MW)

Henry's Law Constant for TCE $1x10^{-2}$ atm-m3/mol Eisenreich, SJ et al, Environmental Seicenc and Technology 15:30-38(1981)

Henry's Constant for 1,1,1-Trichloroethane 8X10-3 atm-cu m/mole [Lyman WJ et al; pp. 15-1 to 15-43 in Handbook of Chem Property Estimation Methods NY: McGraw-Hill (1982)]

Henry's Constant for benzene 5.3X10-3 atm-cu m/mole [Lyman WJ et al; pp. 15-9 to 15-31 in Handbook of Chem Property Estimation Methods NY: McGraw-Hill (1982)]

Henry's Constant for chlorobenzene 3.77X10-3 atm-cu m/mole [No reference given]

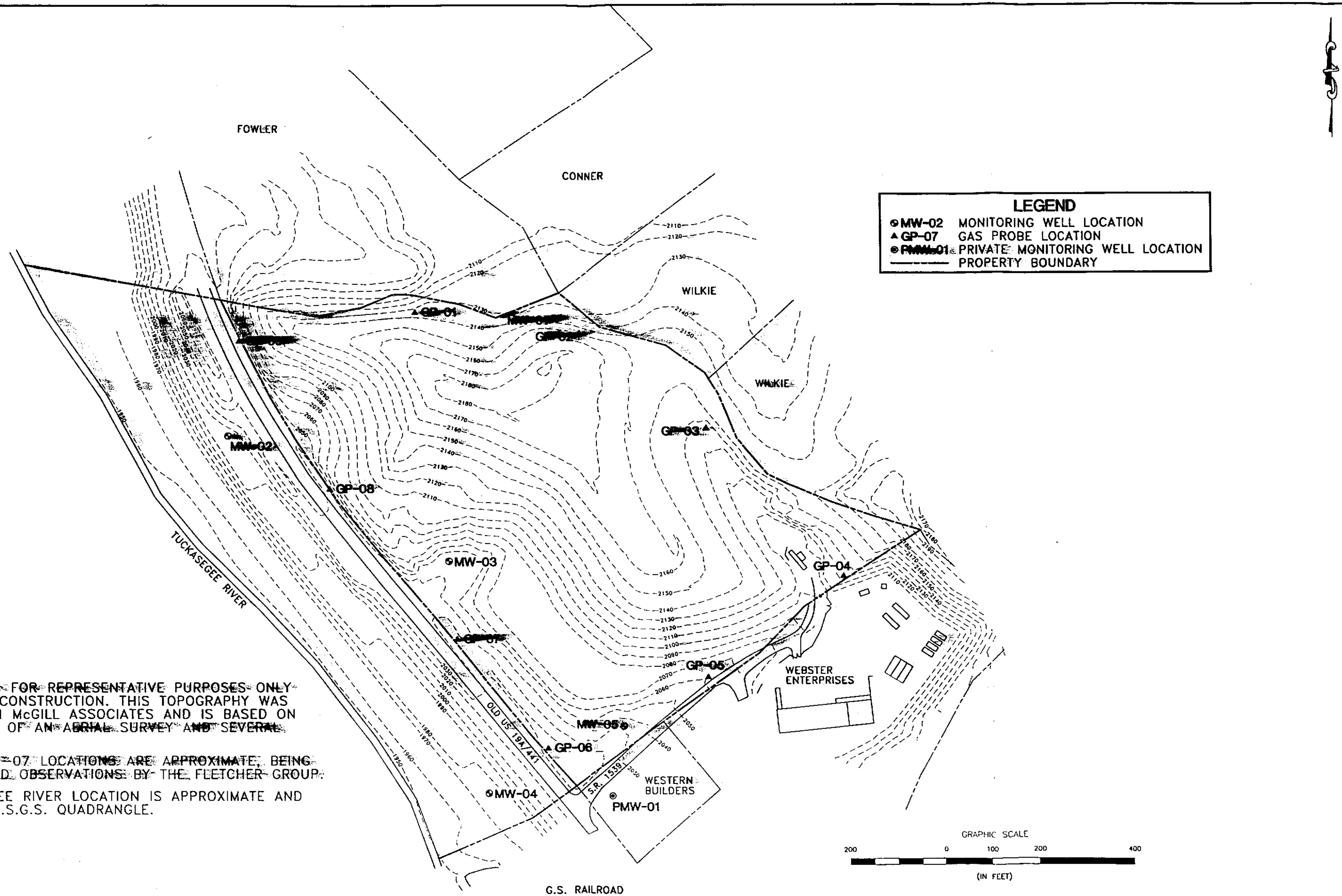


Approximate Scale:
1 in. = 2,000 ft.

February 10, 1999
THE FLETCHER GROUP, INC.
ASHEVILLE, NORTH CAROLINA

FIGURE 1

Site Location Map
Jackson County Landfill
Dillsboro, North Carolina

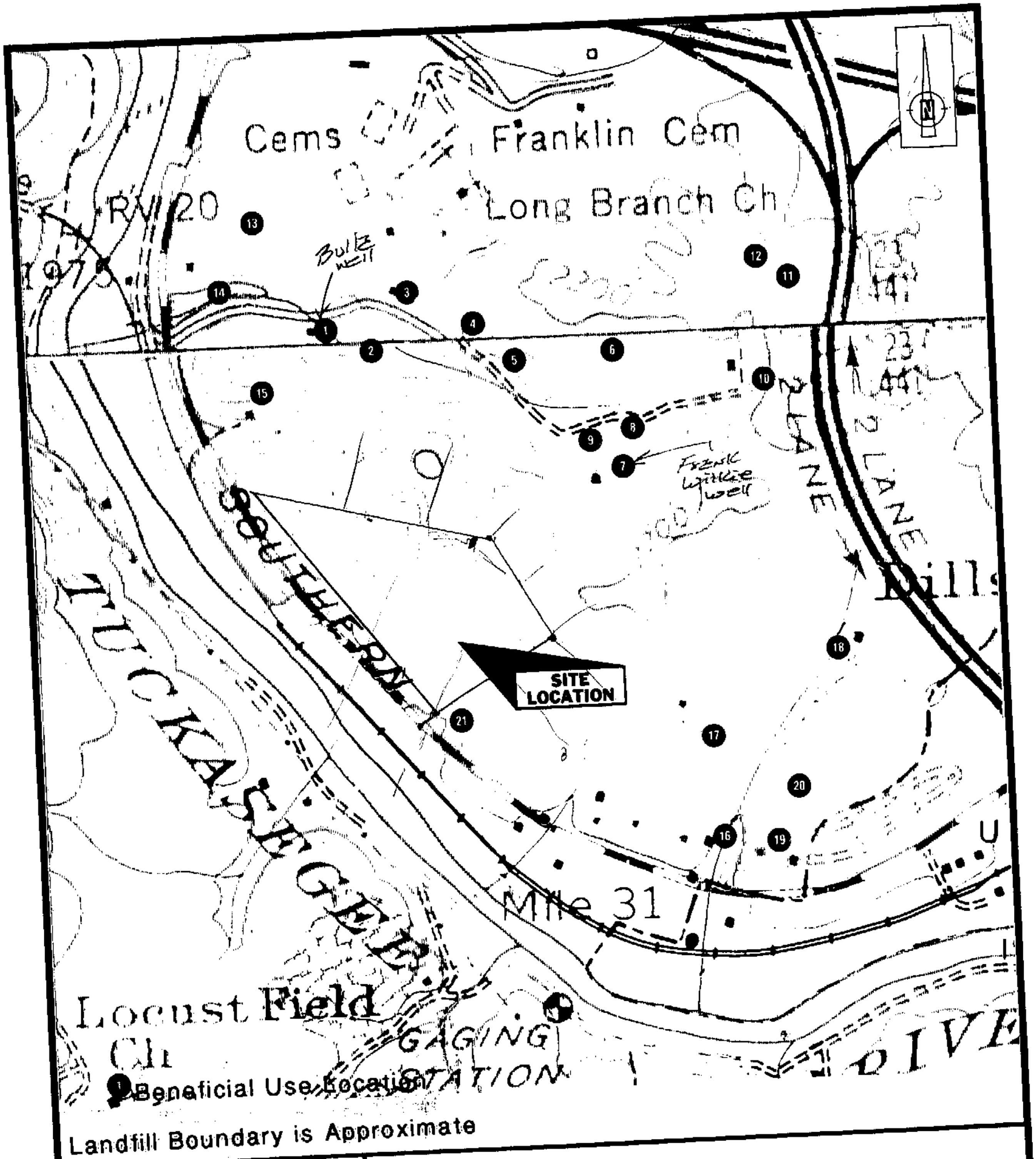


NOTES:

1. TOPOGRAPHY IS FOR REPRESENTATIVE PURPOSES ONLY AND NOT FOR CONSTRUCTION. THIS TOPOGRAPHY WAS OBTAINED FROM McGILL ASSOCIATES AND IS BASED ON A COMPILATION OF AN AERIAL SURVEY AND SEVERAL LAND SURVEYS.
2. GP-06 AND GP-07 LOCATIONS ARE APPROXIMATE, BEING BASED ON FIELD OBSERVATIONS BY THE FLETCHER GROUP.
3. THE TUCKASEGEE RIVER LOCATION IS APPROXIMATE AND BASED ON A U.S.G.S. QUADRANGLE.

THE FLETCHER GROUP Engineering and Environmental Solutions ASHEVILLE, NORTH CAROLINA	FIGURE 2 MONITORING WELL AND METHANE PROBE LOCATION MAP JACKSON COUNTY LANDFILL JACKSON COUNTY, NORTH CAROLINA

DRAWN BY: JOHNC. PROJ MAN: CDE DATE: 02-11-99 CADD FILENAME: P:\DASHVIL\JACKSON CO.040\LANDFILL.01\204001F2.DWG



Approximate Scale:
1.5 in. = 1,000 ft.

February 25, 1999
THE FLETCHER GROUP, INC.
ASHEVILLE, NORTH CAROLINA

FIGURE 3

Groundwater Beneficial Use Location Map
Jackson County Landfill
Dillsboro, North Carolina

APPENDIX A

Example Notification Letter

THE FLETCHER GROUP
Engineering and Environmental Solutions

February 4, 1999

Mr. A.G. Sutton
Dillsboro Road
Sylva, North Carolina 28779

Subject: Results of Water Analysis

Dear Mr. Sutton:

Thank you allowing Jackson County to sample your spring. Enclosed you will find a copy of the analytical laboratory reports for the water quality testing. Two analyses were run on your spring water. The first analysis tested for the presence of volatile organic compounds (VOCs) such as the chemicals detected in the monitoring wells at the landfill. The second analysis tested for the presence of total coliform and fecal bacteria. The analytical method used for the VOC analysis is referred to as United States Environmental Protection Agency (US EPA) method 524.2 and was the method specified by the North Carolina Department of Environment and Natural Resources (DENR). The laboratory analysis tested for a total of 55 VOCs.

No VOCs were detected in your spring water at a detection limit of 0.0005 milligrams per liter (mg/L). Total coliform was detected in your spring water but fecal coliform was not present.

To help explain the VOC analytical results, you will find a table enclosed that lists the DENR and US EPA maximum allowable concentration for each of the 55 VOCs analyzed. The table also identifies which chemicals have been detected in wells at the landfill. As shown, the detection limit for the analytical method used was below both the DENR and US EPA allowable concentration. You may notice that the DENR specified limit for the compounds chloroform, bromoform, and vinyl chloride, is below the analytical method detection limit. This is unavoidable because there is no standard method that can measure to the low level specified by DENR. However, the method detection limit for these compounds was below the allowable concentration specified by the US EPA.

The presence of total coliform is common in surface water. Fecal coliform would be a concern, however it is not present. If your spring is unprotected, animals can introduce both total coliform and fecal bacteria. We suggest that you protect your spring water source in order to maintain its quality.

Again, we appreciate the assistance you have provided. Please feel free to call Mr. Jay Denton or Mr. Chad Parker with Jackson County if you have any questions regarding these results.

Sincerely,

Stuart A. Ryman, P.G.

enclosure

48 Patton Avenue, Suite 303, Asheville, North Carolina 28801 • (828) 281-3350 Fax (828) 281-3351

US EPA Method 524.2 Analytes
and Summary of Regulatory Standards

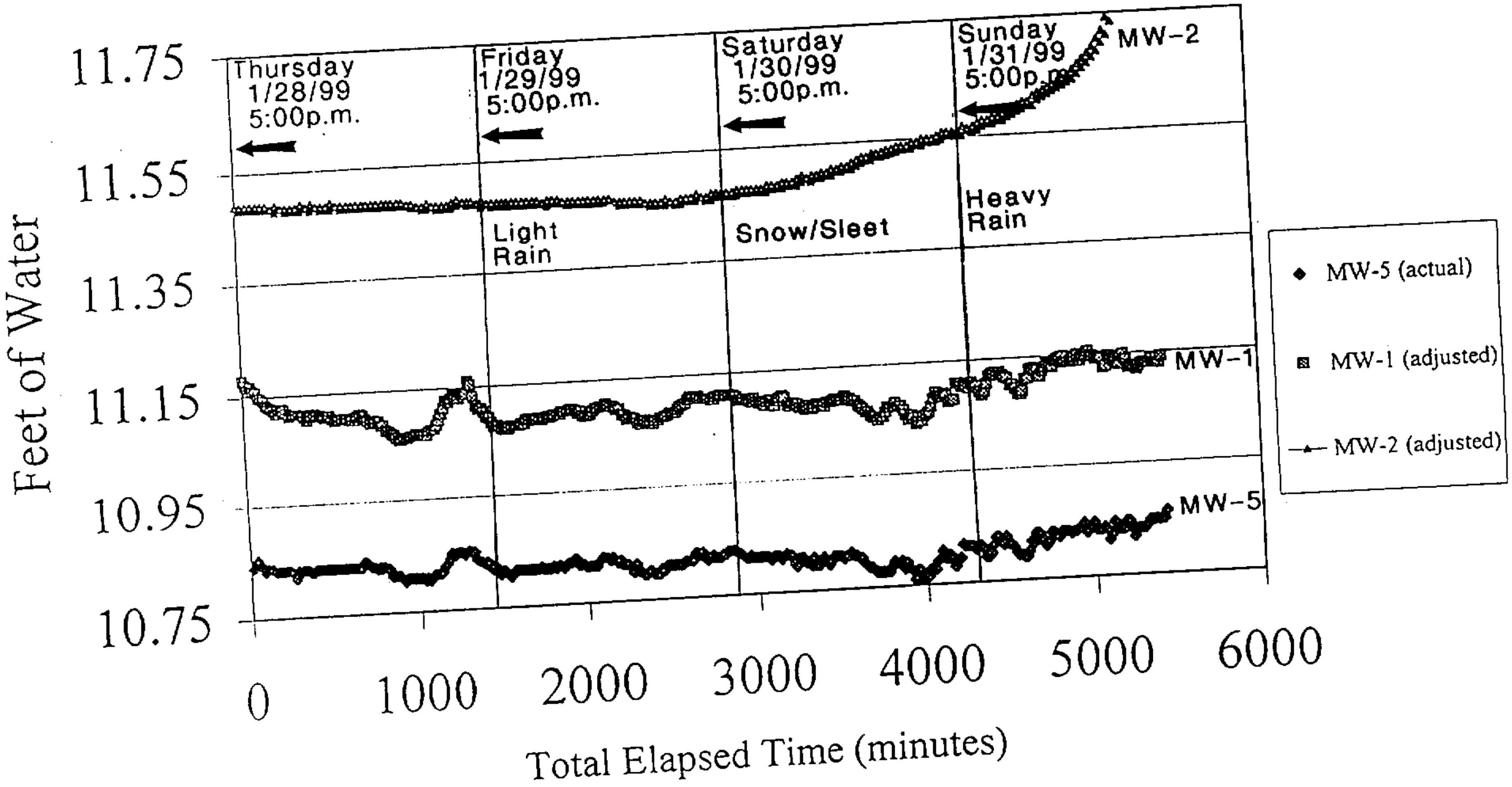
COMPOUND	UNITS	NC 2L Standard	US EPA MCL	Detected in a Landfill Monitoring Well During 1998
p-Isopropyltoluene	mg/L	NL	NL	
Chloromethane	mg/L	NL	NE	●
Dichlorodifluoromethane	mg/L	1.4	NE	●
Bromomethane	mg/L	NL	NE	
Chloroethane	mg/L	NL	NE	●
Fluorotrichloromethane	mg/L	NL	NE	
Hexachlorobutadiene	mg/L	NL	NE	
Naphthalene	mg/L	0.021	NE	
1,2,4-Trichlorobenzene	mg/L	NL	0.07	
Cis-1,2-Dichloroethylene	mg/L	0.07	0.07	●
Dibromomethane	mg/L	NL	NE	
1,1-Dichloropropene	mg/L	NL	NE	
1,3-Dichloropropane	mg/L	NL	NE	
1,3-Dichloropropene	mg/L	NL	NE	
1,2,3-Trichloropropane	mg/L	NL	NE	
2,2-Dichloropropane	mg/L	NL	NE	
1,2,4-Trimethylbenzene	mg/L	NL	NE	●
1,2,3-Trichlorobenzene	mg/L	NL	NL	
n-Butylbenzene	mg/L	NL	NE	
1,3,5-Trimethylbenzene	mg/L	NL	NE	●
Tert-Butylbenzene	mg/L	NL	NE	
Sec-Butylbenzene	mg/L	NL	NE	
Bromochloromethane	mg/L	NL	NE	
Chloroform	mg/L	0.00019	0.1	
Bromoform	mg/L	0.00019	0.1	
Bromodichloromethane	mg/L	NL	0.1	
Chlorodibromomethane	mg/L	NL	0.1	
Xylenes(total)	mg/L	0.53	10	●
Dichloromethane (methylene chloride)	mg/L	0.005	0.005	
o-Chlorotoluene	mg/L	NL	NE	
p-Chlorotoluene	mg/L	NL	NE	
m-Dichlorobenzene	mg/L	NL	NE	
o-Dichlorobenzene	mg/L	NL	0.6	
p-Dichlorobenzene	mg/L	NL	0.075	
Vinyl chloride	mg/L	0.000015	0.002	●
1,1-Dichloroethylene	mg/L	0.007	0.007	
1,1-Dichloroethane	mg/L	0.7	NL	●
Trans-1,2-Dichloroethylene	mg/L	0.07	0.1	
1,2-Dichloroethane	mg/L	0.00038	0.005	●
1,1,1-Trichloroethane	mg/L	0.2	0.2	●
Carbon tetrachloride	mg/L	0.0003	0.005	
1,2-Dichloropropane	mg/L	0.00056	0.005	
Trichloroethylene	mg/L	0.0028	0.005	●
1,1,2-Trichloroethane	mg/L	NL	0.005	
1,1,1,2-Tetrachloroethane	mg/L	NL	NE	
Tetrachloroethylene	mg/L	0.0007	0.005	●
1,1,2,2-Tetrachloroethane	mg/L	NL	NE	
Chlorobenzene	mg/L	0.05	NL	●
Benzene	mg/L	0.001	0.005	●
Toluene	mg/L	1	1	
Ethylbenzene	mg/L	0.029	0.7	
Bromobenzene	mg/L	NL	NE	
Isopropylbenzene	mg/L	NL	NE	
Styrene	mg/L	0.1	0.1	
n-Propylbenzene	mg/L	NL	NE	

< indicates compound not detected at or above the concentration shown
NL indicates that the compound is not listed
NE indicates that a standard has not been established

APPENDIX B

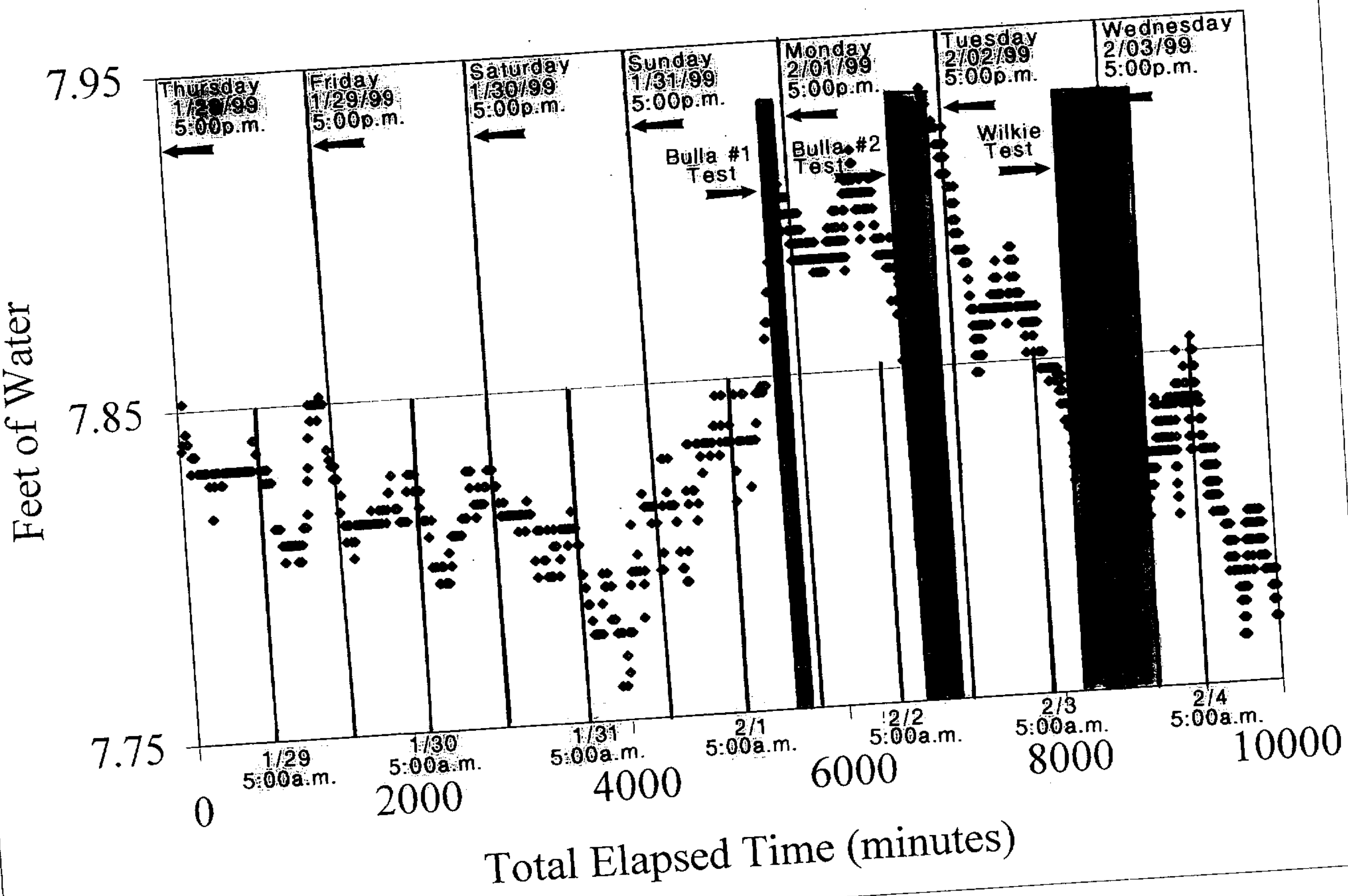
Water Elevation Plots

Wells MW-1, MW-2 and MW-5 - Background Water Levels

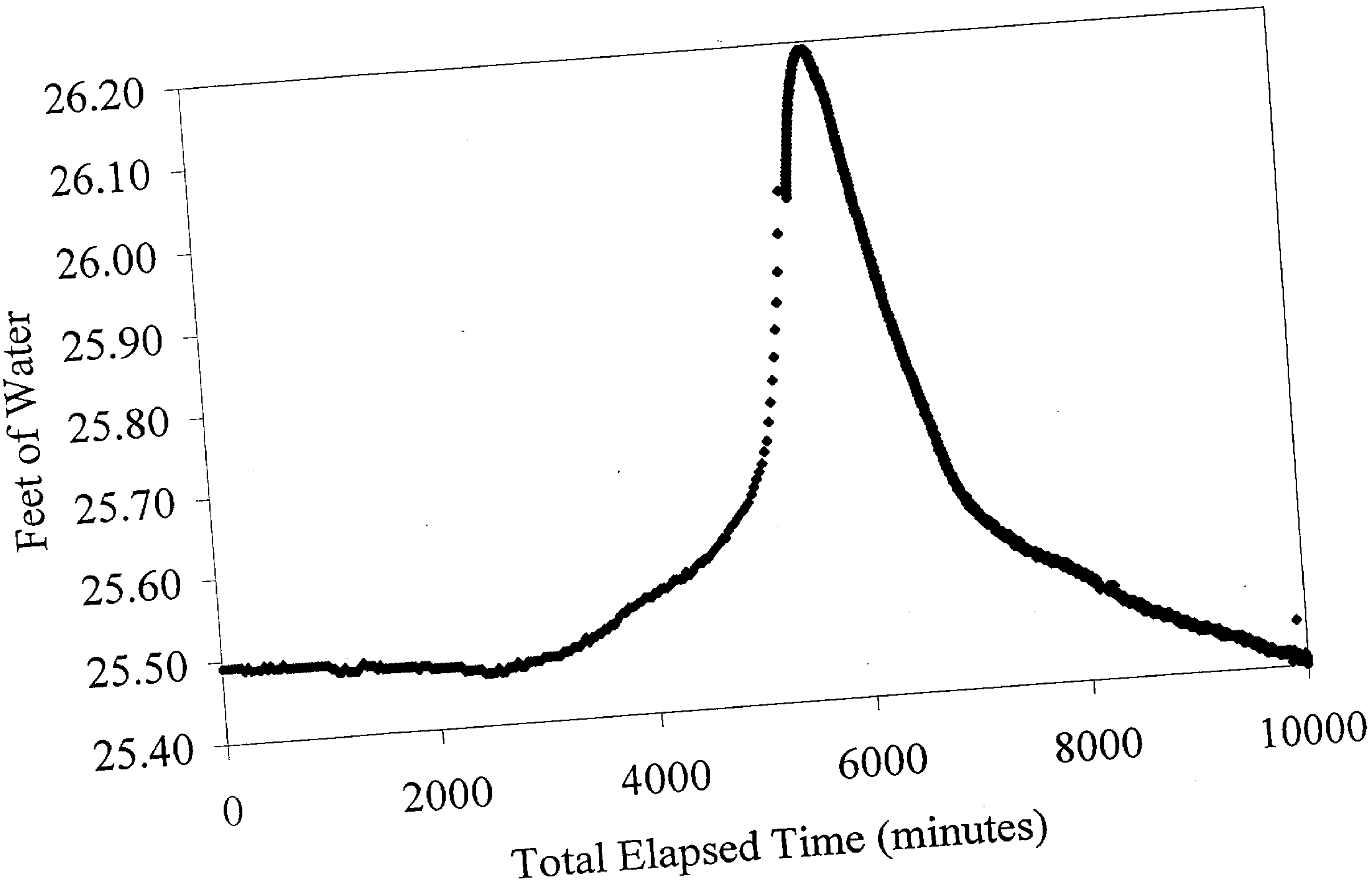


Note: The starting point feet of water data for wells MW-1 and MW-2 have been adjusted to allow for presentation on this chart. The magnitude of water level fluctuations have not been adjusted. Relative water level fluctuations are accurrate.

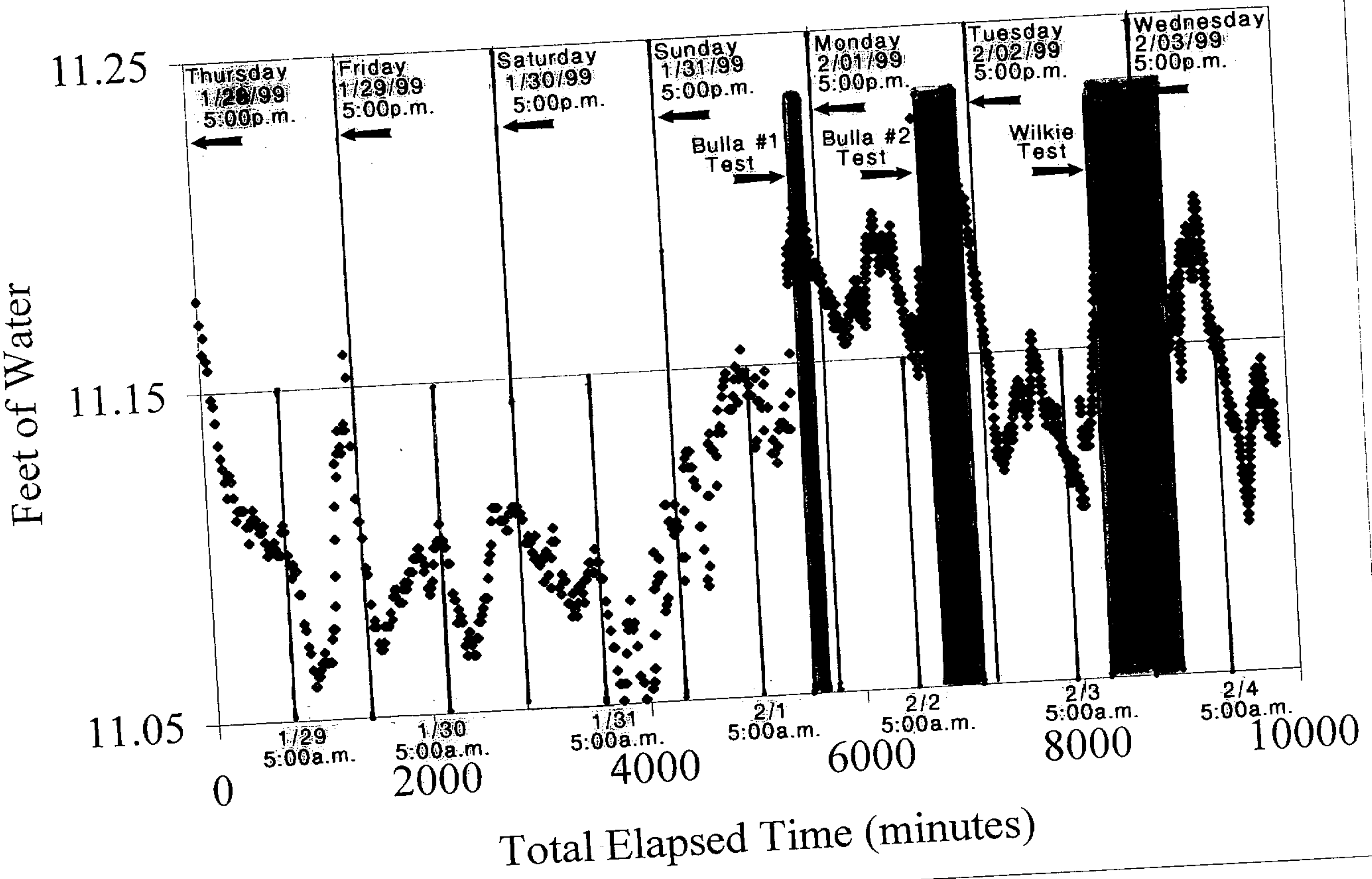
MW-1 Water Level - Entire Test Period



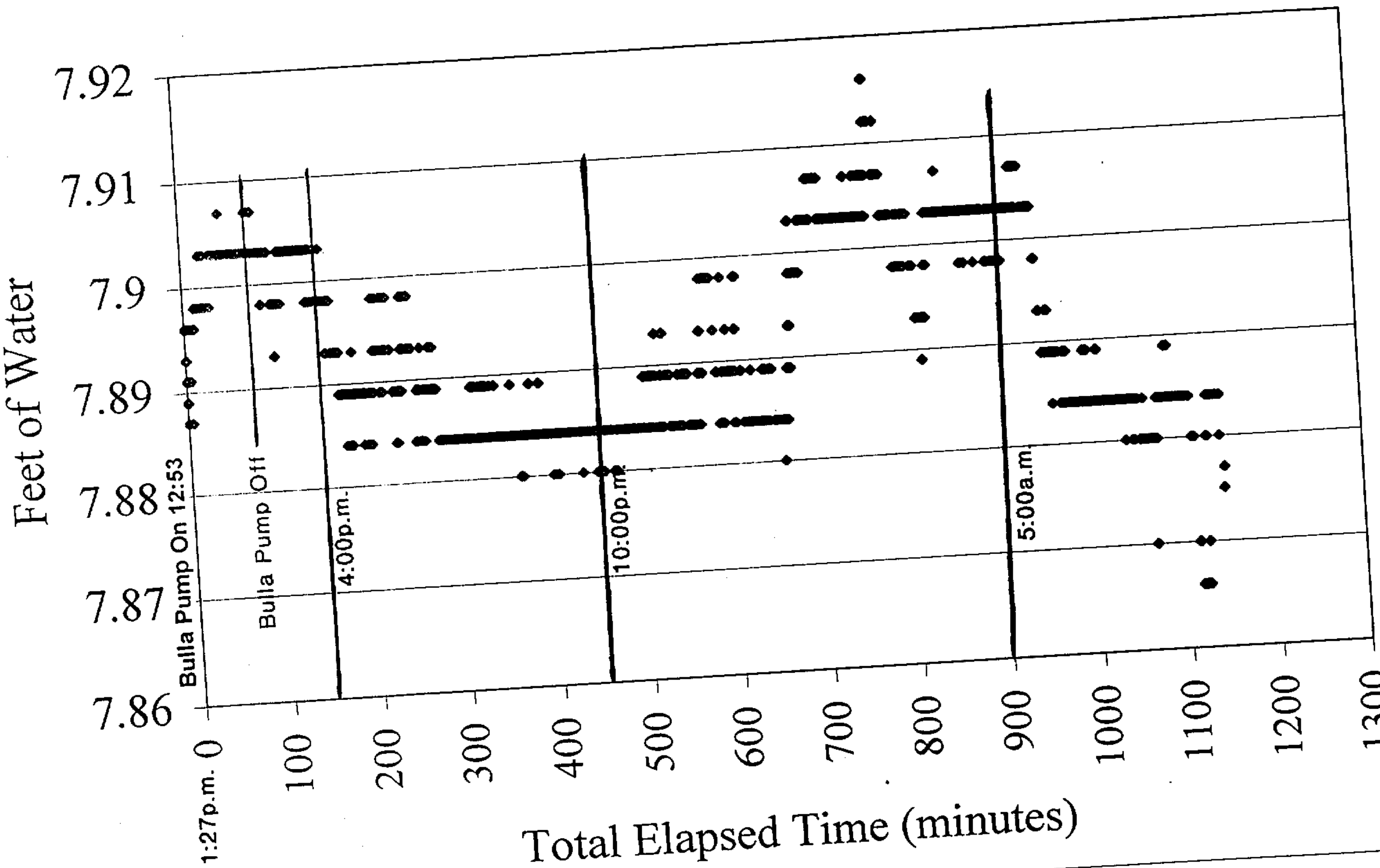
MW-2 Water Level - Entire Test Period



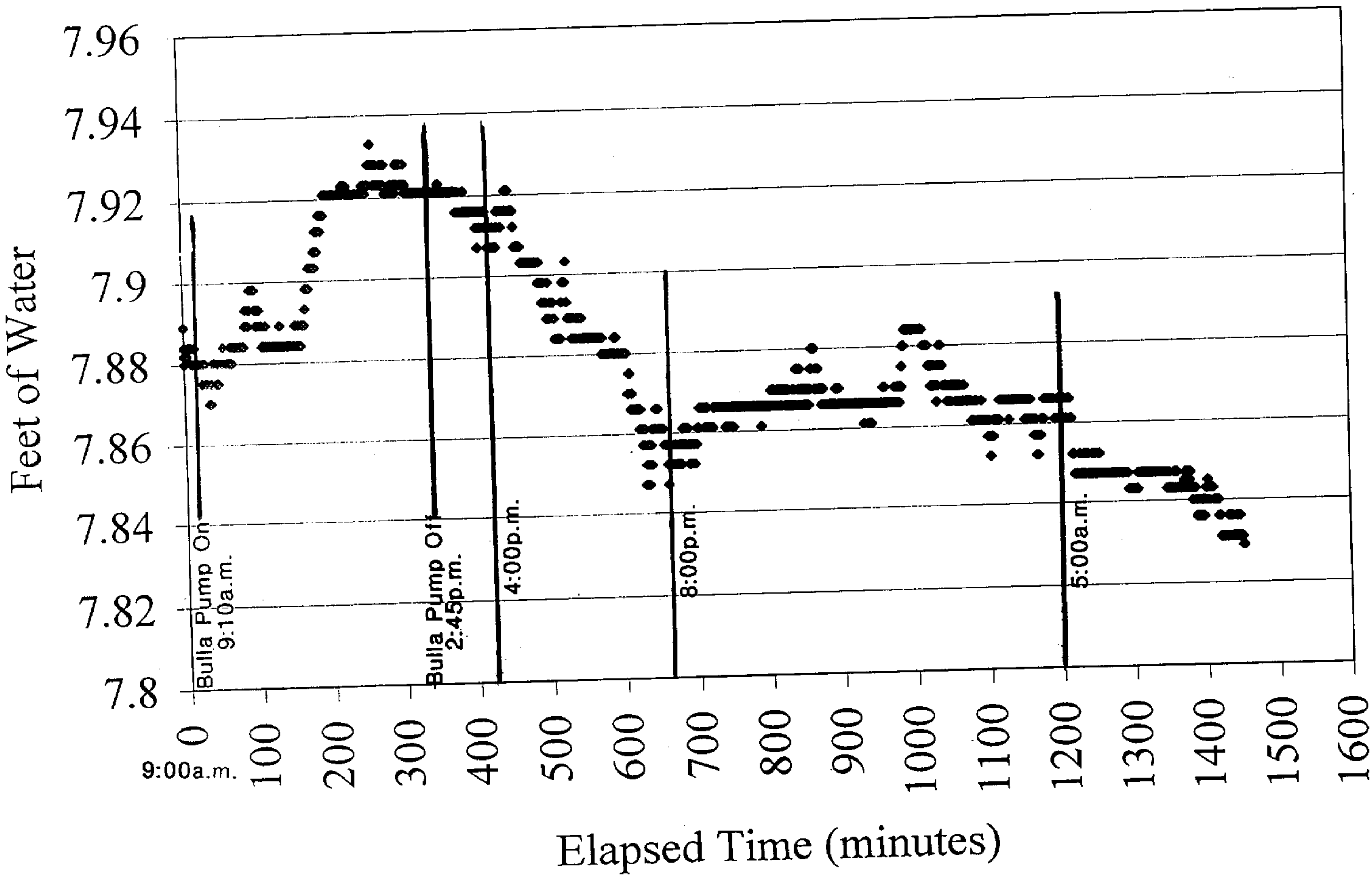
MW-5 Water Level - Entire Test Period

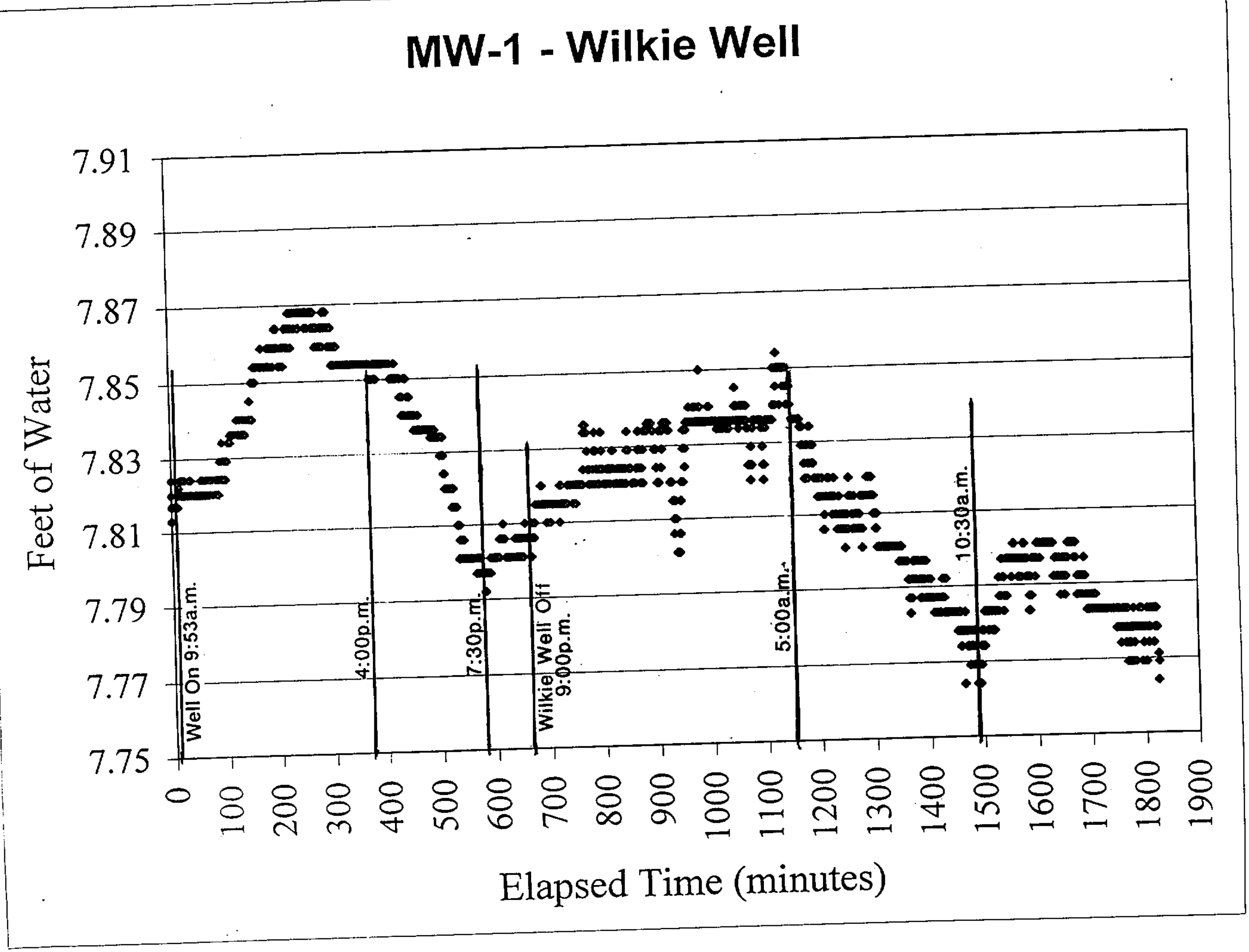


MW-1 - Bulla Test #1

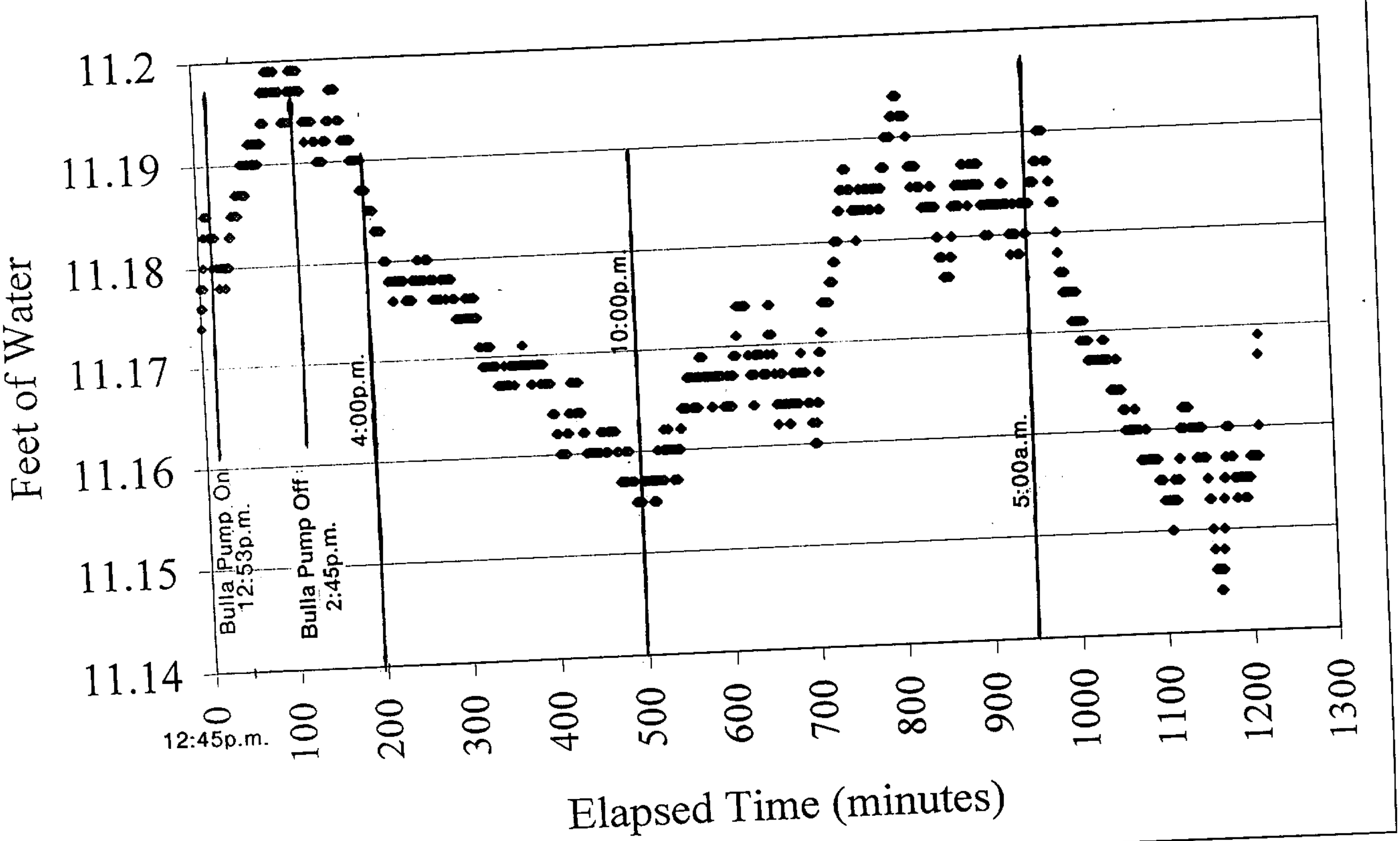


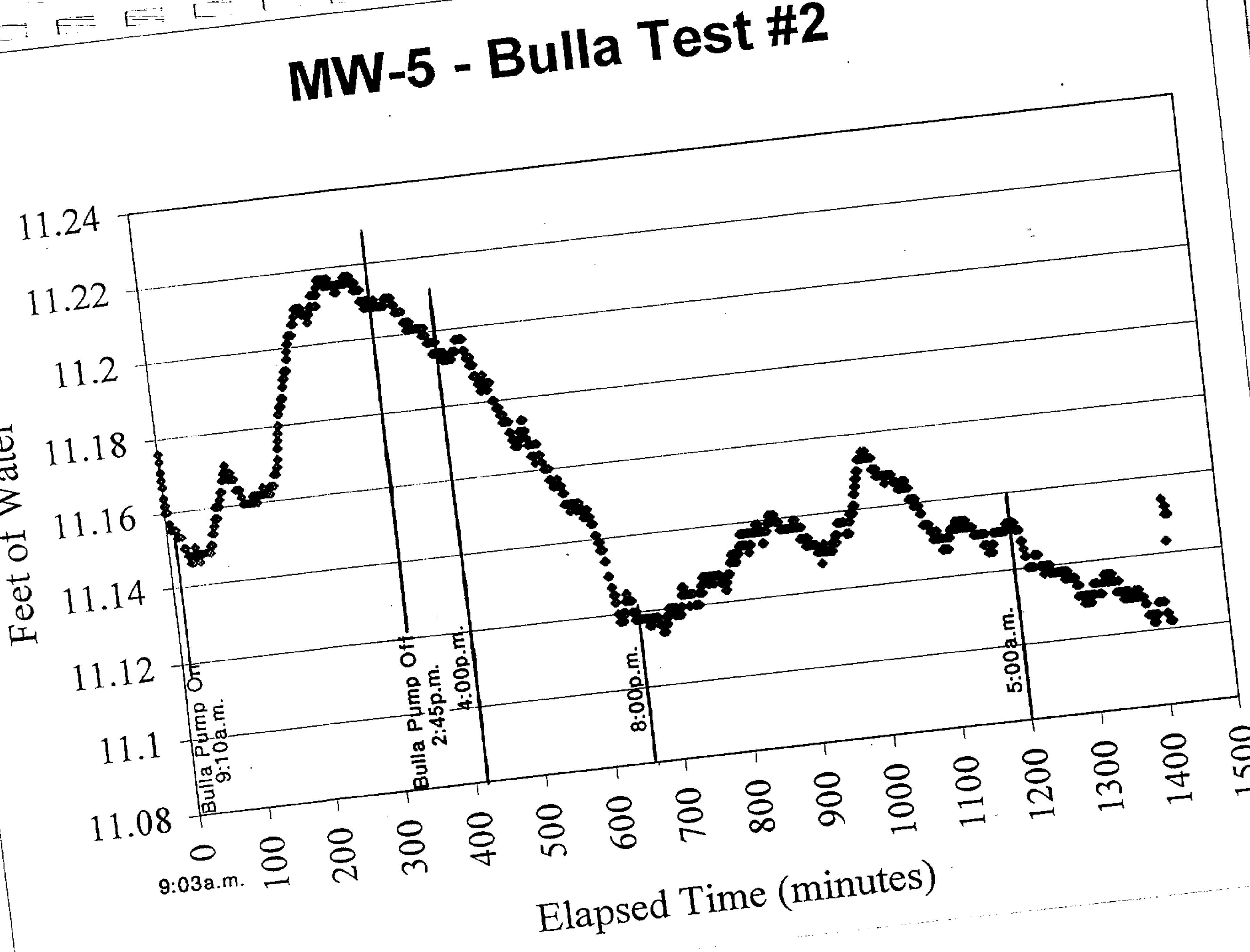
MW-1 - Bulla Test #2



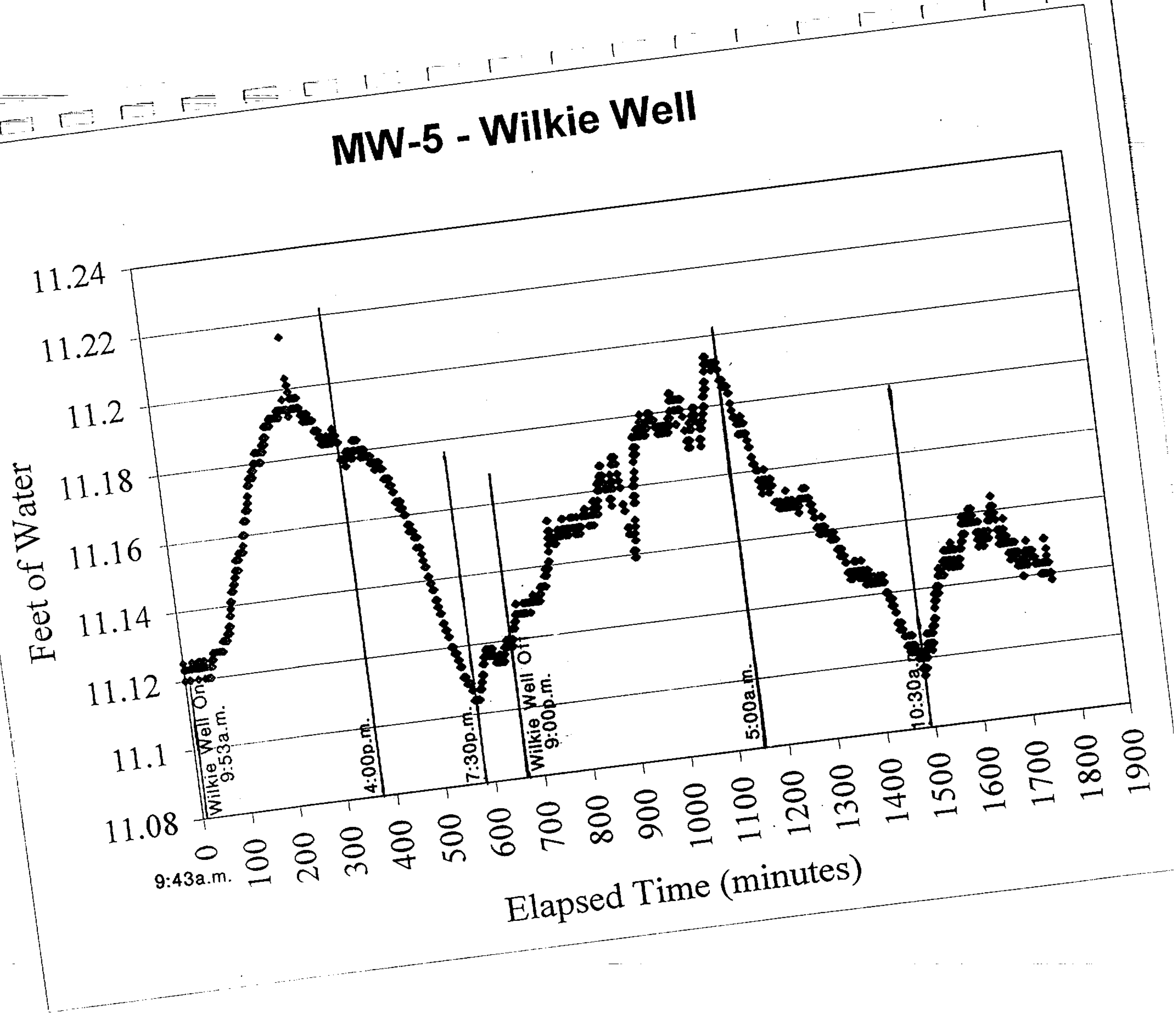

MW-1 - Wilkie Well
Feet of Water
7.91
7.89
7.87
7.85
7.83
7.81
7.79
7.77
7.75
Well On 9:53a.m.
4:00p.m.
7:30p.m.
Wilkie Well Off 9:00p.m.
5:00a.m.
10:30a.m.
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
Elapsed Time (minutes)

MW-5 - Bulla Test #1





MW-5 - Bulla Test #2
Feet of Water
11.24
11.22
11.2
11.18
11.16
11.14
11.12
11.1
11.08
Bulla Pump On
9:10a.m.
Bulla Pump Off
2:45p.m.
4:00p.m.
8:00p.m.
5:00a.m.
0
9:03a.m.
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
Elapsed Time (minutes)



MW-5 - Wilkie Well
Feet of Water
11.24
11.22
11.2
11.18
11.16
11.14
11.12
11.1
11.08
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
1700
1800
1900
9:43a.m.
Elapsed Time (minutes)
Wilkie Well On 9:53a.m.
4:00p.m.
7:30p.m.
Wilkie Well Off 9:00p.m.
5:00a.m.