WELL INSTALLATION

AND

REMEDIAL SELECTION REPORT

Performed for the

Wallkill Wellfield Site

located at

20 Industrial Place
City of Middletown
Orange County, New York

November 2006
(Revised October 2007)

Prepared By:

ECOSYSTEMS STRATEGIES, INC.
24 DAVIS AVENUE
POUGHKEEPSIE, NEW YORK 12603
(845) 452-1658

ESI File: LM97145.45

WELL INSTALLATION

AND

REMEDIAL SELECTION REPORT

Performed on the

Wallkill Wellfield Site

located at

20 Industrial Place
City of Middletown
Orange County, New York

November 2006
(Revised October 2007)

ESI File: LM97145.45

Prepared By:

Ecosystems Strategies, Inc.
24 Davis Avenue
Poughkeepsie, New York 12603

Prepared For:

Laurwal Holding Corporation
P.O. Box 117
Hartsdale, New York 10530

The undersigned has reviewed this Report and certifies to Laurwal Holding Corporation that the information provided in this document is accurate as of the date of issuance by this office.

Any and all questions or comments, including requests for additional information, should be submitted to the undersigned.

Paul H. Ciminello
President

TABLE OF CONTENTS

APPENDICES

Appendix A	Photos and Figures
Appendix B	Tables
Appendix C	Bedrock Core Descriptions/Lithologic Logs–field notebooks
Appendix D	Media: Borehole Videos for Bedrock Wells on DVD

1.0 Introduction

1.1 Purpose

The purpose of the environmental investigation work summarized in this Well Installation and Remedial Selection Report (Report) is to determine the lateral and vertical extent of known groundwater contamination and, in conjunction with previously completed soil and soil gas analyses, to propose remedial actions to effectively respond to these documented conditions. Prior to the implementation of this work, Ecosystems Strategies, Inc. (ESI) prepared and submitted a Workplan for Installation of Additional Monitoring Wells (Workplan), which was reviewed and, subsequent to modifications made to address comments from the United States Environmental Protection Agency (USEPA) and the USEPA's environmental contractors, approved (see USEPA correspondence of June 8, 2004). Preliminary services (contactor bidding, site notification, local agency notification, etc.) were conducted in 2004 and fieldwork was conducted in 2005 and 2006 under the supervision of the USEPA's designated contractor (Malcolm Pirnie, Inc.). Findings/progress was reported to the USEPA in regular written and verbal communications.

The tasks included drilling and coring five bedrock wells, video taping the bedrock walls in each well, packer testing fracture zones in each well, and testing each well by pumping. Another task included drilling and installation of an overburden monitoring well to complete the couplet at the southeast corner of the Site. Chemical analyses of groundwater samples from all monitoring wells were considered in assessing remedial actions. Finally, soil gas sampling data from field work conducted concurrent with this groundwater work has been considered in this Report.

1.2 Site Location

The "Site" as defined in this Report is an irregularly-shaped, approximately 5-acre parcel known as the Wallkill Wellfield Site and portions of adjacent properties, located on the southern side of Industrial Place in the City of Middletown, Orange County, New York (Figure 1-1, Appendix A of this Report).

1.3 Previous Reports

Groundwater and subsurface data have been detailed in reports prepared by ESI and (prior to 1997) other consultants. The most recent comprehensive report on groundwater for this Site is the Draft Interim Summary Data Report of Groundwater Sampling, dated May 2005 and revised June 2005. The most recent sub-surface report for this site is the Summary Report of Subsurface Investigation, dated May 2007 and discussed in Section 4.2.3.

Residential wells were historically utilized to supply the homes along Highland Avenue with water; however, once these residences were supplied with municipal water (November 1983), the direction of groundwater flow changed from southwest to southeast. Generally, the flow had followed fracture zones from the on-Site plant to the Parella well, then toward the Hebrew Day School, drawn by pumping homeowner wells. When pumping ceased, the natural hydraulic gradient resumed and the flow shifted to the south-southeast, as discussed in Section 4.0. Beneath both the Parella property and the Site, groundwater flow is generally toward Industrial Place Extension and the lower Contel parcel.

Data which could be used to illustrate this flow change by the creation of contour maps of water levels, hydraulic gradients, and/or direction of groundwater flow between 1983 and 1994 were not available. In support of the change in flow direction discussed above, anecdotal evidence is available in the form of a net diagram (figure 3-7 from Shakti Site Characterization Report, February 1994) and a map of wells with contamination (Figure 2-7, same report). The net diagram (Figure 1-3) is a three dimensional illustration of the top of bedrock derived from well data. The map of contaminant distribution (Figure 1-4, Appendix A) depicts the property parcels and wells with presence or absence of contaminants. The net diagram was drawn to support the concept of contaminant movement with groundwater flow in the overburden above the bedrock interface. The groundwater flow, at that time, was downhill from the site southwest toward the Hebrew School and other wells along Highland Avenue.

Previous to the work documented in this report, downgradient monitoring wells (MW-11, MW-6, and MW-9) were installed in the overburden. MW-204 was the bedrock well in the most downgradient location. Perchloroethylene (PCE) was monitored in each of these wells during the sampling events prior to 2005. To ascertain the lateral and vertical extent of contamination, additional bedrock monitoring wells were proposed next to each of the three overburden wells (MW-211, MW-206, and MW-209). Also a couplet, consisting of one overburden and one bedrock well (MW-19 and MW-219), was proposed for the southern-most point on the lower Contel property, next to Industrial Place Extension. Finally, one centrally-located bedrock well was planned as a deep bedrock well (MW-220).

The drilling, coring, installation, and video taping of the five bedrock wells are described in Section 2 of this Report. Because groundwater flow occurs primarily in bedrock, this information was reviewed to identify the depths of encountered fracture zones.

Aquifer testing of the overburden and bedrock was conducted with packer tests and pumping tests described in Section 3 of this Report. Packer tests assess the vertical hydraulic connectivity of fracture zones within a single well and pumping tests evaluate the lateral hydraulic connections between wells.

According to available information, chlorinated solvents, including PCE and trichloroethylene (TCE), were used at the Site during the production of electrical components. Prior investigations indicated the presence of PCE in soil and groundwater as a result of historical on-site discharges. A summary of information obtained from previously conducted environmental investigations, which pertains to the work in this Report, is provided below.

In 1983, PCE and TCE were identified in groundwater samples collected from adjoining and surrounding properties. Interim investigation at the site may have occurred but have not been received by ESI; however, as part of this Report, ESI reviewed an investigation (including hydrogeologic studies) by Jacobs and Shakti in March 1993. Jacobs and Shakti identified PCE, trace concentrations of TCE, and trichloroethane, in on-Site soils and groundwater. Two areas of significant soil contamination, designated as the northern and southern "hot spots" (Figure 1-2), were found in the vicinity of the on-Site industrial building, as shown on Shakti maps (1994). Removal of soil from these contaminated areas is documented in ESI's Summary Report of Soil Remediation Activities, dated September 23, 1999.

After review of available documents and consultation with the property owner, an Interim Groundwater Remediation Workplan (Interim Workplan), dated July 23, 1998 (subsequently revised and approved by the USEPA in 2000), was prepared by ESI. Documents reviewed during the preparation of the Interim Workplan included (but are not limited to): the Characterization Report by Jacobs and Shakti; a Groundwater Remedial Design Work Plan by Lawler, Matusky & Skelly Engineers, LLP; USEPA records; and, a Consent Decree issued by the United States District Court for the Southern District of New York.

The Interim Workplan was developed to evaluate groundwater conditions in light of historical groundwater quality and to assess the potential for the installation of additional wells and/or a groundwater remedial system. (The fieldwork summarized in this Report was performed to address the specified sampling requirements of the Interim Workplan).

On April 27, 2001, ESI prepared an Interim Summary Data Report of Groundwater Sampling (April 2001 Groundwater Report), documenting fieldwork and resulting analytical data from the December 2000 and the January 2001 groundwater sampling events. PCE was found at concentrations exceeding NYSDEC guidance levels in groundwater samples collected from both on-Site and off-Site wells. Contaminant concentrations, however, were detected at lower levels relative to PCE concentrations documented in sampling events in 1992 (both peak PCE concentrations and the number of wells indicating high PCE concentrations were reduced). Laboratory results indicated that high levels of PCE still existed in monitoring wells located southeast of the on-site industrial building (in the immediate vicinity of the former southern hot spot). The April 2001 Groundwater Report noted that the previous removal of a significant amount of contaminated soil from the northern and southern hot spots may be directly responsible for the decrease in the extent and severity of groundwater contamination.

The April 2001 Groundwater Report recommended continued sampling of all on-Site monitoring wells to document groundwater quality. Installation of two (2) wells in the vicinity of MW-11 was recommended because MW-11 was often dry as a result of either poor recharge or a lowering of the local water table. In addition, implementation of active groundwater remediation using an extraction well in the immediate vicinity of MW-4 and MW-5 would be considered, with the objective of reducing on-site PCE concentrations in groundwater.

Recommendations provided in the May 2003 Interim Summary Report included (in addition to the recommendations made in the April 2001 Groundwater Report) the installation of additional bedrock monitoring wells in order to monitor the downgradient migration of contamination. The installation of those wells (MW-206, MW-209, MW-211, MW-219, and MW-220) is described in detail in this Report.

The distribution of total volatile organic compound (VOC) contamination in groundwater has changed significantly since the earliest sampling in 1983 and 1984. Those changes have occurred in both the overburden water-bearing zone and bedrock aquifers.

In the overburden, total VOC concentrations were essentially non-detected (ND) north, west, and southwest of the on-Site industrial building. With the exception of MW-5, the total VOC concentrations measured in the overburden wells have declined between 1992-1993 and 2005. In 1992, the concentration measured in MW-2 was 350 microgram per liter (µg/L) but by 2005 the concentration had declined to ND. In 2005, the highest total VOC concentration was in well MW-5 (28,050 µg/L), which had increased from the 1992 measurement of 4,100 µg/L. At MW-3 and MW-16, concentrations have declined respectively from 27,000 µg/L and 8,300 µg/L in 1992 to 3,520 µg/L and 2,740 µg/L in 2005. In well MW-4, total VOC concentrations have declined from 26,000 µg/L in 1992 to 7,810 ug/L in 2005. Concentrations in MW-6 indicate that the well is located on the edge of the plume with values of 27 µg/L in 1992 and 145 ug/L in 2005. In the downgradient location, MW-9 shows a decline of an order of magnitude from 2,700 µg/L in 1993 to 980 µg/L in 2005. Near Industrial Place Extension in the most downgradient location, the new well MW-19 shows a similar concentration of 1,503 µg/L in 2005.

In the bedrock aquifers, the upgradient Parella well (W-30) had the highest concentration of the wells sampled in 2005 (130,000 µg/L). A total VOC concentration at this level is an indication of potential free product accumulation in the bottom of the well. MW-202 has declined from the historical high of 34,000 µg/L in 1984 to 2,787 µg/L in 2005. Likewise, MW-207 shows a decline from 2,500 µg/L in 1992 to ND in 2005. Concentrations in MW-204 have remained more or less constant at about 1,100 µg/L. In downgradient locations, all five new bedrock wells show concentrations on the order of a few hundred µg/L.

PCE concentrations indicate that there are a few groundwater hot spots (Parella Well, MW-5, and the area defined by MW-3 and MW-203). A lower level of PCE contamination remains in the downgradient overburden and bedrock locations. This Report evaluates hydrogeologic conditions that will be used in planning the remediation of PCE and other chlorinated volatile organic compounds (VOCs), which have been found at this site.

1.4 Organization of the Report

This Report summarizes all well installation services, groundwater analysis (both physical and chemical) services, and remedial alternative assessments performed by ESI and designated subcontractors. This work is organized as follows:

Section 2 This section includes a description of activities relating to drilling, coring, installing, and developing five bedrock wells and one overburden well on the Site. Core descriptions, core photographs, and video tapes of borehole walls are presented for identification of fracture zones for the wells.

Section 3 In this section, aquifer testing (packer tests and pumping tests) is described and evaluated for the overburden and bedrock wells. Packer tests are used to assess the vertical hydraulic connectivity of fracture zones within a single well and pumping tests are used to evaluate the lateral hydraulic connections between wells. In addition, VOC analyses of groundwater samples from individual packer zones are reported.

Section 4 This section includes a discussion of the hydrogeological conclusions reached by ESI as a result of the analyses performed and the data gathered to date. This section also documents a conceptual hydrological model of the Site, which is used to support selection of a remedy. In addition, this section includes a summary of the interim remedial actions performed at the Parella well and describes their impact relating to remedial alternatives.

Section 5 This section consists of a comparison of five remedial alternatives being considered for the Site. A tiered process is utilized to rank the five remedial alternatives for the Site. The following criteria are utilized in the ranking process: overall protection of human health and the environment; compliance with applicable or relevant and appropriate requirements (ARARs); long-term effectiveness and permanence; reduction of toxicity, mobility, or volume; short-term effectiveness; implementability; cost; state acceptance; and, community acceptance.

2.0 Well Installation Activities

2.1 Bedrock Well Drilling and Coring

Five locations for bedrock wells were chosen in the downgradient area between the on-Site industrial building and Industrial Place Extension (Figure 1-2, Appendix A). Bedrock wells were positioned to track or map movement of dissolved VOCs in the groundwater flow field. MW-211 was drilled to provide a bedrock well couplet with MW-11, a well showing some contamination on the edge of the on-site groundwater flow pattern. Likewise, MW-206 and MW-209 were drilled to provide bedrock wells associated with the shallow wells MW-6 and MW-9 located near Industrial Place Extension and downgradient from the former electrical plant. MW-219 and MW-19 were drilled on the southeast corner of the Site in the most downgradient position and on/near a fracture zone identified in previous geophysical studies. MW-220 was drilled downgradient of MW-5, a shallow overburden well showing the greatest contamination in recent sampling events. MW-220 is centrally located within the groundwater flow pattern and may be a good location for potential pumping remediation.

2.1.1 Bedrock Well Drilling and Coring Objectives

Each well was installed with continuous coring from top of bedrock to total depth. The cores were used to identify hydrostratigraphic features such as lithology, bedding, structures, soft sediment deformation, and fracture porosity.

2.1.2 Bedrock Well Drilling Field Procedures

Drilling services were provided by Soiltesting, Inc. of Oxford, Connecticut (Soiltesting) from February 22 to March 28, 2005. A five foot core barrel was used with a 4-wheel, tractor-mounted drill rig. The core barrel and drill bit cut a 4-inch wellbore and a 2.5-inch core. Potable water was obtained from the City of Middletown to use as the drilling fluid. The five-foot core sections were cleaned with distilled water and dilute hydrochloric acid. The acid etches the carbonate material on the outside of the core, so the lithologic features are easier to see. The core sections were placed in five-foot core boxes and the depth was labeled both inside and outside of the boxes. Table 2-1 (Appendix B) summarizes dimensions of the new wells and preexisting wells.

2.1.3 Bedrock Core Descriptions/Lithologic Logs

Bedrock features were described in graphic format in the field note book (reproduced here as Appendix C). All cores had excellent recovery with very few separate pieces from each core barrel. Occasionally, the core was slightly longer than the five-foot storage boxes and the core had to be broken with a hammer. In addition, hammering on the core barrel may have occasionally broken the full rock core. Core recovery ranged from 95 to 105% of the nominal five-foot core barrel. For these reasons, rock quality designations (RQD) were not computed.

During drilling very little fluid was lost to the water-bearing fractures encountered by the core bit. The lack of lost fluid was indicated by the increased viscosity of recirulated drilling fluids due to suspended gray shale & silt fragments. The viscosity of the fluid often made it difficult to raise the core barrel.

Fractures were identified and photographed (Appendix A) as were other pertinent sedimentary features. Copies of the lithologic logs were joined to create five logs, one for each well. Attempts to correlate bedrock features from one well to another were made by aligning the five logs side-by-side; however, this attempt was not successful. Lateral stratigraphic changes may occur between wells. Structural dip of the bedding may result in comparison of vertical sections which are above and/or below each other in the original stratigraphic sequence.

Examination of the cores reveals two main lithologies (see photographs of cores in Appendix A), fine-bedded dark gray shale and light gray massive fine-sandy siltstone. Beds of white calcite are generally 0.1 to 0.2 inches, occasionally 1 to 2 inches, and rarely 2 to 6 inches in thickness. The interbedded shale suggests the calcite represents original sedimentation indicating a shallow, warm water high-energy marine environment of deposition. Prominent fractures, which were observed in the cores and shown in photographs, are described in Table 3-3 (Appendix B). It was observed that some of the fractures cut the core at right angles, as indicated by a circular face. Other fractures cut the core at a low-angle (less than 45 degrees from horizontal) and were characterized by elliptical surfaces. In addition, sometimes the face was observed to be weathered. Other times the face is associated with a thin calcite bed and sometimes a very thin layer of shiny black carbonaceous material, striated with slickensides indicating slippage along the bedding plane.

For overburden well MW-19, the driller's well construction diagram and lithologic log are included as Figures 1-5 and 1-6, respectively, in Appendix A.

2.2 Video Taping New Bedrock Wells

2.2.1 Borehole Video Field Procedure

Borehole video taping was utilized in place of geophysical logging because fractures could be viewed directly and compared with the bedrock cores. A GeoVision Micro (model number GVMICROM1) was used to video the bores. The following process was used at each well. First, the camera and tripod was setup then the depth counter was calibrated to measure from the ground surface (as zero) and increasing in magnitude downward. Calibration of the depth counter assured that the depths of the core would match the depths recorded on the video frames. The camera was recording while traveling both down and then back up the borehole.

2.2.2 Selection of Fracture Zones from Borehole Videos

The video tapes (one per well) were copied to DVDs and are included with this report (Appendix D). The most readily distinguished feature on the videos are the bedding planes, where they look like circles when bedding is horizontal or ellipses when bedding is tilted. The pervasive thin white calcite beds are clearly recognizable because of the birefringence (bright refraction of light) of the calcite mineral. The fractures appear as openings in the sides of the borehole. Sometimes, cracks can be seen on opposite sides of the borehole, or sometimes completely around the borehole as a circle or ellipse. Notes were made indicating the presence of fractures observed on the videos and then they were compared with core descriptions and photographs. A description of the fractures observed in each well is provided in Table 3-3. In several instances, further analysis of the core was needed to confirm the presence or absence of fractures at a particular depth.

3.0 Aquifer Testing and Quantitative Interpretation

3.1 Packer Testing

3.1.1 Packer Testing-Objectives

The packer testing program was planned to aid in the remediation design by identification and evaluation of bedrock fractures conducting contaminated groundwater. The packer tests demonstrate the vertical connectivity of fracture zones within a well and how much water each packer zone can yield.

3.1.2 Packer Testing-Field Procedures

Packer tests are conducted by sealing off a vertical section of a well and then either pumping water into or out of the packer interval, and subsequently into or out of the bedrock formation. In this case, water was pumped from the interval, and the effect on overlying and underlying zones was observed. A sample of water was taken from the packer interval near the end of the test. Multiple packer tests were preformed in each well at different depths depending on where fractures are located.

The packer tests were conducted from July 15 to July 28, 2005. Packers and other testing equipment were provided by Soiltesting. The packer assembly consisted of two inflatable packers each 4.5 feet long separated by ten feet of 1-inch diameter perforated steel pipe (Figures 3-1 and 3-2, Appendix A). The ten feet between the packers is the "packer zone" or "packer test zone." The two rubber packers are inflated with nitrogen (Figure 3-3) in order to have a tight seal on the bedrock wall in the packer zone. Water entering the packer zone from the bedrock fractures is isolated from the wellbore both above and below the packers. Above the top packer, the central perforated pipe is attached to two-inch steel casing sections to the top of the well casing.

The packer tests involve pumping water out of the sealed packer zone, obtaining a sample of water, and recording water levels during pumping and recovery. By monitoring drawdown and recovery, the recharge rate was estimated for each packer zone. A Grundfos Redi-flo2 pump was placed in the central casing just above the upper packer in order to obtain a fresh water sample from the bedrock at the end of pumping (Figures 3-4 and 3-5). The validity of the sample was then determined based on the pumping duration. If the duration was long enough to evacuate the original volume of water in the packer zone to the surface through the tubing attached to the pump, the sample was considered "valid". After pumping, recovery (if any) was monitored for a brief time and then the packers were deflated and moved to the next test depth. Accuracy of the packer interval was obtained using short pieces of casing (5, 3, 2, and 1-feet in length).

The depths of the fracture zones to be tested were identified from studies of the rock cores and the video recordings. In most cases, bedrock openings observed in the video correspond to fractures observed in the cores. Photographs of fractures observed in the cores and associated with some of the packer tests are described in Table 3-3 (Appendix B).

Solinist Leveloggers and In-Situ miniTrolls (data logging probes) were used to continuously monitor the water levels above, below and within the packer zone. The Leveloggers were lashed to the exterior of the packer assembly just below the lower packer, just above the upper packer, and within the packer zone. A miniTroll was used to monitor the packer zone in real time by lowering it down the central conductor pipe and placing it in the perforated center pipe. The Leveloggers were able to measure down to a maximum depth of 100 feet; therefore in the deeper tests, data from the miniTrolls was utilized because they were rated to 300 feet. The logging interval was set at every 30 seconds. Temperature and feet of water above the pressure transducer was recorded in the internal memory of the Leveloggers and miniTrolls.

Communications with the two miniTrolls could not be re-established once they began logging. Hence, they continuously recorded temperature and pressure at 30-second intervals from the beginning of testing until the data was recovered by the manufacturer. Consequently a water level indicator was used to monitor water levels within the packer zone.

When packer testing was completed, the miniTrolls were returned the manufacturer, In-Situ, Inc. in Fort Collins, Colorado. The data was downloaded and sent, via e-mail, to Pine Environmental (the rental service) and ESI. Some of the data were duplicated by the Leveloggers and the miniTrolls at depths less than 100 feet.

The water sampling was designed to determine if groundwater in the packer zone fractures contained any contaminants. Only those samples tested from zones with recharge are valid samples because the others would be compromised with commingled waters.

Once the packers were inflated and seated, the pump was turned on and the flow was adjusted to a rate of 0.25, 0.5, or 1.0 gallon per minute (gpm). The water level in the central conductor casing was monitored. If the recharge seemed to keep up with pumping, the pumping rate was increased. Once the water level was drawn down to within 1 to 2 feet of the pump in the central conductor casing, a sample was collected and the pump shut off. The well was then allowed a few minutes to recharge through the fractures in the packer zone, if possible.

3.1.3 Packer Testing-Interpretation of Field Data

Packer testing began with well MW-211 and proceeded with MW-206, MW-209, and MW-219 and ended with MW-220. Graphs of water levels were plotted showing the height of water above each transducer versus time. On the x-axis (horizontal scale), time is shown in minutes increasing to the right (Figure 3-6 to 3-41, Appendix A). Transducer measurements were taken every 30 seconds.

On each graph (except for MW-211), the three Leveloggers curves are shown as green triangles above the packer zone, as magenta (dark pinkish purple) square boxes in the packer zone, and as purple diamonds below the packer zone. In the packer zone, the miniTroll data is shown in cyan (greenish blue) X's. The two curves for the Levelogger and miniTroll in the packer zone provide duplicate data, except when the depth to the logger was greater than 100 feet (out of range for the Leveloggers).

The beginning and ending time for each graph is shown in the upper margin. The time the pump is turned on is indicated on the curve of the water levels measured in the packer zone. If the pumping rate is greater than the natural recharge rate, the water level drops in the packer zone and is shown as an upward curve through time due to the decline in the column of water over the transducer. The y-axis (vertical scale) is the height of the water above the transducers with magnitude increasing downward, thereby providing data curves, which relate to their physical orientation within the wellbore. On occasion, the water level in the packer zone appears to be below the water level in the zone below the lower packer because the miniTroll was seated in the bottom of the center pipe of the packer assembly. The center pipe is isolated from below the packers, but does extend below the base of the lower packer.

Packer test results are summarized in Table 3-1, Appendix B. The data are used to estimate rate of drawdown and the rate of recharge for each packer test in each bedrock well. The drawdown rate is calculated from the water levels recorded at Time 1 and Time 2 during pumping, while the recovery rate is calculated from water levels recorded at Time 3 and Time 4 after pumping stopped. The drawdown rate (ddrate) and recovery rate (RecovRate) are calculated in feet per minute.

When the calculations were completed, some qualifiers were entered into the matrix (Tables 3-1 and 3-3) in order to compare recovery or recharge rate in each packer zone as well as the zones above and below the packer interval for each test. For each test, by observation of the graph of water levels in the zones above and below the packer interval, recharge or discharge are indicated with a qualifier, such as "no", "some", "little", "good", and "best" (Table 3-1). For each well, the recharge in each packer zone is similarly noted (Table 3-3). These descriptions are empirical and relate only to the values in each individual well. One value for each well is described as "best" and then the rest of the values are compared to this value and described accordingly using the other qualifiers.

The validity of each water sample was determined by calculating the total volume of water pumped from the packer zone and then discharged. If at least one full volume was removed, the sample was judged "valid".

MW-211 (Figures 3-6 through 3-11)

Six fracture zones were identified in MW-211. The first packer test was set up on the interval of 37 to 47 feet. Duplicate data for the packer zone was not available for the tests conducted in MW-211 because testing began with one miniTroll in the packer zone (cyan triangles on graphs) and two Leveloggers, one above the packer zone (magenta square boxes) and one below the packer zone (purple diamonds).

For well MW-211, the first packer test (37 to 47 feet) was a series of pump on and pump failures with recovery after each breakdown. There were sufficient data to estimate drawdown and recovery rates, but no information on pumping rates was recorded, because breakdowns occurred before measurements could be taken.

The top three zones exhibited very slow recovery. The lower three zones had good recharge. Zone 4 (85 to 95 feet) was able to sustain pumping at two gpm with little drawdown. Zone 5 (103 to 113 feet) had the most rapid recharge. Zone 6 (113 to 123 feet) had little drawdown and good recharge. Zones 5 and 6 appear to be hydraulically connected because the water level below the lower packer in Test 5 had pumping effect and recovery mimicking response in the packer zone.

In Test 6, it is believed that installation of the packers disturbed sediment in the well because the Levelogger recorded great depth of water most likely due to suspended sediment in the water column. As the sediment settled, the Levelogger below the packer zone exhibited a response similar to the miniTroll in the packer zone, thereby verifying hydraulic connectivity of Zones 5 and 6.

MW-206 (Figures 3-12 through 3-16)

Packer Test 1 (22 to 32 feet) showed no recovery after the pump was turned off. Packer Test 2 (43 to 53 feet) indicated good recharge and hydraulic connectivity with fractures below the packers. Tests 3, 4, and 5 exhibited fracture zones isolated from water above and below the packer interval. Good recharge occurred in all three tests and the water samples are considered "valid."

MW-209 (Figures 3-17 through 3-23)

During Test 7 (20 to 30 feet), Test 1 (28-38 feet) and Test 2 (41 to 51 feet) the water level dropped in the packer zones during pumping. When the pump was turned off, recovery appeared to be slow. In addition, when the recharge from above the packers is observed, the slope of recharge is approximately the reverse slope of recovery. Consequently, those three tests show no significant recharge from the wellbore within the packer zones. Test 3 (58 to 68 feet) and Test 4 (70 to 80 feet) indicated isolated fracture zones with some recovery from fractures within the packer interval. Test 5 (95 to 105 feet) and Test 6 (108 to 118 feet) indicate suspended sediment in the zone below the packers. Both responded to pumping and recovery in the packer zones and both were recharged from below the packers. However, Zone 5 showed significantly better recharge than any other zone in the well. In Test 5 when pumping stopped, the lower packer may have become unseated and allowed water to seep upward between the packer and the wellbore during recovery as indicated by increasing recharge from below. In Test 6, the packer was seated on the wellbore, but recharged from below during pumping and recovery. Because of lack of recharge from fractures during pumping in the other Tests, only the water sample from Zone 5 is considered "valid."

MW-219 (Figures 3-24 through 3-30)

Test 1 (21 to 31 feet) shows a packer zone with slight recovery by recharge from above the packer zone. Test 2 (35 to 45 feet) shows a fracture zone with some recharge from above the packers and more from the fractures intersecting the wellbore within the packer zone. Test 3 (45 to 55 feet) indicates good yield and good recharge with some recharge from both above and below the packers. Test 4 (65 to 75 feet) indicates a situation similar to Test 5 in MW-209 in which the packer zone exhibits isolation and drainage during pumping. When the pump is turned off, recovery begins and recharge occurs from below with the rate of recharge increasing with time. Test 6 (115 to 125 feet) and Test 7 (127.5 to 128.5 feet) indicated isolated fracture zones with some recovery. Recharge in Zone 6 is greater than in Zone 7. With the exception of the sample from Zone 1, all of the other water analyses are considered "valid."

MW-220 (Figures 3-31 through 3-41)

The packer tests in this well indicate that it is quite different hydrogeologically compared to the other four bedrock wells because each of the 11 packer tests indicate an isolated packer zone with no recharge from above or below the packer interval. Recharge did not occur in Tests 1, 2, and 5 and samples from those zones are deemed "invalid." The other 8 tests exhibited sufficient pumping and recharge to render the water samples as "valid." Some recharge from fractures occurred in Tests 3, 6, 8, and 10. Test 10 indicated slight recharge from above the packers during recovery. Good recharge occurred in Tests 4, 7, 9, and 11 with the best recharge in Test 7. Prior and at the start of pumping, most of the tests indicated a rise in water level in the zone above the packers. That effect may be due to adjustment of the water table to the downward movement and inflation of the packers.

3.2 Chemical Analyses from Packer Zones

Associated with each packer test, a groundwater sample was collected at the surface from the Grundfos pump discharge tubing after the pump was shut off and prior to recovery and deflation of the packers. The tubing was disconnected at the well head and the water which remained in the line was collected for sampling, field parameters (i.e. temperature, pH, dissolved oxygen, turbidity, etc.) were not measured at the time of sampling. The procedure did not conform to low flowing sampling protocol because the objective was to measure recharge of each packer zone. The sampling was conducted to discern if contamination varied in different packer zones. As stated in Section 3.1.3, the samples were judged "valid" if sufficient water was pumped to evacuate the packer zone volume at least once. That level of purging assures a significant portion of the sample comes from recharge from bedrock fractures.

For MW-219 Test 5 (93 to 103 feet), sample vials were broken in transit to the laboratory. From MW-220, samples were not taken from the packer zone for Test 10 (168-178 feet) and Test 11 (183 to 193 feet) because the packer zone was pumped dry and recovery was inadequate to a get a sample.

Toluene was detected in 25 of the 33 water samples at levels between 1.0 and 150 ug/L (Table 3-2). Toluene had not previously been detected at this site. The toluene seems to have been introduced with the inflatable packers. Toluene was not detected in any of the field blanks. It is believed that this occurred because the field blanks were prepared without any contact with the packers. Compounds detected in most of the field blanks are compounds of concern for the Site. In some instances, the concentrations detected in the field blanks were greater than the concentrations detected in the groundwater samples. The presence of these compounds in the field blanks indicates that the packers, pumps, and/or sampling equipment may not have been properly decontaminated before first use and in between wells. The possible cross contamination of the samples should be a factor when using the packer testing samples in any future analysis.

The volatile organic compounds detected in the samples are listed in Table 3-2. Generally, concentrations of VOCs in the valid samples are 1.5 to 2 times the levels observed in the invalid samples. The invalid samples represent static or dormant well conditions, where at least a portion of the "valid" or "fresh" samples were drawn from fractures in the surrounding bedrock. The samples are characterized by the presence of the following contaminants (reported in µg/L):

	Valid Samples N = 18		Invalid Samples N=15	
	Range	Average	Range	Average
1,2 Dichloromethylene	9 - 110	41	1 - 110	48
Chloroform	ND - ND	ND	2 – 200	13.4
Tetrachloroethylene	100 - 710	319	3 - 450	176
Toluene	ND - 120	150	ND - 85	319
Tricholoroethylene	5 - 120	43	2 - 140	44

Because the number of samples in each classification is low, the average values may not be significantly different. The distribution of contaminants indicates that the analytes are pervasive throughout the fractures at all depths in the bedrock wells.

3.3 Aquifer Testing: Pumping Tests

Pumping tests were conducted to ascertain the potential yield of wells and observe drawdown in nearby wells to quantify overburden and bedrock hydrogeologic conditions.

3.3.1 Pumping Test-Objectives

The pumping tests were designed to characterize lateral or horizontal groundwater flow and connectivity between bedrock wells and to determine if vertical hydraulic conductivity exists between the overburden and bedrock exists.

3.3.2 Pumping Test-Field Procedures

Five pumping tests were conducted in April 2006. Continuous recording pressure transducers were placed in the wells on April 16, 2006 and removed on April 24, 2006. Transducers were placed in the five new bedrock wells (MW-206, MW-211, MW-209, MW-220, and MW-219), which were pumping wells. Transducers were also placed in the nearby shallow wells (MW-3, MW-4 and MW-7) and bedrock wells MW-203, MW-204 and MW-207 as well as MW-5 and MW-16. Each logger was programmed to take measurements of the pressure of water above the transducer at one-minute intervals. All of the loggers were synchronized. One logger was setup to measure barometric pressure. The barometric variation was compensated for when the records were uploaded to a computer.

The pump was placed about 10 feet above the bottom of the well. Each well was pumped for about 12 hours during the day and allowed to recover during the night (Table 3-4, Appendix B). Water levels were monitored during pumping and recovery in all wells.

The wells were pumped at a constant rate with stabilized drawdown. A Grundfos Redi-flo2 pump was used for all of the wells except MW-220. Based on the packer test results, MW-220 was thought to have a potential yield on the order of 12 gpm. To pump at a greater rate, a Grundfos Redi-flo3 was used in MW-220.

The pumped water passed through two carbon filter units and discharged through tubing to the storm drains along Industrial Place Extension. Fresh carbon cartridges were used for testing each well.

3.3.3 Pumping Test-Interpretation of Data

Graphs from each of the pumping wells (MW-206, MW-209, MW-211, MW-219, and MW-220) for April 17, 2006 through April 22, 2006 depict drawdown and recovery for each of the tests (Figures 3-42 through 3-49, Appendix A). These graphs show that the radius of influence of pumping for each well is greater than the distance between the most distant pair, greater than 700 feet. The terms upgradient and downgradient refer to horizontal flow from Highland Avenue toward Industrial Place Extension.

Records of MW-206, MW-209, MW-211, and MW-220 (Figures 3-43, 3-44, 3-42, and 3-45) show that as the pumping tests progressed, these wells did not recover fully to pretest static water levels, suggesting limited recharge of those wells. The 5-day graph for MW-219 (Figure 3-46) showed progressively higher recovery above pre-test static levels after each pumping event. That condition may indicate that water was moving downgradient (for the purpose of this document "downgraident" will refer to the horizontal movement of water, not the vertical movement) and recharging the area around MW-219 by raising the water table during the week of testing. In the bedrock wells, the potentiometirc surface did not return to pre-test levels indicating that less hydraulic pressure was available because water was pumped out of the aquifer. That condition is referred to here as "limited recharge".

Under uniform aquifer conditions, lesser drawdown is expected in observation wells at progressively greater distances from the pumping well. The two wells that show the least impact on each other were MW-220 and MW-219, although they are not farthest apart. MW-211 and MW-219 are farthest apart and demonstrate greater impact on each other than MW-219 and MW-220. These observations indicate that the aquifer is not homogeneous with respect to flow rates in different directions. For a discussion of pumping tests for each pumping well, see Section 3.3.4.

The water levels in MW-203 do not show any impact from the five pumping tests (Figure 3-47) indicating that the area around MW-203 is hydraulically isolated from the neighboring bedrock wells (MW-220 and MW-211). Drawdown and recovery from each of the five pumping tests are clearly shown on the water levels recorded at MW-204 (Figure 3-48), which is expected because it is centrally located. Water levels in MW-207 (Figure 3-49) clearly show only the effect of pumping MW-220, which is the closest pumping well to MW-207. Also the water table around MW-207 was apparently lowered by pumping MW-220 because recovery was limited. The pumping tests seemed to have an effect of water moving downgradient (toward Industrial Place Extension) and insufficient water was available from upgradient (from Highland Avenue) to recharge the aquifers to pretest levels.

No impact from any of the five pumping tests in the bedrock wells is shown on the graphs of water levels in the shallow overburden wells (Figures 3-50 through 3-58, Appendix A). Those observations support the idea that the fractured bedrock aquifer is confined from the overlying overburden groundwater. However, all of the overburden wells do show a slight decline during the aquifer testing period. The tests were conducted after a few weeks with little precipitation. In those overburden wells, water table decline is most likely the result of no recharge from precipitation and insufficient recharge from upgradient. Because the decline in the water table was minimal and expected due to a lack of precipitation, elimination of background effects were not performed for the data sets. The exception to the water table decline was MW-19. Similar to MW-219, the water table rose in both of these wells over the course of testing. In the vicinity of MW-19 and MW-219, both the overburden and bedrock aquifers seem to have been recharged by downgradient flow of groundwater during the testing period. The recharge came from the waters in the overburden and bedrock in the middle of the Site moving from Highland Avenue toward Industrial Place Extension.

3.3.4 Graphic Analysis of Pumping Tests

To interpret pumping test data, a critical step involves identifying the theoretical aquifer model, which the pumping and recovery curves represent. Empirical methods have been developed with mathematical functions representing various aquifer conditions such as:

- Confined or unconfined
- Leakage from source beds or impermeable beds
- Delayed yield
- Partial penetration of the well into the aquifer
- Well-bore or casing storage
- Cone of depression intercepting recharge boundaries
- Cone of depression intercepting impermeable boundaries
- Fracture and block model with dual porosity system
- Isotropic or Anisotropic, homogeneous or directional properties

An unconsolidated aquifer of loose sediments and/or a consolidated aquifer of fractured or porous cohesive bedrock can be characterized by one or a combination of the above listed conceptual aquifer model properties. Each model has diagnostic curve shapes when pumping well or observation well water levels are plotted as semilog or log-log graphs of drawdown versus time. Sketches of diagnostic drawdown curves have been copied and reproduced here, in Appendix A, as Figures 3-59 to 3-61 from Aquifer Testing by Dawson and Istok (1991) and Figures 3-62 to 3-65 from Analysis and Evaluation of Pumping Test Data by Kruseman and deRidder (1990, second edition).

Water level data from pumping wells and/or observation wells can be used for aquifer model selection. Observation wells tend to have more pronounced signatures when compared to their pumping wells so they are more useful in identifying aquifer conditions. The semilog plots tend to be somewhat easier to work with than the log-log plots. In this study, aquifer model verification is done with semilog time drawdown graphs for both pumping and observation wells for each test.

The basic assumption made here is that nonequilibrium or transient equations apply to the Site because these equations were developed to evaluate confined aquifers under transient conditions, which best matches the condition encountered at the Site. This means that the aquifer conditions vary with time and involve storage. Specific assumptions for such equations include:

- The aquifer is confined, horizontal, homogeneous, isotropic, of uniform thickness, and infinite areal extent.
- The pumping well is of infinitesimal diameter and fully penetrates the aquifer.
- Flow to the well is radial, horizontal, and laminar.
- All water comes from storage in the aquifer within the area of influence and is released from storage instantaneously with decline of pressure.
- Transmissivity and storativity of the aquifer are constant in time and space.

Since the pumping tests were conducted and observed in bedrock wells, the aquifer is considered consolidated. Each of the time drawdown plots exhibits a similar characteristic curve which has been interpreted to represent the following aquifer conditions:

- Leaky Confined with drainage from Wellbore Storage

The diagnostic parts of the curves are identified on semilog graphs. The wellbore storage is actually the quick pump down of the water from inside the wellbore or well casing. At the beginning of pumping, the effect occurs over a very short time period because drawdown is limited in the wells and the pumping rates are relatively low. There are insufficient data to demonstrate if the leakage effect is related to source beds or impermeable beds at the Site. The pumping time was not long enough to observe and differentiate the origin of the leakage.

The terms "confine" and "leaky" or "leakage" at first seem to be opposites and mutually exclusive. This dichotomy is explained in the US Department of Interior Ground Water Manual (1985, page 121) as:

"Under sufficient head, even apparently impermeable geologic materials will transmit water, and confining layers enclosing artesian aquifers are no exception. Where two or more aquifers are separated by a confining layer, pumping may disturb the mutual hydraulic balance and result in an increase or decrease in leakage between the aquifers. Such leakage is a boundary condition. Theoretically, the area of influence of a discharging well expands until leakage into the aquifer induced by the well equals the well discharge. At this point the area of influence stabilizes and the drawdown becomes constant with time. Conversely, if discharge from a well in an aquifer that is losing water by leakage balances the amount of leakage, the area of influence will stabilize."

At the Site, aquifer conditions consist of a bedrock aquifer confined from the overlying overburden till material. As pumping continues, leakage affects successive observation wells as the cone of depression expands. As discussed above, background effects were not removed from the data sets after the pumping tests.

Pumping Test for Well MW-211 (Figures 3-66, 3-67, 3-68, 3-69, and Tables 3-5, 3-6)

The pumping test at MW-211 was the most successful in terms of providing a textbook example of data. All the pumping curves are smooth because the pumping rate of 2.0 gpm was maintained throughout the pumping period. Semilog plots of pumping well MW-211 and observation well MW-204 were prepared for aquifer model verification (Figures 3-66 and 3-67). The confined aquifer condition is the straight line portion of the curve (Figure 3-59a, Figures 3-60 and 3-61, and Figure 3-62 A and A'). The effects of leakage are shown in the curved line portion of the curve after the confined straight line segment (Figure 3-59 b, Figures 3-60 and 3-61 Leakage and Figure 3-62 C and C'). As logic would predict, the wellbore storage effect is shown in the pumping well, but not in the observation well. The well storage (casing storage or wellbore storage) effect is the rapid early drawdown when water is pumped out of the casing (Figures 3-60 and 3-61 Well Storage and Figure 3-64 A and A'). The wellbore diameter of the bedrock wells is approximately 4-inches and the well storage is pumped out in about 2 minutes, lowering the water level a little more than one foot below static.

Using Jacob's Approximate Solution for the Non-equilibrium Equations, with pumping well recovery data (Figure 3-68), "delta s' " is the change in drawdown measured over a time interval of one log cycle on the residual drawdown plot. Transmissivity of the pumping well is calculated at 136 gpd/ft based on delta s' of 1.55 feet and pumping rate of 2.0 gpm (Table 3-5).

Applying Jacob's Approximate Solution for the Non-Equilibrium Equations, using pumping data from the observation wells, "delta s" and "t-zero" are measured from the semilog graph of s versus t/t' (Figure 3-69), where "s" is the drawdown during pumping and "t-zero" is the time on the horizontal axis where the projected straight (confined) portion of the curve intersects the horizontal axis at drawdown equal to zero (s = 0.0). "t" is the time since pumping began and t' is the time since pumping stopped. With the distance between the pumping well and the observation well, "delta s," and "t-zero," transmissivity (T) and storativity (S) of the intervening aquifer was calculated (Table 3-5).

In the confined bedrock aquifer, the potentiometric surface was lowered with pumping tests; however, the upper portion of the bedrock remained saturated. Calculations of T and S were based on the total thickness of the aquifer.

Review of the relative position of observation wells on the drawdown plot (Figure 3-69) provides supporting data for the interpretation of anisotropic aquifer conditions. An "isotropic" aquifer has uniform flow conditions in all directions and the cone of depression around the well is concentric. An "anisotropic" aquifer has preferred directions of groundwater flow, usually associated with fracture or bedding orientation. In the Hudson Valley, preferred flow is generally in the North 30 degrees East to South 30 degrees West (N30°E to S30°W) orientation parallel to the strike of isoclinal folded beds in the region. Usually an anisotropic aquifer is associated with an elliptical cone of depression with the long axis parallel to the preferred direction of groundwater flow. The ellipse at various times shows the advance of the cone of depression. The cone of depression advances faster in the preferred direction of flow and slower at right angles to the preferred direction.

Table 3-6 was constructed from inspection of the curves of the observation wells during pumping of MW-211 (Figure 3-66). The order of most- to least-pronounced pumping drawdown was listed as MW-204, MW-220, MW-206, MW-209, and MW-219 as recorded in the first column for MW-211. The next column has the distance from MW-211 to the observation well listed in column one. One can see that wells MW-220, MW-206, MW-209, and MW-219 are progressively farther from pumping well MW-211. However, MW-204 shows a more-pronounced response (greater drawdown) to pumping of MW- 211 than the closer wells MW-220 and MW-206. That effect reflects the lowest storativity value between MW-211 and MW-204. The greatest transmissivity value is calculated between MW-211 and MW-219 defining a preferred flow direction and showing anisotropic conditions in the aquifer.

Pumping Test for Well MW-206 (Figures 3-70, 3-71, 3-72, 3-73 and Tables 3-5, 3-6)

Pumping well MW-206 was the first of the five pumping tests conducted in the new bedrock wells on site. Some complications arose during the test including regulating the pumping rate at the beginning of the test, the generator ran out of fuel after 2 hours and 20 minutes of pumping, and there was difficulty in balancing the pump discharge with the back pressure from the carbon filter and tubing. Due to those mechanical mishaps, the semilog pumping well drawdown plot (Figure 3-70) is not particularly useful in selecting or verifying an aquifer model. However, the semilog time drawdown plot for observation well MW-204 clearly verifies leaky confined aquifer conditions.

The residual drawdown recovery plot (Figure 3-72) was used to measure delta s', and to calculate T. From the semilog drawdown plots from pumping well MW-206 and the observation wells (Figure 3-73), delta s and t-zero were measured and S and T calculated for the aquifer (Table 3-5). Based on Table 3-6, Figure 3-73, and T calculations, MW-209 and MW-219 have the greatest drawdown in response to pumping at MW-206 because they have the lowest storativities among the observation wells. The highest transmissivity value between MW-206 and MW-219 indicates a preferred direction of groundwater flow related to fracture pathways.

Pumping Test for Well MW-209 (Figures 3-74, 3-75, 3-76, 3-77, and Tables 3-5, 3-6)

MW-209 is the well exhibiting artesian conditions with groundwater overflow from the top of the well casing during most of the year, except during drought. Initially, pumping the well showed drainage of wellbore storage from zero to 15 feet in 8 minutes (Figure 3-74). The pump was adjusted at 9 minutes and pumping rate stabilized at 3 gpm. After 156 minutes of pumping, the observed signs of drawdown leveling off indicated leaky aquifer conditions for the remainder of the test. The leaky confined aquifer model is verified by the semilog drawdown plot for observation well MW211 (Figure 3-75). Delta s' was measured on Figure 3-74 and delta s and t-zero were measured on Figure 3-77. The measurements and calculated values for T and S are shown in Table 3-5). The order of pumping response shown in observation wells (Figure 3-77) and recorded in Table 3-6 indicates the greatest drawdown in observation wells MW-206 and MW-219, as occurred when MW-206 was the pumping well. The highest transmissivity occurs between MW-209 and MW-220.

Pumping Test for Well MW-220 (Figures 3-78, 3-79, 3-80, 3-81 and Tables 3-5, 3-6)

From the packer tests, the summation of the yields from individual test zones suggested well MW-220 might be capable of pumping about 12 gpm. The limit of a Grundfos Redi-flo2 is about 8 gpm. A Redi-flo3 was installed in the well for the pumping test to accommodate the expected greater pumping rate. The pump was turned on at 12 gpm and water level in the well declined to a depth of 170 feet within 22 minutes. The pumping rate was adjusted in an attempt to stabilize drawdown. Stabilization was not easily achieved and the pump was turned off. In 36 minutes, the well recovered to within 30 feet of the static level. The pump was turned on and the water level was found to stabilize at 2.5 gpm for the remaining 290 minutes of the test.

The semilog plot of pumping well MW-220 (Figure 3-78) could not be used for model verification because of the drawdown and recovery prior to stabilization. However, the semilog drawdown plot for observation well MW-206 (Figure 3-79) shows the expected curve of a leaky confined aquifer. The residual drawdown recovery plot for pumping well MW-220 was used to estimate delta s' (Table 3-5). Delta s and t-zero were measured for each of the observation wells on the time drawdown plot (Figure 3-81). The calculated values of S and T are shown in Table 3-5. The greatest pumping response (Figure 3-81) was shown at the nearest wells: MW-211, MW-204, and MW-206. The greatest transmissivity was calculated between MW-220 and MW-219 indicating a preferred flow direction in the anisotropic aquifer. The transmissivity between MW-220 and MW-207 was lower than that for MW-219, but high enough to delineate another preferred flow direction.

Pumping Test for Well MW-219 (Figures 3-82, 3-83, 3-84, 3-85 and Tables 3-5, 3-6)

An inspection of the semilog drawdown plot for pumping MW-219 (Figure 3-82) indicates that after four minutes of pumping and 7 feet of drawdown from wellbore storage, the water level stabilized and actually rose somewhat for 20 minutes. The end of decline and slight rise in water level is interpreted as the cone of depression reaching a nearby recharge boundary after four minutes of pumping. Such a recharge boundary may be associated with a nearby wetland to the north or a leaky storm sewer beside the road. The pump rate was increased slightly and the water level dropped nearly five feet in four minutes, then stabilized for 18 minutes. After pumping for a total of 286 minutes, the pump was accidentally turned off because a truck parked on the discharge tubing. The water rose in the well for 30 minutes until the truck was moved and the pump restarted.

The semilog plot of drawdown in observation well MW-209 (Figure 3-83) verifies the leaky confined aquifer model of interpretation. Delta s' was measured on the semilog residual drawdown of recovery data from the pumping well (Figure 3-84). Likewise, delta s and t-zero values were measured for each of the observation wells on the semilog pumping drawdown plot (Figure 3-85). Calculations for T and S are shown in Table 3-5. The greatest drawdown is shown in wells MW-209 and MW-206 due to low storativity values (as also shown while pumping those wells). Inspection of Figure 3-85 and Table 3-6 shows the greatest transmissivity occurring between wells MW-219 and MW-211 and between wells MW-219 and MW-220, reflecting preferred flow directions in the aquifer.

Spatial Distribution of Transmissivity and Storativity

The storativity and transmissivity calculations for each pair of pumping well and observation well resulted in 26 values for S and T. Twenty-six of those parameters are paired values computed from pumping well A with observation well B and pumping well B with observation well A. Two maps were constructed to show the two-dimensional spatial distribution of the aquifer parameters Storativity and Transmissivity. A map of preferential flow directions was drawn using the higher value of the pairs of the calculated transmissivities (Figure 3-86). A map of areal variations in storativity (Figure 3-87) shows four areas:

- Horizontal Flow Isolation
- Very Slightly Leaky Confined Aquifer
- Slightly Leaky Confined Aquifer
- Moderately Leaky Confined Aquifer

Hydraulic conductivity is a common parameter used to compare aquifers. Hydraulic conductivity (k) can be calculated from transmissivity, by knowing the thickness of the aquifer. Based on the packer tests, the thickness of the aquifer in each well is defined as the interval between the bottom of the deepest productive packer zone to the top of the most shallow productive packer zone. Estimates of hydraulic conductivity for the total aquifer are shown in Table 3-7. The packer tests indicate that there are two productive aquifer zones in the bedrock wells, with the exception of MW-211 with only one. The top of the most productive zone tends to be about 90 feet below the land surface and the zone averages 40 feet thick, except for MW-220. The top of the lesser water-producing zone is 39 feet below land surface and averages 22 feet in thickness. In addition, calculations of hydraulic conductivity of the lower aquifer are shown in Table 3-7.

4.0 Hydrogeologic Testing Results, Conceptual Site Hydrogeological Model, and Summary of Interim Remedial Measures at the Parella Well (W-30)

This section provides an evaluation of hydrogeologic conditions with conclusions from aquifer testing of the new wells installed at the site. The packer tests and pumping tests provide information on vertical and horizontal connectivity of fractures in bedrock. A conceptual hydrogeologic model of the Site defines subsurface overburden and bedrock setting, contaminant distribution, and geochemical aquifer conditions. Based on previous site characterizations, two interim remedial measures were proposed for specific areas of the site prior to initiation of a site-wide remedial alternative. The interim progress reported in this document (for the Parella Well Pumping and Sub-Building Vapor Testing) was previously reported in a separate document dated May 2007. For the Site-wide groundwater cleanup, remedial alternatives are evaluated in Section 5.0.

4.1 Summary of Hydrogeologic Testing Results

Prior to this study, the aquifer conditions were defined based on water level measurements taken when samples were collected from the monitoring wells. At that time, groundwater flow direction was determined to be to the south. Artesian conditions were known to exist at MW-9, located in the downgradient area close to the west side of Industrial Place Extension.

Packer testing and pumping tests in the bedrock wells have been used to more accurately evaluate the subsurface aquifer conditions in the groundwater flow field downgradient from the on-Site industrial building. This data has been used to provide a quantitative conceptual aquifer model (in three dimensions) for the Site. Productive aquifer zones have been identified in each well with packer testing. Horizontal flow conditions, from observation wells toward the pumping wells, have been evaluated to demonstrate the area and magnitude of pumping influence. Aquifer parameters including sustainable well yield, aquifer thickness, storativity, transmissivity and hydraulic conductivity have been evaluated. Graphic plots of pumping drawdown versus time verify the leaky confined aquifer model throughout the flow field. Leakage is found to increase upgradient to the northwest away from Industrial Place Extension. In other words, the top of the bedrock aquifer is more confined and less leaky in the downgradient wells near Industrial Place Extension. Preferred directions of groundwater flow have been identified between wells and interpreted as a result of more efficient movement through fracture systems. It is possible that contaminant concentrations may be a result of variations in flow conditions between upper and lower aquifer zones and lateral location in the groundwater flow field.

Drilling Wells and Bedrock Coring

A total of 671 feet of core (2.75-inch diameter) was obtained while installing the five bedrock wells (MW-206, MW-209, MW-211, MW-219, and MW-220). The cores were inspected for fractures and described in terms of lithology and sedimentary features (Table 3-3, Appendix B). Fractures in the core ranged from horizontal to vertical with the most open fractures near vertical with limited vertical extent (less than 10 feet). Fifty-six photographs provide a record of fractures and sedimentary features in cores (Appendix A).

Borehole Video Taping

The bedrock wellbore of each of the wells was photographed on video tape and later copied to DVD. The video shows the camera descending and ascending in the borehole. By carefully examining the detail of the tape, the viewer can determine where fracture openings actually exist in the well. Sometimes the video showed fractures at depths where the core did not exhibit open fractures and vice versa. Both bedrock coring and video taping were helpful, but borehole video tape was by far the most cost effective and efficient method of determining aquifer conditions in this area. Thirty-six fracture zones were identified in cores and video for packer testing (Table 3-3).

Packer Testing

A total of 36 packer tests were conducted in five bedrock wells (MW-206, MW-209, MW-211, MW-219, and MW-220). The packer assembly provided 10 feet of vertical separation between the two packers. Depths of test zones were selected from evidence of fractures in the rock core and/or on the video tape. During testing, some of the selected test zones were not productive. In other words, water pumped from the packer zone was not recharged with water entering from the surrounding bedrock formation. The nonproductive test zones were most often found to be located near the ground surface. This condition probably arises because groundwater enters the well from deeper fractures and moves up in the well.

Most of the wells, with the exception of MW-211, have two productive zones, which have been broken down for the purpose of this report into the "most productive zone" and the "lesser productive zone". The top of the most productive zone (lower aquifer zone) tends to be about 90 feet below the land surface and averages about 40 feet thick. The top of lesser productive zone (upper aquifer zone) is about 39 feet below land surface and averages 22 feet in thickness.

Some of test zones were found to be hydraulically connected to water in the formation above or below, as indicated by decline of the water level in response to pumping in the packer interval. However, the pervasive nature of fractures indicated in earlier reports was not confirmed in this study.

Pumping Tests

Pumping tests demonstrate that the bedrock aquifer is characterized as a confined aquifer with increasing leakage upgradient to the west. Calculated hydraulic conductivity of the aquifer is in the range (1 to 10 gpd/ft^2) expected for fractured bedrock. The wells near Industrial Place Extension (MW-206, MW-209, and MW- 219) show nearly confined conditions based on calculated storativity values. The aquifer is anisotropic with preferred groundwater flow direction generally parallel to Industrial Place Extension (ranging from N 14˚E to N 41˚E) as shown by high transmissivities between MW-219 and MW-220, and between MW-219 and MW-211. A secondary direction of strong flow seems to be between MW-220 and MW-207 (about S 60˚W or N 120˚W). A small recharge boundary very close to the well was interpreted from drawdown data for pumping well MW-219. Recharge may be from the nearby wetland or a leaky storm sewer.

For the bedrock wells, the sustainable yield or pumping rate is 2.5 gpm or less. However, such a low pumping rate has been demonstrated to have a radius of influence beyond the wells in the project area. If remediation is to involve pumping, the deepest well (MW-220) is centrally located and has good hydraulic connection with all of the wells, with the exception of the isolated cluster at MW-203. In addition, some contribution from the overburden will flow downward into the bedrock due to the leaky aquifer condition, although this will occur somewhat slowly.

Contaminant Distribution in Packer Test Samples

Groundwater samples were collected at the end of each packer test. The validity of each sample was established based on the evacuation of a full packer interval and tubing volume prior to sampling. If not fully evacuated, the sample was deemed "invalid." Concentrations of 1,2 dichloromethylene, tetrachloroethylene, toluene, and TCE were all below 500 µg/L. The highest concentration, since December 2000, was 710 µg/L of tetrachloroethylene measured in MW-220. That concentration is at least two orders of magnitude lower than the highest concentration previously measured in MW-5, which is immediately upgradient of MW-220, and most of the bedrock flow field. Although the possibility of cross-contamination should be considered when reviewing the results from the packer testing samples (see Section 3.2), it is of note that the concentrations measured were lower than those previously measured in 2000. These findings indicate that contamination may be decreasing under natural conditions.

Analysis of the packer samples indicates that in MW-220 and MW-219 the highest concentrations seem to be in the upper aquifer zone when compared to the lower aquifer zone. In MW-209, concentrations in both upper aquifer and lower aquifer zones are about equal. In MW-206, concentrations were found to be significantly lower than other wells. In MW-211, there is no upper aquifer zone and concentrations of water from the lower aquifer zone are greater than dormant waters in the well. These observations suggest that MW-206 and MW-211 are on the edges of the contaminant plume.

4.2 Conceptual Site Hydrogeologic Model

A general outline of Section 4.2 and subsequent remedial design (Figure 4-1, Appendix A) comes from an online document prepared by Department of Defense Strategic Environmental Research and Development Program (2004) entitled "*Principles and Practices of Enhanced Anaerobic Bioremediation of Chlorinated Solvents*". Although the specific title and content developed in that document pertain to enhanced bioremediation of chlorinated solvents, the outline and conceptual development apply to screening and planning for remediation of groundwater at any site. Hence, the top three steps of the anaerobic bioremediation road map (Figure 4-1) provide an outline for defining remedial objectives, justifying a remedial approach, presenting details of a conceptual site model, and discussing the site model with respect to anaerobic biodegradation and alternate technologies. This section is written to synthesize the hydrogeologic data provided above with chlorinated solvent contaminant distribution data from groundwater sampling events and geochemical data used in evaluation of potential natural biological degradation.

The conceptual site model (Figure 4-2) encompasses hydrogeologic information including: contaminant source characterization, contaminant distribution in the overburden and bedrock water-bearing zones, and risk assessment. These factors will be discussed with the exception of risk assessment. Because the homes in this area were connected to municipal water lines over 25 years ago, it is believed that the risk to human receptors by contaminated water is limited.

The downgradient extent of contamination has not been encountered. Wells have been drilled at the most downgradient extent of adjacent undeveloped properties. A report (Lubricants Packaging and Supply Company, Inc. (LPS) report, June 2002) was obtained from NYSDEC documenting groundwater contaminants at LPS, a property on the southeast side of Industrial Place Extension across from monitoring wells MW-206 and MW-209. Most of the wells at LPS commingle waters from overburden and bedrock, but there is one well that is screened in bedrock only. In the 2002 sampling event at LPS, contaminants identified included: PCE, TCE and cis-1,2-DCE, which have also been identified in the Wallkill Well Field subsurface, as well as trichloroethane (TCA), chlorobenzene, and other ethanes, which have not been found at the Wallkill site.

Groundwater flows off-site in a southeast direction in both the overburden and the bedrock water-bearing zones. Beyond LPS, Risdon Buildings and the railroad track, there is an undeveloped low area with a stream called "Draper Run" as identified in the LPS report. Sampling associated with the LPS facility detected TCA in the stream, but no PCE or TCE. It was indicated, in the report that was reviewed, that the TCA concentration (1.6 ug/L) from the stream sample could have originated from anywhere in the drainage basin. Although TCA has not been found during sampling events at the Site, the absence of PCE and TCE in surface water does not necessarily define the end of the contaminant plume.

Cottage Street is located parallel to Industrial Place Extension on the other side of Draper Run. Similar to the homes on Highland Avenue, the homes on Cottage Street are supplied by municipal water from the City of Middletown. For that reason, it is believed that there the risk to human receptors from the groundwater downgradient from the site, is limited. The LPS report draws the same conclusion with respect to human receptors.

Pumping tests of MW-219, MW-209, and MW-220 indicate that the wells have a large downgradient area of influence, assuming some symmetry of drawdown. Those wells are potentially capable of reversing plume migration and could be used to draw contaminant waters back to the site for cleanup with the selected in-situ remedy. However, such an action would most likely bring contaminants, believed to originate at the LPS facility, into the subsurface at the Wallkill Well Field Site. The bedrock well at LPS and an additional well at Ridson could potentially be used to monitor downgradient groundwater conditions.

4.2.1 Contaminant Source Area

Soil and soil gas analyses conducted on the Site have been used to define the extent and location of subgrade (and, within the footprint of the on-Site building, sub-slab) soil contamination. The following conclusions were reported in the Summary Report of Subsurface Investigation, ESI, May 2007:

- Only one boring at one depth (SB-8 16'-16.5') contained levels of PCE above the site-specific action level. PCE is present at 460,000 µg/kg, compared to the action level of 12,000 µg/kg. This boring is located to the south of the northern "hotspot" and may be spatially connected to this area. Residual PCE contamination in the vicinity of SB-8 warrants a response action (e.g., removal, treatment).

- All other borings on the Site documented levels of PCE well below the site-specific action levels, including several samples where PCE was not detected at all. These data support the following conclusions:

  - The physical extent of contamination under the building is very limited.
  - There does not appear to be any connection between the "northern" and the "southern" hot spots.

- Remediation of soils in the vicinity of SB-8 is complicated by the presence of the building. In-situ remediation may be more cost effective.

In addition, the following conclusions have also been drawn about the extent and location of subgrade soil contamination:

- Groundwater is within 5 to 10 feet of the ground surface around the on-Site industrial building. The seasonal fluctuation is about 7 feet and direction of flow is to the east-southeast from the building. Any substantial volume of soil under the building containing significantly elevated concentrations of PCE could be a source of dissolved PCE in wells to the east-southeast of the structure. However, a PCE concentration of 460,000 µg/kg in one soil boring, as found at soil boring SB-08 in May 2007, does not constitute a substantial volume or a source.

- The PCE is suspected to be in the soil and groundwater at the soil/bedrock interface. The mobility of dissolved PCE in groundwater could pose a potential for continued contaminant dispersal in groundwater. However, soil borings SB-8, and SB-11 were the deepest borings near the area of suspected contamination. With groundwater flow to the southeast and shallow borings in that direction, the PCE may be trapped in a low bedrock basin. A specific remedial effort may be required to reduce the PCE concentrations in this hydraulic trap.

- An exact location of a source area for the groundwater plume has not been identified near the building. The north and south "hot spots" were excavated and backfilled with clean material. In general, levels of PCE are declining in the overburden and bedrock groundwaters most likely due to downgradient flow, hydrodynamic dispersion, and natural dechlorination.

4.2.2 Hydrogeologic Synopsis

Hydrogeologic data has been obtained from 23 monitoring wells and 3 former residential water supply wells (Table 4-2, Appendix B). As discussed above, groundwater flow is generally in a south-southeast direction from the on-Site industrial building. In the residential area to the southwest of the building, groundwater flow is generally to the southeast.

In the overburden (composed of sand, silt, and glacial till); monitoring wells, approximately 10 to 15 feet deep, are associated with flow along the overburden-bedrock interface. These wells have approximately 5 to 10 feet of standing water. Pumping tests demonstrate that the bedrock aquifer is confined from the overburden, with the exception of some leakage under pumping conditions.

The bedrock aquifer has two productive zones, as discussed in Section 4.1. The top of the "more productive zone" (lower aquifer) is at a depth of approximately 90 feet and averages 40 feet thick. The top of the "lesser productive zone" (higher aquifer) is at a depth of 39 feet with an average thickness of 22 feet. Groundwater movement in the aquifer (consisting of interbedded silty shale and silty-fine sandy siltstone bedrock) is associated with fractures. Pumping tests demonstrate hydraulic connectivity between bedrock wells throughout the flow field. Hydraulic conductivity between bedrock wells ranges from 1.7 to 11.5 gpd/ft^2 (0.8 to 5.4 E-04 cm/sec) for the full thickness of the bedrock aquifer (Table 3-7).

Calculations of hydraulic conductivity prove to be somewhat higher in the lower aquifer at 4.1 to 20.1 gpd/ft^2 (1.9 to 9.5 E-04 cm/sec). The hydraulic conductivities are within about one order of magnitude indicating somewhat uniform flow conditions within the fractures. In bedrock under natural flow conditions (no pumping), average linear flow ranges from 0.14 to 0.64 ft/day, whereas under pumping conditions, flow velocity ranges from 1.06 to 3.93 ft/day, averaging 1.91 ft/day (Table 4-1). Table 4-2A, Quarterly Depth to Water and Static Groundwater Elevations, includes depth to water and static aquifer conditions for the site.

4.2.3 Contaminant Distribution

Dissolved PCE, TCE, and DCE have been found in several on-Site monitoring wells down-gradient of the on-Site building (Figures 4-3 and 4-4, Appendix A). In November of 2006 and March of 2007, eighteen sub-slab soil boring were located at the Site, as reported in the Summary Report of Subsurface Investigation. A significant concentration of PCE, but no free product, was detected south of the identified northern "hot spot" (Figure 1-2). It was determined, however, that the extent of the contamination under the building is limited. A separate proposal has been submitted to the USEPA to remediate this area.

Previously, ESI identified four areas that might require specific remedial actions. Additional information led to a proposal for the remediation of a small area under the building near SB-8 as reported in a separate report and workplan. The other three locations will be treated with the Site-wide remedial action identified in Section 5. These areas are as follows:

- The former Parella Well;
- Well MW-5, overburden well downgradient from source area;
- MW-3, MW-16, MW-203 Triplet in isolated zone, and,
- The overburden and bedrock aquifers outlined by MW-202, MW-219, MW-206, and MW-211.

Overburden monitoring well MW-5 lies within the outlined aquifer area, but it has shallow groundwater and the contaminant concentration is a statistical outlier because apparently an unknown source area is dispersing contamination.

The hydraulically isolated triplet of wells (MW-3, MW-16, and MW-203) are also located within the outlined aquifer area. None of the three wells showed a response to pumping of the downgradient bedrock wells (MW-206, MW-209–MW-211, MW-219, and MW-220). Dissolved chlorinated solvent contamination from the source area moves downgradient and apparently becomes trapped in this area. However, these three wells (MW-3, MW-16, and MW-203) have a limited response to the pumping of the Parella Well (W-30), which indicates a hydraulic connection in the upgradient direction.

Review of previous reports (Table 4-2), indicates that total VOC concentrations have been diminishing over the duration of four sampling events: December 2000, January 2001, December 2002, and April 2005.

4.2.4 Geochemical Conditions in Aquifers

Given that the contaminants in the groundwater plumes are comprised of chloroethane, PCE, TCE, and DCE with very minor occurrences of VCs; potential degradation processes are limited to anaerobic reductive dechlorination, metabolic anaerobic reduction, or a biotic transformation (Table 4-3). The reactive process of these degradation alternatives are described briefly in Table 4-4. The reaction necessary to drive the degradation from PCE to TCE to DCE to VC is shown in Figure 4-5.

A review of overburden and bedrock aquifer characteristics suitable for enhanced anaerobic bioremediation (Table 4-6) indicates that both of the Site aquifers would be classified as suitable with respect to the following:

- Dense non-aqueous phase liquid (DNAPL) presence (Figures 4-3 and 4-4);
- plume size;
- limited infrastructure;
- presence of cis-1,2-DCE as evidence of dechlorination of PCE;
- depth to water table is less than 50 feet in both overburden and bedrock;
- hydraulic conductivity (Table 3-7);
- groundwater velocity (Table 4-1); and,
- sulfate concentrations less than 500 parts per million (ppm) (Tables 4-8, 4-9 and 4-10).

A compilation of the pH measurements taken in the field indicates a variation in readings in the same well from event to event (Table 4-9). The most recent set of readings (April-May 2005), and the only ones for the new bedrock wells, indicates that all of the bedrock wells have a pH that ranges from 6.0 to 8.0 and only three of the overburden wells (MW-4, MW-6, and MW-9) do not fall in this range.

A compilation of oxidation-reduction potential (ORP) measurements taken during sampling events (Table 4-10) has been compared with the range needed for optimal anaerobic dechlorination (Figure 4-6). Measurement from two of the bedrock wells (MW-203 and MW-209) are outside the optimal range needed for an oxidation-reduction reaction, indicating that the majority of the bedrock aquifer may be a good candidate for anaerobic dechlorination of the chloroethenes dissolved in the groundwater.

A classification system for chlorinated solvent plumes (Figure 4-7 and Table 4-5) divides plumes into Types 1, 2, and 3 based on available organic carbon (electron donor), electron acceptors present, redox conditions, and the presence of certain degradation products. The presence of cis-1,2-DCE places the Site aquifers in the second row of Table 4-5. With respect to the presence or absence of dissolved oxygen (Table 4-11), the measured results vary from sample event to the next, but the last complete round of sampling indicates that the bedrock wells have little to no dissolved oxygen and are therefore in a Type 1 aquifer, and the overburden wells have dissolved oxygen and are in a Type 3 aquifer.

The presence of a Type 3 aquifer in the overburden and a Type 1 aquifer in the bedrock may make the Site a good candidate for remediation according to the hydrogeologic information provided in Figure 4-7 and Table 4-5. The bedrock aquifer has by far the greatest quantity of water to be treated, so anaerobic conditions in the bedrock aquifer appear to make it a candidate for remediation. Leakage of the overburden to the bedrock aquifer under pumping conditions would have the undesired effect of moving the dissolved contaminants from the overburden into the bedrock aquifer and possibly from aerobic to anaerobic conditions. The volume of leakage from the overburden is likely to be small compared to the volume for potential mixing in the bedrock, which would perpetuate anaerobic conditions. That effect, however, supports some form of remediation in-situ without pumping.

4.3 Summary of Interim Remedial Measures at the Parella Well (W-30)

4.3.1 History of the Parella Well (W-30)

The Parella well (W-30) was originally a residential water supply well for the house located at 320 Highland Avenue, which is southwest of the former General Switch building. Currently, the house is owned by Mr. Piccolo and rented to tenants. The total depth of the well is 129 feet from top of casing (TOC) at 642.8 feet relative to mean sea level (see Table 4-10, from 1994 Site Characterization Report by Jacobs, Shakti, and Sadat).

From October 17 to December 26, 1983, the Parella well (W-30) was used as an extraction well by pumping at approximately 0.5 gpm. An estimated 21 pounds of tetrachloroethylene was removed from the well (Site Characterization Report, page 1-6).

Until the introduction of municipal water supply to the homes along Highland Avenue (1983), pumping of domestic supply wells created flow of groundwater from the General Switch building to the southwest. It is theorized that dissolved contaminant and possibly free product moved toward the Parella well and then downgradient from there. Once residential wells stopped pumping, static conditions indicate downgradient groundwater flow is to the southeast (Site Characterization Report, page 7-18 and 7-19).

For a period of time, the location of the Parella well was unknown. On April 25, 2005 Mr. Piccolo, was on site during groundwater sampling activities and identified the well, which is located beneath the left rear corner of the front gardening shed. The wellhead is only accessible from inside the shed or through a back panel released from inside of the shed.

Laboratory analyses of samples taken in 2005 measured 130,000 µg/L tetrachloroethylene in groundwater from the Parella well; however, free product measurements were not taken during the sampling event. This concentration is one-half of the historical high (260,000 µg/l) detected at the well in 1983 (Site Characterization Report, pages 1-5). It is not known how the contaminant is accumulating in the Parella well, although it may be from backflow due to the change in static conditions described above.

4.3.2 Pumping Test of the Parella Well (W-30) June 2007

In order to determine both the need for and design of an appropriate remedial system for the collection and disposal of the suspect DNAPL in the Parella well (W-30), testing was implemented in order to collect data from the well.

Observation Wells

The workplan called for five observation wells, including shallow bedrock wells MW-12 and MW-13, and deep bedrock wells MW-202, MW-204 and MW-207. Pressure transducers were installed at each observation well to monitor water level fluctuations. To confirm electronic monitoring, manual water level measurements were taken with a water level indicator in each of the monitoring wells five times during daylight hours. During installation of tranducers, it was decided to monitor additional shallow wells MW-2, MW-5, MW-6, MW-7, MW-10 and bedrock wells MW-203 and MW-220. The pressure transducers were set to record water level and temperature every ten minutes. The transducers were placed at a depth of 10 feet below the water level and at least 10 feet above the bottom of the well to record variations in water levels in the wells from the pumping of W-30. A pressure transducer was set up near MW-203 to monitor barometric pressure in order to correct the pressure readings. Product thickness at W-30 was measured prior to the pump test using a Solinst or Heron interface meter capable of indicating the interface of water and the DNAPL; no free product was detected in the well.

Pumping Test

A Grundfos Redi-flo2 and dedicated Teflon tubing were installed to the bottom of W-30. The Grundfos pump was used because it allowed very fine control of the discharge rate with the variable frequency drive. A recording transducer (Instrumentation Northwest 15 psi) was placed in the pumping well (W-30) in order to record real-time depth to water at 5-second intervals. A passive transducer (Solinst Levelogger 250 psi) recorded water levels at one minute intervals throughout the entire testing period at a depth of approximately 130 feet below TOC.

Pumping began with 0.5 gpm and was increased by 0.5 gpm in 6 intervals. The water was pumped into a tank at the south corner of the building. A 55-gallon drum was used to store the water during flow rate measurements. Pumping continued from June 26, 2007 11:20 AM until June 27, 2007 1:36PM. The transducers were left in the wells until Friday morning, June 29, 2007.

Disposal of Discharge Water

All liquids generated during the pump test were containerized on-Site in a storage tank of sufficient capacity. Contents of the tank were removed for proper disposal by Enviro Waste Oil Recovery, LLC on October 9, 2007.

Pumping Well Water Levels

Water levels and elevations, hydraulic pressures, and barometric pressures were tabulated for four significant times: installation of transducers, start of pumping, end of pumping, and removal of transducers (Table 4-13).

Graphs of the pumping well (W-30) illustrate drawdown and recovery (Figure 4-11) for the well. The six steps of drawdown are shown with pumping rate and duration (Figure 4-12).

Observation Well Water Levels

The wells closest to the Parella well showed the greatest response during pumping (Figure 4-14). MW-12, at a distance of less than 20 feet from the Parella well, had a maximum drawdown of 19.41 feet. MW-2 and MW-203 were also affected by the pumping test. Likewise, MW-7 and MW-207 show a similar effect with lesser amplitude because they are farther away from the pumping well.

The greatest response to the pumping test was observed in the bedrock wells, diminishing with increasing distance from the pumping well (Figure 4-15).

Maps of Static Water Levels and Maximum Drawdown

Pre-test water elevations in the bedrock wells are depicted as Figure 4-17. The maximum drawdown for the bedrock wells is depicted as Figure 4-18 and for the overburden wells is shown on Figure 4-19. Similarities exist between the current figures and the three maps from the 1992 pumping test.

Chemical Analyses from Pumping Well W-30

Laboratory analyses for VOCs are summarized in Table 4-14. Water from the holding tank was also sampled. Two additional samples were taken in July to determine if additional DNAPL was entering the well.

As shown in Table 4-14, three VOCs were detected above laboratory detection limits in the samples from June 2007. The first sample taken from the pumping well about 40 minutes after pumping began, had 31,000 ug/L cis-1,2,-DCE, a biodegradation product of PCE. PCE and TCE were not detected in the sample. It appears that in the previous two years PCE was converted to TCE and then further degraded to cis-1,2,-DCE in the area of the Parella well.

As pumping continued, PCE and TCE entered the well and the concentration of cis-1,2,-DCE diminished to 19 ug/L. The level of cis-1,2,-DCE was 14 ug/L in July 2007. During this time, PCE and TCE remained fairly constant at 200 ug/L and 40 ug/L, respectively.

Since PCE and TCE are the chemicals of concern at this site, the presence of cis-1,2,-DCE indicates that natural reductive dechlorination is occurring in the groundwater in the vicinity of the Parella well.

Conclusions from Parella Well Pumping Test of June 2007

1. Stabilized drawdown during the pumping test indicates that recharge into the well is equal to the pumping rate. The maximum pumping rate was 3 gpm.

2. No free product was detected in the well. All chlorinated ethenes were dissolved in the water.

3. After pumping for 40 minutes, the first water sample was collected from a sampling port in the pump discharge line. No PCE was detected in the water; however, cis-1,2,-DCE, was detected at 31,000 ug/L. The presence of cis-1,2,-DCE and the absence of PCE indicates that natural dechlorination of PCE was occurring in the well.

4. As pumping continued, the concentration of cis-1,2,-DCE diminished while PCE and TCE increased.

5. In July 2007, approximately 15 ug/L of cis-1,2,-DCE, 200ug/L of PCE and 40 ug/L of TCE were detected in two samples. These concentrations indicate that chloroethenes are entering the well slowly.

6. Annual sampling and analysis of the Parella Well will be necessary to assess the movement of chlorinated ethenes into the well.

7. The isolated zone around monitoring wells MW-3, MW-16, and MW-203 shows some response to pumping of the Parella well (June 2007) with a drawdown of a small magnitude at 0.13, 0.15, and 0.15 feet, respectively. A general decline in the wells was observed during the pumping tests for the new bedrock wells (April 2006), but drawdown relative to a specific pumping well was not discernable. For unknown reasons, the flow barrier appears to be located downgradient of the well triplet since hydraulic connection is evident with the upgradient Parella well, but not with the downgradient bedrock wells.

5.0 Detailed Analysis of Remedial Alternatives

This section has its basis in the "Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA", USEPA, October 1988. In this section a tiered process is used to rank remedial alternatives for the Site. The following criteria have been specified by the USEPA for use in the ranking process:

- Overall protection of human health and the environment;
- Compliance with applicable or relevant and appropriate requirement (ARARs);
- Long-term effectiveness and permanence;
- Reduction of toxicity, mobility, or volume;
- Short-term effectiveness;
- Implementability;
- Cost;
- State acceptance; and,
- Community acceptance.

5.1 Remedial Alternatives

Alternative 1 – No Action

The no action alternative is evaluated as a procedural requirement and as a basis for comparison. This alternative leaves the Site in its present condition and will not provide additional protection to human health or the environment.

Criteria Assessment

Alternative 1 does not reduce the risk to human health or the environment and could potentially allow continued migration of the contamination, although some natural attenuation of the contamination would occur (see Alternative 2). This option does not include controls or long-term management measures and does not meet ARARs. However, no additional risks are posed to this community, workers, or to the environment during implementation of this alternative, and no additional costs would be associated with this alternative.

Alternative 2 – Natural Attenuation with Continued Monitoring

Alternative 2 is based on the assumption that natural attenuation is taking place under the site and throughout the plume area in soil, overburden and bedrock. As discussed earlier in the report, there is some evidence to support the occurrence of natural degradation of contaminants at the Site. Annual monitoring would be continued to track the natural reduction of contamination in the groundwater.

Criteria Assessment

Alternative 2 would be protective of human health by controlling exposure to the contaminated groundwater (houses in the area are connected to the municipal water system and do not rely on well water), however, it is likely that many years would be needed to reduce the contaminant to the site-specific groundwater remediation ARAR (or a concentration agreed to be protective of human health by the USEPA). In addition, deed restrictions would likely be needed to ensure that human exposure is controlled.

Alternative 2 would not provide for a reduction of toxicity, mobility, and volume of the contaminated water through treatment. Groundwater monitoring wells are currently in place, and would continue to be monitored at least annually for the life of the project.

Although groundwater monitoring wells are currently in place, it may be necessary in the future to put in additional wells, or replace existing wells. The cost of monitoring would be approximately $20,000 per year and will have to continue for the life of the project. New wells, if necessary, would be an additional cost.

Alternative 3 – Ex-Situ Groundwater Treatment

Alternative 3, ex-situ groundwater treatment, is the process of pumping groundwater to the surface for removal of contaminants. On this Site, groundwater would be pumped from monitoring well MW-220, treated on-site utilizing an air stripper, and then released to the City of Middletown Municipal Treatment System after remediation to the site-specific groundwater remediation ARAR (or a concentration agreed to be protective of human health by the USEPA). MW- 220 has been chosen because the recharge is adequate to be able to continuously pump water to the surface and because it is centrally located at the site, factors which make it a good candidate for an ex-situ treatment operation. However, it is suspected that there may be an additional bedrock contaminate source at the Site that has yet to been identified. Ex-situ treatment located at MW-220 would be most effective if it is near this suspected source of additional contamination.

Criteria Assessment

Alternative 3 would be protective of both human health and the environment; however, some additional risk of contact with contaminated water could occur during installation and maintenance of the system. This risk will be minimized by following manufacture's recommendations during installation and maintenance of the system. This alternative would meet ARARs for the site and would be designed to meet State air pollution control standards. This method would reduce the toxicity, mobility, and volume of the contamination and could be implemented using existing technologies. However, the fractured nature of the bedrock and location of the suspected bedrock source may impact the effectiveness and the estimated time frame for this alternative. The groundwater will need to be monitored at least annually for the life of the project.

The capital cost of the system is estimated to be $140,000, the annual operation and maintenance (O&M) costs of the system are estimated to be $72,000 per year, and annual monitoring of the wells is estimated at $20,000 per year.

Alternative 4 – In-Situ Bioremediation

In order to implement in-situ bioremediation, the existing natural population of Dehalococcoides bacteria would be estimated by taking water samples from several overburden and bedrock wells. Assuming additional microbes are needed, bioaugumentation would be implemented with introduction of microbes into the wells.

A proprietary microbial Bioremediation treatment (Bio-Dichlor Inoculum) will be applied to selected monitoring wells to accelerate existing bio remediation. Bio-Dichlor Inoculum is an enriched microbial consortium containing species of Dehalococcoides produced by Regenesis, Inc. The following monitoring wells would be treated: MW-3, MW-5, MW-6,

MW-11, MW-16, MW-18, MW-203, MW-206, MW-211 and, MW-220. The application of Bio-Dichlor Inoculum will be supplemented with HRC Advanced, a hydrogen release compound, which feeds and accelerates the Bio-Dichlor Inoculum bio-remediation process.

Materials published by the manufacturer indicate that HRC Advanced has been proven to rapidly dechlorinate contaminants during in-situ bioremediation processes. This material is viable for at least one year and, over time, is expected to bring concentrations of PCE in groundwater down to below the site specific guidance level (or a concentration agreed to be protective of human health by the USEPA).

HRC Advanced will be applied to the water column at each of the above monitoring wells using socks or canisters (depending on the depth of the well and/or the depth of zones of active recharge within the wells). The socks/canisters of HRC Advanced will be left in place for a year and withdrawn for quarterly monitoring.

The cost of the bioremediation is estimated to be $140,000, with annual monitoring of the wells estimated at $20,000 per year.

Criteria Assessment

Alternative 4 would be protective of both human and the environment, however, some additional risk to workers of contact with contaminated water could occur during installation of the bioremediatial treatment. This risk will be minimized by following manufacture's recommendations during installation. This alternative would meet ARARs for the site. This method would reduce the toxicity, mobility, and volume of the contamination and could be implemented using existing technologies. The groundwater will need to be monitored a least annually for the life of the project.

Alternative 5 – Chemical Oxidation

A proprietary chemical oxidation compound (RegenOX) will be injected into bedrock fractures in order to remediate PCE-impacted groundwater.

Criteria Assessment

Alternative 5 would be protective of both human health and the environment; however, some additional risk to workers of contact with contaminated water could occur during installation of the chemical treatment. This risk will be minimized by following manufacture's recommendations during installation. This alternative may not meet the site-specific groundwater remediation ARARs for the site. RegenOx rapidly breaks down (over a period of weeks) and needs to be in direct contact with the source of contamination during this time in order to be effective. Since the exact location of the suspected source of on-site PCE contamination is unknown, the effectiveness of RegenOX cannot be guaranteed. Furthermore, although RegenOX can be injected into bedrock, a reduction in permeability may result if multiple injections of ORC are made. The groundwater will need to be monitored at least annually for the life of the project.

Assuming three applications of RegenOX to wells MW-3, MW-5, MW-6, MW-11, MW-16, MW-18, MW-203, MW-206, MW-211 and, MW-220 the cost of the chemical oxidation is estimated to be $160,000, with annual monitoring of the wells estimated at $20,000 per year. This estimate includes second application of the RegenOX treatment for five wells; if other wells need re-treatment this will be an additional cost per well treated.

5.2 Comparative Analysis

In the following sections the alternatives are evaluated in relation to one another for each of the evaluation criteria (listed in Section 5.0). The alternatives are as follows:

1. No Action
2. Natural Attenuation with Continued Monitoring
3. Ex-Situ Groundwater Treatment
4. In-Situ Bioremediation
5. Chemical Oxidation

5.2.1 Overall Protection of Human Health and the Environment

Alternatives 3, 4, and 5 protect both human health and the environment by actively treating the groundwater to reduce contamination to acceptable levels. However, Alternatives 4 and 5 are better choices for the protection of human health because both are in-situ treatments that do not require pumping contaminated groundwater to the surface, as is required by Alternative 3. Alternative 2 adequately protects human health through the use of deed restrictions and municipal water supplies but does not adequately protect the environment, and only Alternative 1 does not provide protection to either human health or to the environment.

5.2.2 Compliance with ARARs

Alternatives 3 and 4 meet Site specific ARARs. Alternatives 2 and 5 have the potential to meet Site specific ARARs; however, this is dependent on conditions encountered during the implementation of the Alternatives. Alternative 1 does not meet site specific ARARs.

5.2.3 Long-term Effectiveness and Permanence

Alternatives 3, 4, and 5 provide the best choices for long-term effectiveness and permanence because each method utilizes a treatment technology to reduce contamination at the site. These alternatives also reduce the potential for continued migration of the contaminant. However, the biological agent used for Alternative 4 will be active and in the sub-surface at least one year and during that time has the potential to treat areas of previously unknown contamination. Alternative 3 will be most effective if the pumping is located near the area of highest contaminate concentrations. The chemical used for Alternative 5 must come into contact with contaminated groundwater quickly (within weeks) in order to be effective, which could potentially lower its long-term effectiveness. As mentioned in Section 5.1.1, the long-term effectiveness of Alternative 4 and 5 may be increased by the addition of pumping groundwater.

Alternatives 1 and 2 rely on natural biological activity to reduce contamination, which depends greatly on unknown natural conditions (e.g. natural biological populations and seasonal variation) that may affect the long-term effectiveness of these alternatives.

5.2.4 Reduction of Toxicity, Mobility, or Volume

All Alternatives reduce toxicity and volume of the contamination. Alternatives 3, 4, and 5 use available technologies that should, due to the reduced time scale needed for treatment, also reduce the mobility of the contamination at the site. Pumping of groundwater, which occurs during Alternative 3 and is also a possibility during Alternatives 4 and 5, could diminish plume size by drawing water, contaminants, and treatment media (Alternatives 4 and 5) back toward the center of the site.

Alternatives 1 and 2 do not adequately reduce mobility of the contaminant at the Site due to projected length of treatment.

5.2.5 Short-term Effectiveness

Provided that the chemical oxidant would come into contact with the contamination, Alternative 5 would have the greatest short-term effectiveness. However, the time required for dispersal throughout the contaminant plume is more favorable for Alternative 4 than Alternative 5 because the biological agents persist for years and the chemical reactants only for weeks. Alternative 3 could potentially have a short-term effectiveness similar to Alternative 5; however, this would be contingent on distance from the area of highest contamination and location of additional bedrock source areas as mentioned above.

Alternatives 1 and 2, which rely on natural attenuation of the contamination, would have the least short-term effectiveness of the five Alternatives.

5.2.6 Implementability

Alternative 1 would be the simplest to implement, and Alternative 2 would be the next simplest with annual monitoring required. Alternatives 3, 4, and 5 are all more complex, with the installation and maintenance of equipment required for Alternative 3, and the injection of materials required for Alternatives 4 and 5. Alternative 5 will require relatively extensive use of Geoprobe equipment to perform the required injections of RegenOX.

5.2.7 Cost

Assuming a project lifetime of 30 years, all the alternatives with the exception of Alternative 1 (No Action) have a base cost of $300,000 for annual monitoring over 30 years. The costs for the implementation of each of the alternatives are as follows.

	Initial Application ($)	Annual O & M for 30 Years ($)	Annual Groundwater Monitoring for 30 Years	Total ($)
Alternative 1	None	None	N/A	0
Alternative 2	None	None	600,000	600,000
Alternative 3	140,000	2,160,000	600,000	2,900,000
Alternative 4	120,000	None	600,000	720,000
Alternative 5	160,000	None	600,000	760,000

5.2.8 State Acceptance

To be addressed in the Record of Decision (ROD).

5.2.9 Community Acceptance

To be addressed in the (ROD).

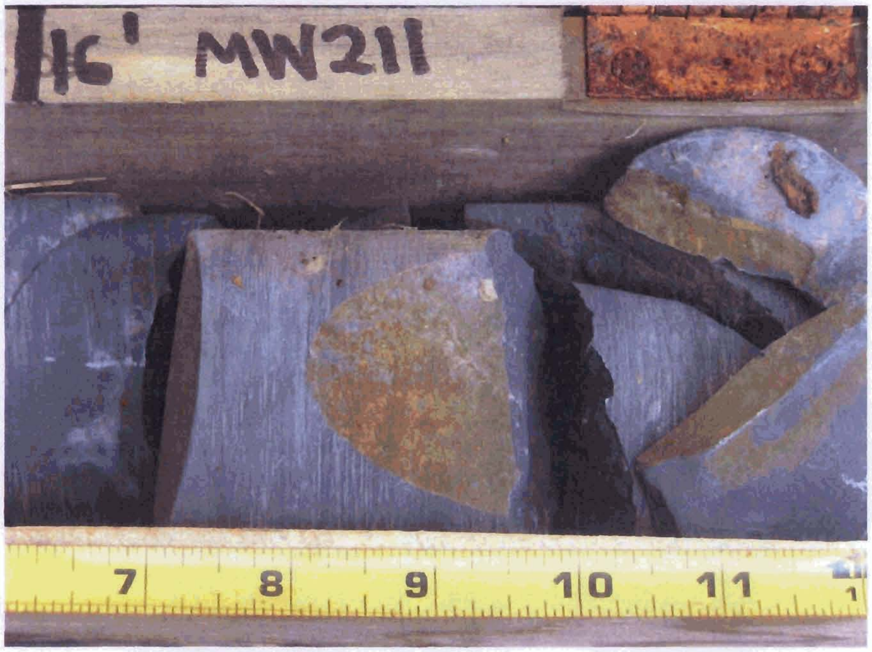
5.3 Alternative Selection

The alternative that best fits the criteria found in the Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA is Alternative 4, in-situ bioremediation (bioremediation). As discussed above, bioremediation is protective of human health because the groundwater is left in place instead of being brought to the surface for treatment, it will meet Site specific ARARs, the length of treatment (at least one year per application) is effective long-term, it will reduce the toxicity, mobility, and volume of the contaminate, is implementable with current technologies, and is the most cost effective alternative. Because Alternative 4, bioremediation, best meets USEPA criteria, ESI is recommending bioremediation for use at the Wallkill Wellfield Site.

APPENDIX A

Photographs and Figures

PHOTOGRAPHS



1. Well MW211 - 16 feet

2. Well MW211 - 39.5 feet

PHOTOGRAPHS

3. Well MW211 - 43 & 44 feet

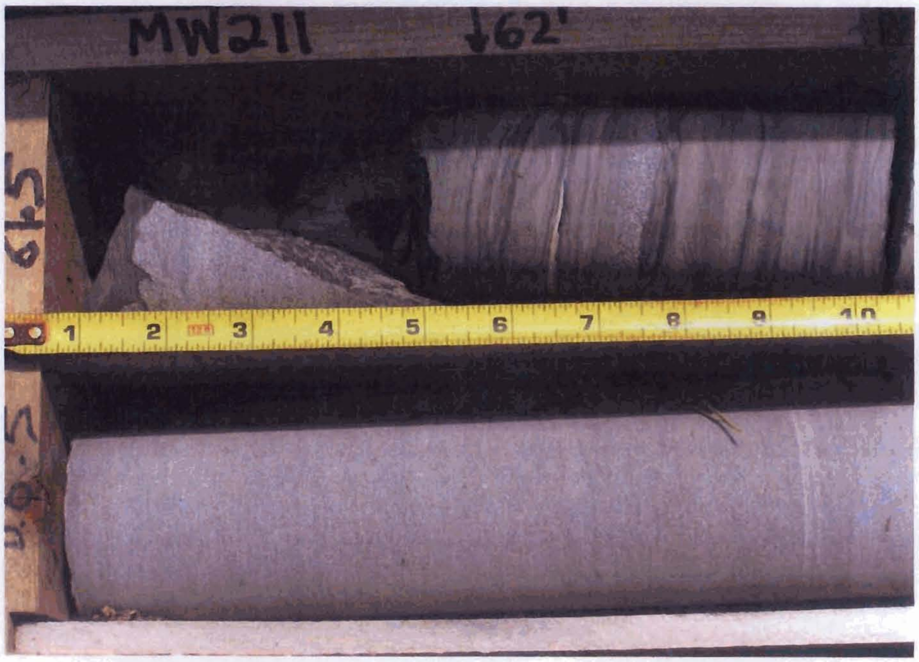
4. Well MW211 - 46.5 feet

PHOTOGRAPHS

5. **Well MW211 - 56.5 feet**

6. **Well MW211 - 61 feet**

PHOTOGRAPHS



7. **Well MW211 - 62 feet**

8. **Well MW211 - 74 feet**

PHOTOGRAPHS

9. Well MW211 - 75.5 – 76.5 feet

10. Well MW211 - 78 feet

PHOTOGRAPHS

11. Well MW211 - 88 feet

12. Well MW211 - 89 feet

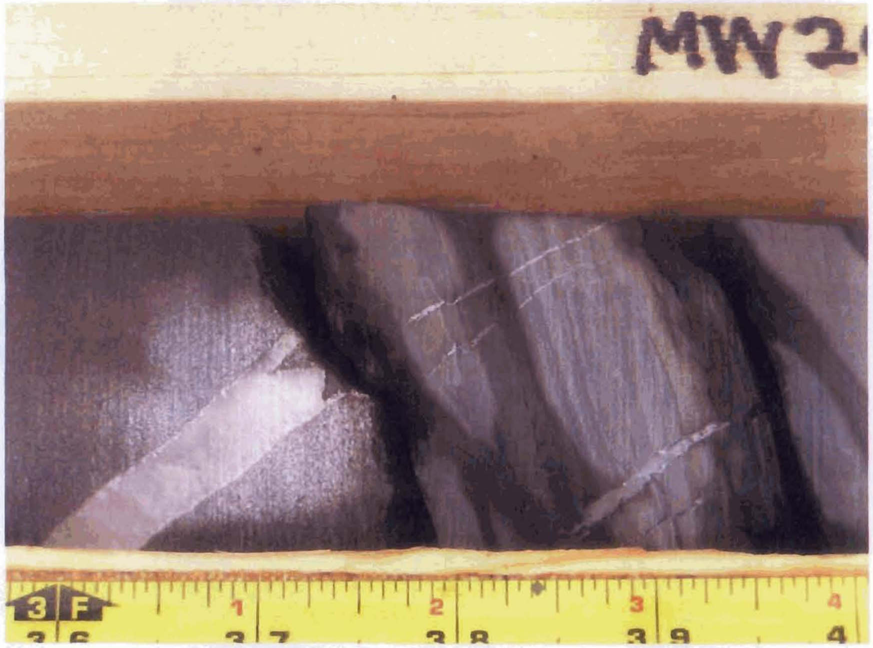
PHOTOGRAPHS

13. **Well MW211 - 90 feet**

14. **Well MW211 - 91 feet**

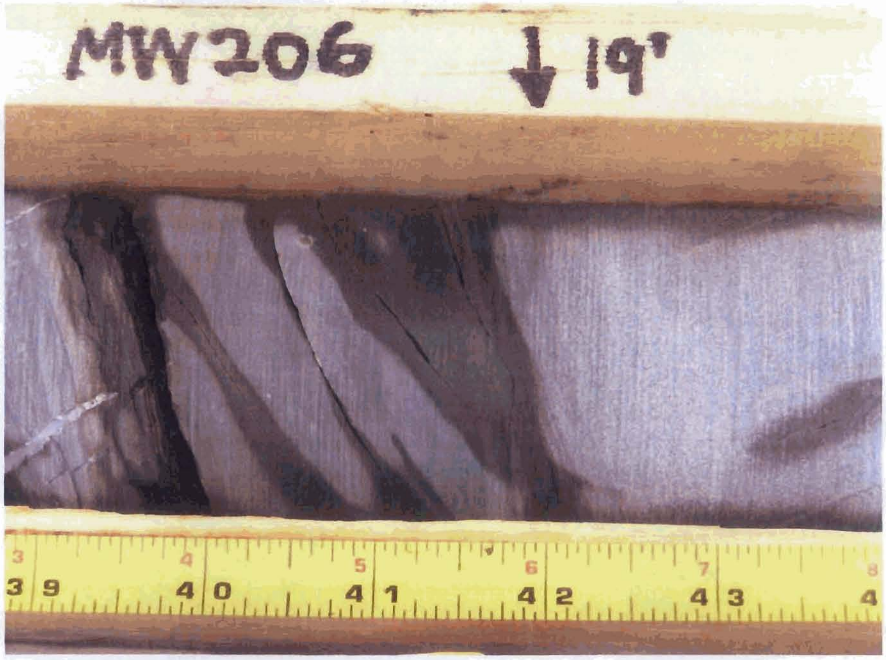
PHOTOGRAPHS

15. Well MW211 - 114 & 115 feet



16. Well MW206 - 18 feet

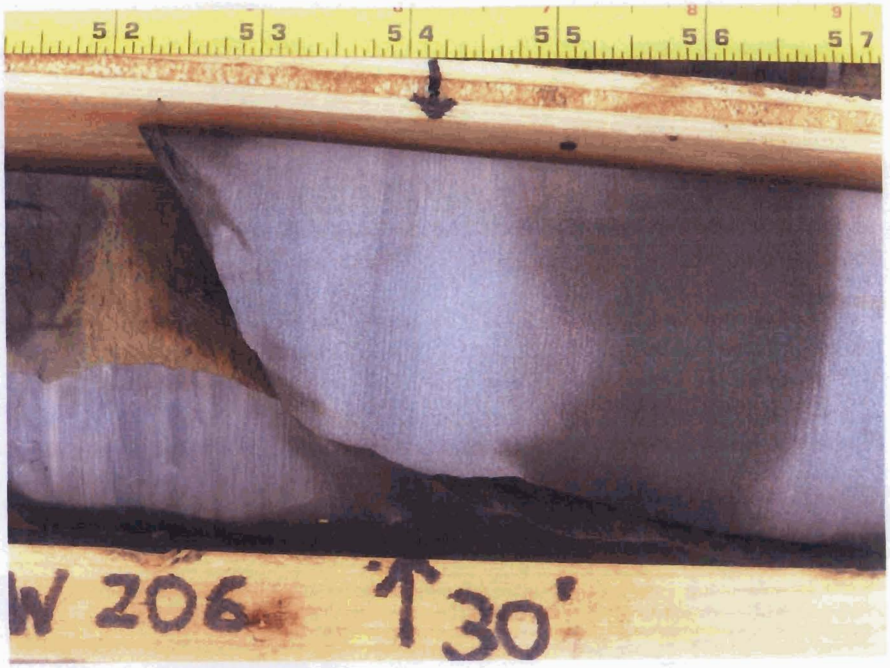
PHOTOGRAPHS



17. Well MW206 - 19 feet

18. Well MW206 - 26 feet

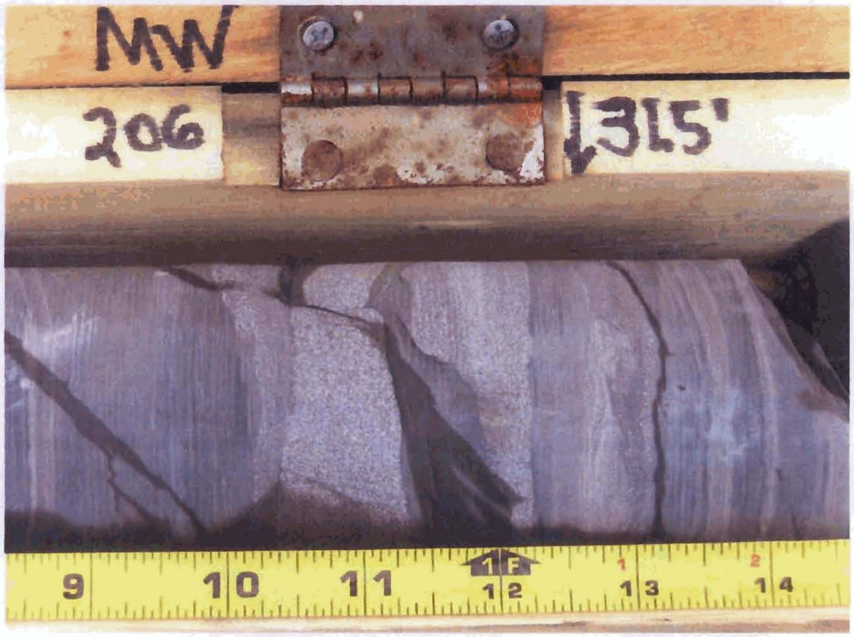
PHOTOGRAPHS



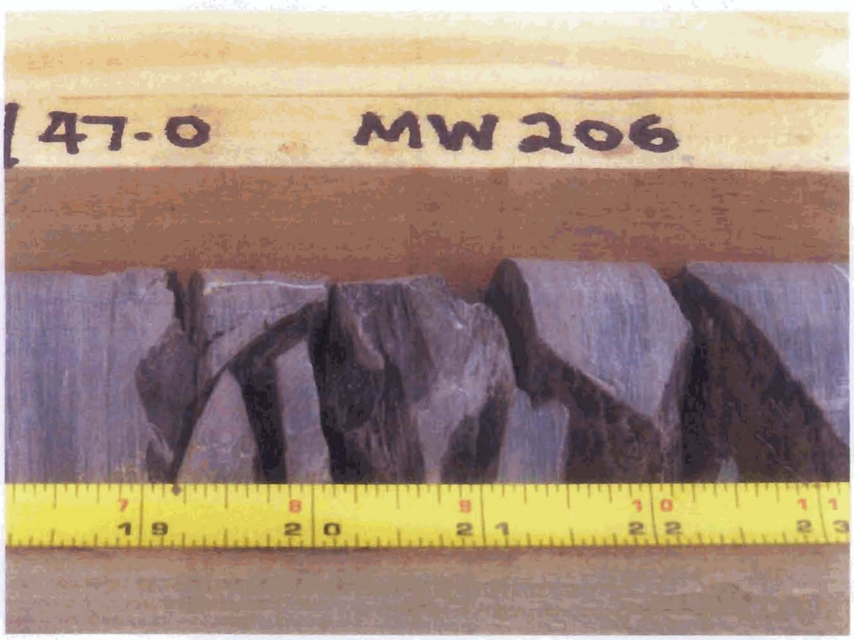
19. Well MW206 - 30 feet

20. Well MW206 - 31 feet

PHOTOGRAPHS



21. Well MW206 - 31.5 feet



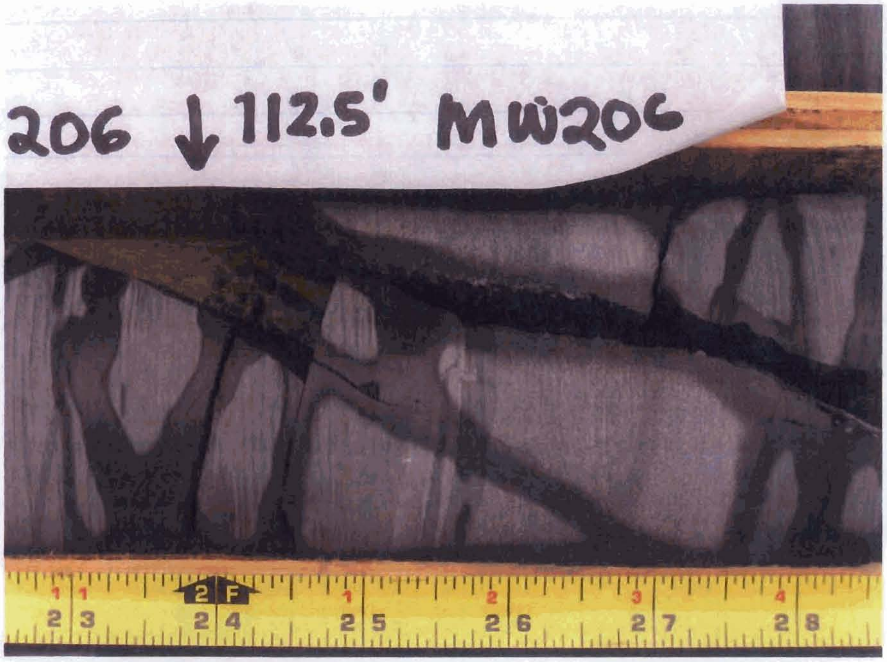
22. Well MW206 - 47 feet

PHOTOGRAPHS

23. Well MW206 - 94.5 feet

24. Well MW206 - 95.5 feet

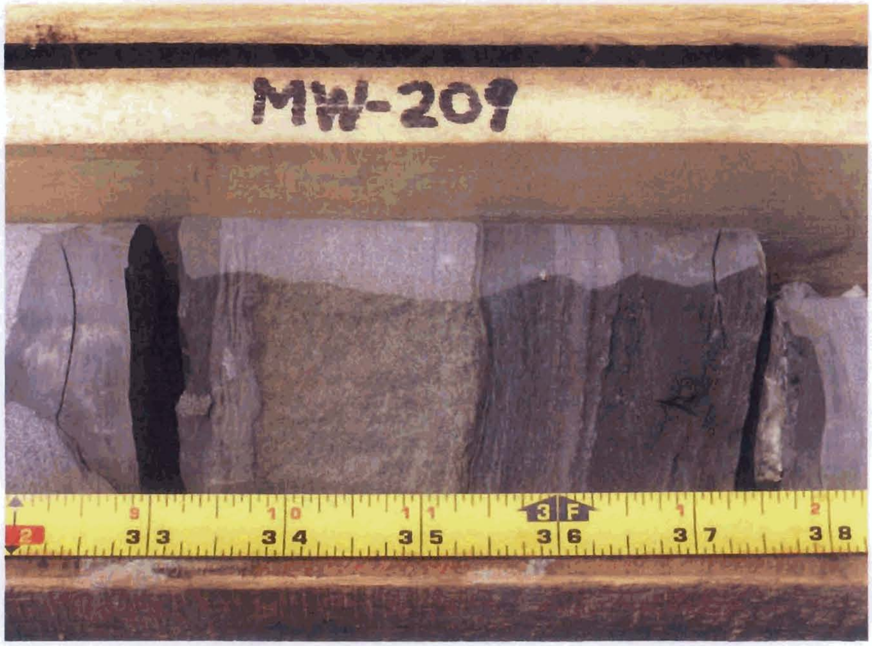
PHOTOGRAPHS



25. Well MW206 - 112.5 feet

26. Well MW209 - 22 feet

PHOTOGRAPHS



27. Well MW209 - 23.5 feet

28. Well MW209 - 40 and 45 feet

PHOTOGRAPHS

29. Well MW209 - 75.5 and 76 feet

30. Well MW209 - 100 feet

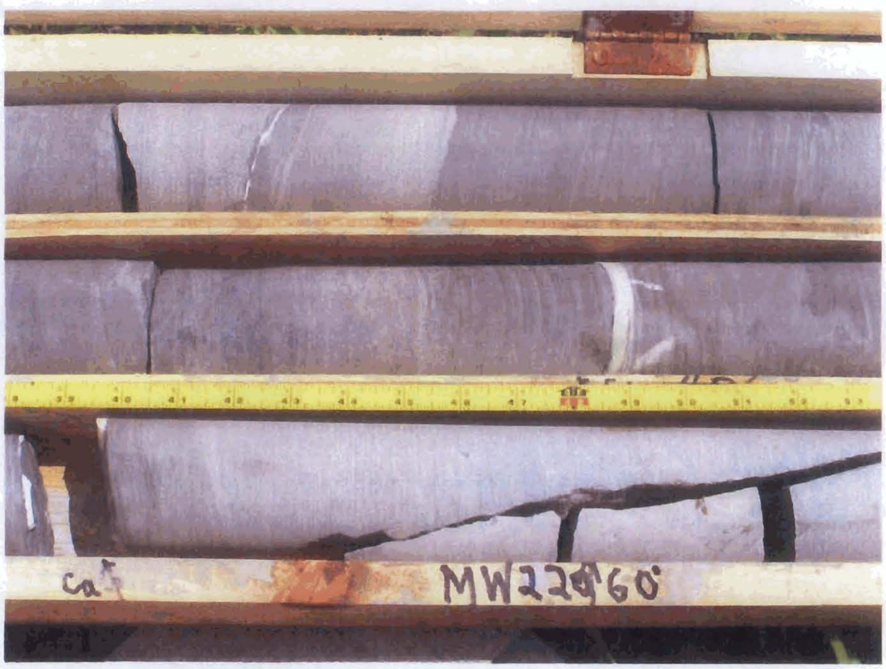
PHOTOGRAPHS

31. Well MW209 - 110 feet

32. Well MW209 - 117 feet

PHOTOGRAPHS

33. Well MW220 - 42 feet



34. Well MW220 - 60 feet

PHOTOGRAPHS

35. Well MW220 - 62.5 feet

36. Well MW220 - 63.5 feet

PHOTOGRAPHS

37. Well MW220 - 65 feet

38. Well MW220 - 67 feet

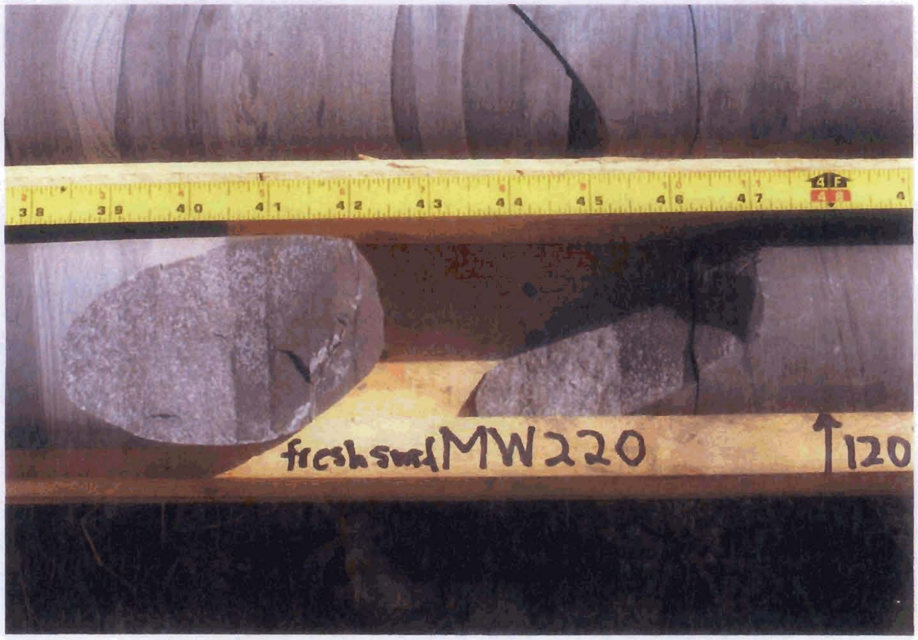
PHOTOGRAPHS

39. Well MW220 - 102 feet

40. Well MW220 - 103 feet

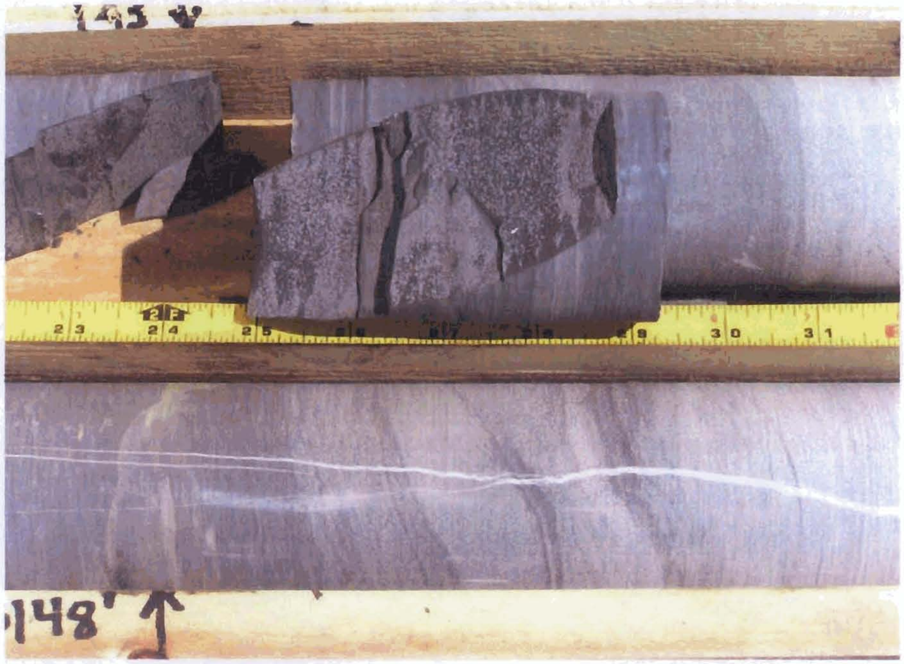
PHOTOGRAPHS

41. Well MW220 - 116 feet



42. Well MW220 - 120 feet

PHOTOGRAPHS



43. Well MW220 - 143 feet

44. Well MW220 - 149 feet

PHOTOGRAPHS

45. Well MW220 - 174 feet

46. Well MW220 - 178 feet

PHOTOGRAPHS

47. Well MW219 - 22.5 feet

48. Well MW219 - 28 feet

PHOTOGRAPHS

49. Well MW219 - 43 feet

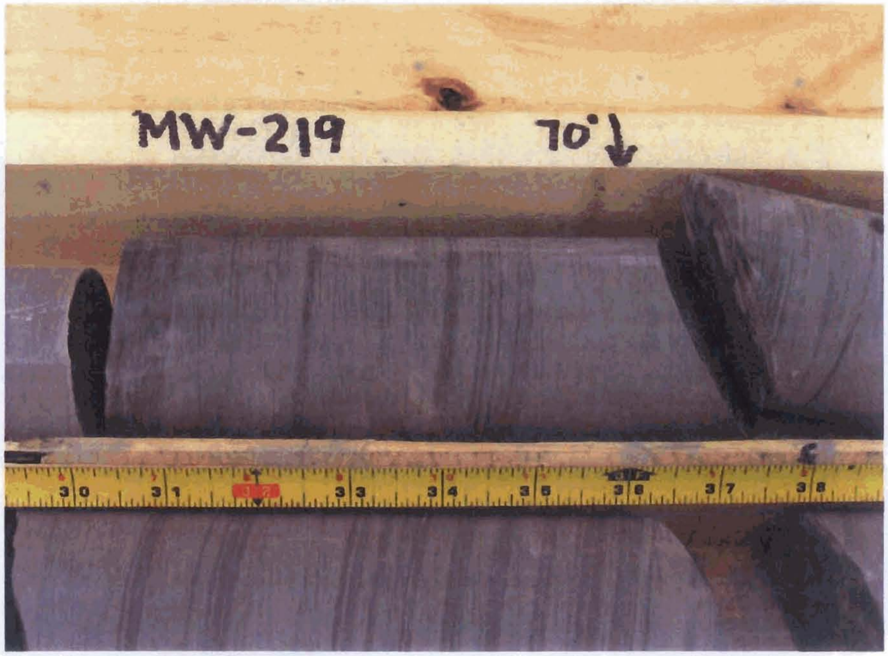
50. Well MW219 - 44.5 feet

PHOTOGRAPHS

51. Well MW219 - 49 feet

52. Well MW219 - 70 feet

PHOTOGRAPHS



53. Well MW219 - 70 feet

54. Well MW219 - 118.5 feet

PHOTOGRAPHS

55. Well MW219 - 134 & 135 feet

56. Well MW219 - 135 and 136 feet

PHOTOGRAPHS

57. Well MW219 - 136 feet

58. Well MW219 - 138 feet

List of Figures

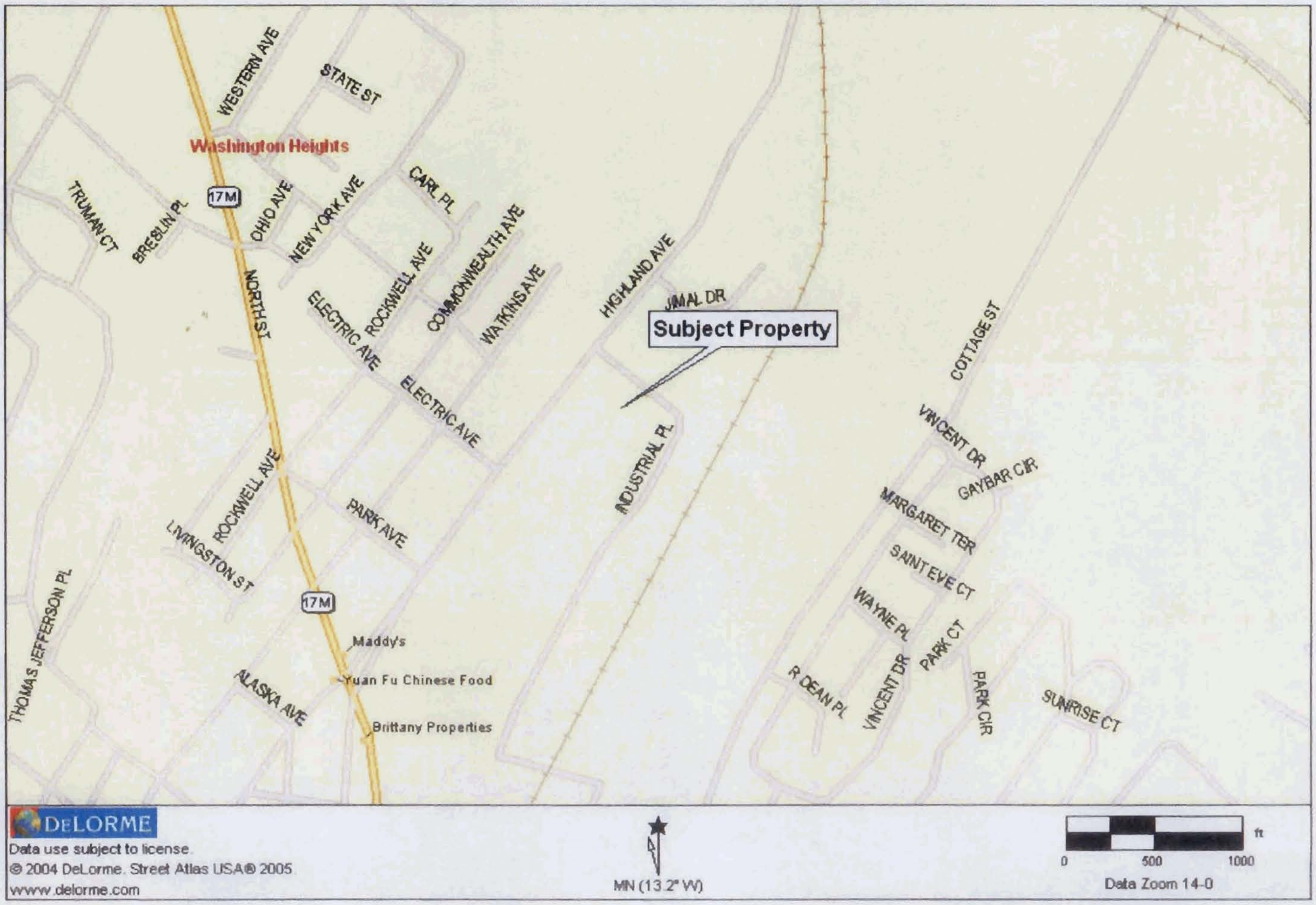
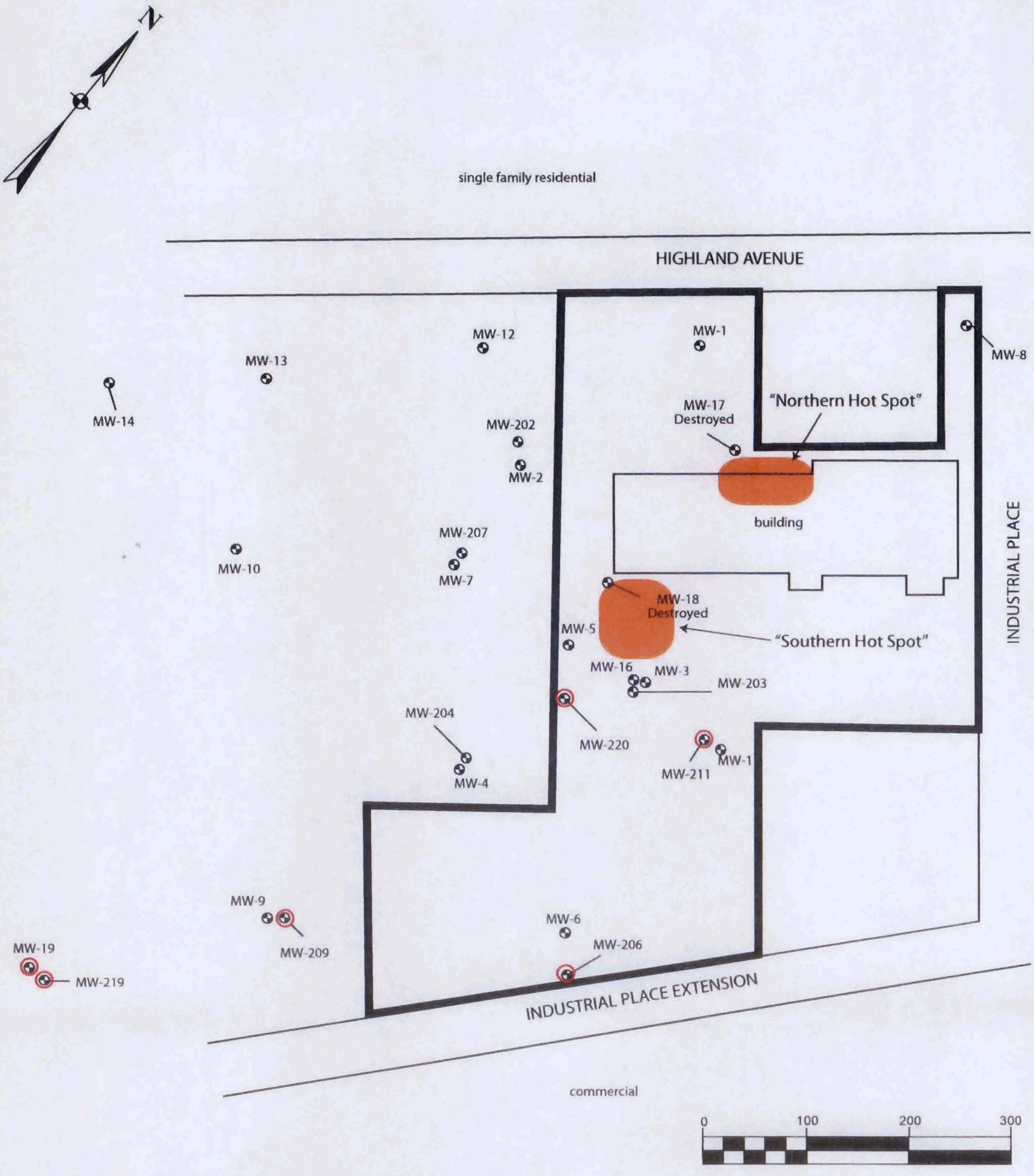


Figure 1-1 - Site Location Map Wallkill Wellfield Site City of Middletown Orange County, New York	N	ESI File: LM97145.45 Date: October 2007 Appendix A



All feature locations are approximate. This map is intended as a schematic to be used in conjunction with the associated report, and it should not be relied upon as a survey for planning or other activities.

Figure 1-2 - Monitoring Well Location and "Hot Spots" Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: subject property border monitor wells installed prior to 2005 monitor wells installed February 22 to March 28, 2005	ESI File: LM97145.45 October 2007 Scale as shown Appendix A

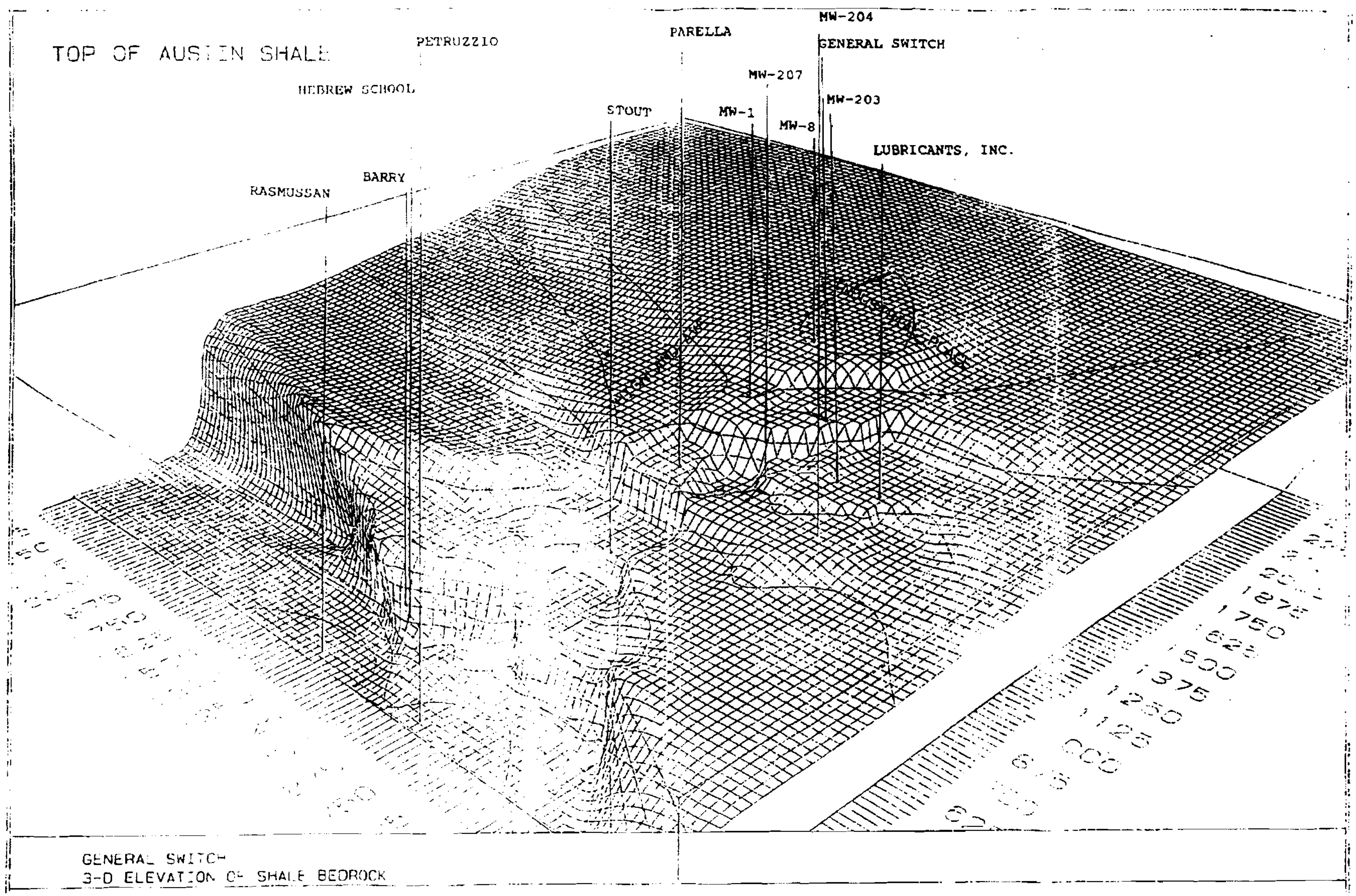


Figure 1-3 - Net Diagram of Top of Bedrock Derived from Well Data

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

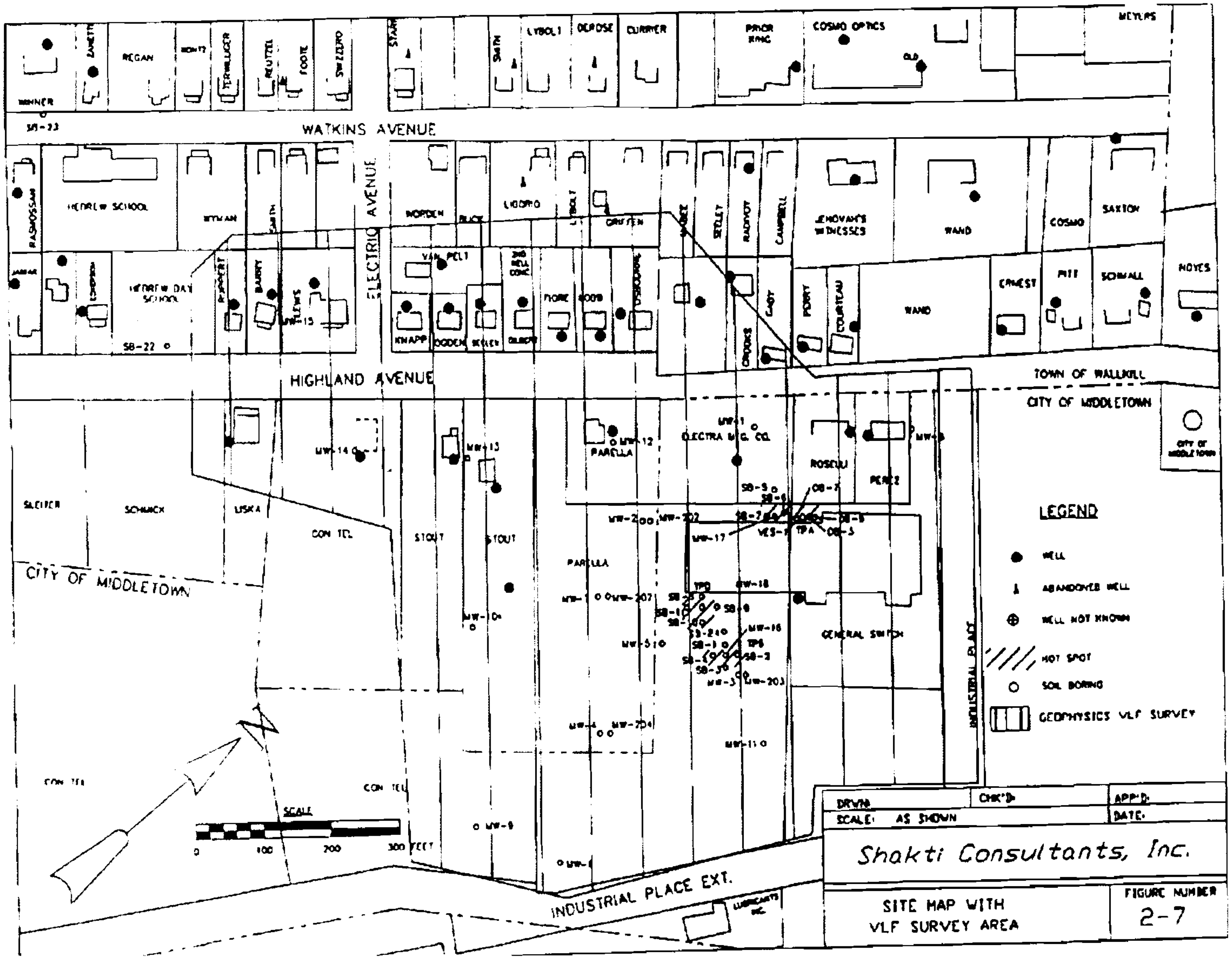


Figure 1-4 - Contaminant Distribution Map

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

Phone
(203) - 888-4531
Telefax
(203) - 888-6247

WHITE PLAINS, N.Y.
(914) - 946-4850

MONITOR WELL INSTALLATION DETAIL

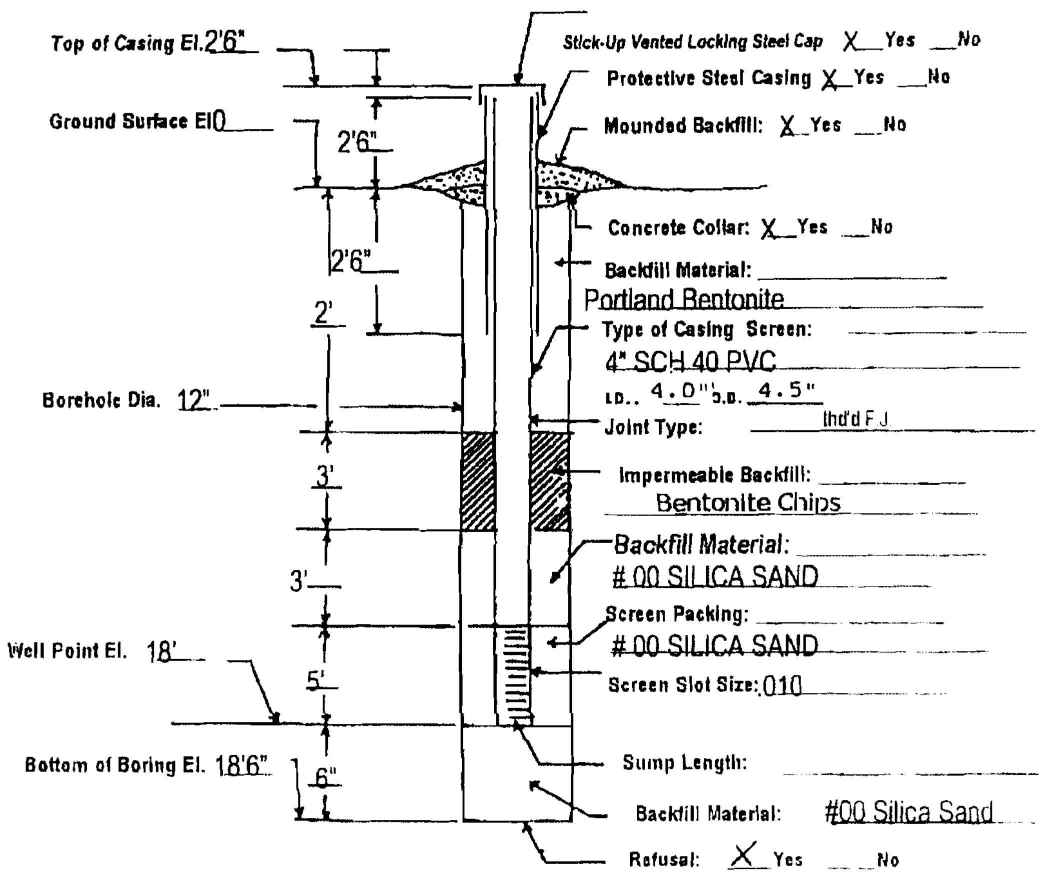
SOILTESTING, INC.

140 OXFORD ROAD - OXFORD, CONN. 06478-1943

GEOTECHNICAL / ENVIRONMENTAL SUBSURFACE INVESTIGATIONS - Test Borings - Core Drilling
Monitoring Wells - Recovery Wells - Direct Push/Probe Sampling

Observation Well # MW19

CLIENT: Ecosystems Strategies,
JOB# : E58-7139-04



Materials Used:

Screen	5'	Bentonite Pellets		Locking Exp. Plug	1
Riser	15'	Bentonite Chips	2	Lock	1
Plug	1	Concrete Mix	2	D/O	
Slip Ca		Portland	3	S/U	1
Silica Sand	450#				
Powdered Bentonite					

Figure 1-5 - MW19 Well Construction Diagram
Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

SOILTESTING, INC. 140 OXFORD RD. OXFORD, CT 06478 CT (203) 888-4531 NY (914) 946-4850	CLIENT: Ecosystems Strategies, Inc. PROJECT NO. E58-7139-04 PROJECT NAME General Switch Property 20 Industrial Place	SHEET 1 OF 1 HOLE NO. MW-9 BORING LOCATIONS per plan
FOREMAN - DRILLER PD/dj	LOCATION Middletown, NY	
INSPECTOR		OFFSET

	CASING	SAMPLER	CORE BAR
TYPE	HSA	SS	
SIZE I.D.	6 5/8"	1 3/8"	
HAMMER WT.		140#	BIT
HAMMER FALL		30"	

GROUND WATER OBSERVATIONS
AT 4 FT AFTER 0 HOURS
AT __ FT AFTER __ HOURS

DATE START 9/30/04
DATE FINISH 9/30/04
SURFACE ELEV.
GROUND WATER ELEV.

DEPTH	CASING BLOWS PER FOOT	SAMPLE NO	Type	PEN	REC	DEPTH @ BOT	BLOWS PER 6 IN ON SAMPLER (FORCE ON TUBE) 0-6	6-12	12-18	CORING TIME PER FT (MIN)	DENSITY OR CONSIST / MOIST	STRATA CHANGE DEPTH / ELEV	FIELD IDENTIFICATION OF SOIL REMARKS INCL. COLOR, LOSS OF WASH WATER SEAMS IN ROCK, ETC
		1	ss	24"	1"	2'0"	1	2			wet		
							3	4			v.loose		Brn FM SAND & SILT,lit C gravel
		2	ss	24"	9"	4'0"	3	3			wet		
							3	4			soft		Gry SILT,sm F sand
5		3	ss	24"	8"	6'0"	3	5			wet		
							8	19			compact		Rd/Gry F SAND & SILT,lit F gravel
		4	ss	24"	9"	8'0"	14	15			wet		
							20	16			compact		Tan F SAND & SILT,sm F gravel
		5	ss	24"	12"	10'0"	11	13			wet		
10							15	16			compact		Tan VFF SAND,lit silt
		6	ss	24"	14"	12'0"	8	8			wet		
							8	8			compact		SAME
		7	ss	24"	10"	14'0"	5	4			wet		
							5	6			loose		SAME
15		8	ss	24"	4"	16'0"	2	2			wet		
							3	5			loose	17'0"	Brn/dk Brn-Gry FSAND, lit silt
		9	ss	24"	19"	18'0"	3	6			wet		lt Brn FMC SAND & SILT,sm FC gravel,rock frag.
							10	20			compact	18'6"	Decomposed Rock Frag AUGER REFUSAL
													E.O.B. 18'6"
20													
25													
30													
35													
40													

GROUND SURFACE TO ______ FT. USED ____________ CASING THEN ______ CASING TO ______ FT HOLE NO. MW19

A = AUGER UP = UNDISTURBED PISTON T = THINWALL V = VANE TEST
WOR = WEIGHT OF RODS WOH = WEIGHT OF HAMMER & RODS C = COARSE
SS = SPLIT TUBE SAMPLER H.S.A = HOLLOW STEM AUGER M = MEDIUM
PROPORTIONS USED: TRACE = 0 - 10% LITTLE = 10 - 20% SOME = 20 - 35% AND = 35 - 50% F = FINE

Figure 1-6 - MW19 Well Log
Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

Figure 3-1 - Packer Assembly

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

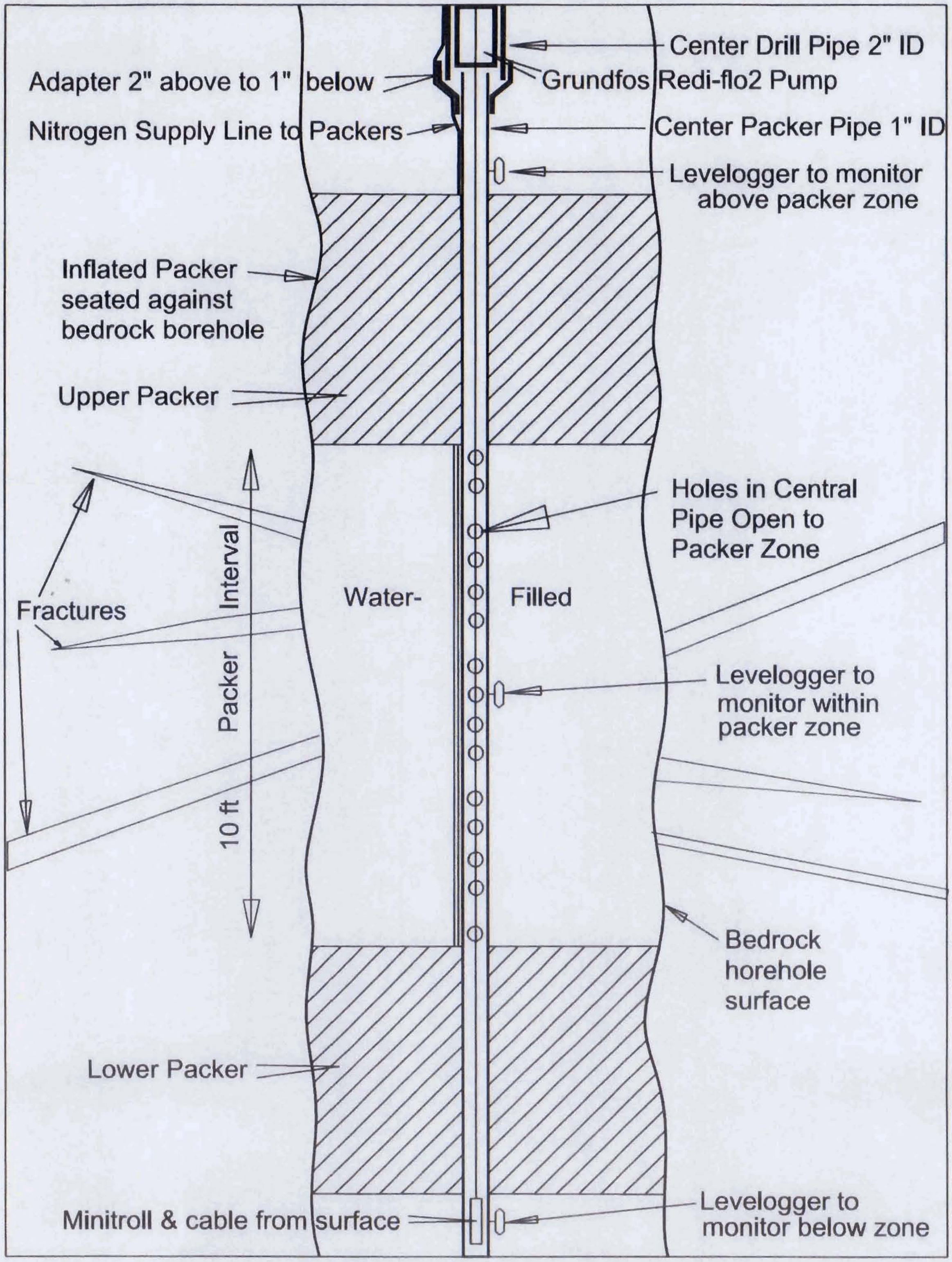
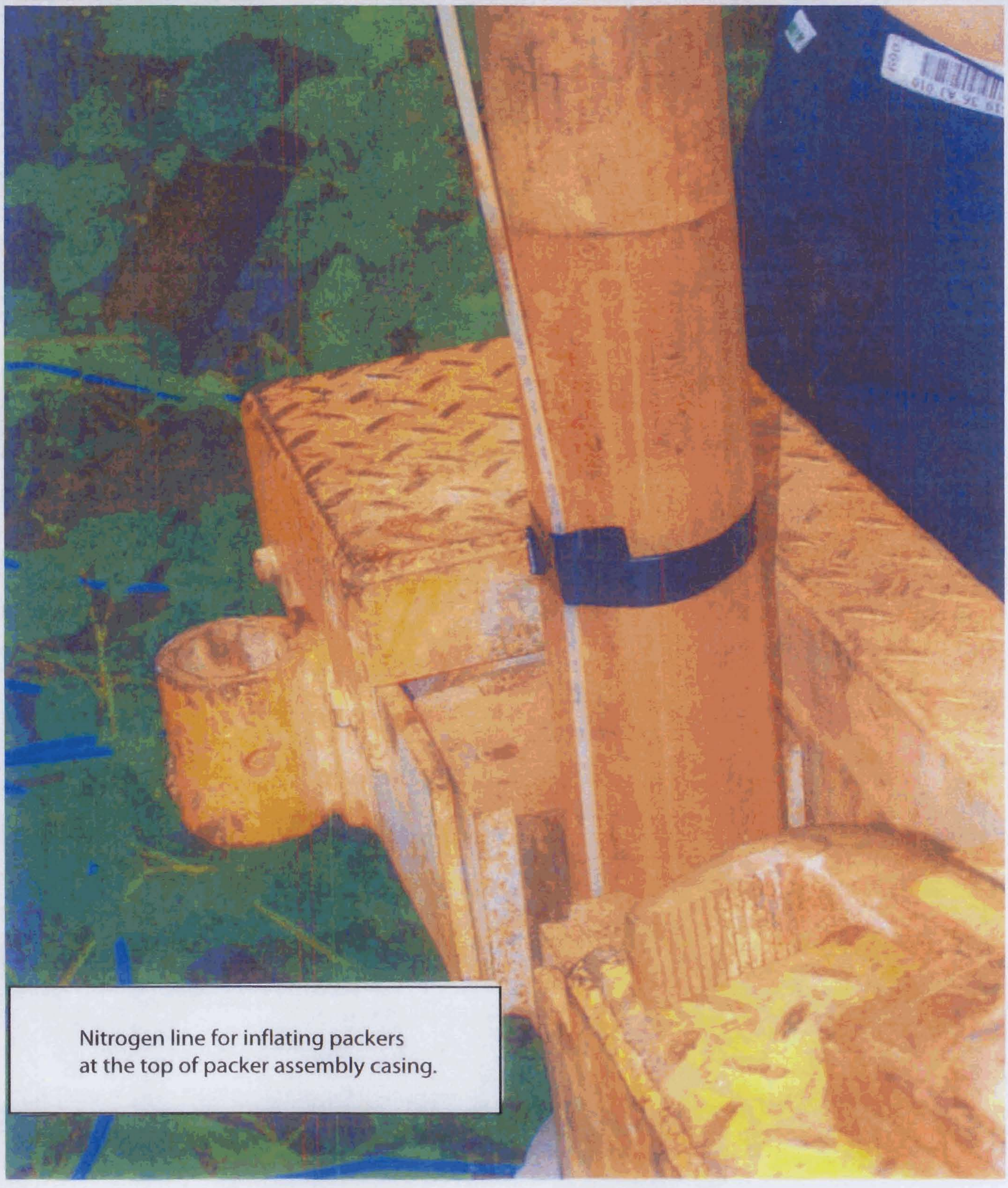


Figure 3-2 - Diagram of Packer Assembly Unit in Well

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	



Nitrogen line for inflating packers
at the top of packer assembly casing.

Figure 3-3 - Nitrogen Line

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

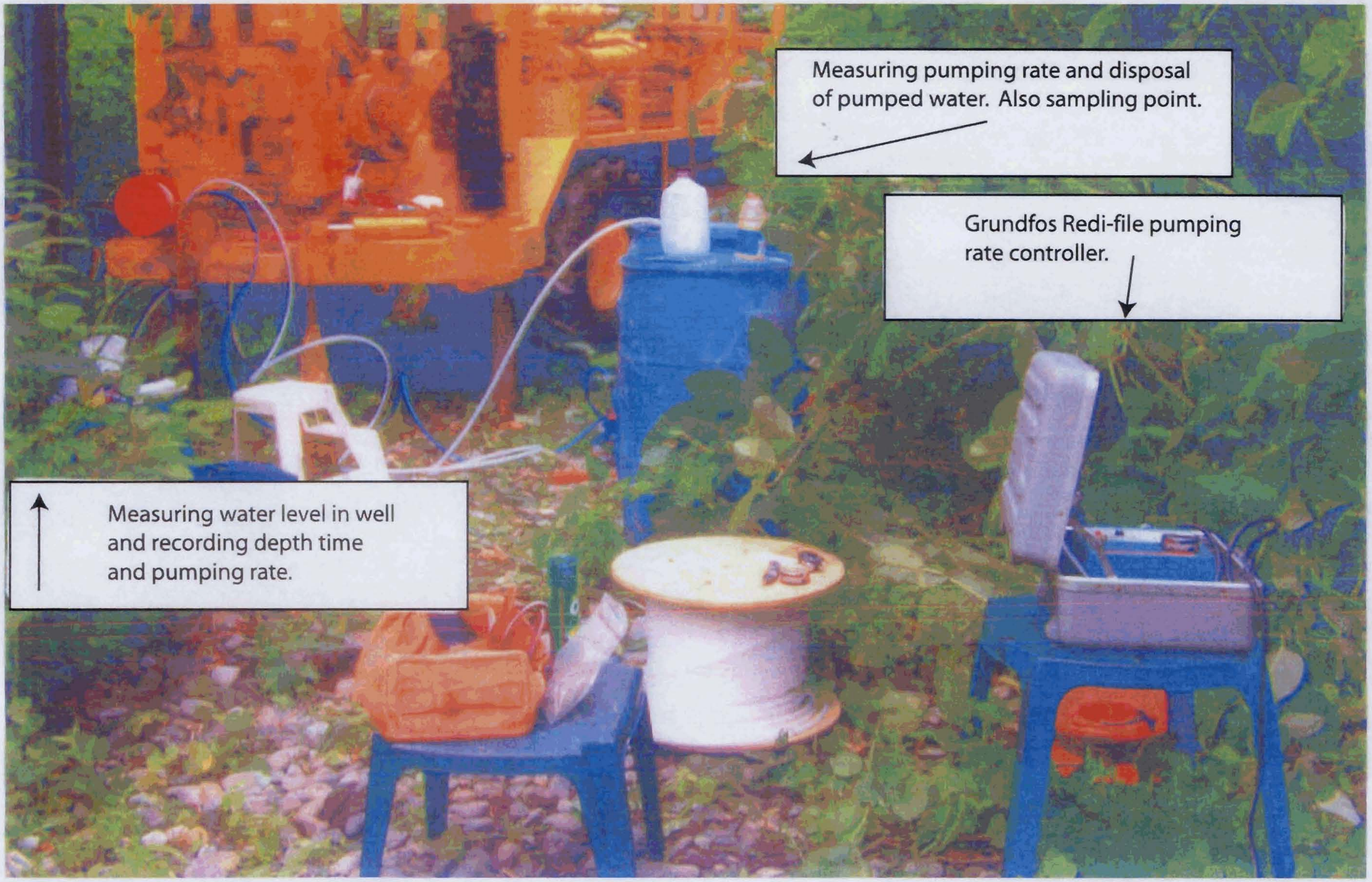


Figure 3-4 - Three Work Stations for Conducting Packer Tests
Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

Figure 3-5 - Tank on Track Vehicle

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

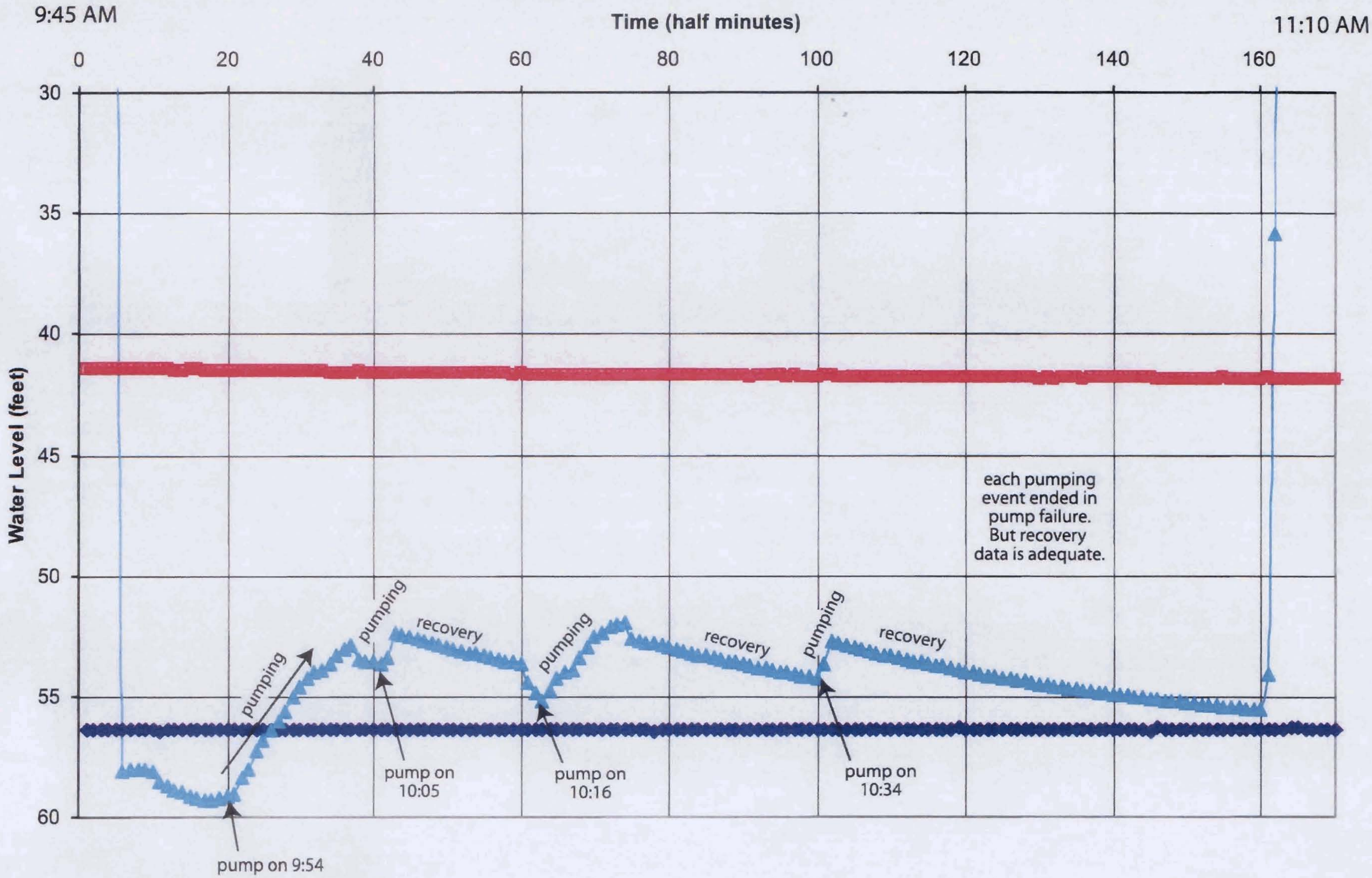


Figure 3-6 - Well MW211, Packer Test 1, 37-47 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

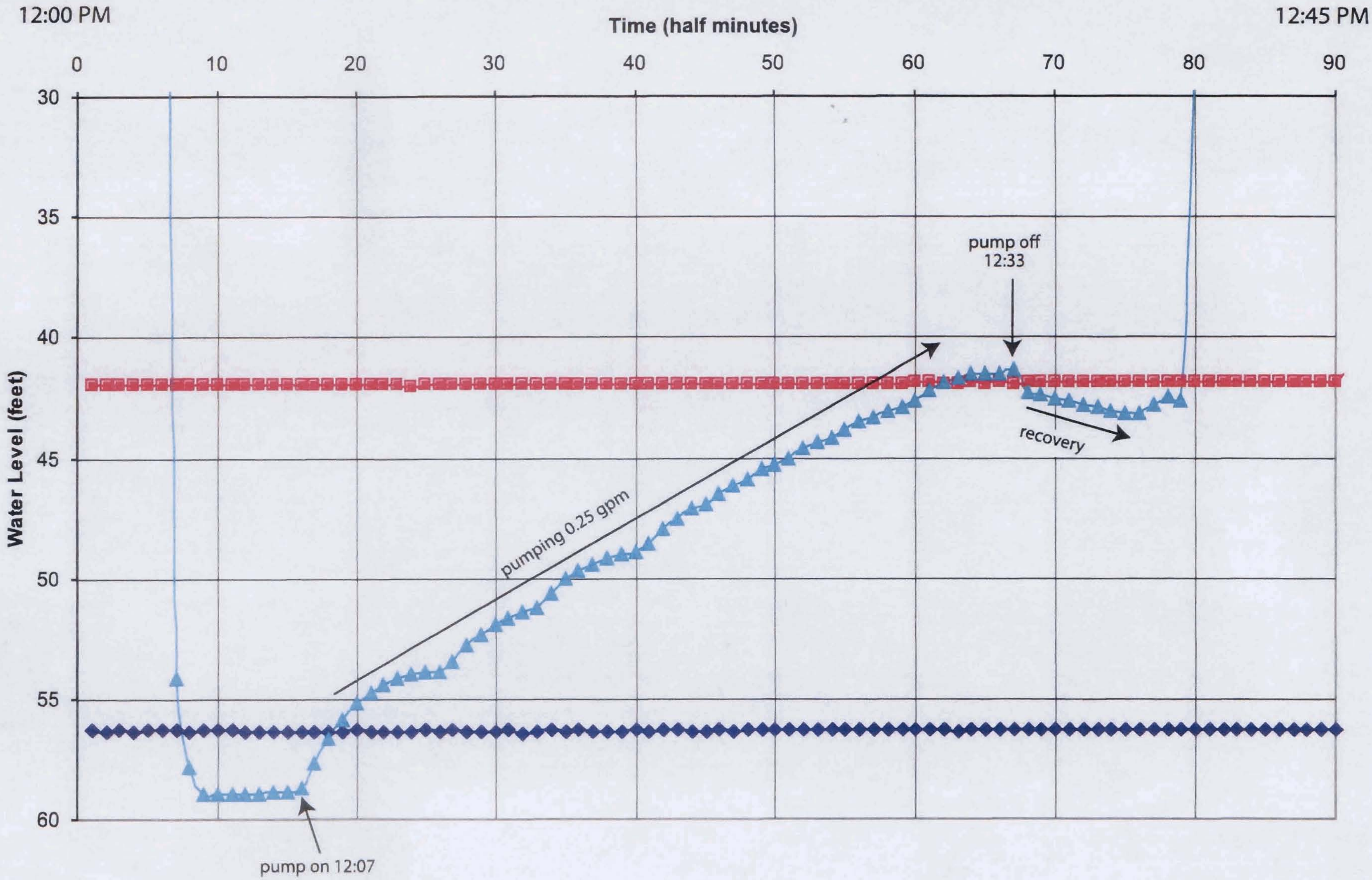


Figure 3-7 - Well MW211, Packer Test 2, 54-64 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: levelogger below Packer Zone levelogger above Packer Zone minitroll in Packer Zone	ESI File: LM97145.45 October 2007 Appendix A

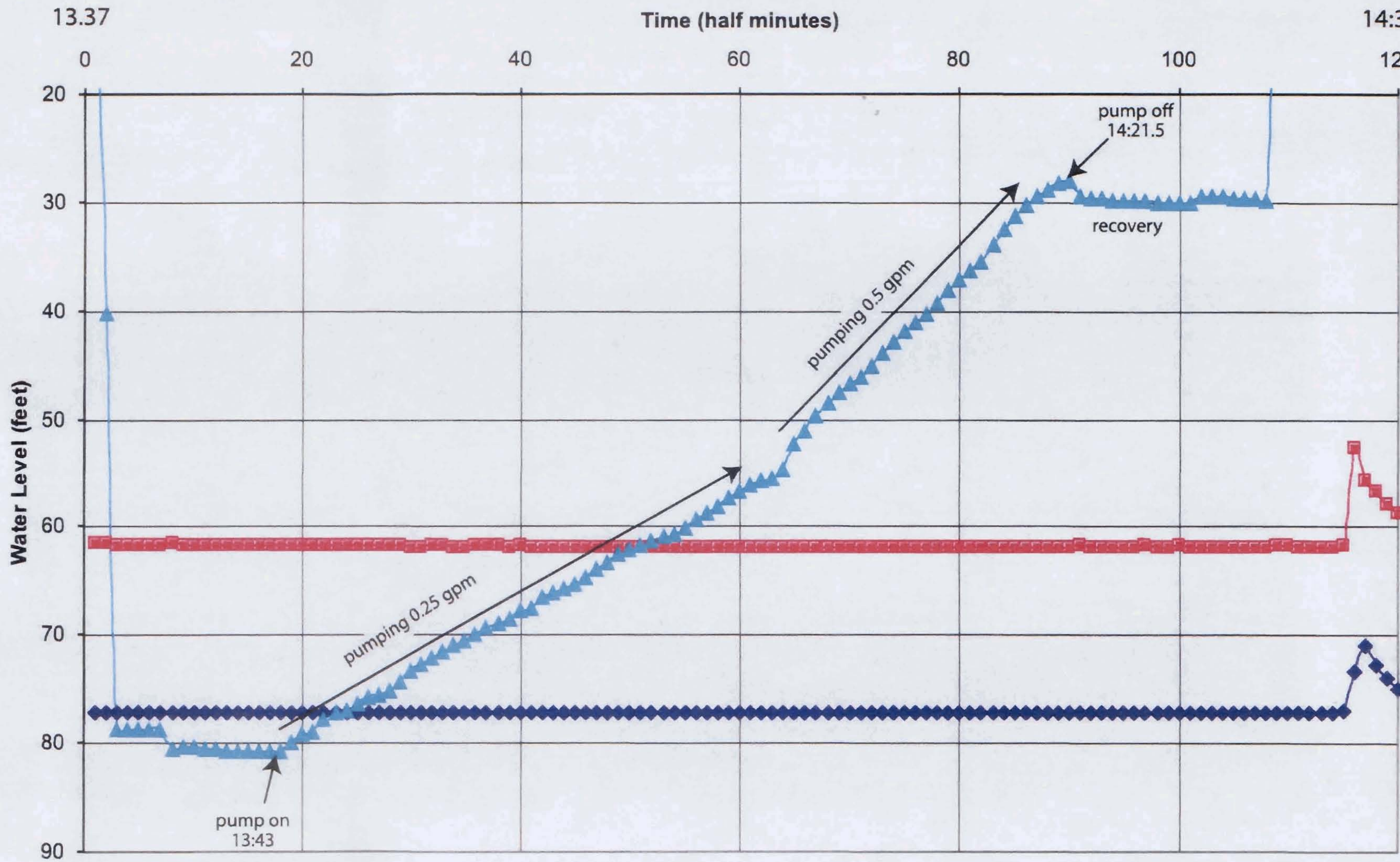


Figure 3-8 - Well MW211, Packer Test 3, 73-83 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

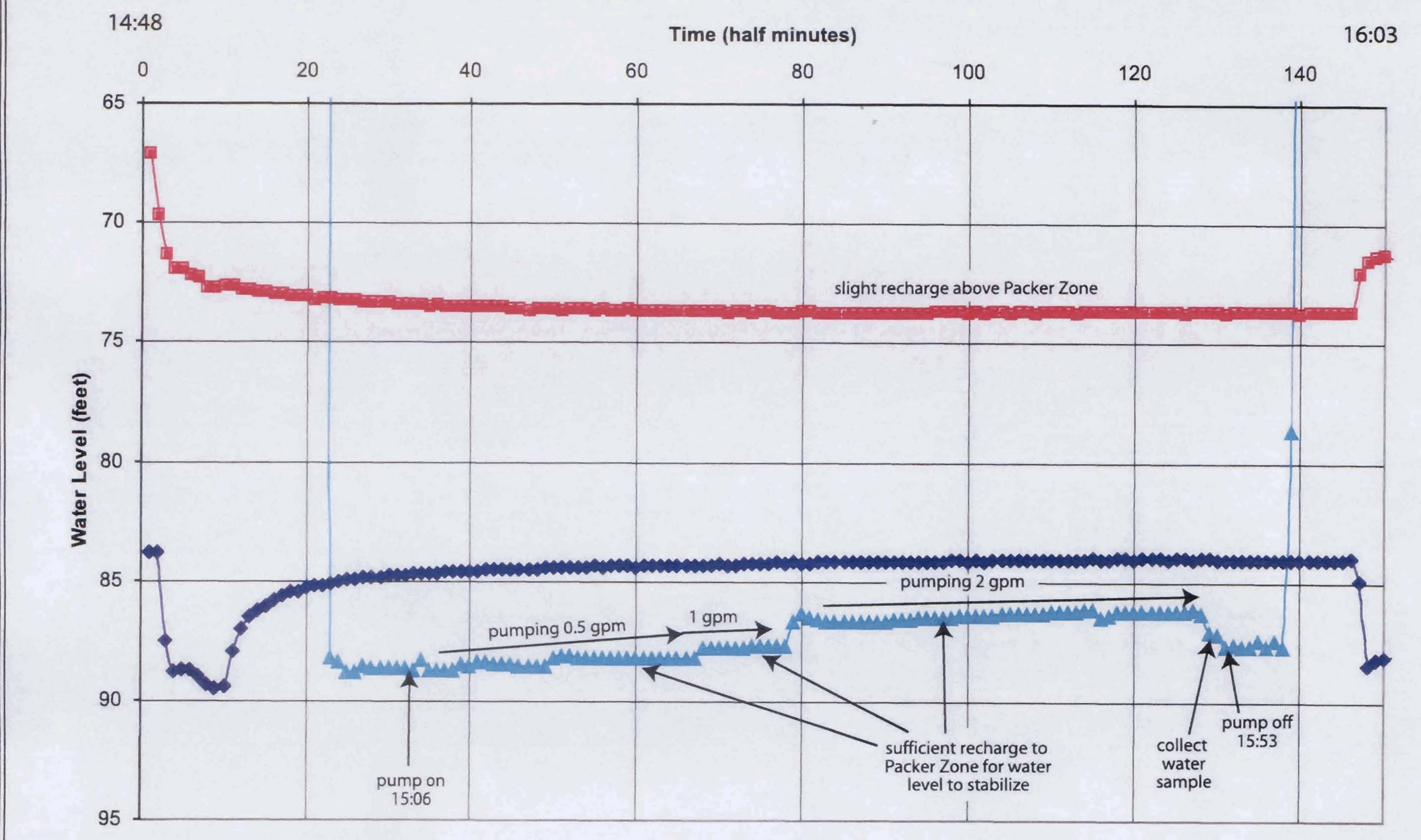


Figure 3-9 - Well MW211, Packer Test 4, 85-95 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

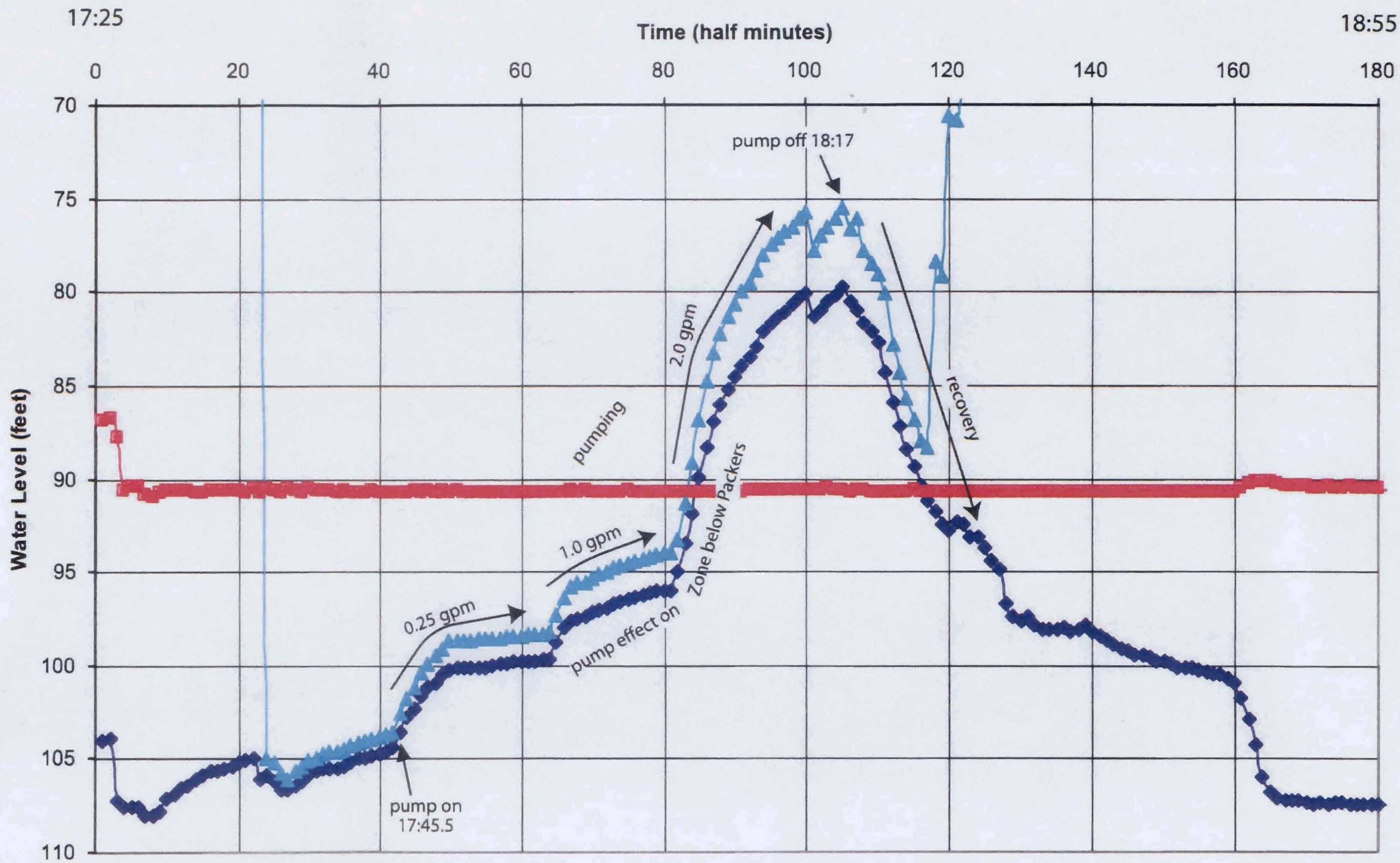


Figure 3-10 - Well MW211, Packer Test 5, 103-113 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

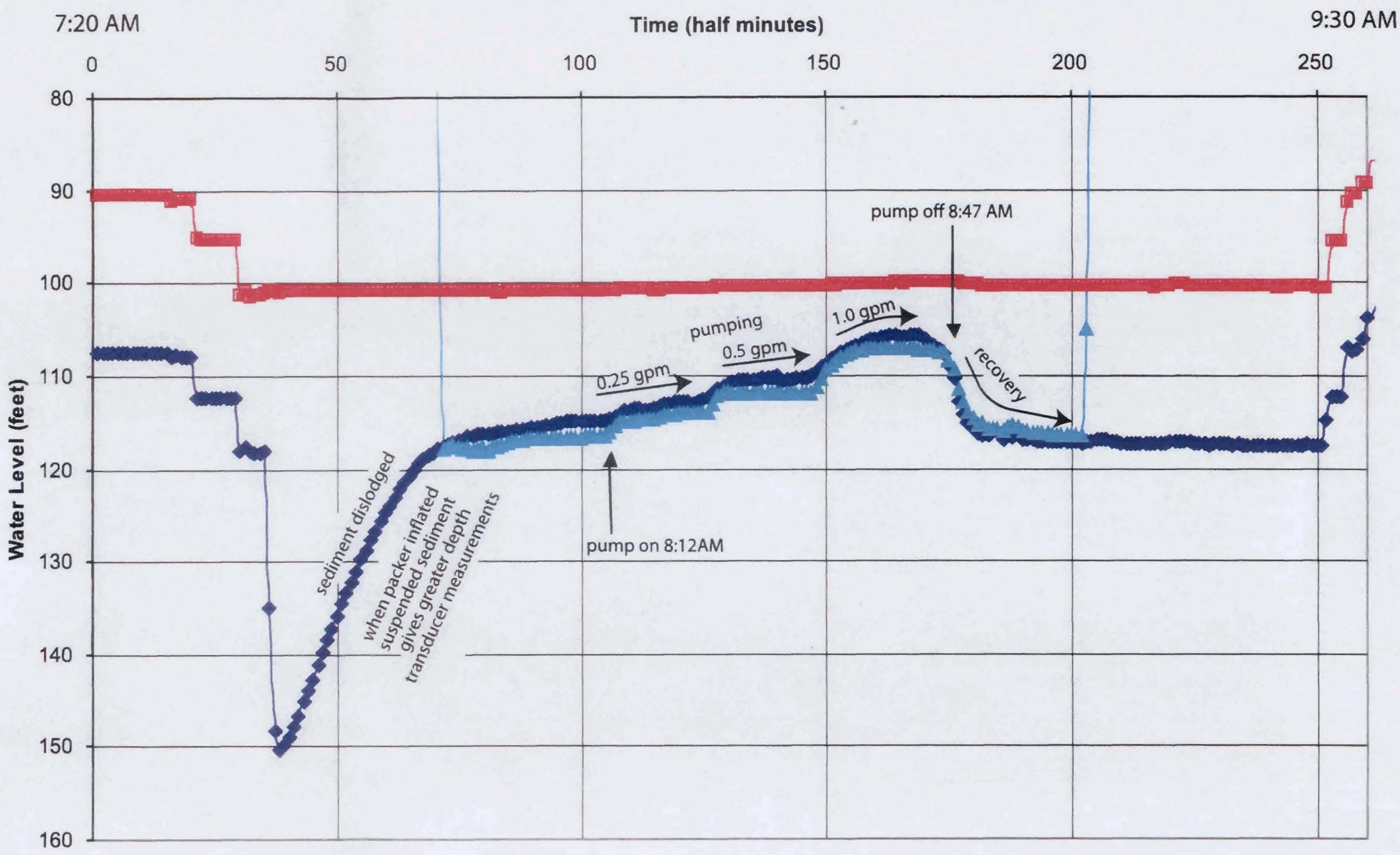


Figure 3-11 - Well MW211, Packer Test 6, 113-123 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: levelogger below Packer Zone levelogger above Packer Zone minitroll in Packer Zone	ESI File: LM97145.45 October 2007 Appendix A

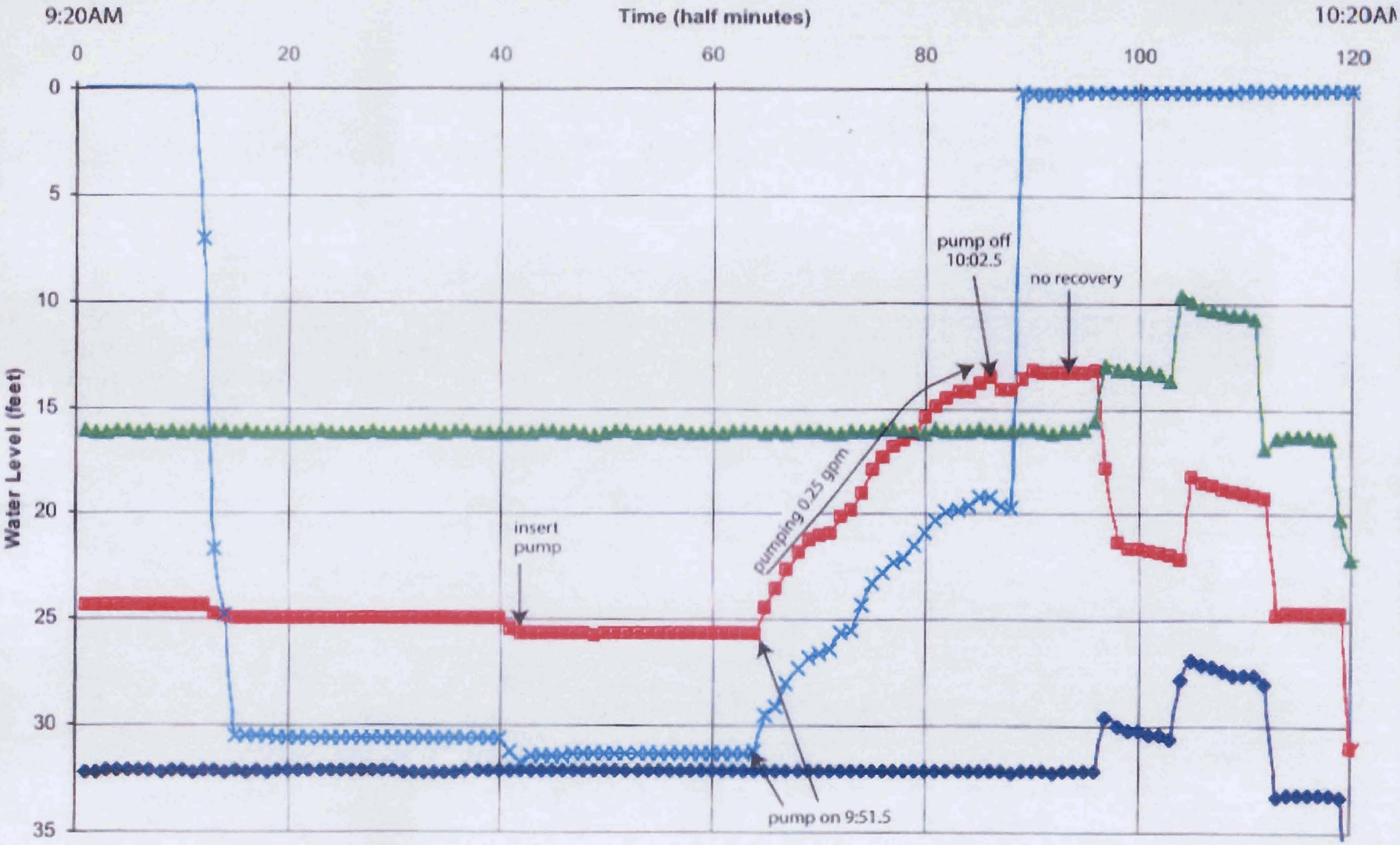


Figure 3-12 - Well MW206, Packer Test 1, 22-32 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

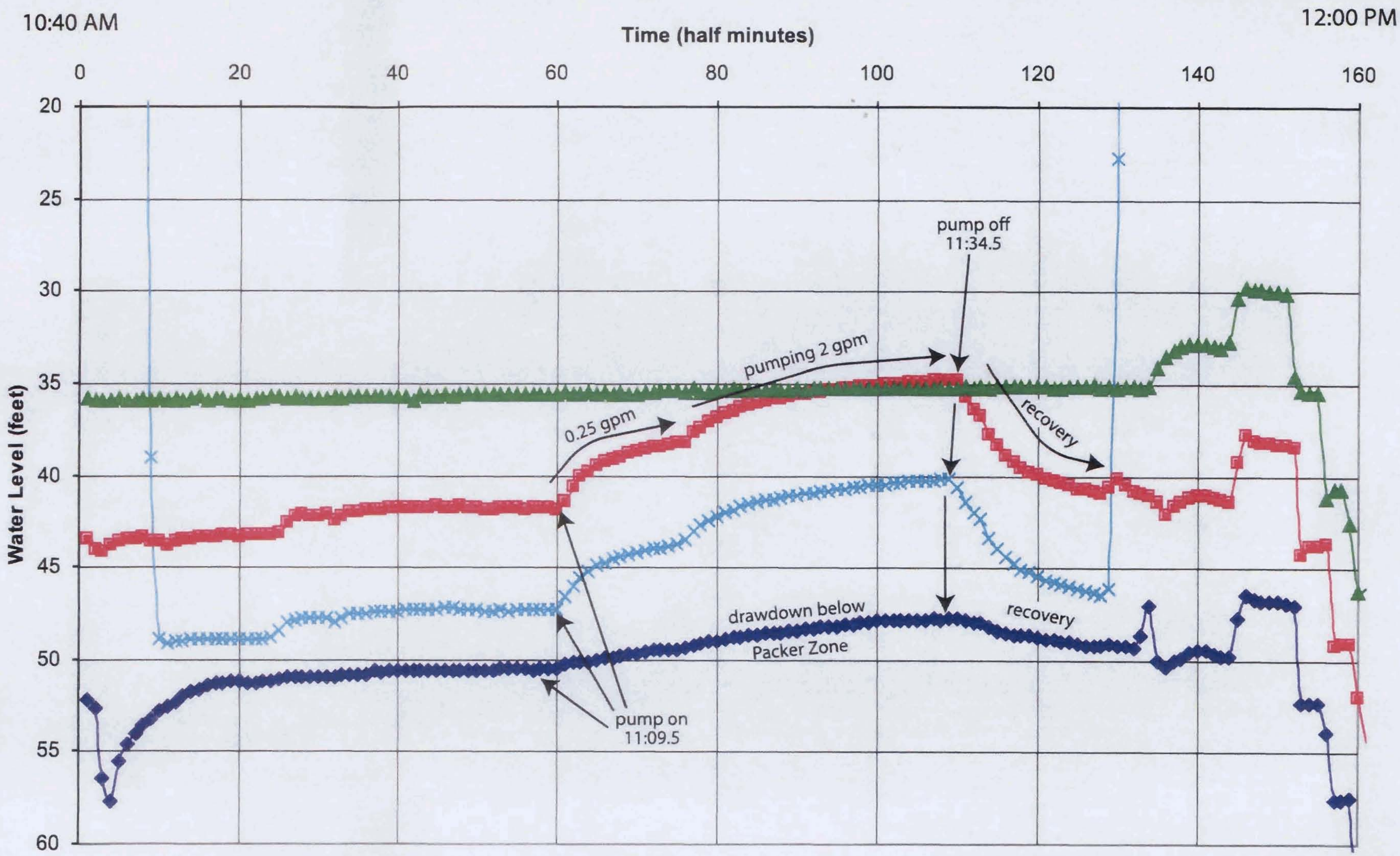


Figure 3-13 - Well MW206, Packer Test 2, 43-53 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

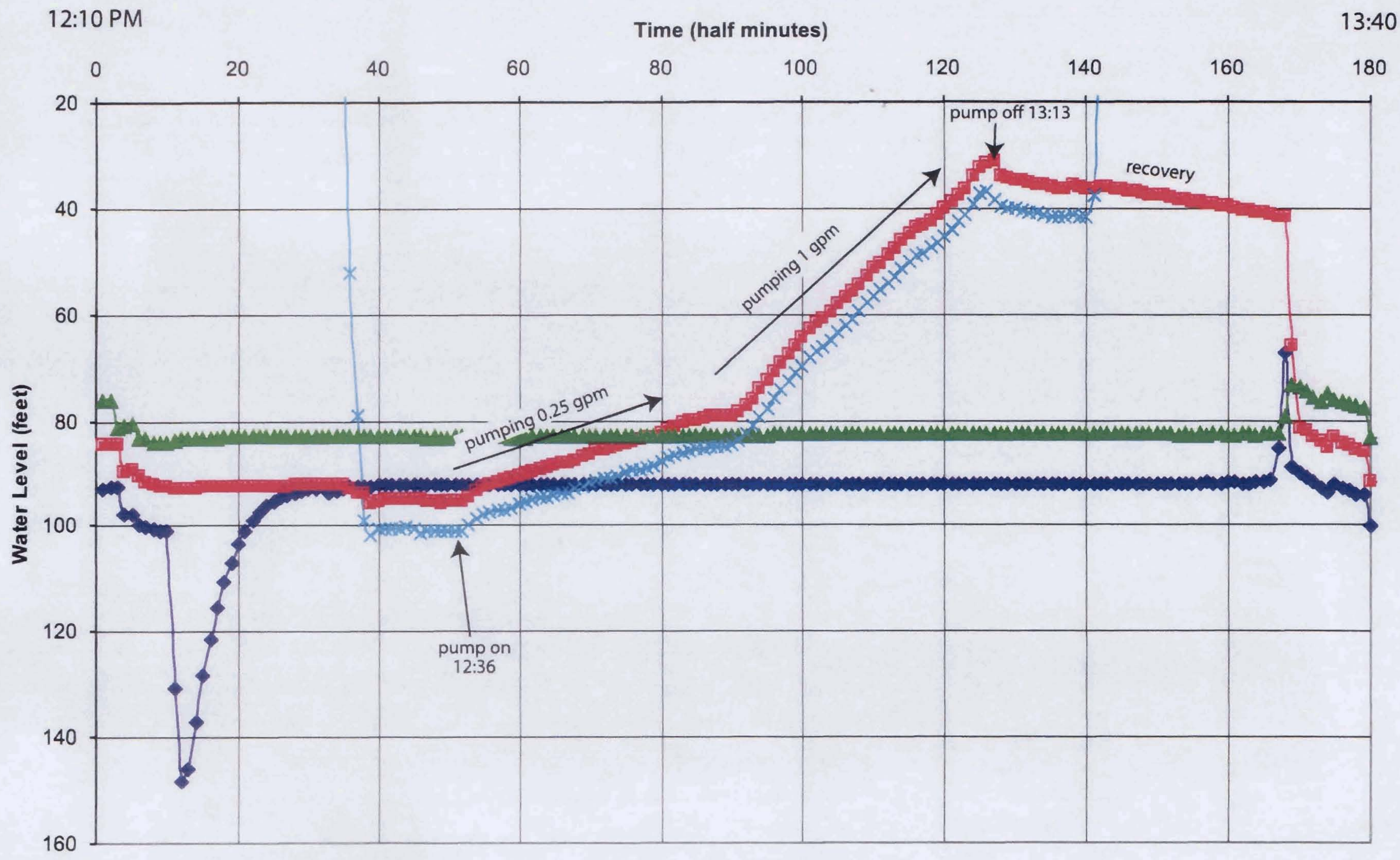


Figure 3-14 - Well MW206, Packer Test 3, 91-101 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

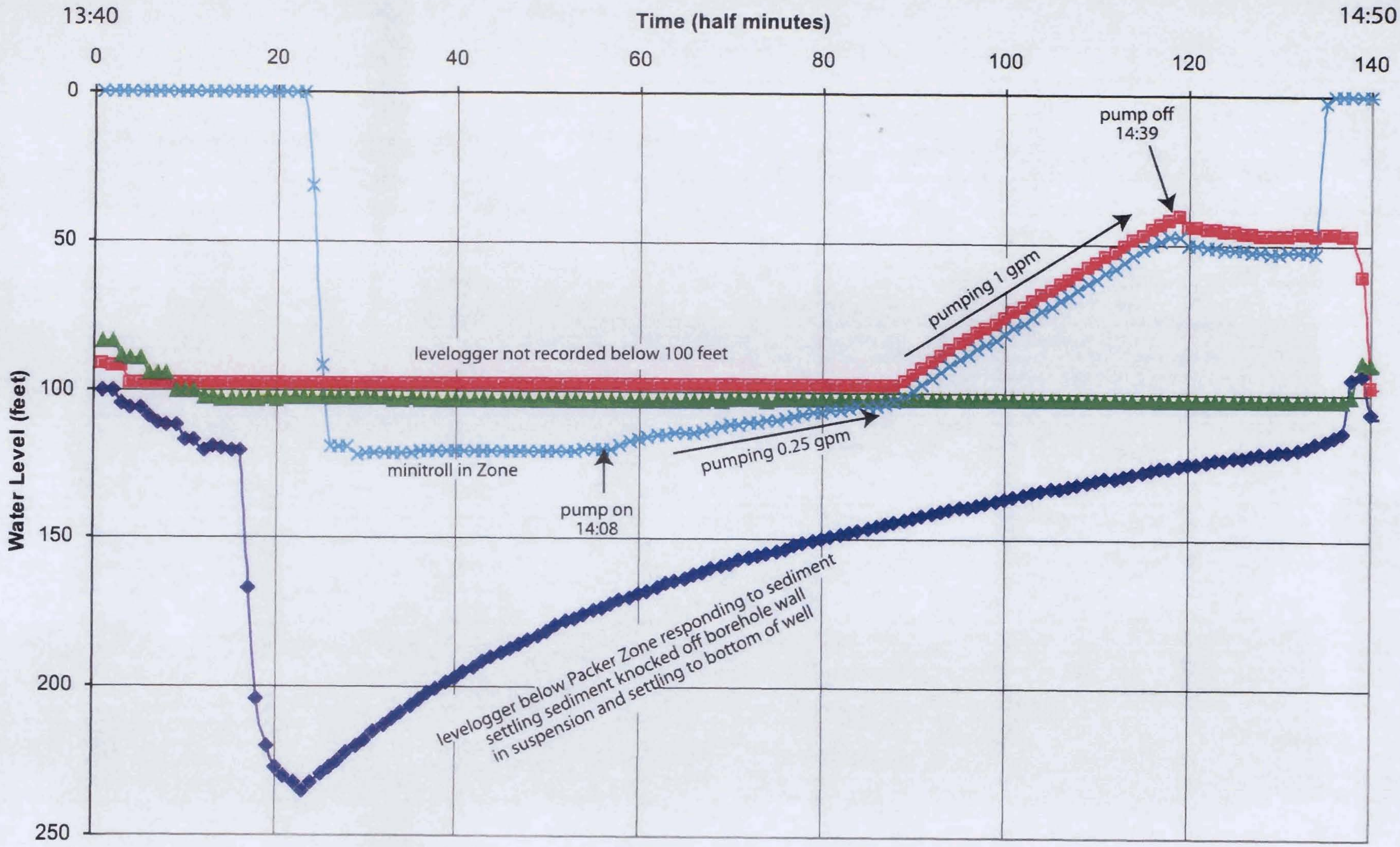


Figure 3-15 - Well MW206, Packer Test 4, 110-120 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: levelogger below Packer Zone; levelogger in Packer Zone; levelogger above Packer Zone; minitroll in Packer Zone	ESI File: LM97145.45 October 2007 Appendix A

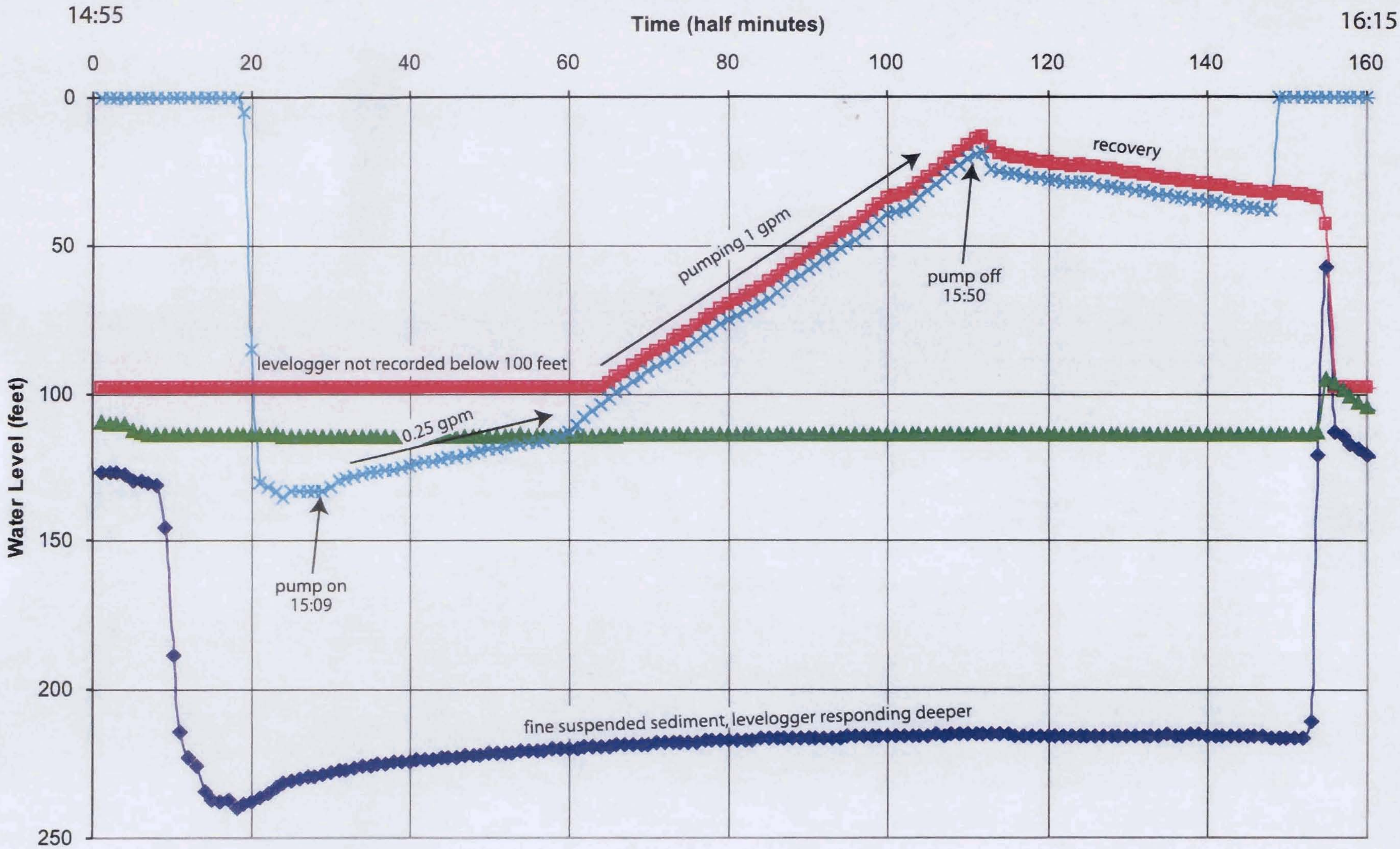


Figure 3-16 - Well MW206, Packer Test 5, 122-132 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

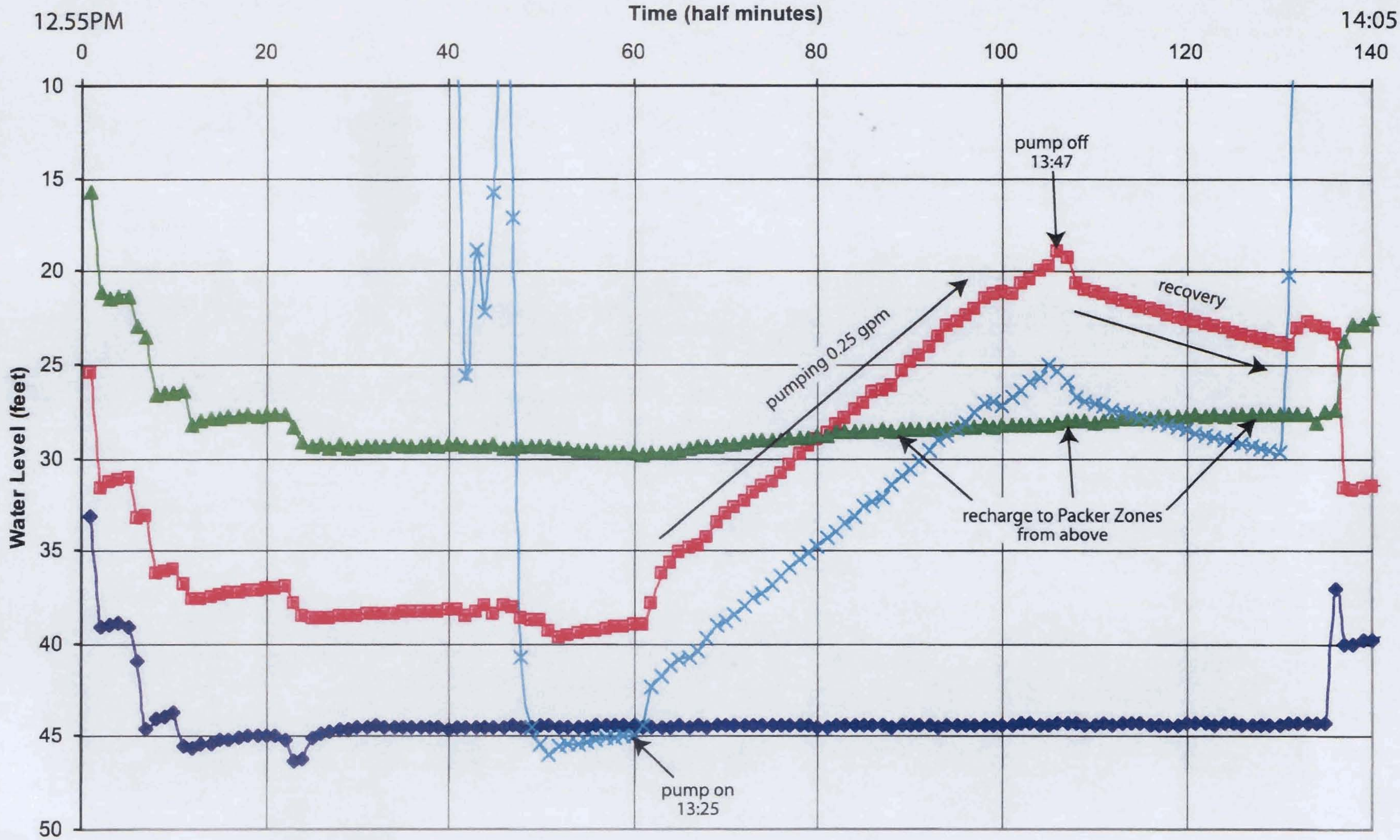


Figure 3-17 - Well MW209, Packer Test 1, 28-38 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: levelogger below Packer Zone; levelogger in Packer Zone; levelogger above Packer Zone; minitroll in Packer Zone	ESI File: LM97145.45 October 2007 Appendix A

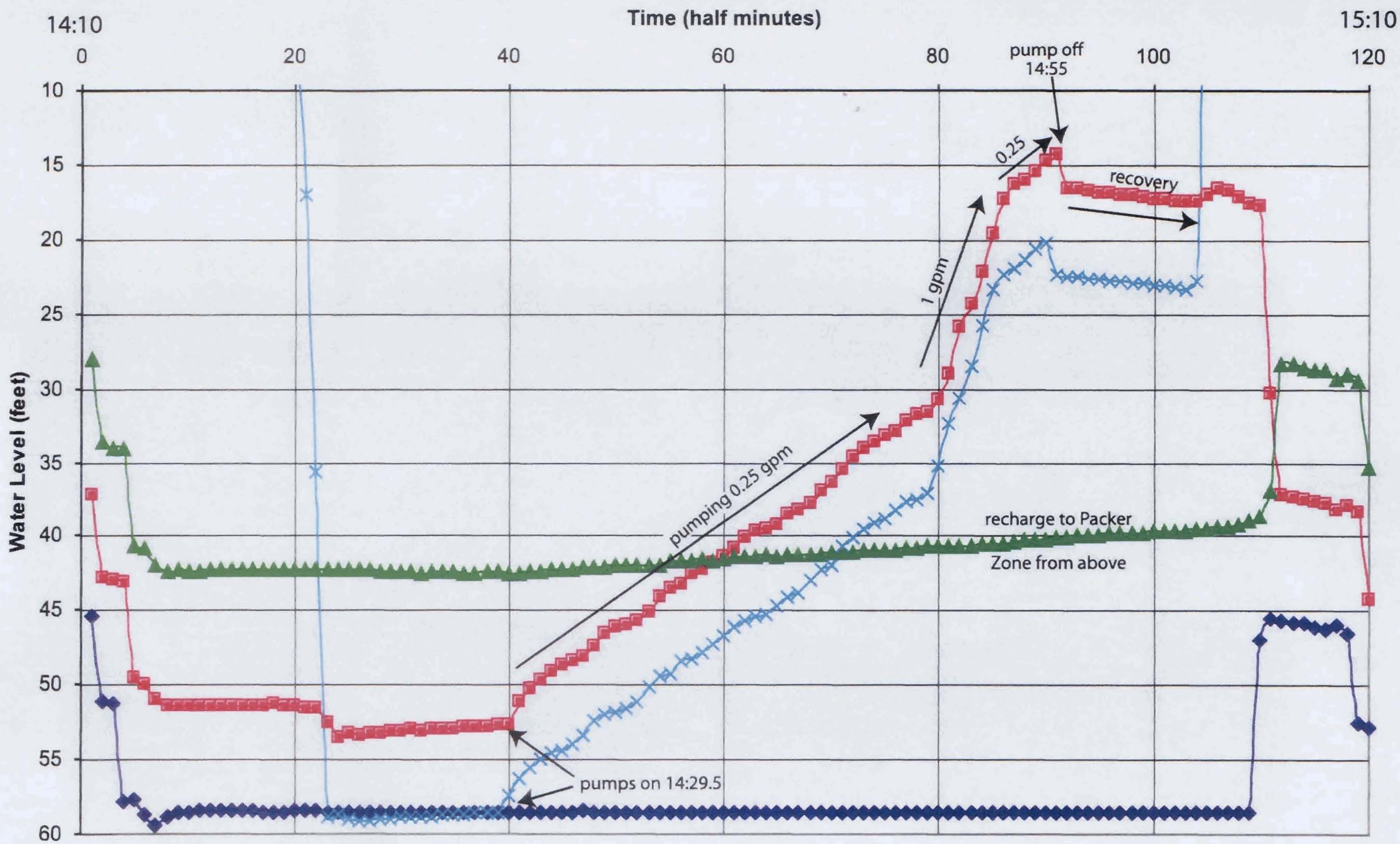


Figure 3-18 - Well MW209, Packer Test 2, 41-51 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

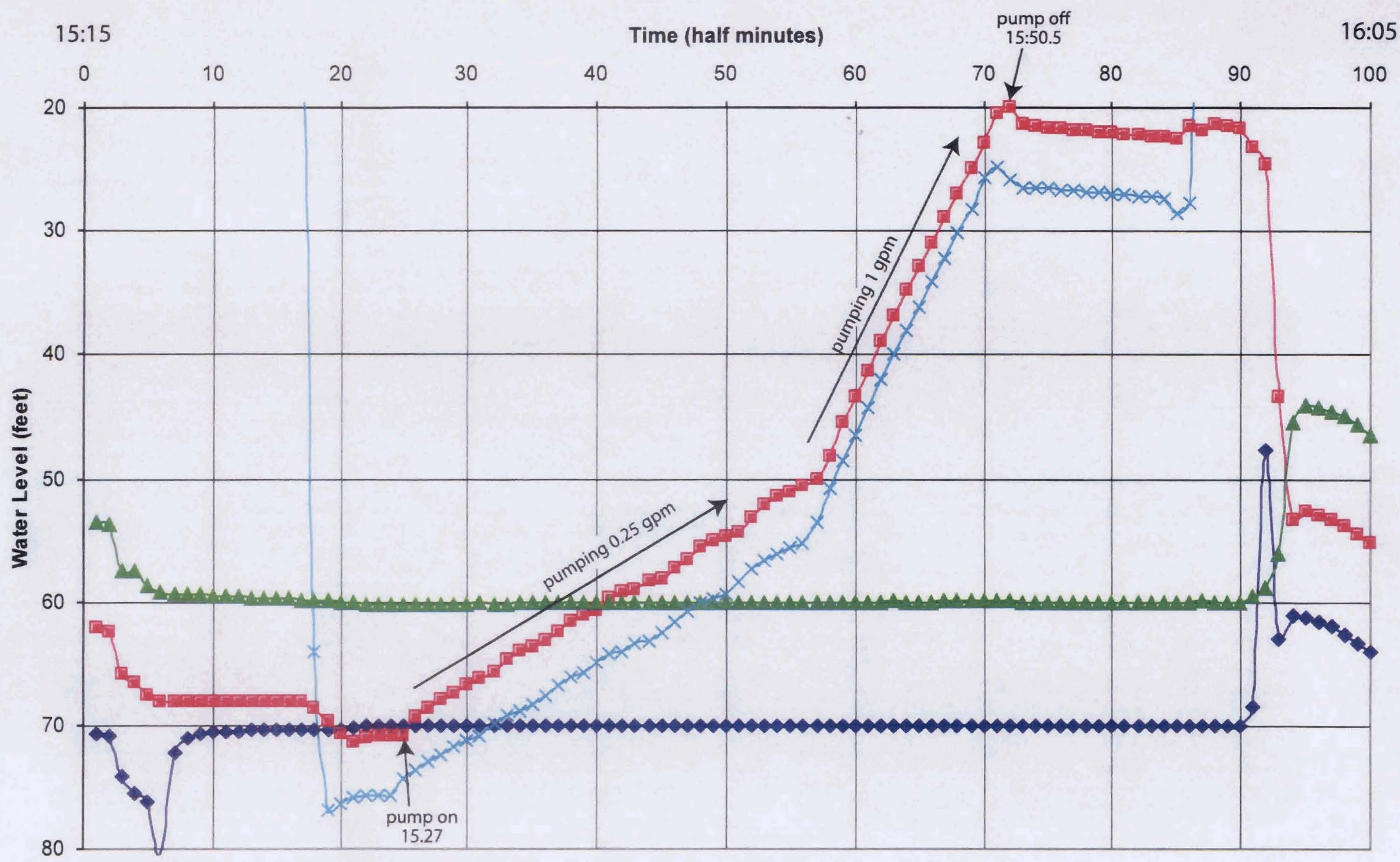


Figure 3-19 - Well MW209, Packer Test 3, 58-68 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

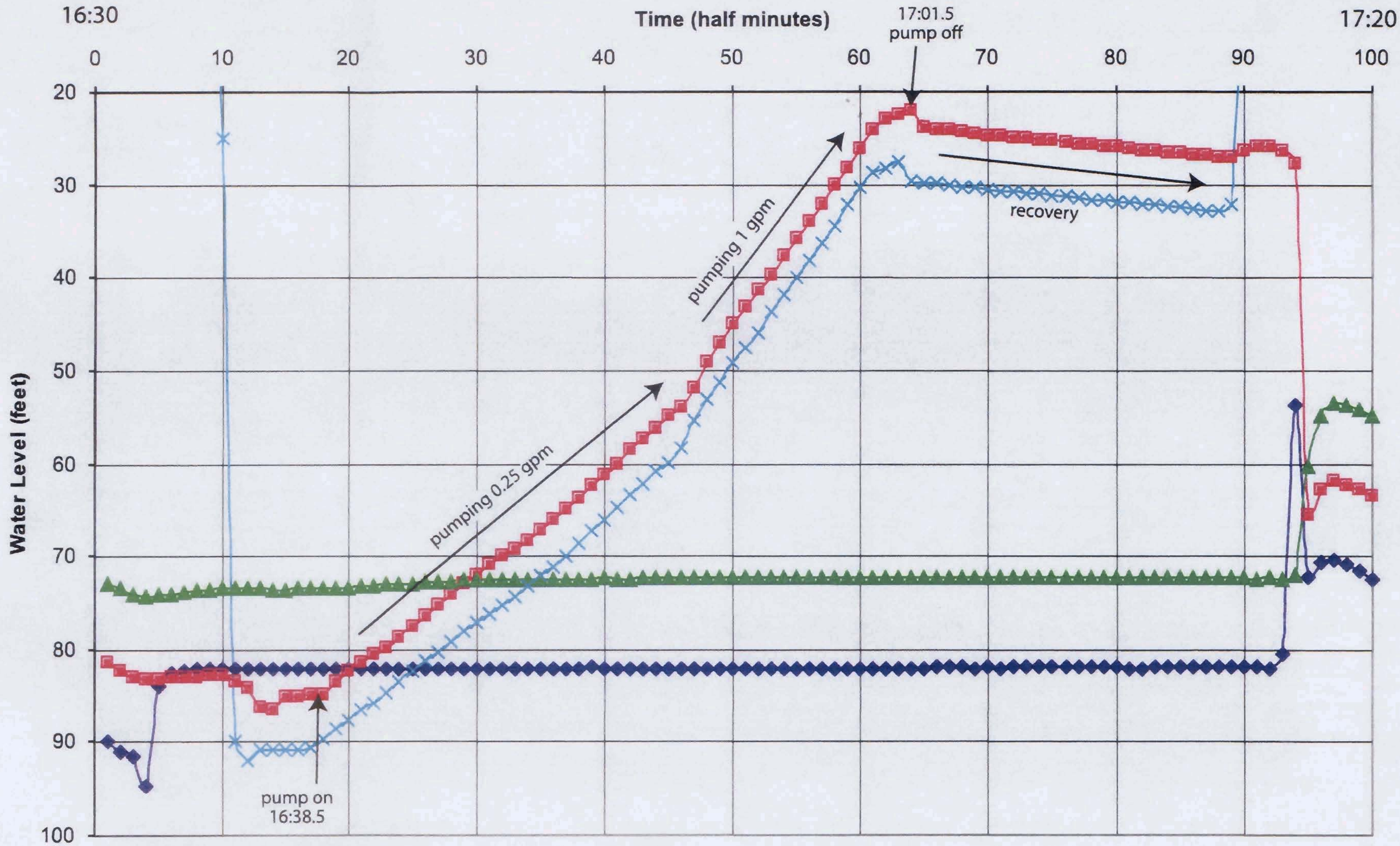


Figure 3-20 - Well MW209, Packer Test 4, 70-80 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

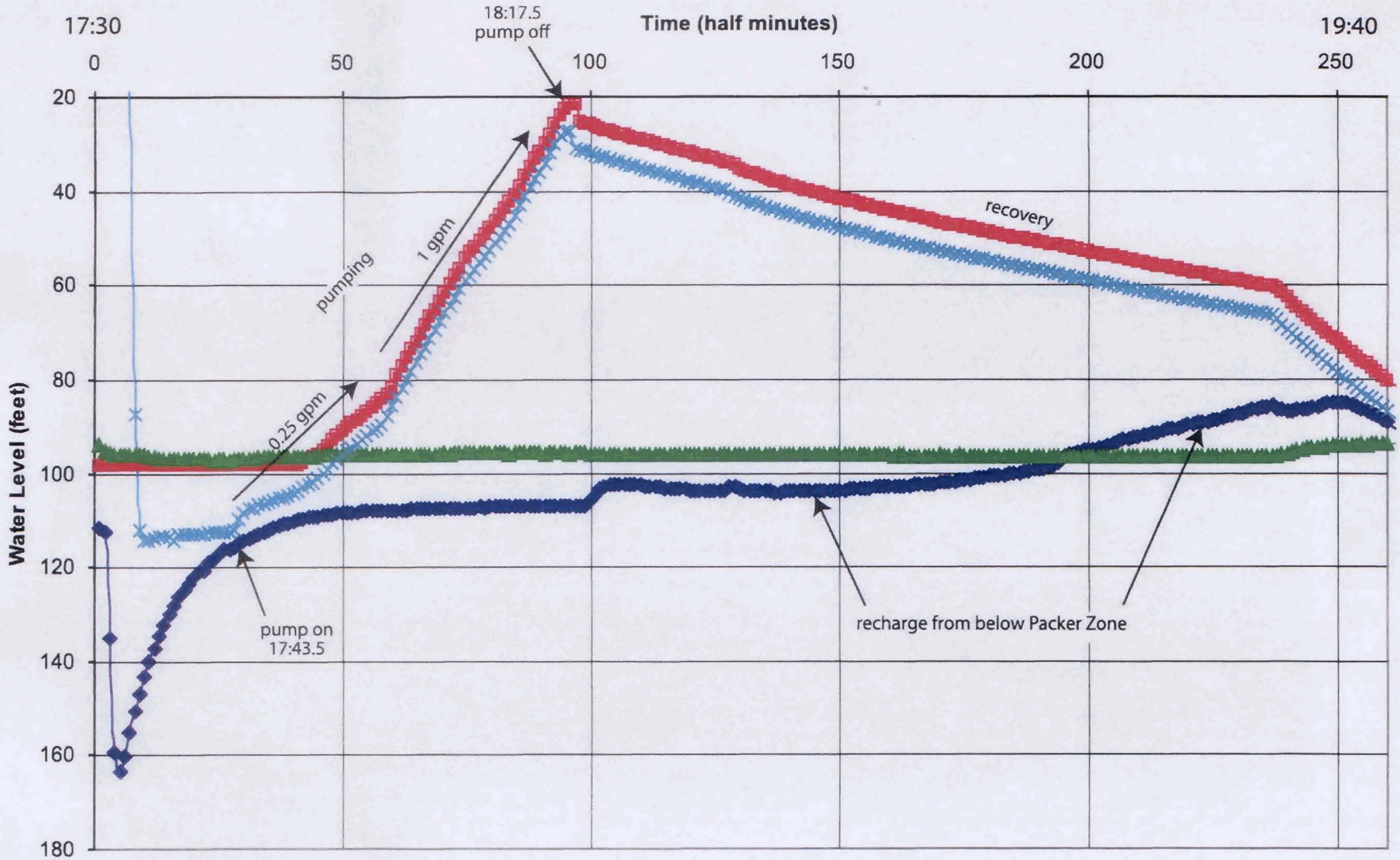


Figure 3-21 - Well MW209, Packer Test 5, 95-105 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45	
	October 2007	
	Appendix A	

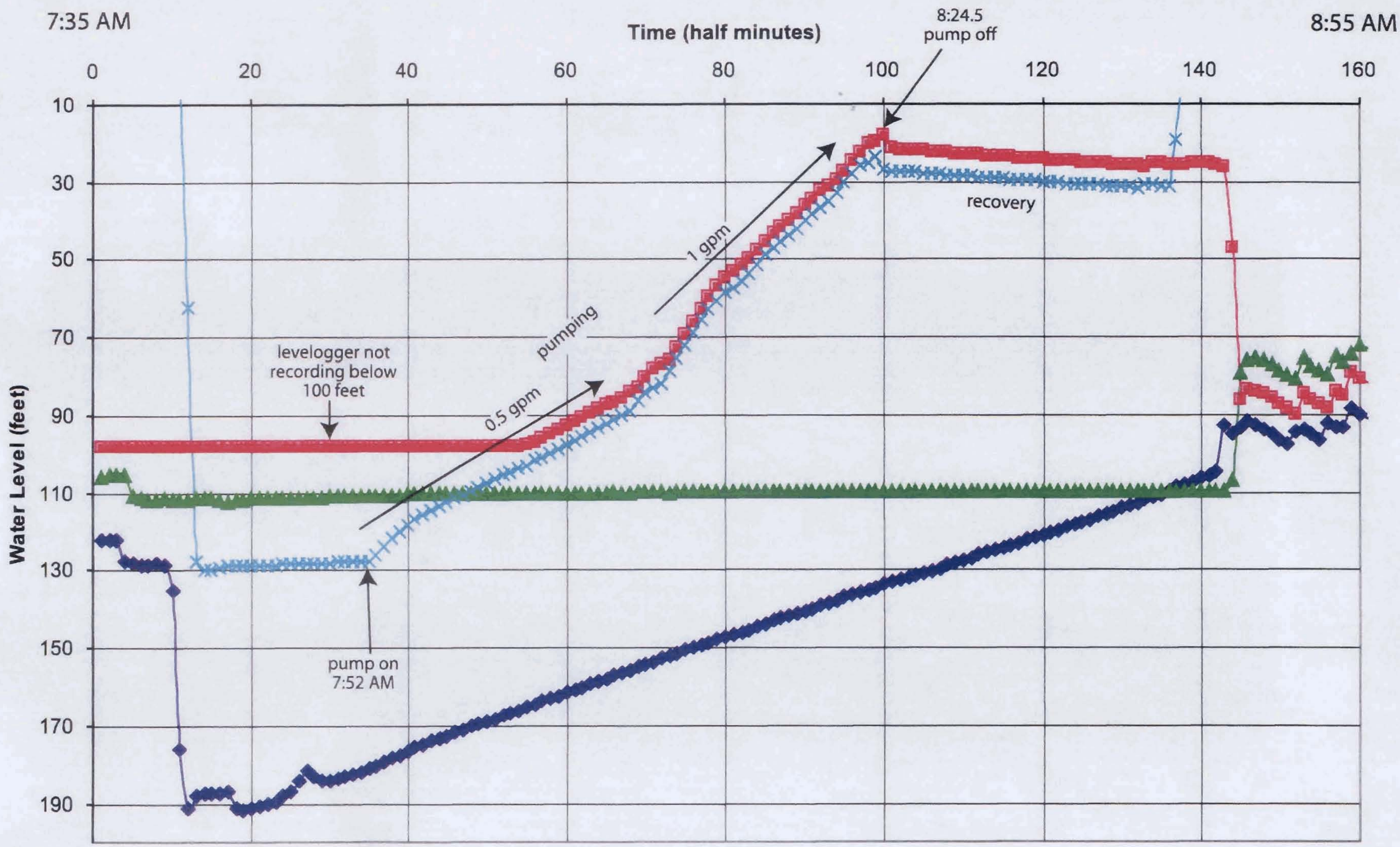


Figure 3-22 - Well MW209, Packer Test 6, 108-118 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend: levelogger below Packer Zone; levelogger in Packer Zone; levelogger above Packer Zone; minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

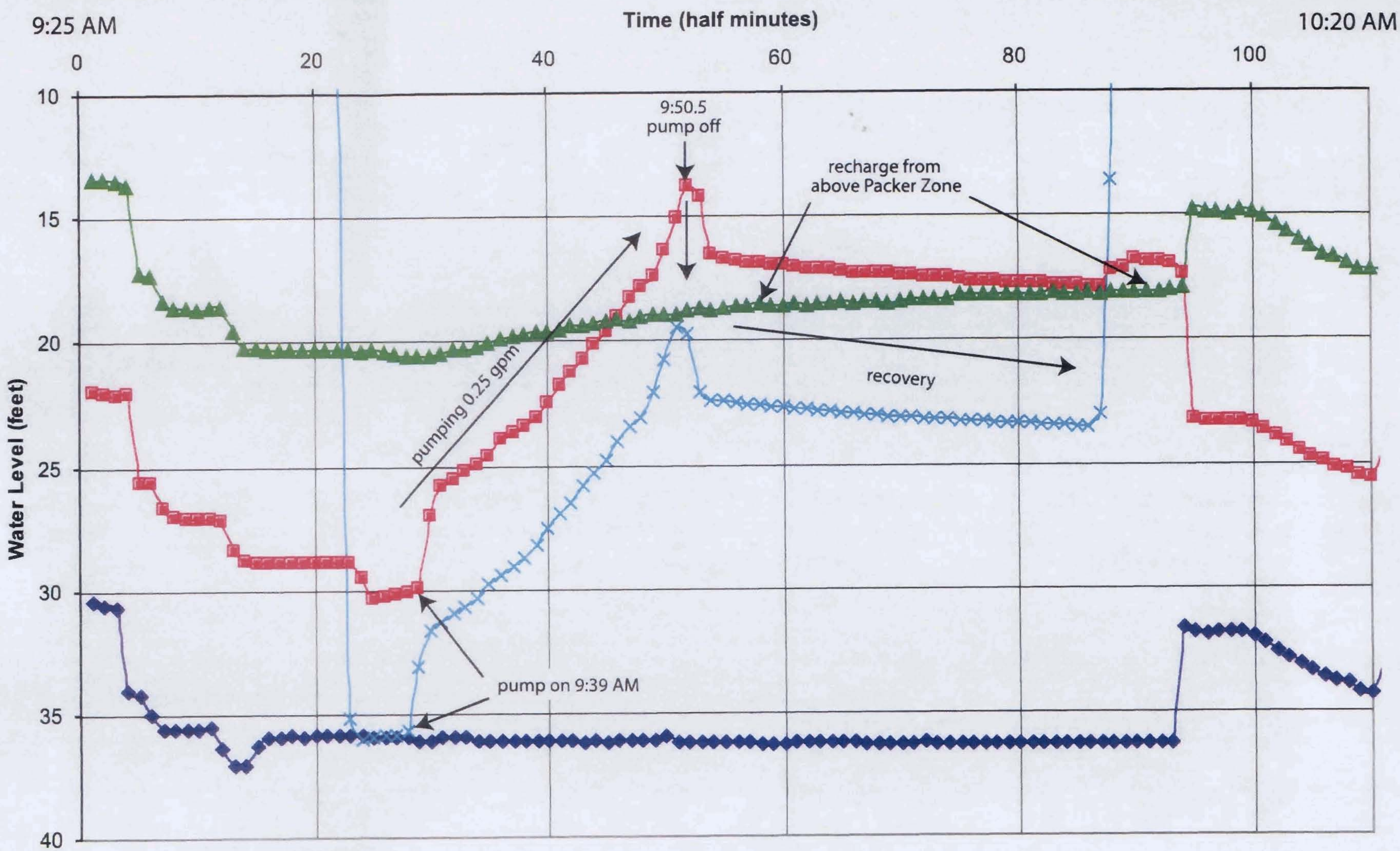


Figure 3-23 - Well MW209, Packer Test 7, 20-30 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

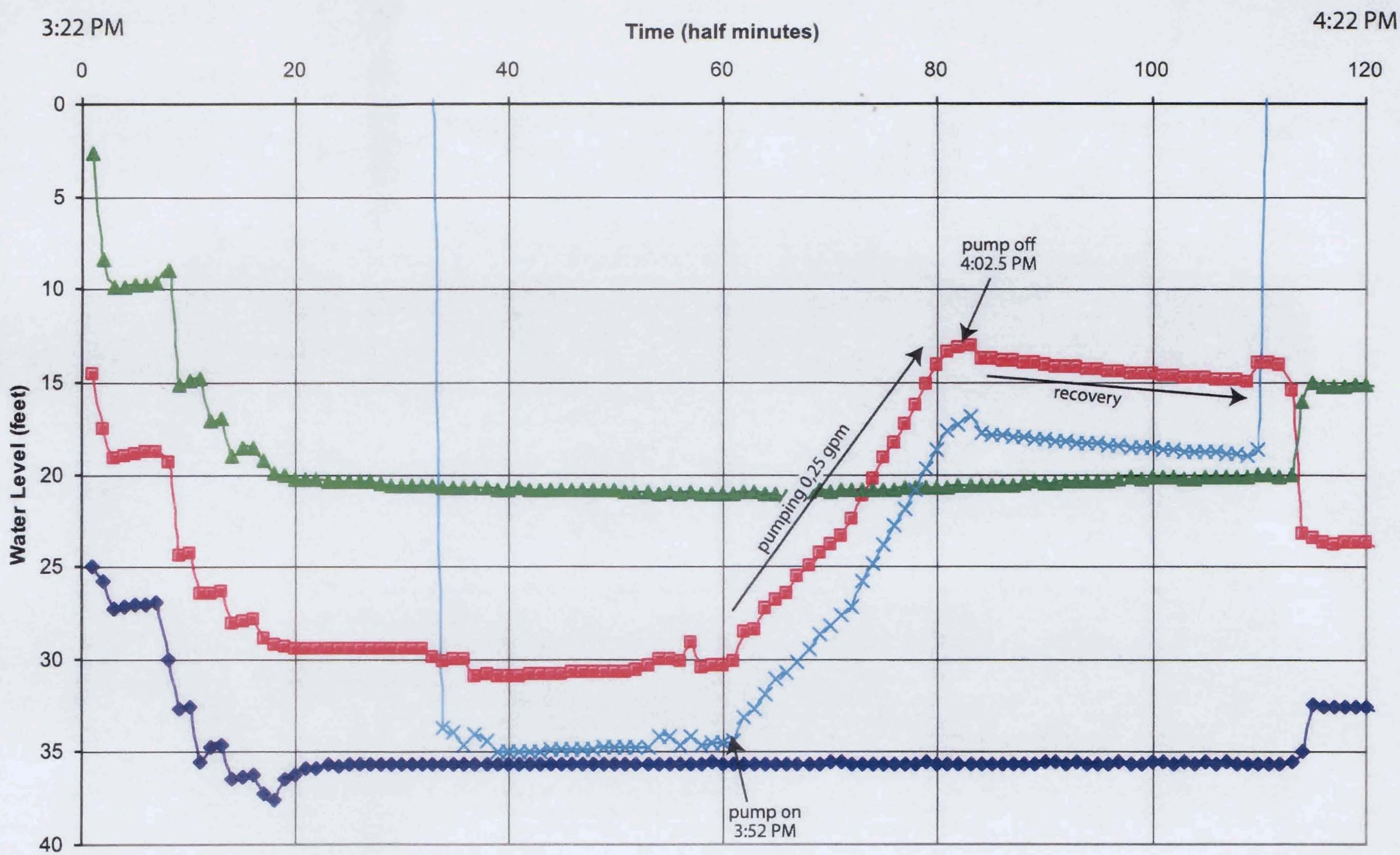


Figure 3-24 - Well MW219, Packer Test 1, 21 - 31 Feet
Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

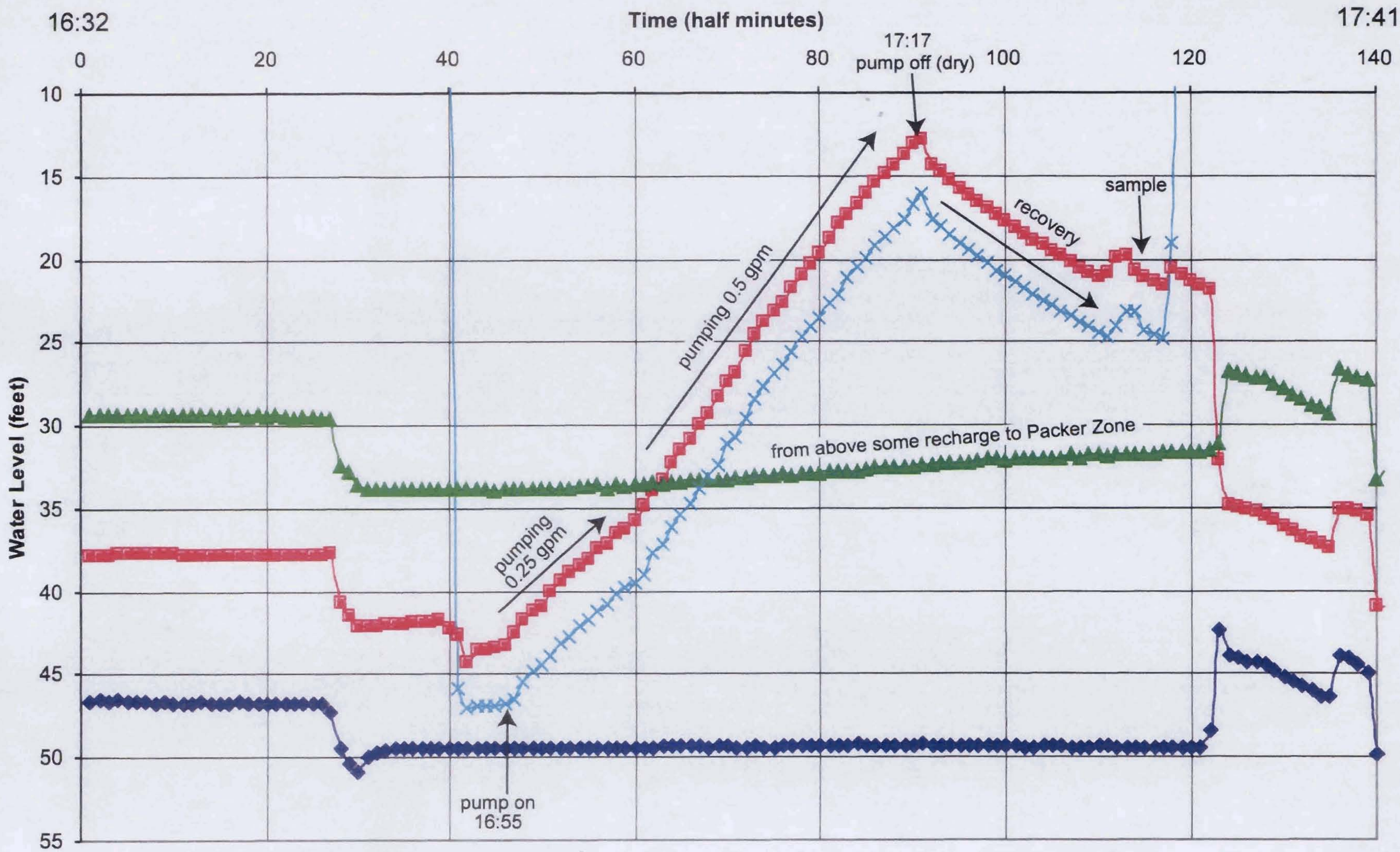


Figure 3-25 - Well MW219, Packer Test 2, 35 - 45 Feet
Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

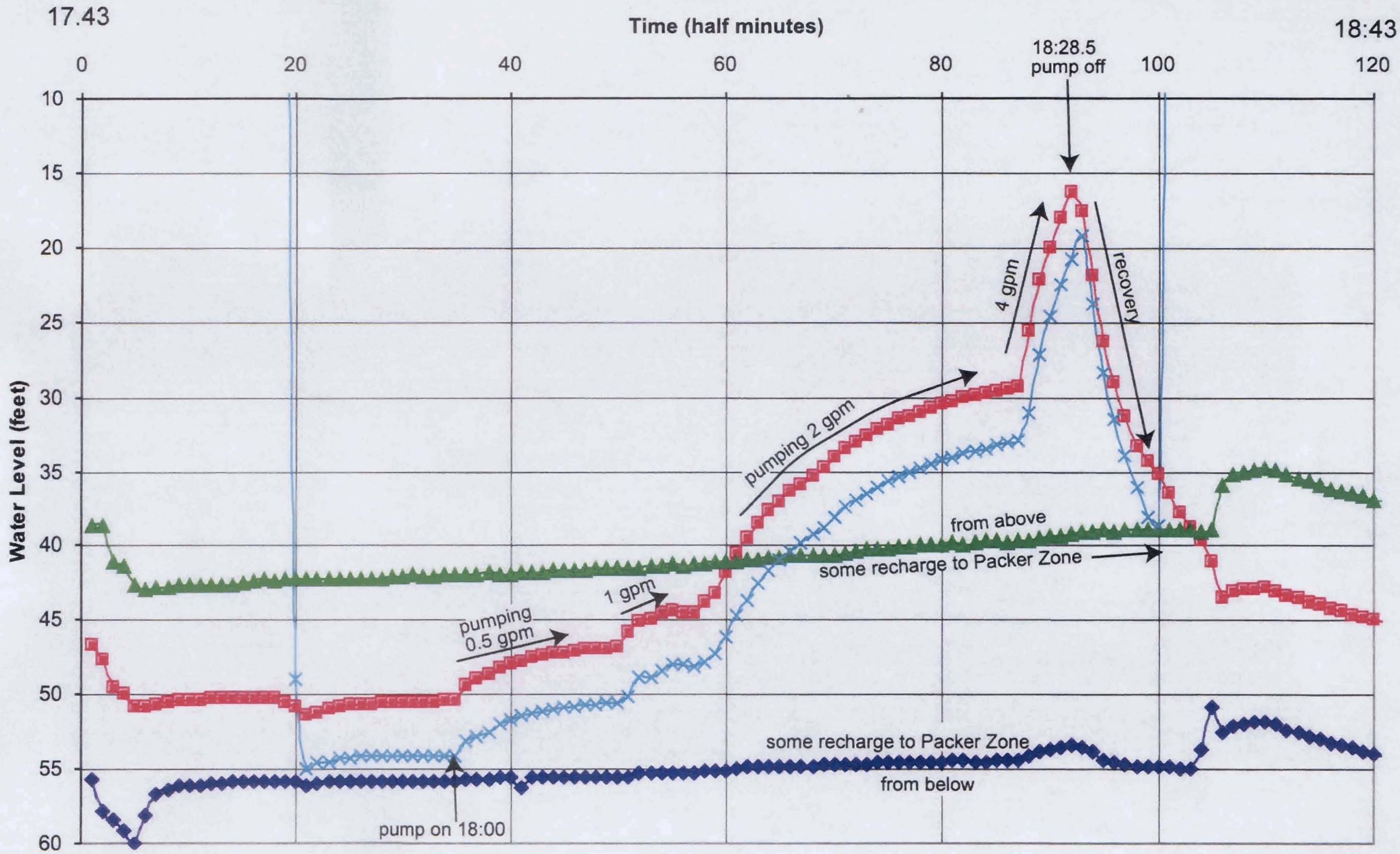


Figure 3-26 - Well MW219, Packer Test 3, 45 - 55 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

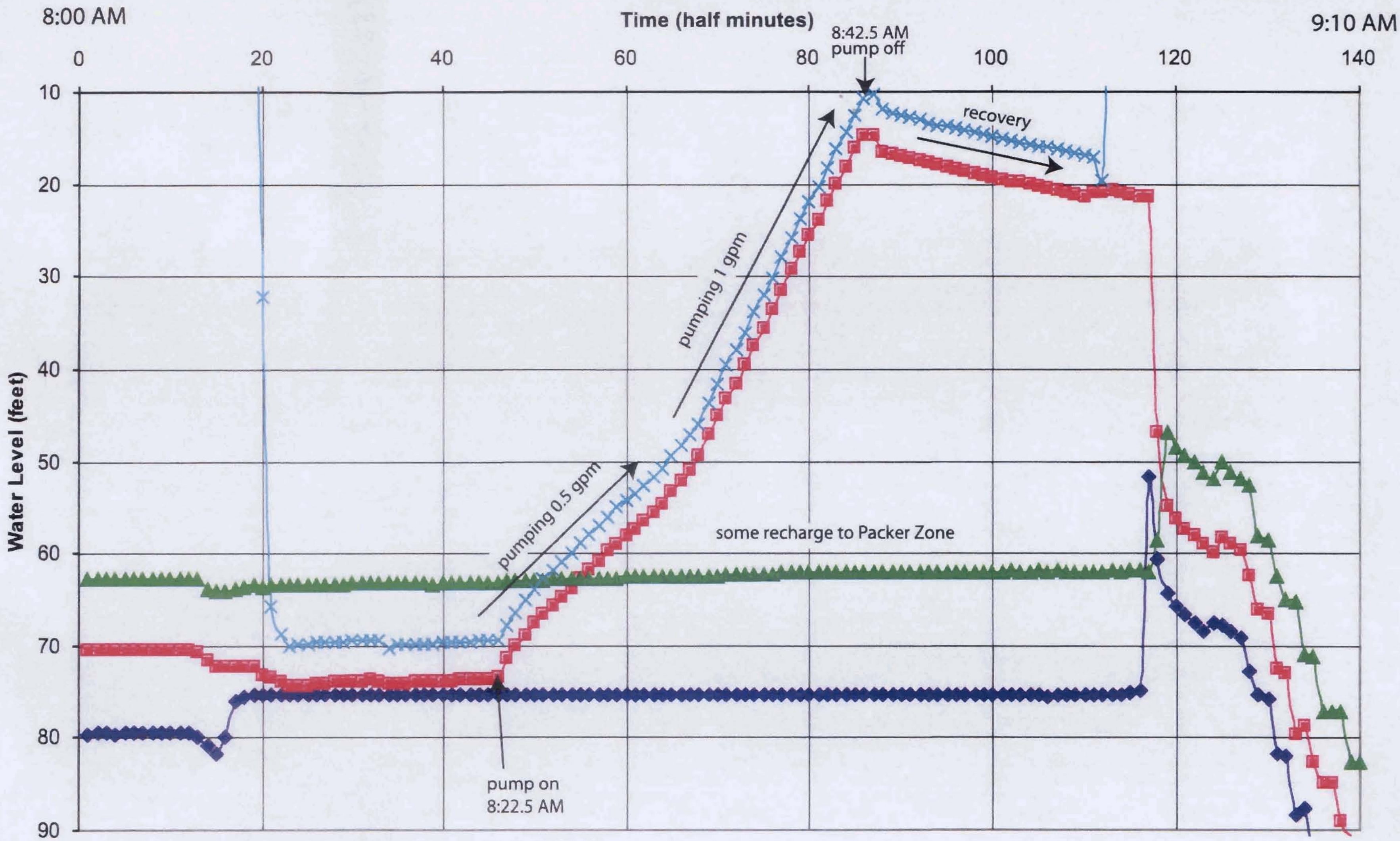


Figure 3-27 - Well MW219, Packer Test 4, 65 - 75 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

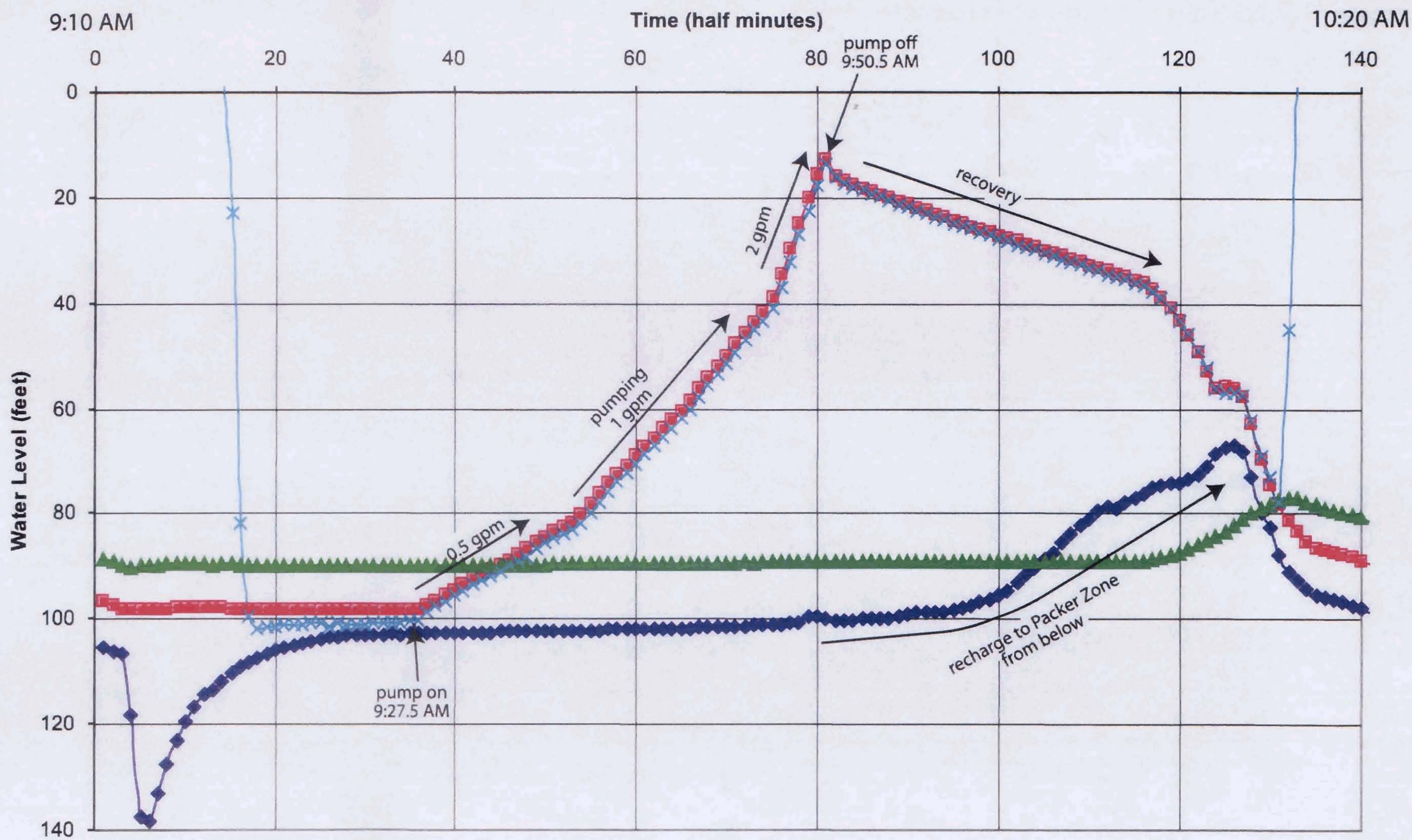


Figure 3-28 - Well MW219, Packer Test 5, 93 - 103 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: levelogger below Packer Zone; levelogger in Packer Zone; levelogger above Packer Zone; minitroll in Packer Zone	ESI File: LM97145.45 October 2007 Appendix A

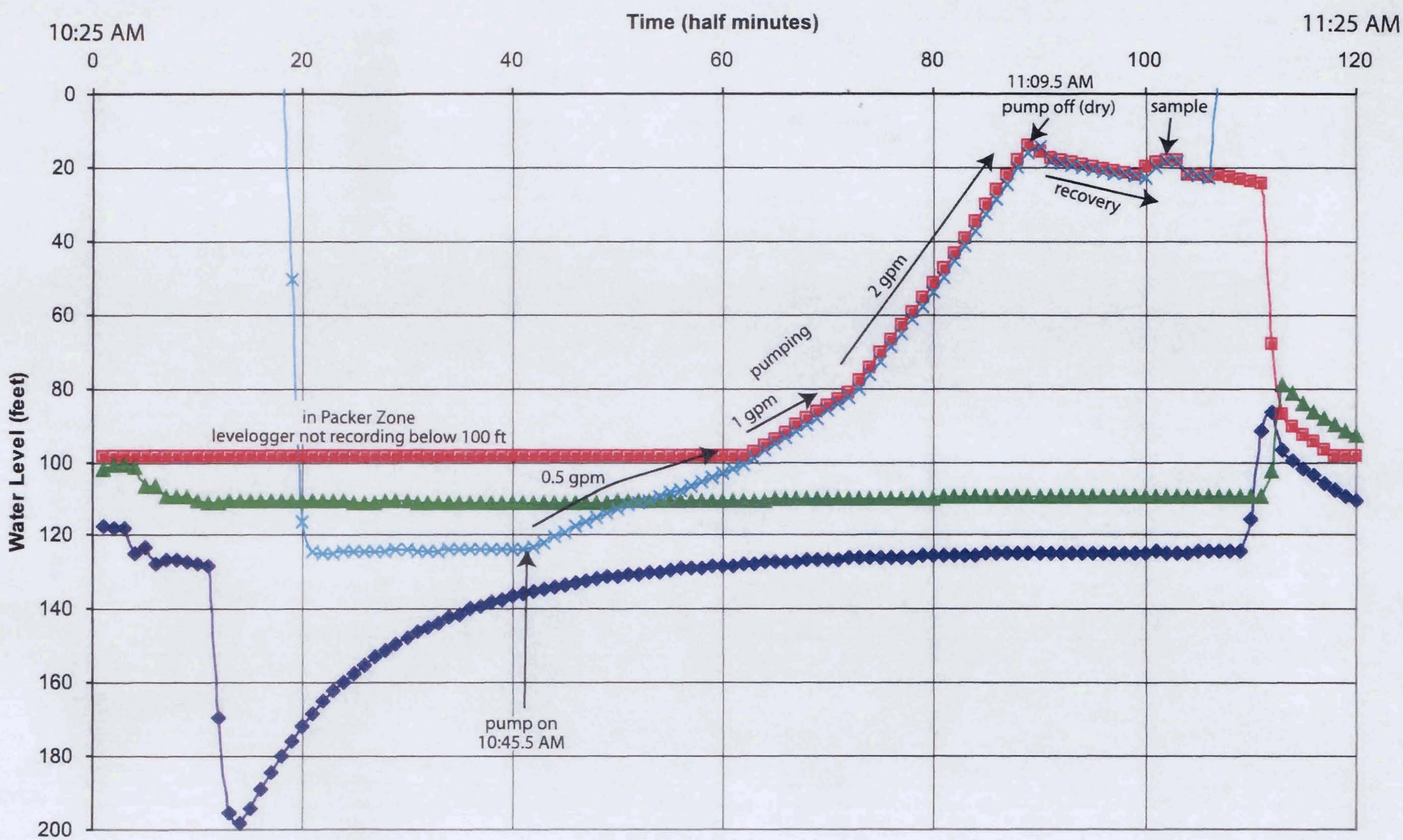


Figure 3-29 - Well MW219, Packer Test 6, 115 - 125 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

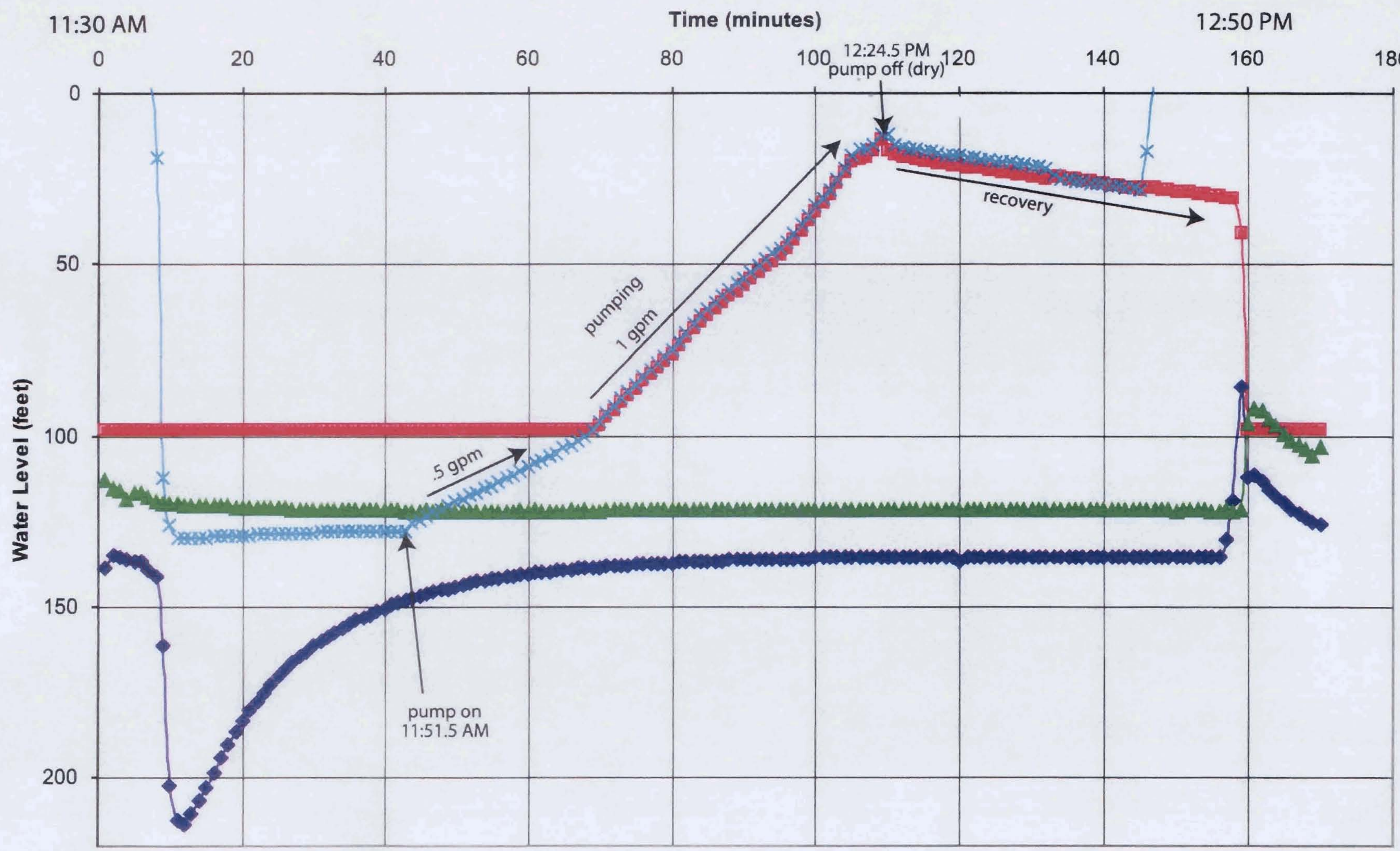


Figure 3-30 - Well MW219, Packer Test 7, 127.5-137.5 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

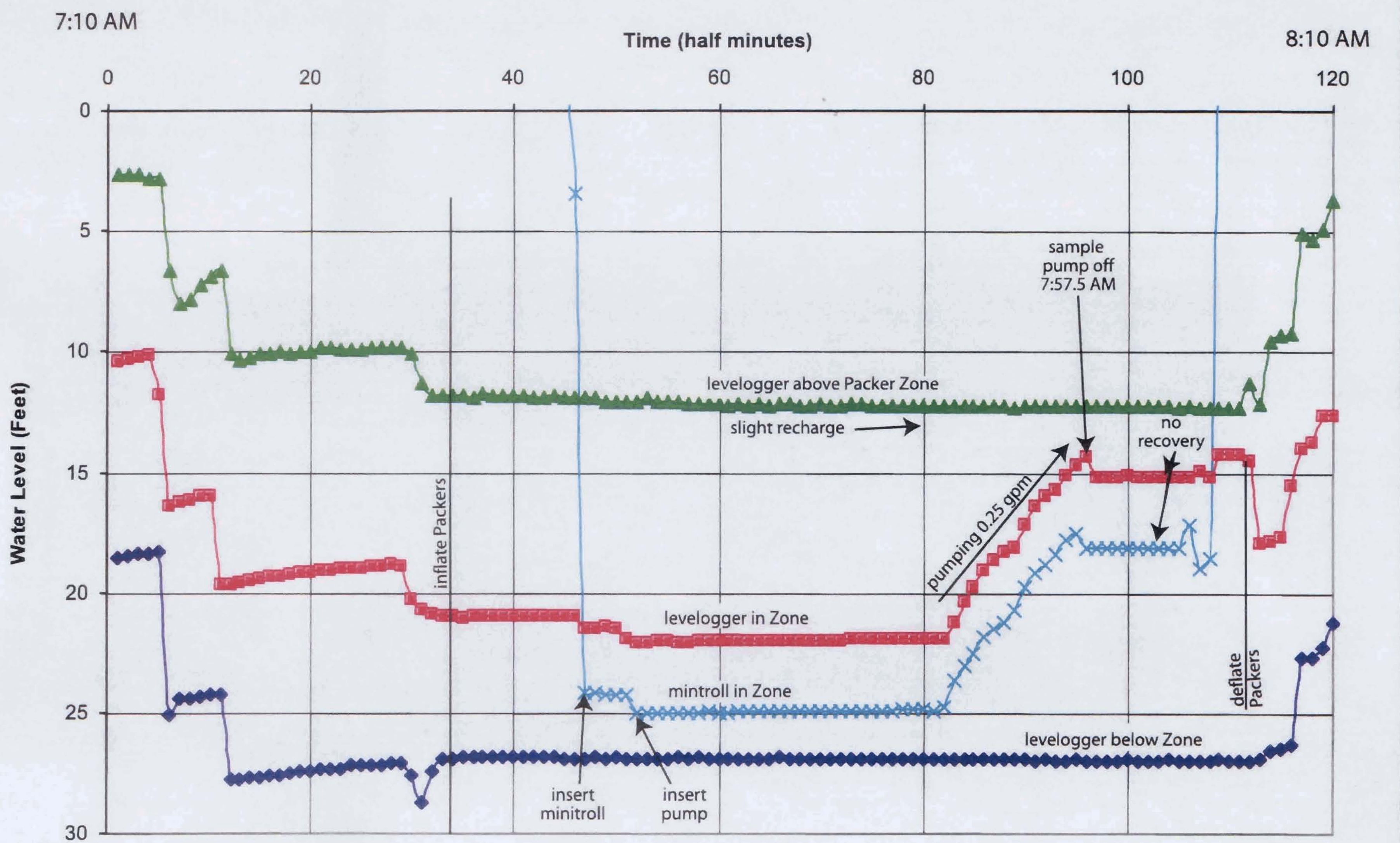


Figure 3-31 - Well MW220, Packer Test 1, 20-30 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

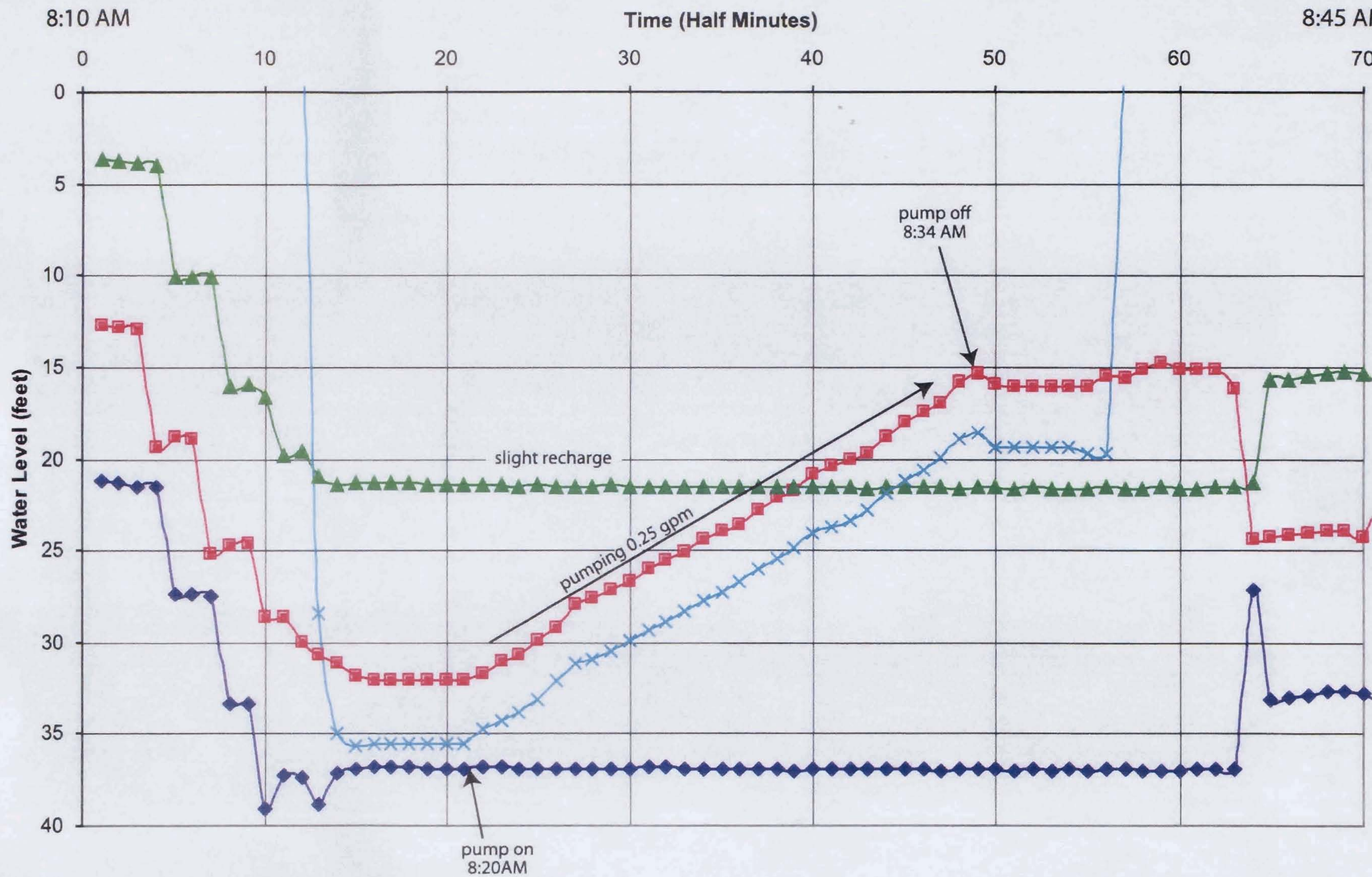


Figure 3-32 - Well MW220, Packer Test 2, 30-40 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

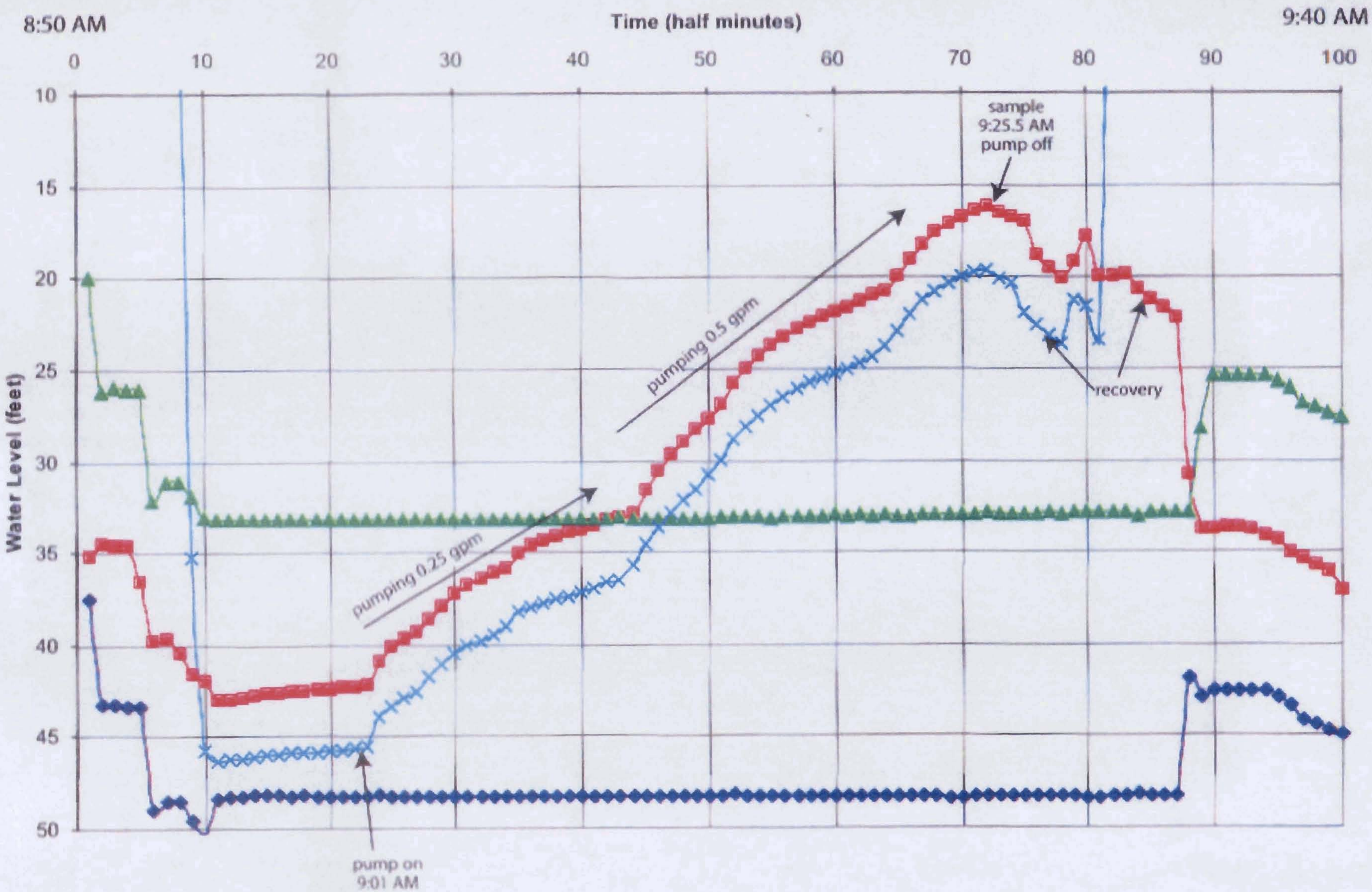


Figure 3-33 - Well MW220, Packer Test 3, 41-51 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

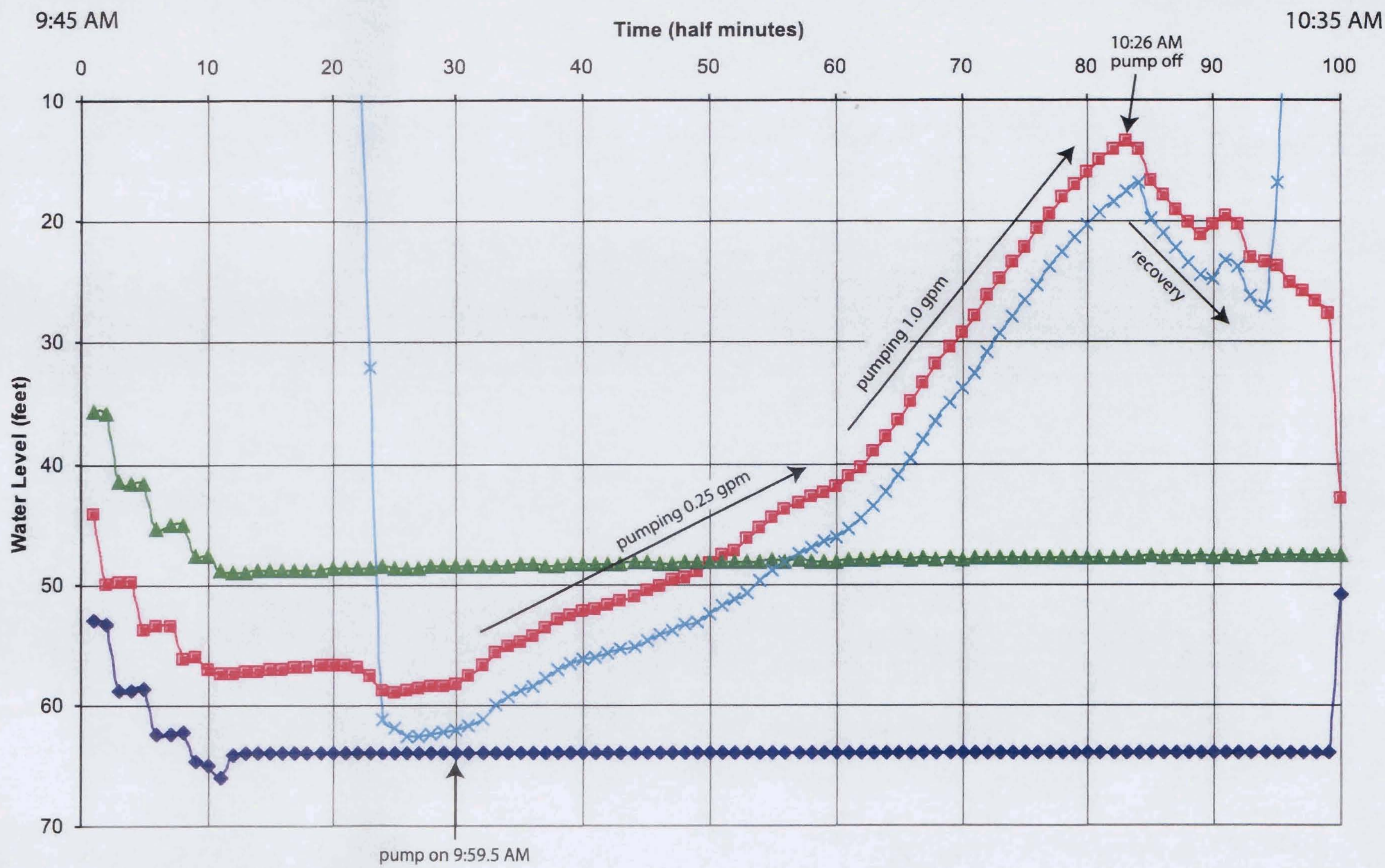


Figure 3-34 - Well MW220, Packer Test 4, 57-67 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

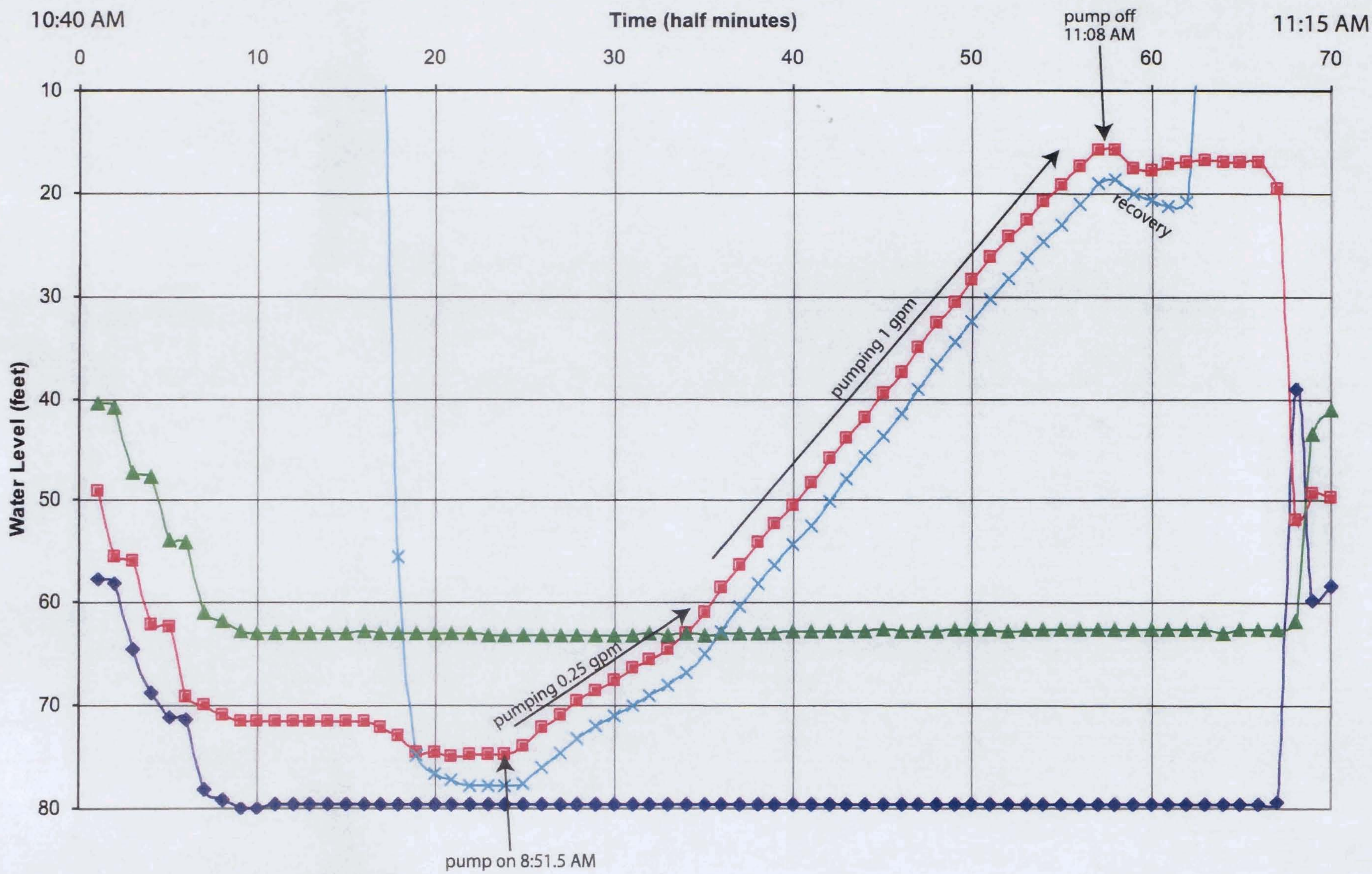


Figure 3-35 - Well MW220, Packer Test 5, 73-83 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

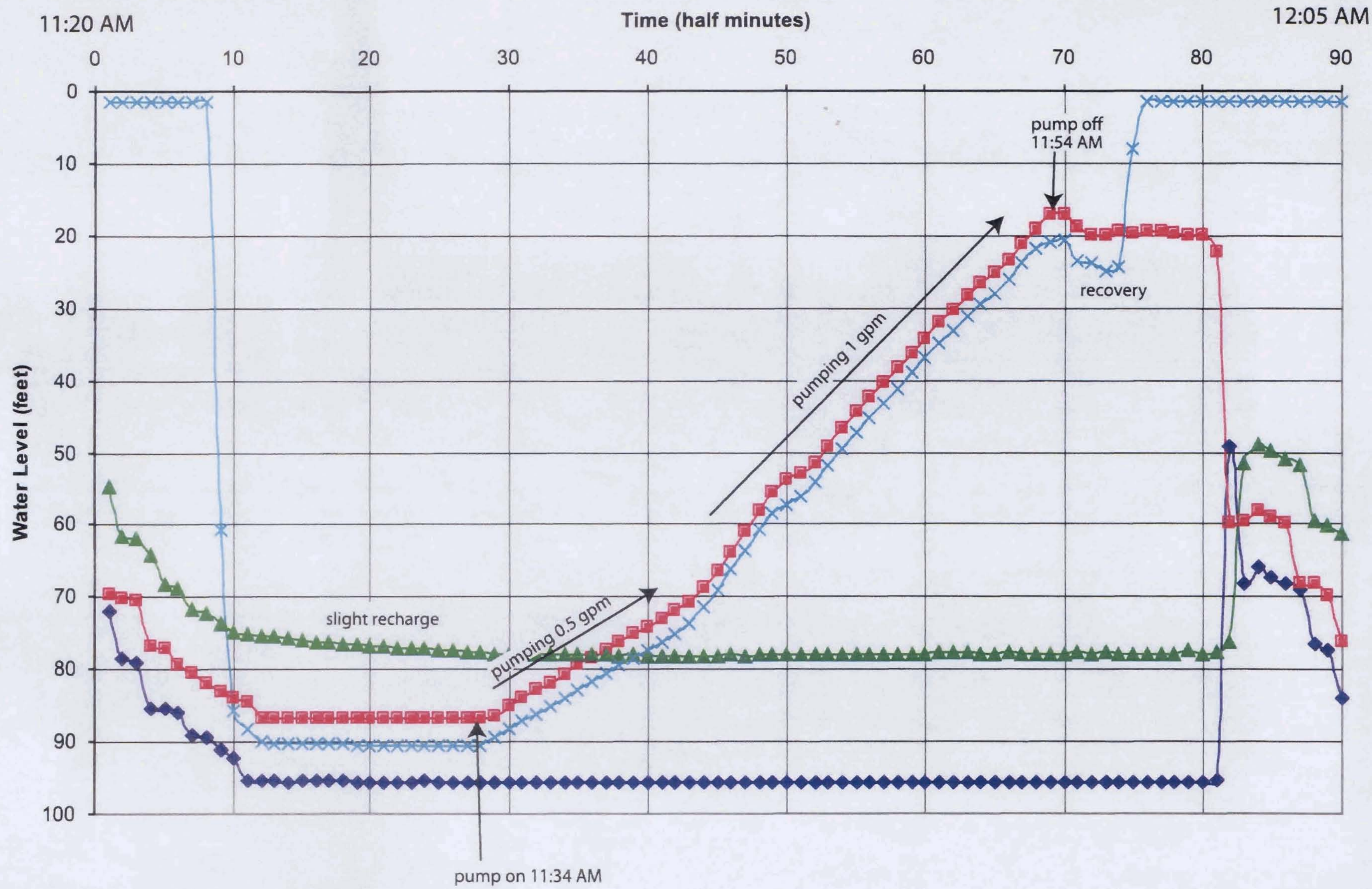


Figure 3-36 - Well MW220, Packer Test 6, 89-99 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

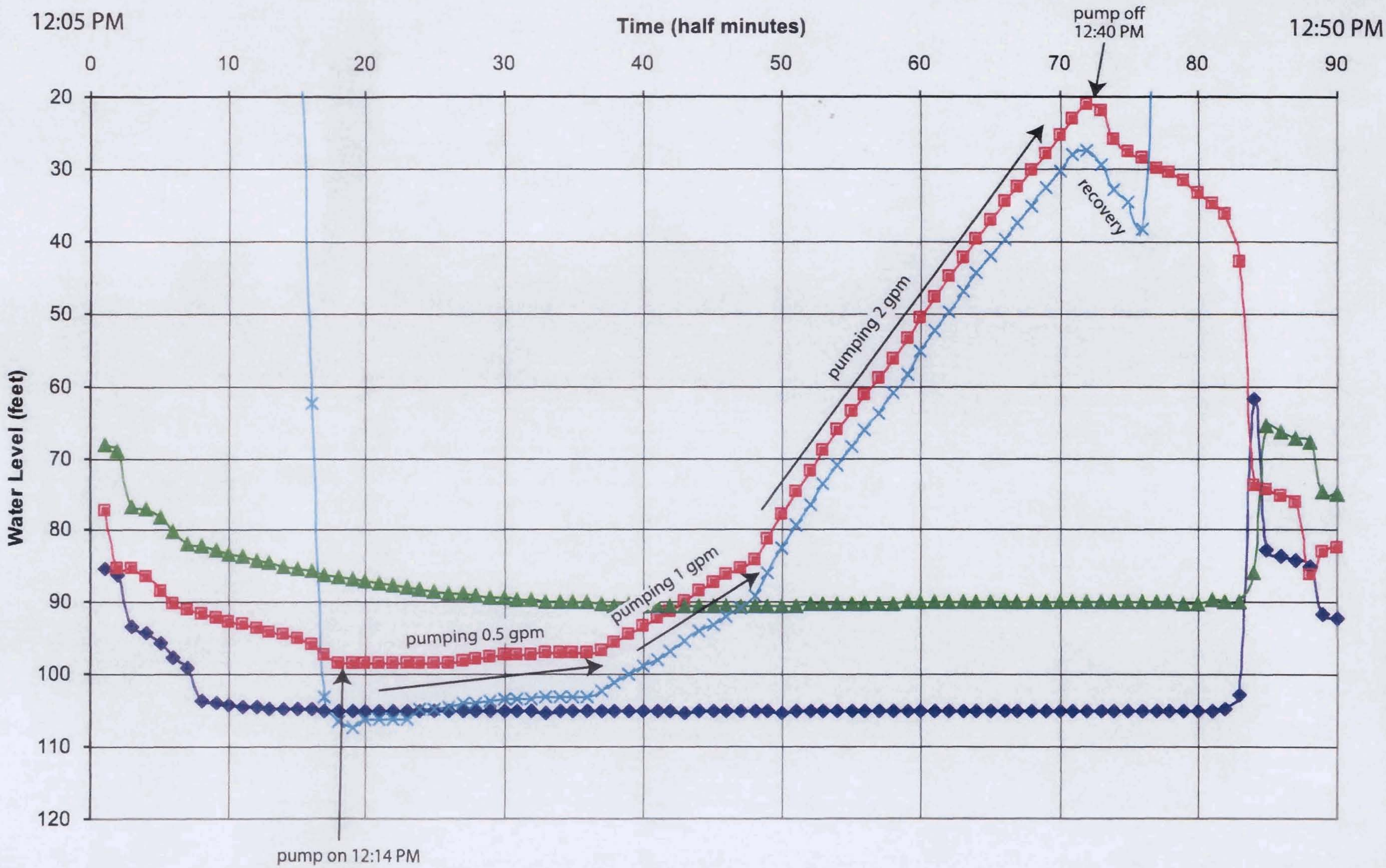


Figure 3-37 - Well MW220, Packer Test 7, 101-111 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

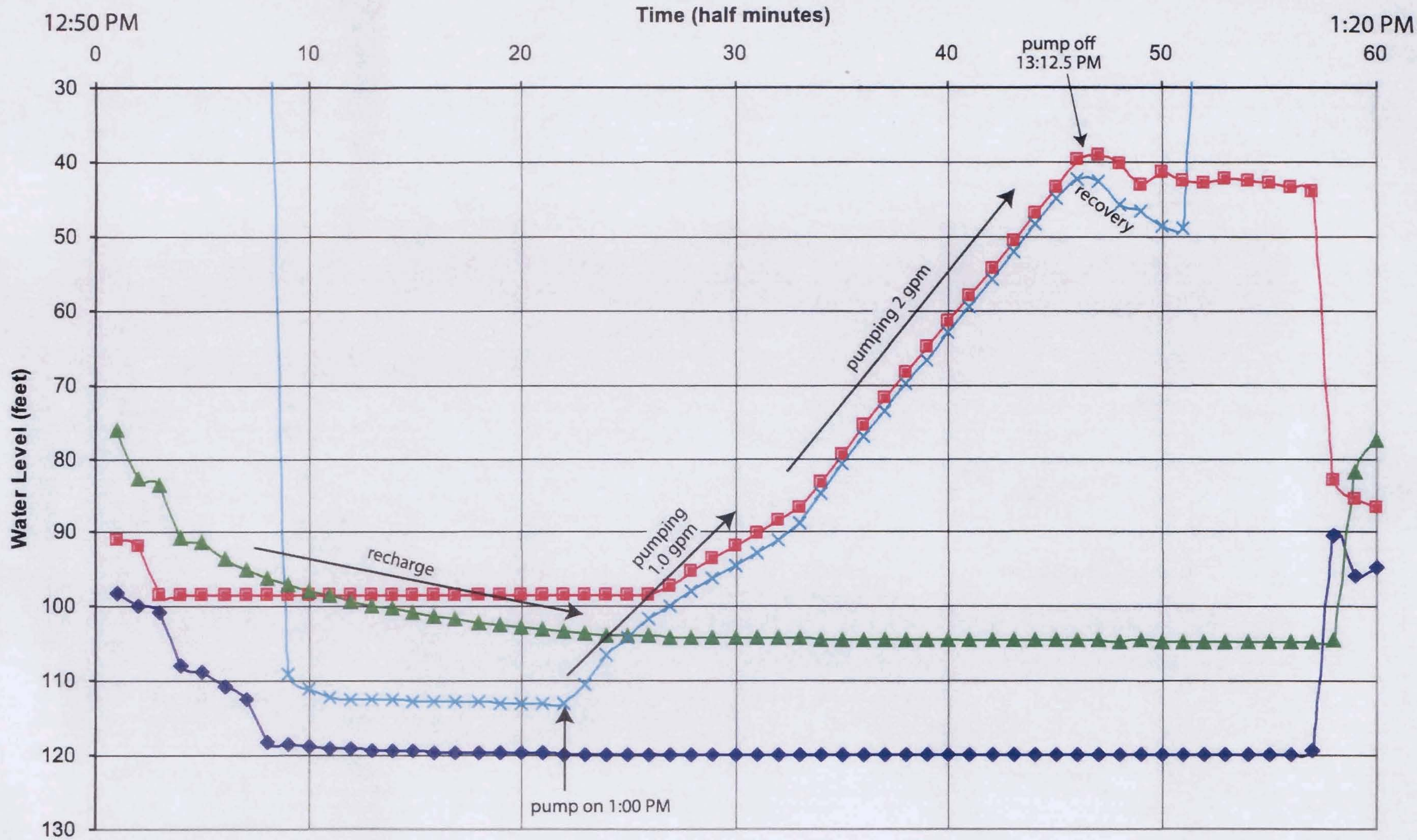


Figure 3-38 - Well MW220, Packer Test 8, 116-126 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

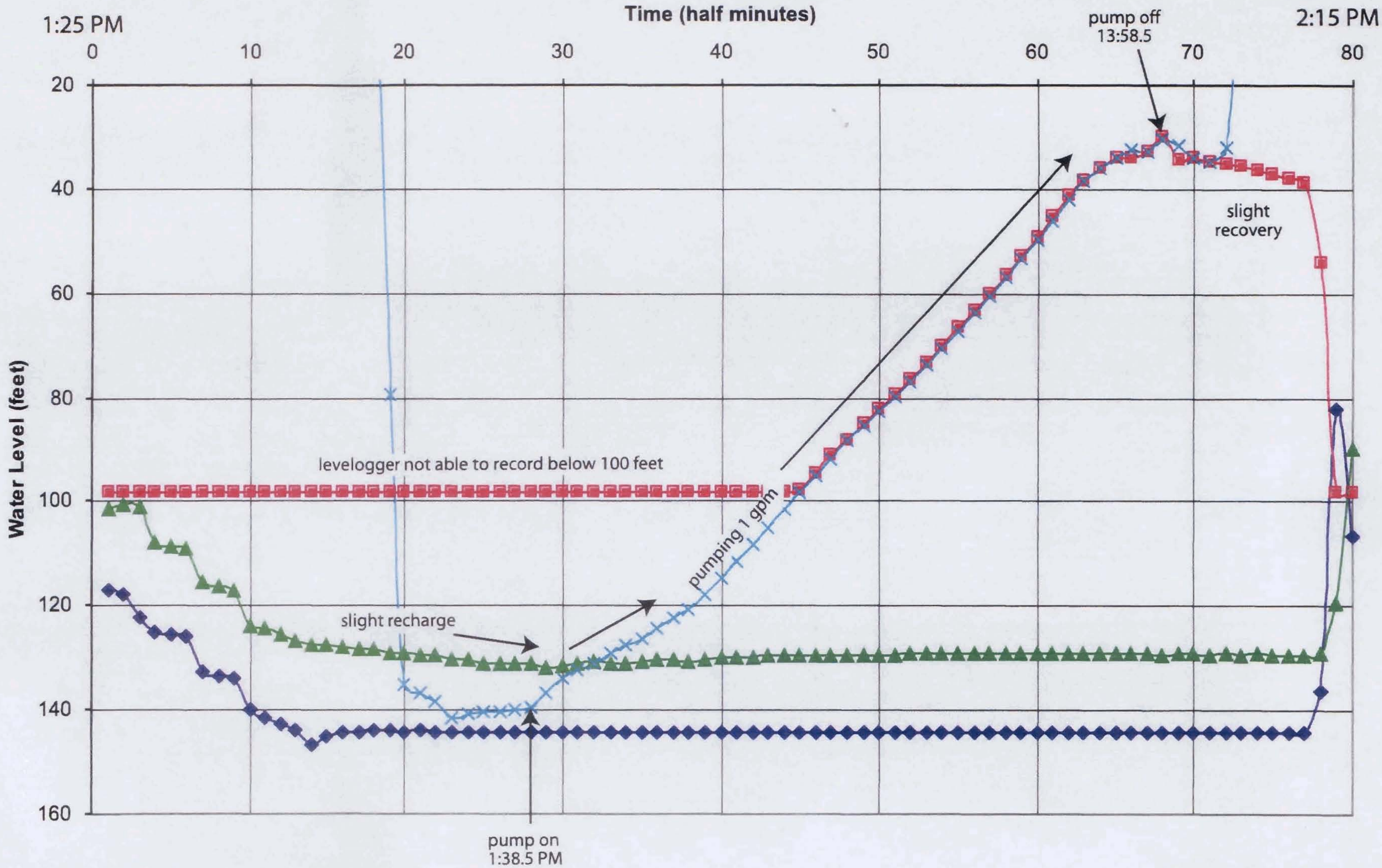


Figure 3-39 - Well MW220, Packer Test 9, 141-151 Feet Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

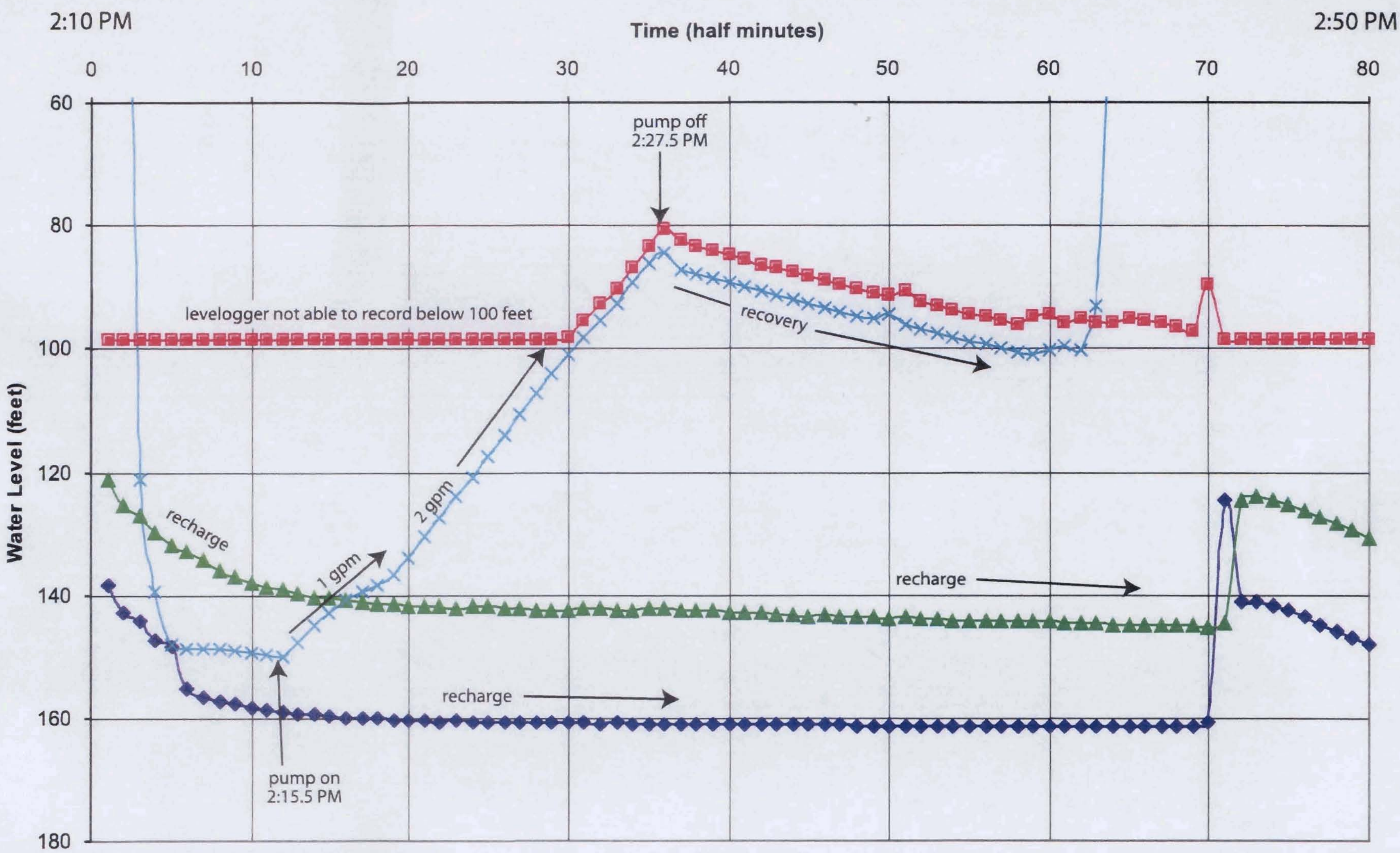


Figure 3-40 - Well MW220, Packer Test 10, 168-178 Feet

Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45

October 2007

Appendix A

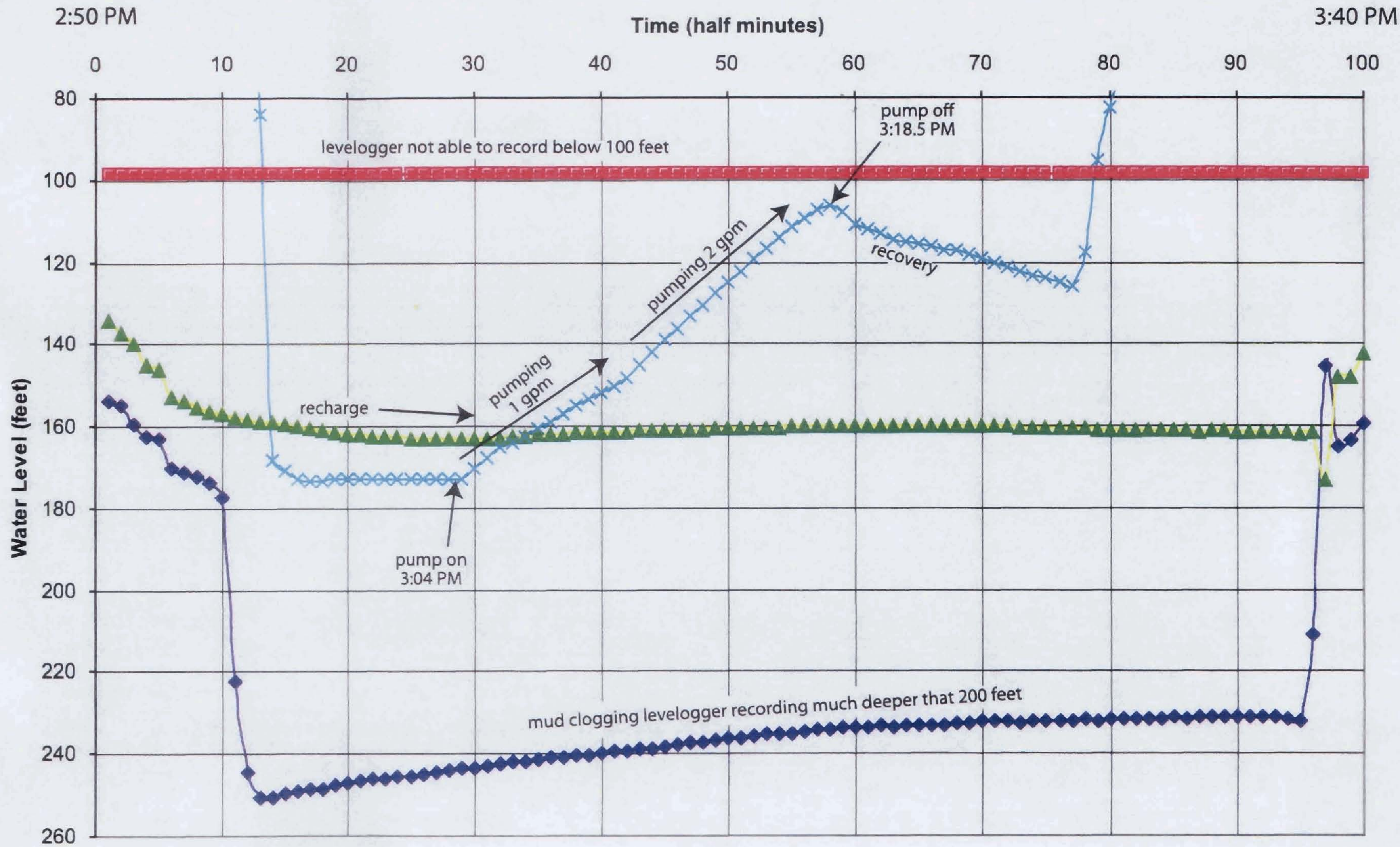


Figure 3-41 - Well MW220, Packer Test 11, 183-193 Feet
Wallkill Wellfield Site
City of Middletown
Orange County, New York

Legend:
- levelogger below Packer Zone
- levelogger in Packer Zone
- levelogger above Packer Zone
- minitroll in Packer Zone

ESI File: LM97145.45
October 2007
Appendix A

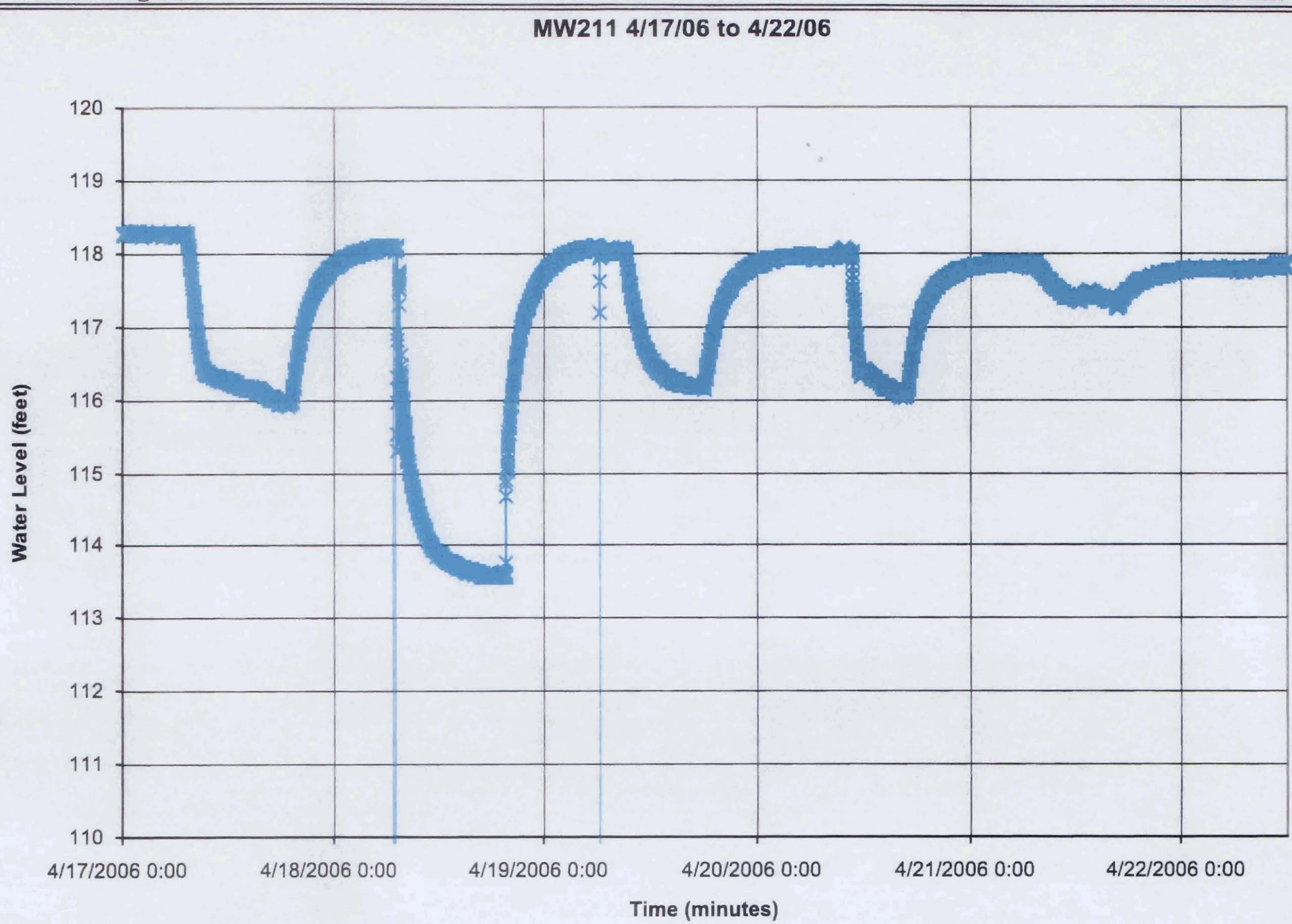


Figure 3-42 - MW211 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

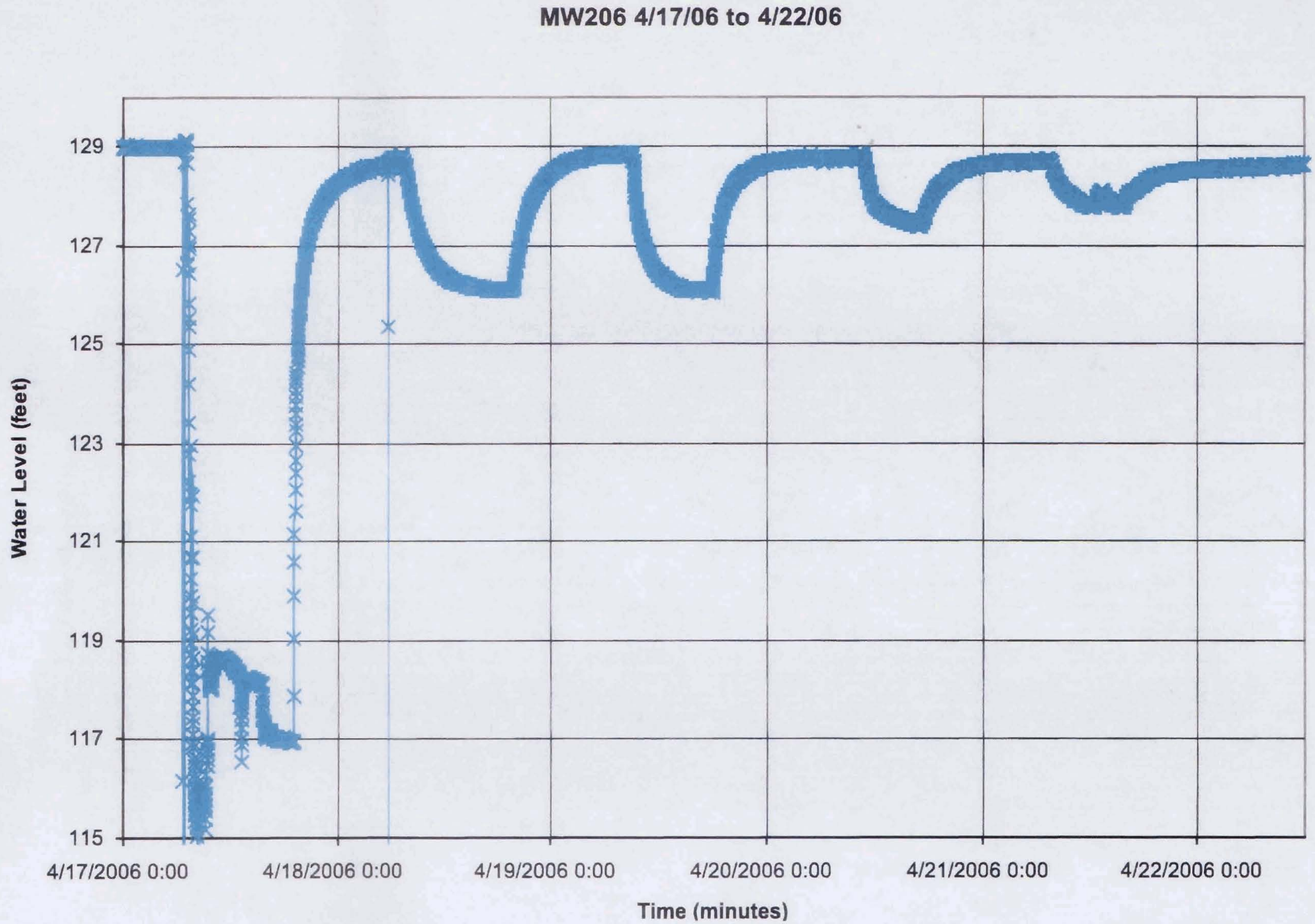


Figure 3-43 - MW206 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

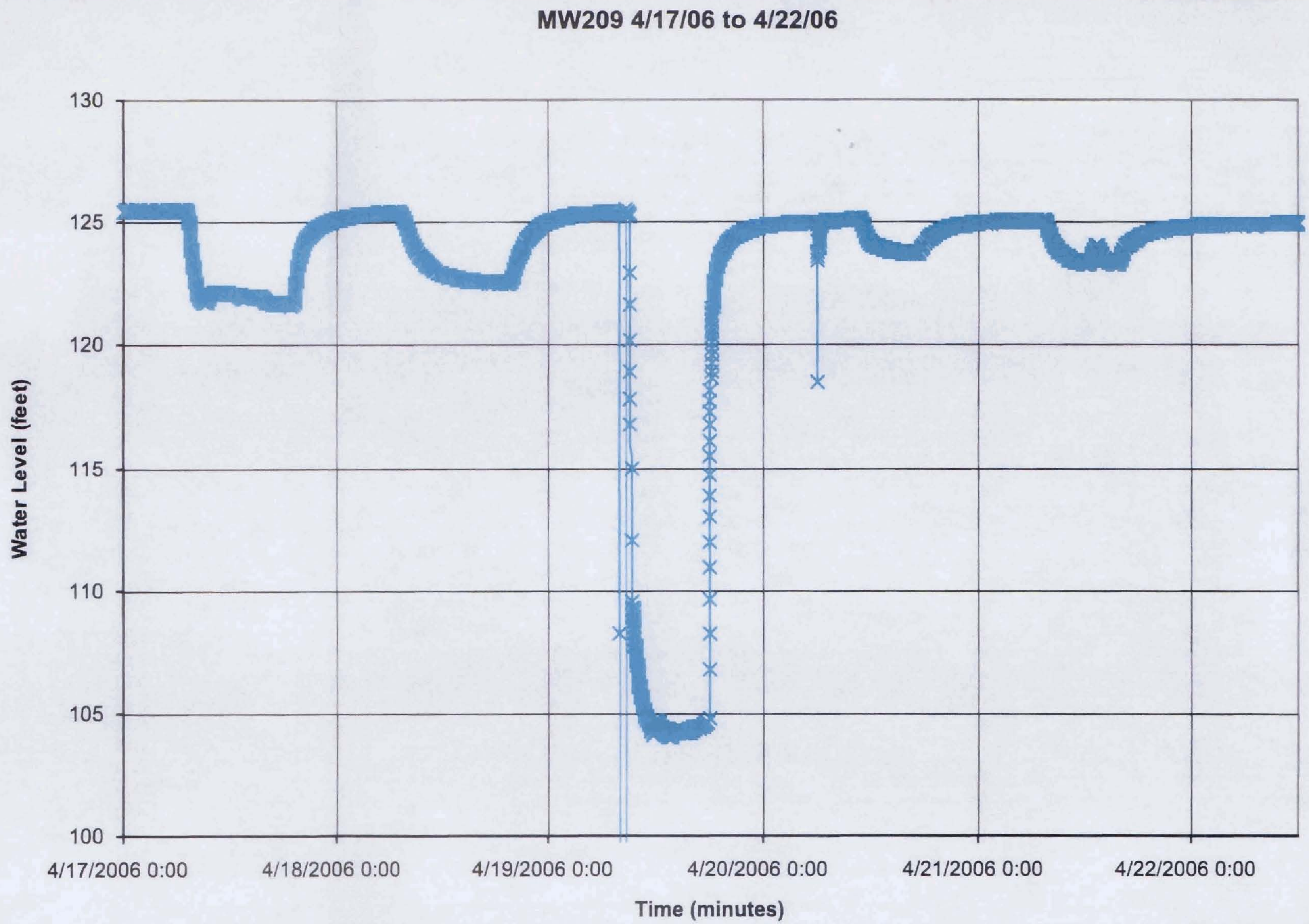


Figure 3-44 - MW209 - Water Level vs Time - April 17 to 22, 2006 Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

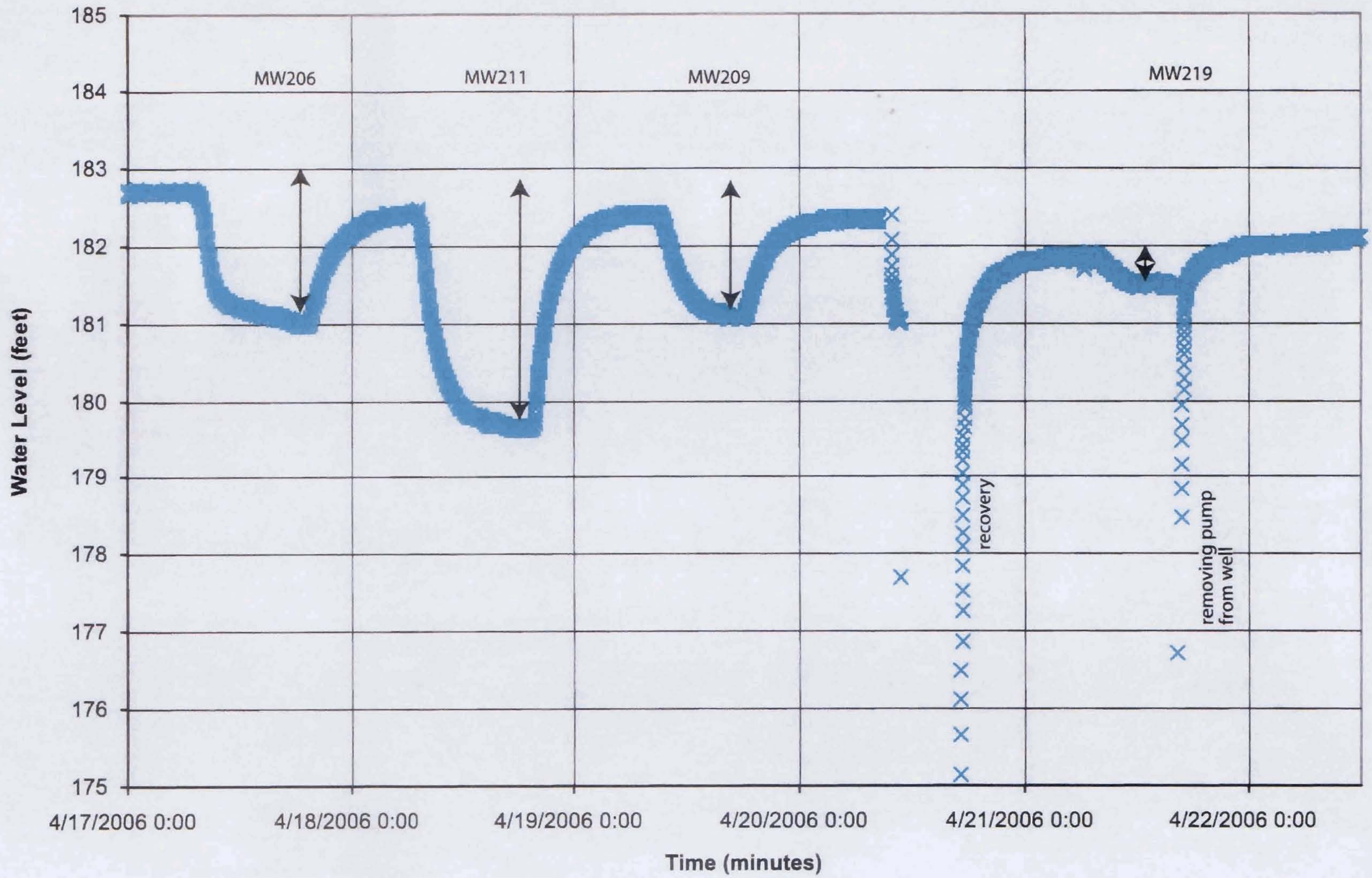


Figure 3-45 - MW220 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

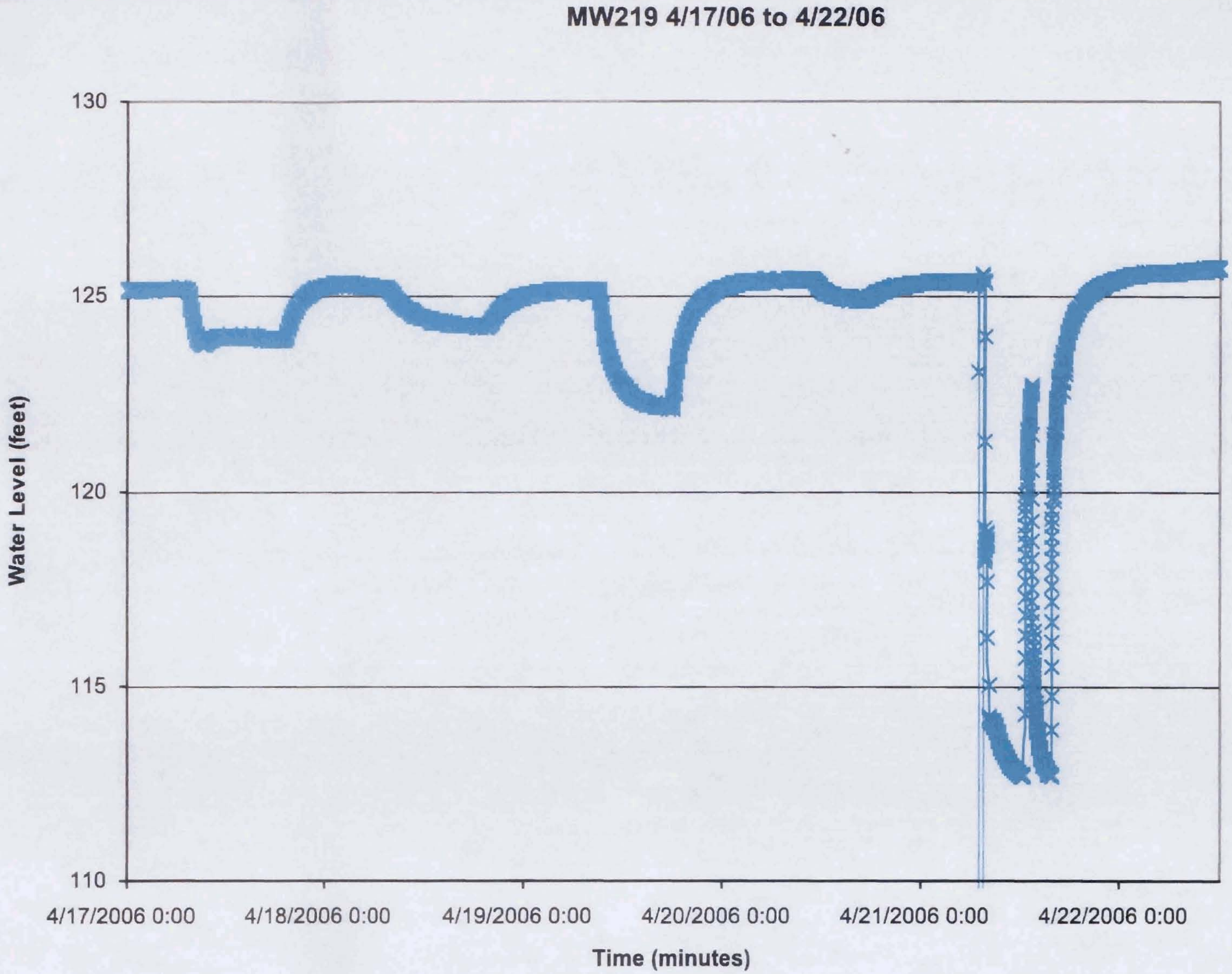


Figure 3-46 - MW219 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

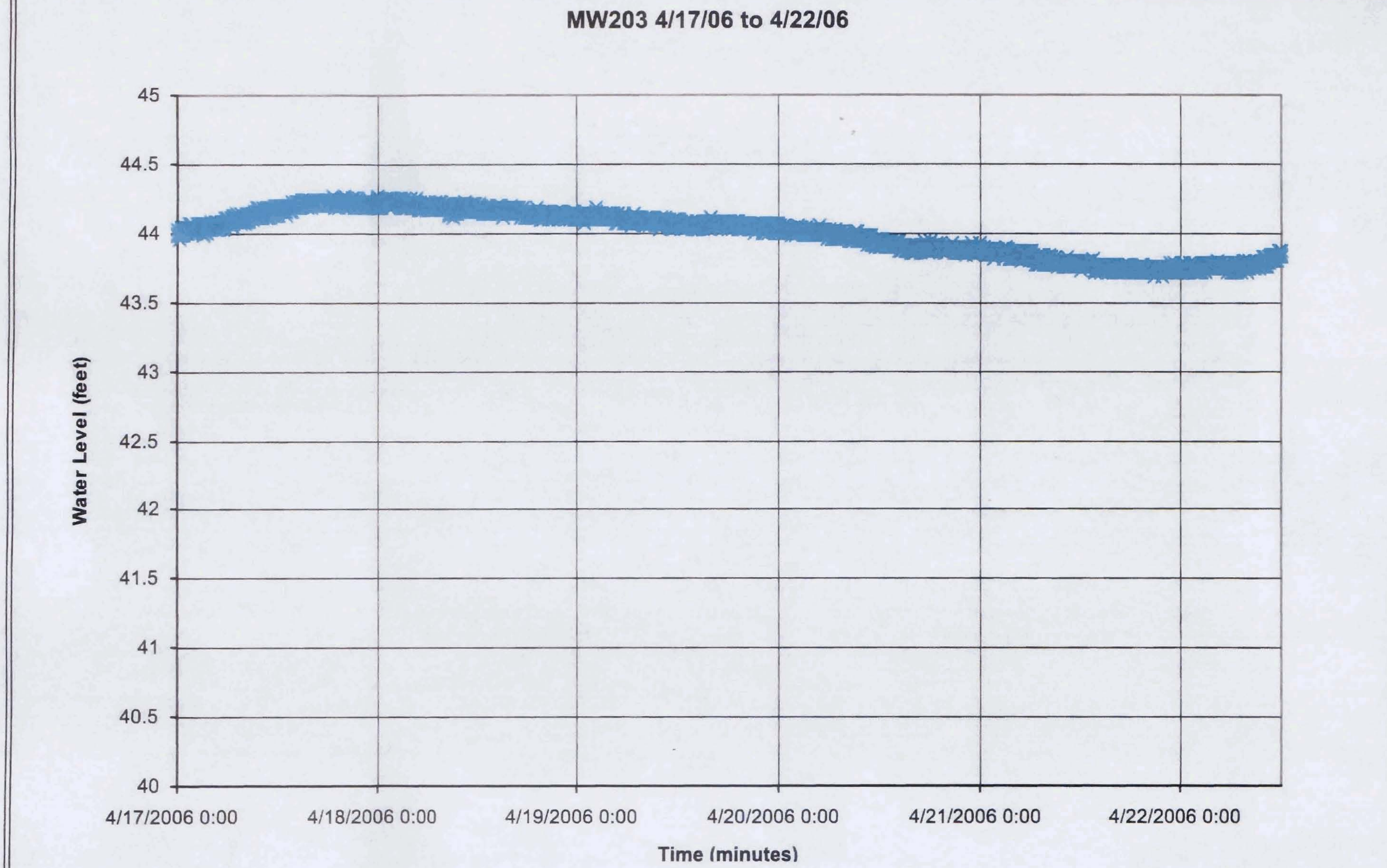


Figure 3-47 - MW203 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

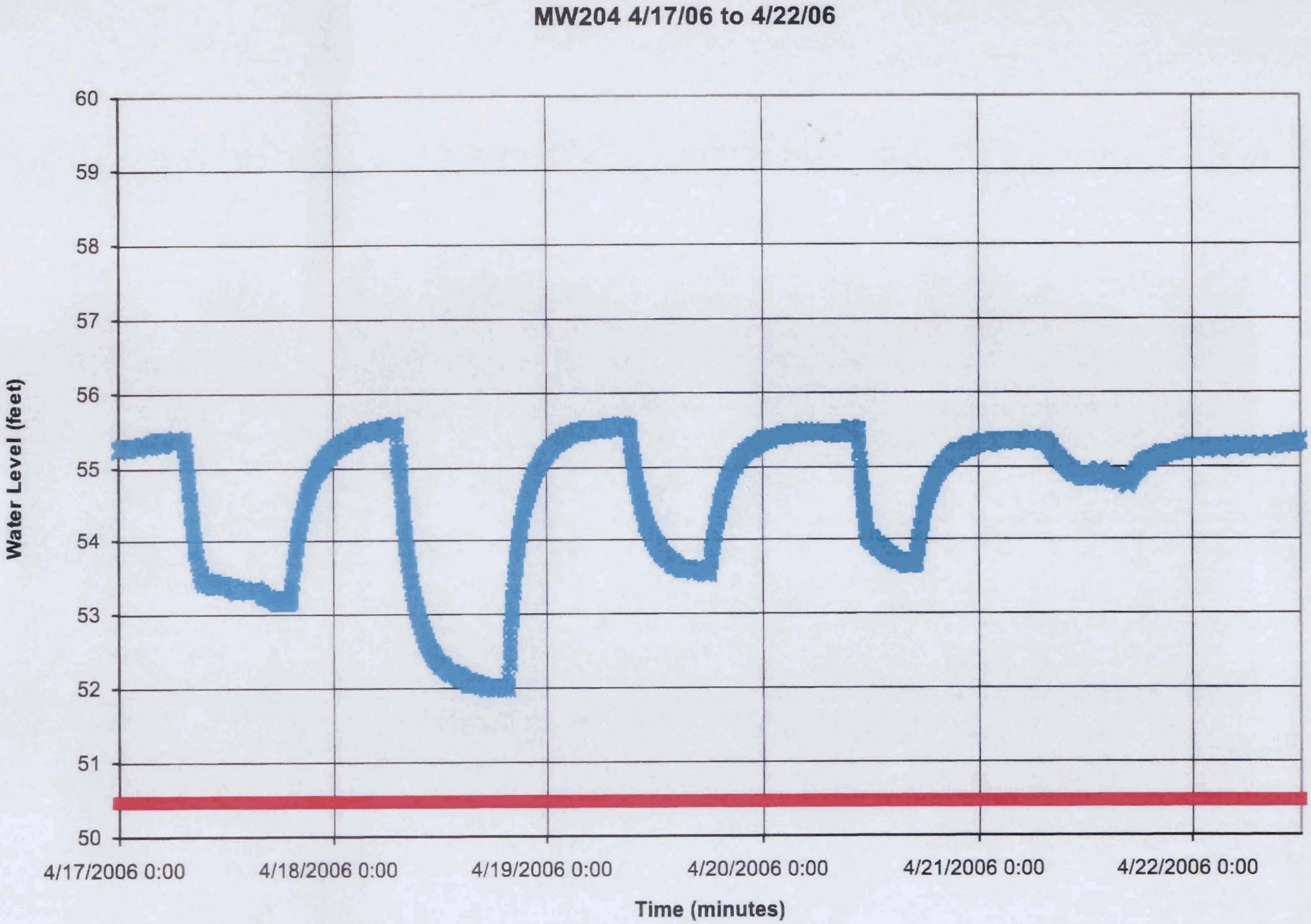


Figure 3-48 - MW204 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

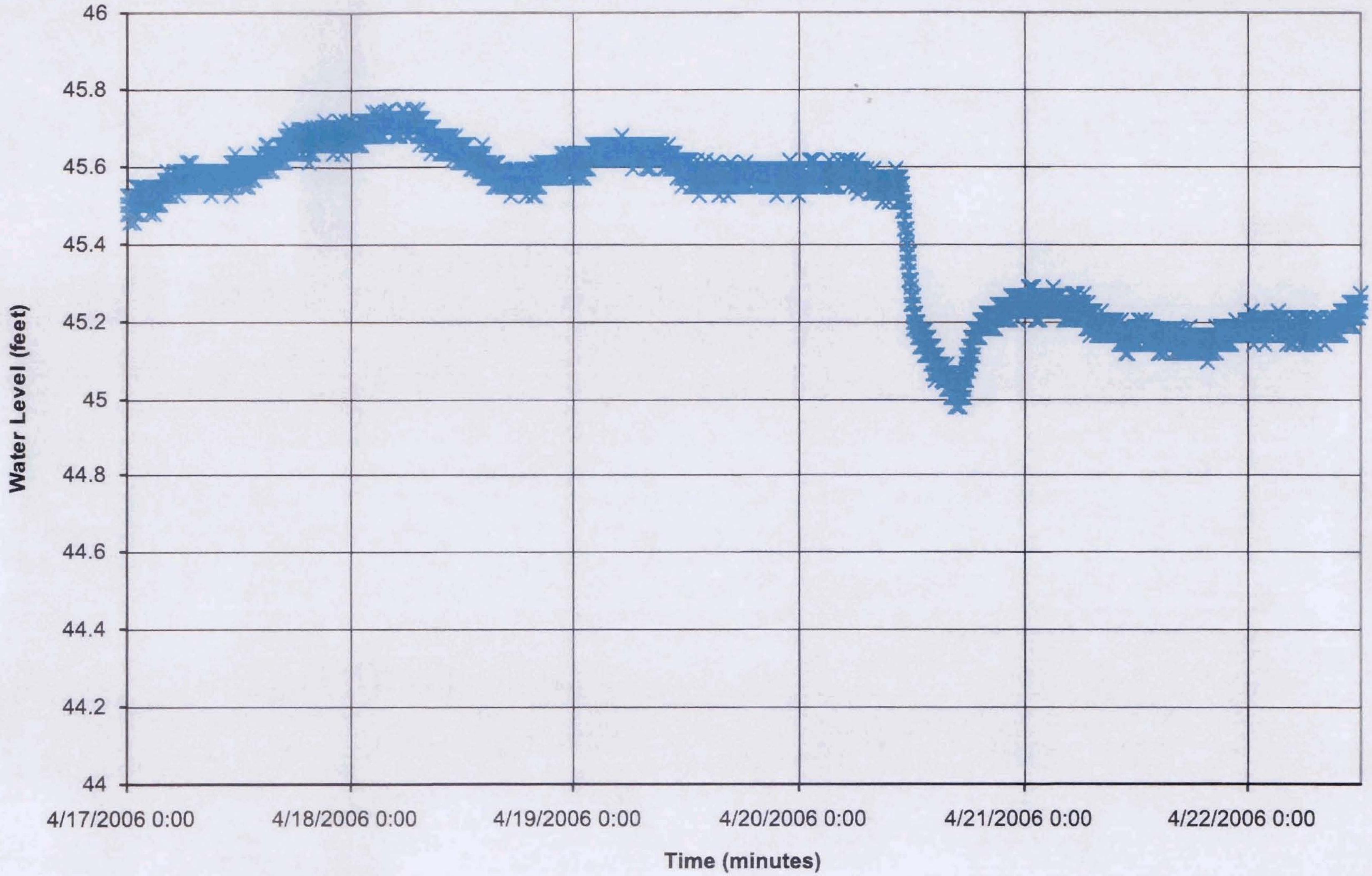


Figure 3-49 - MW207 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

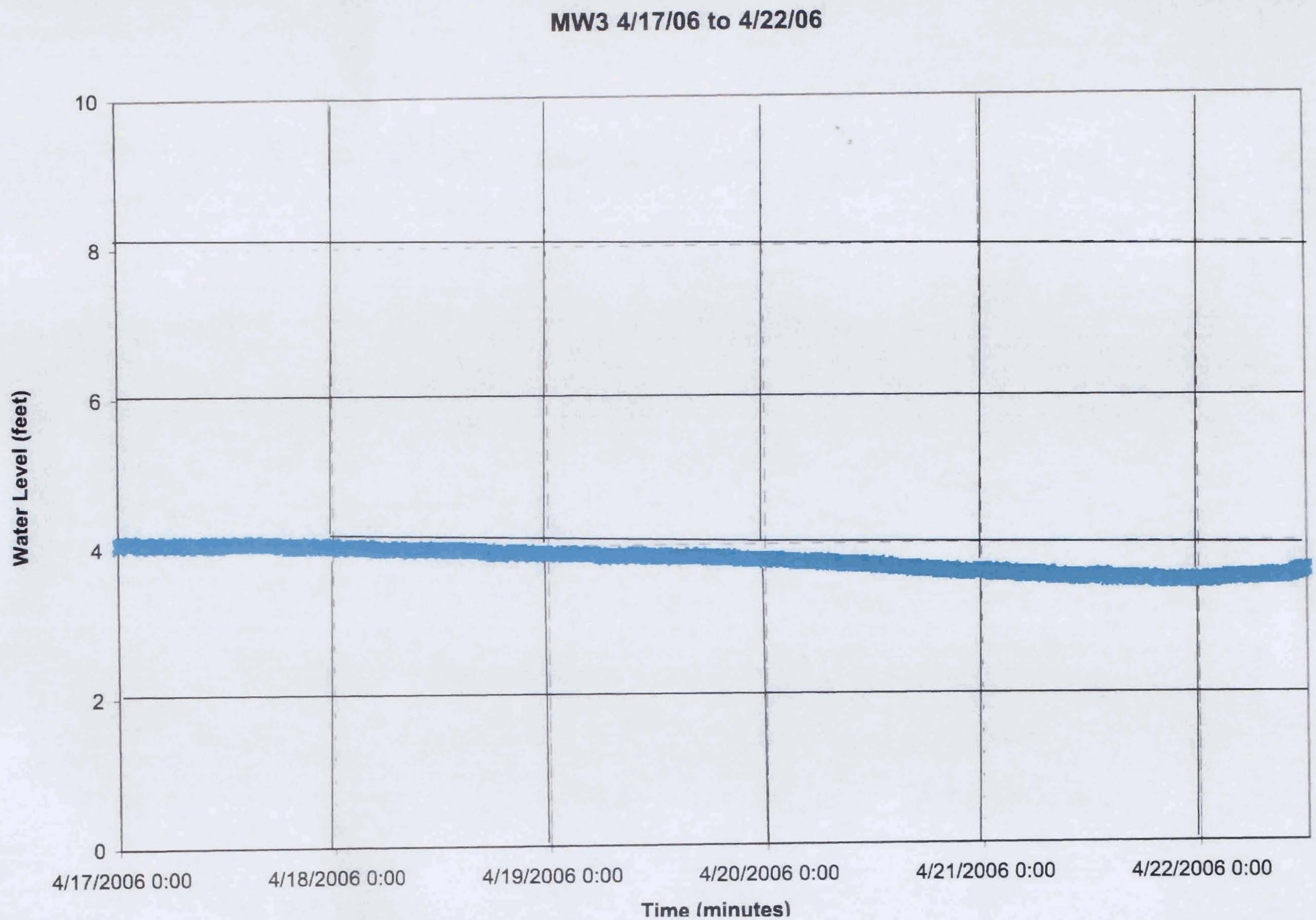


Figure 3-50 - MW3 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

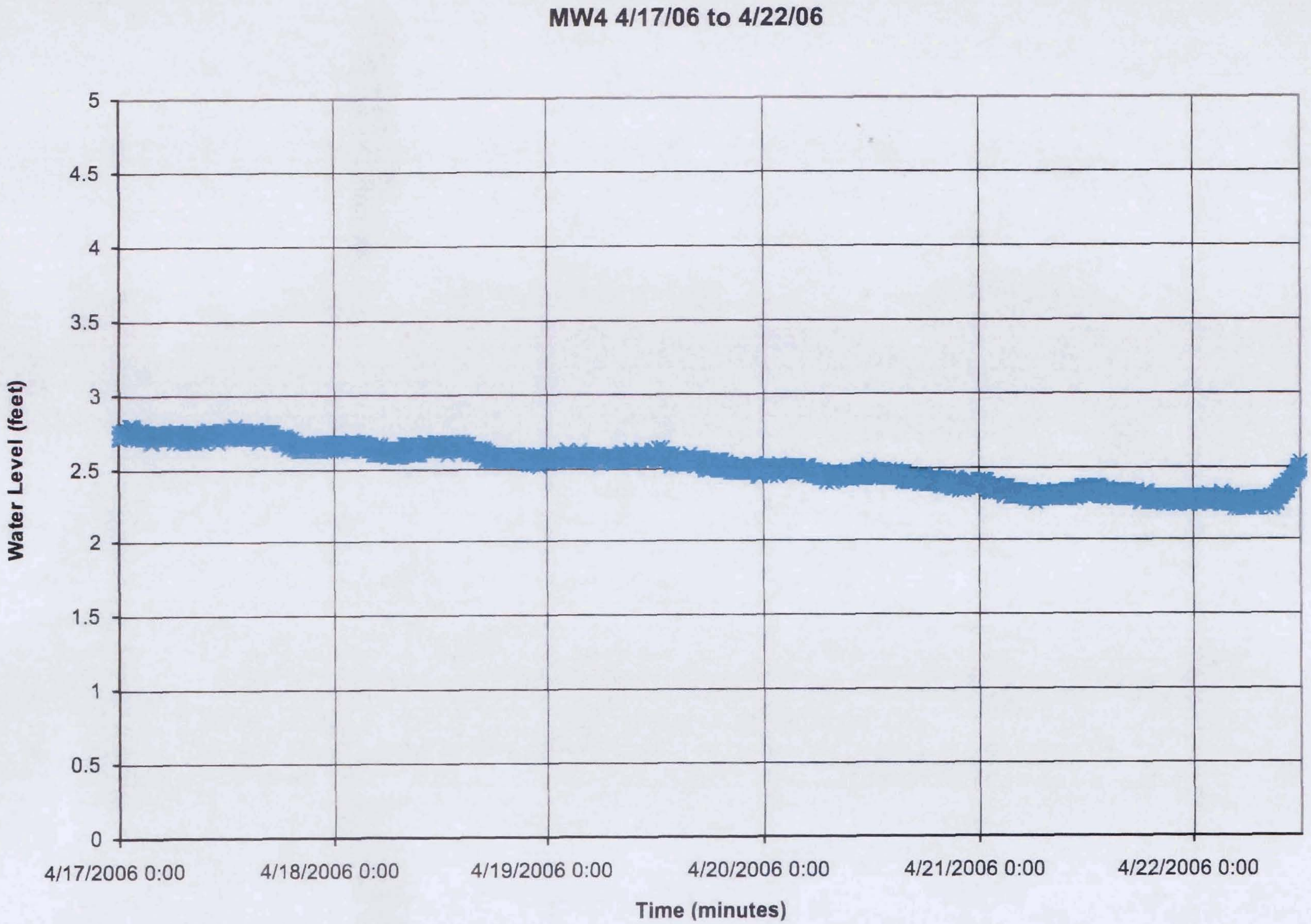


Figure 3-51 - MW4 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

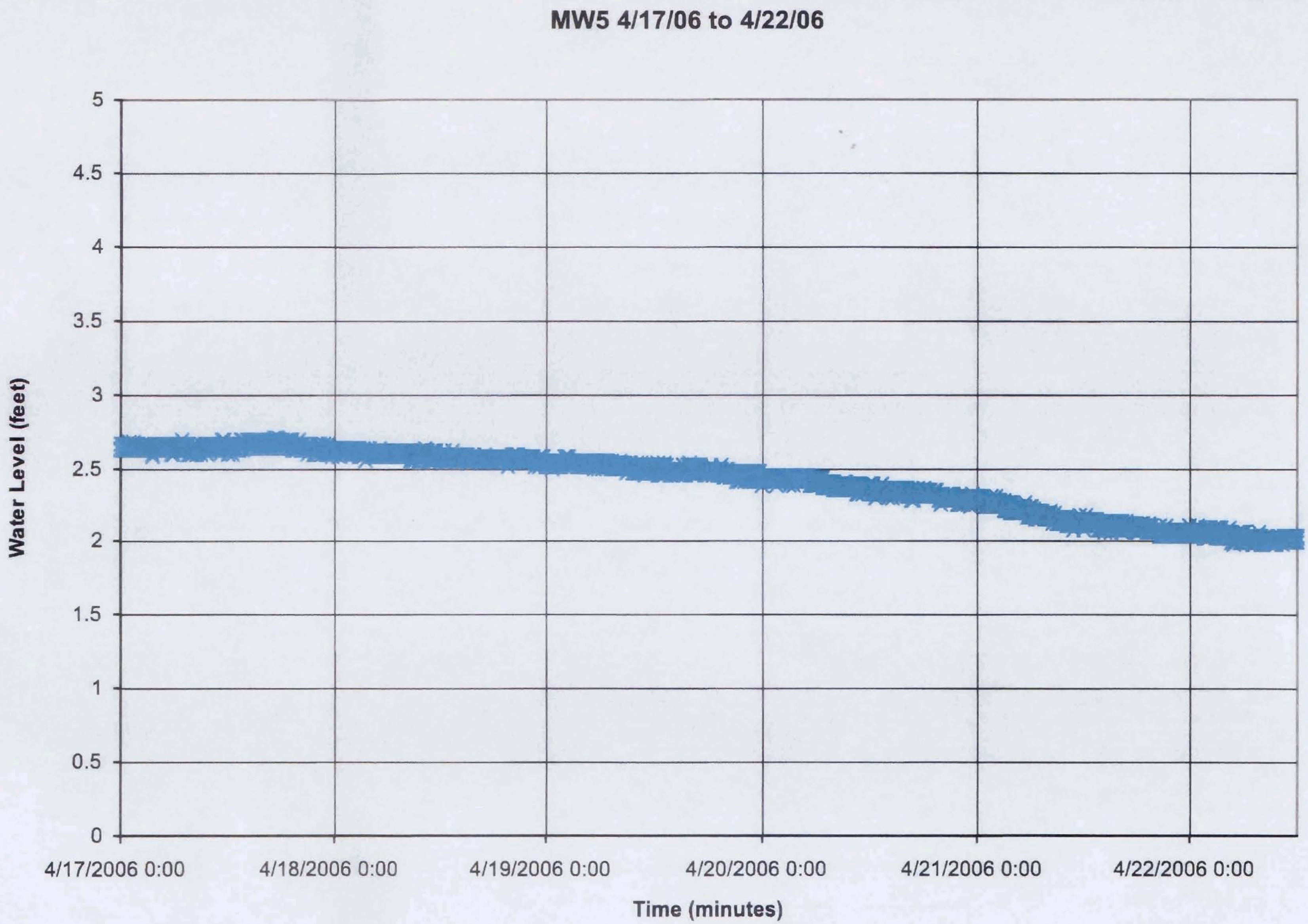


Figure 3-52 - MW5 - Water Level vs Time - April 17 to 22, 2006 Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

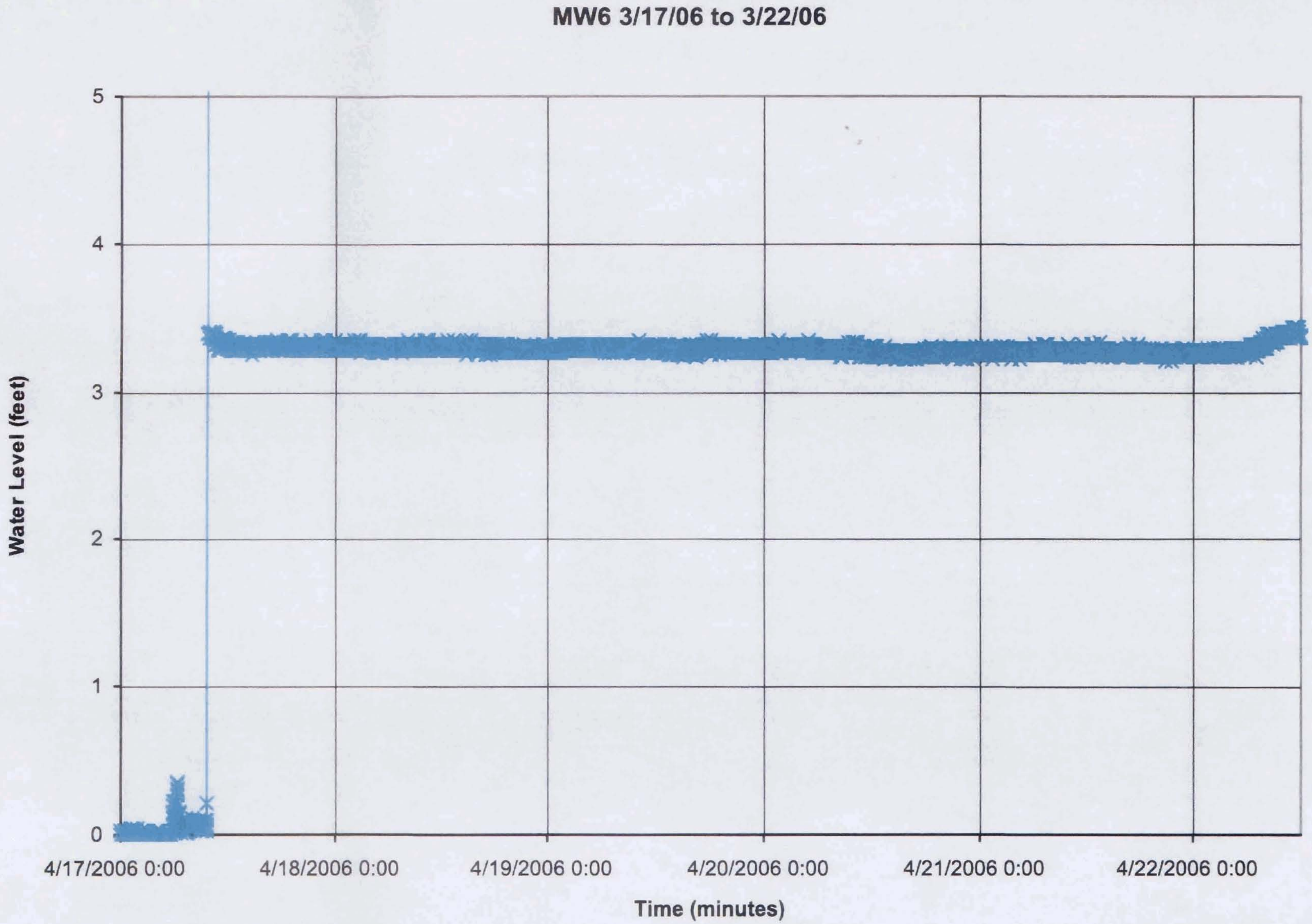


Figure 3-53 - MW6 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

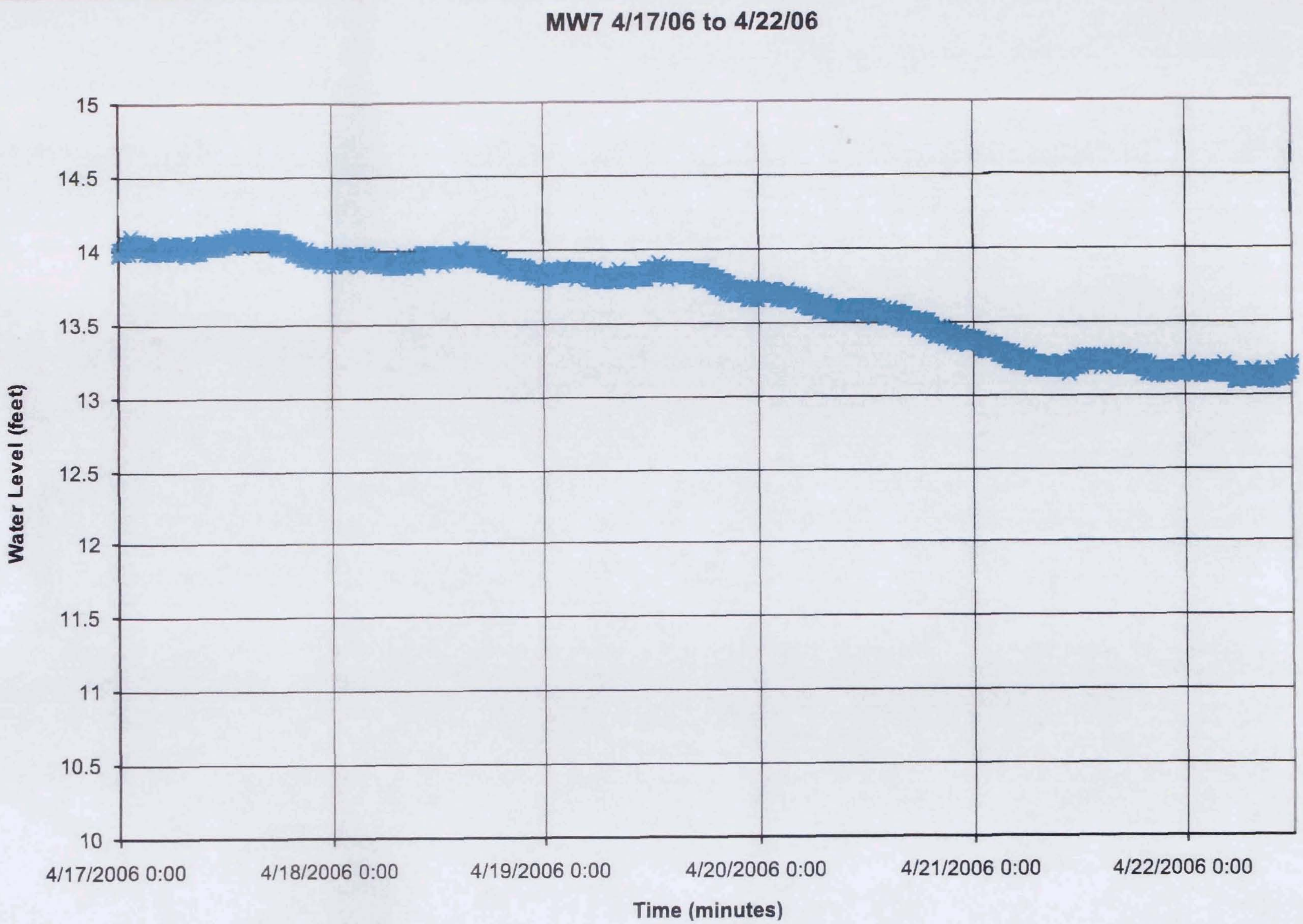


Figure 3-54 - MW7 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

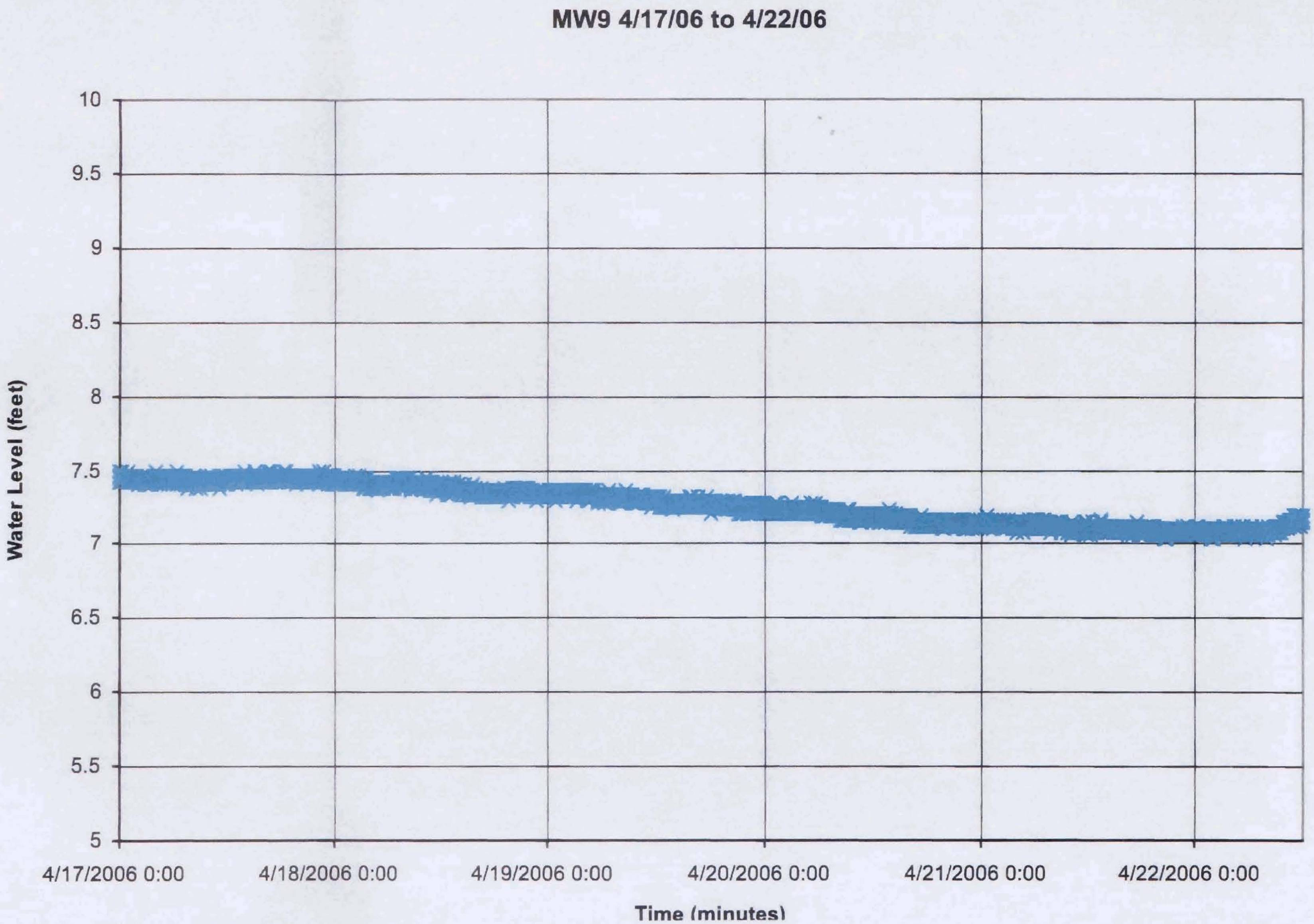


Figure 3-55 - MW9 - Water Level vs Time - April 17 to 22, 2006 Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

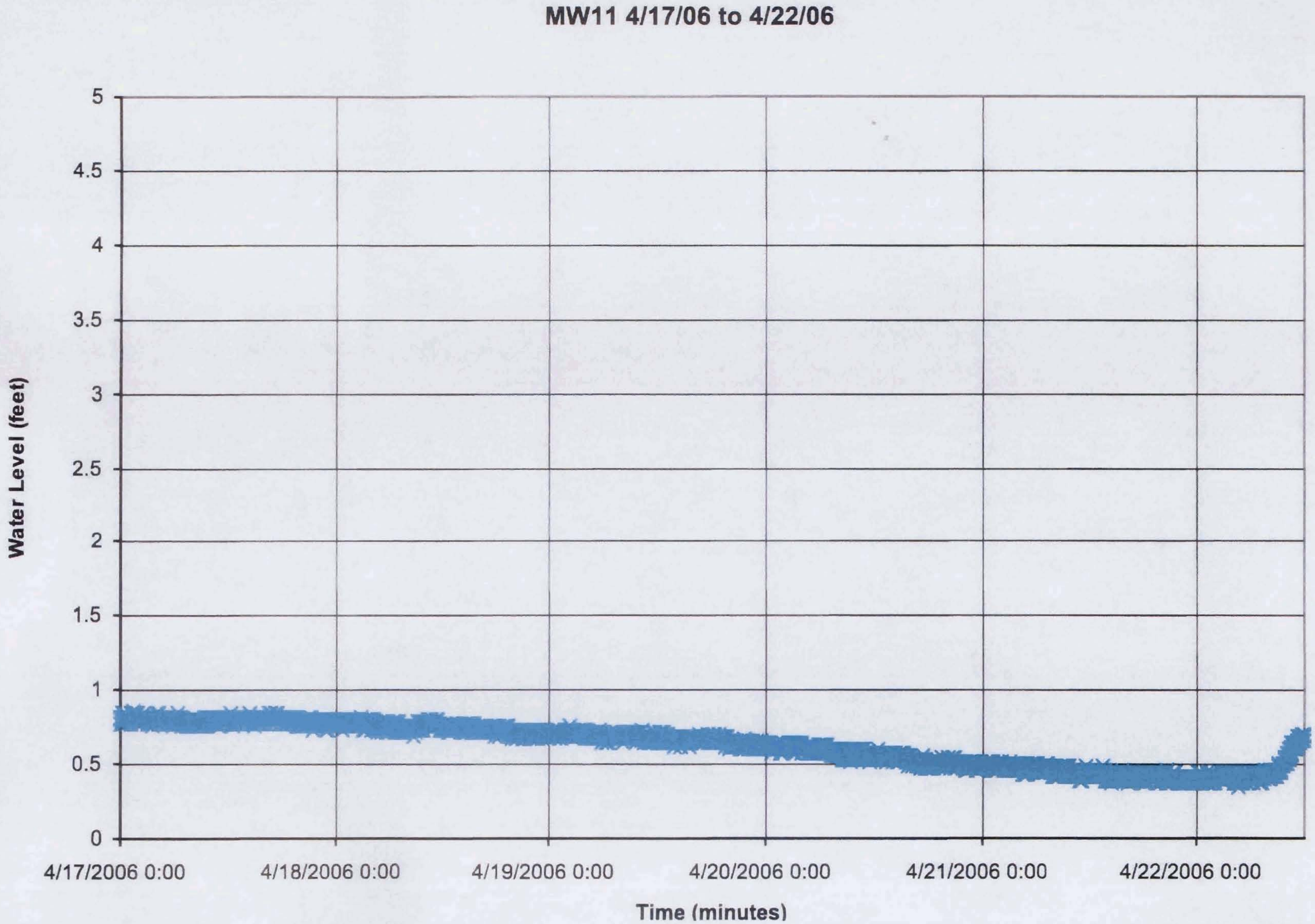


Figure 3-56 - MW11 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

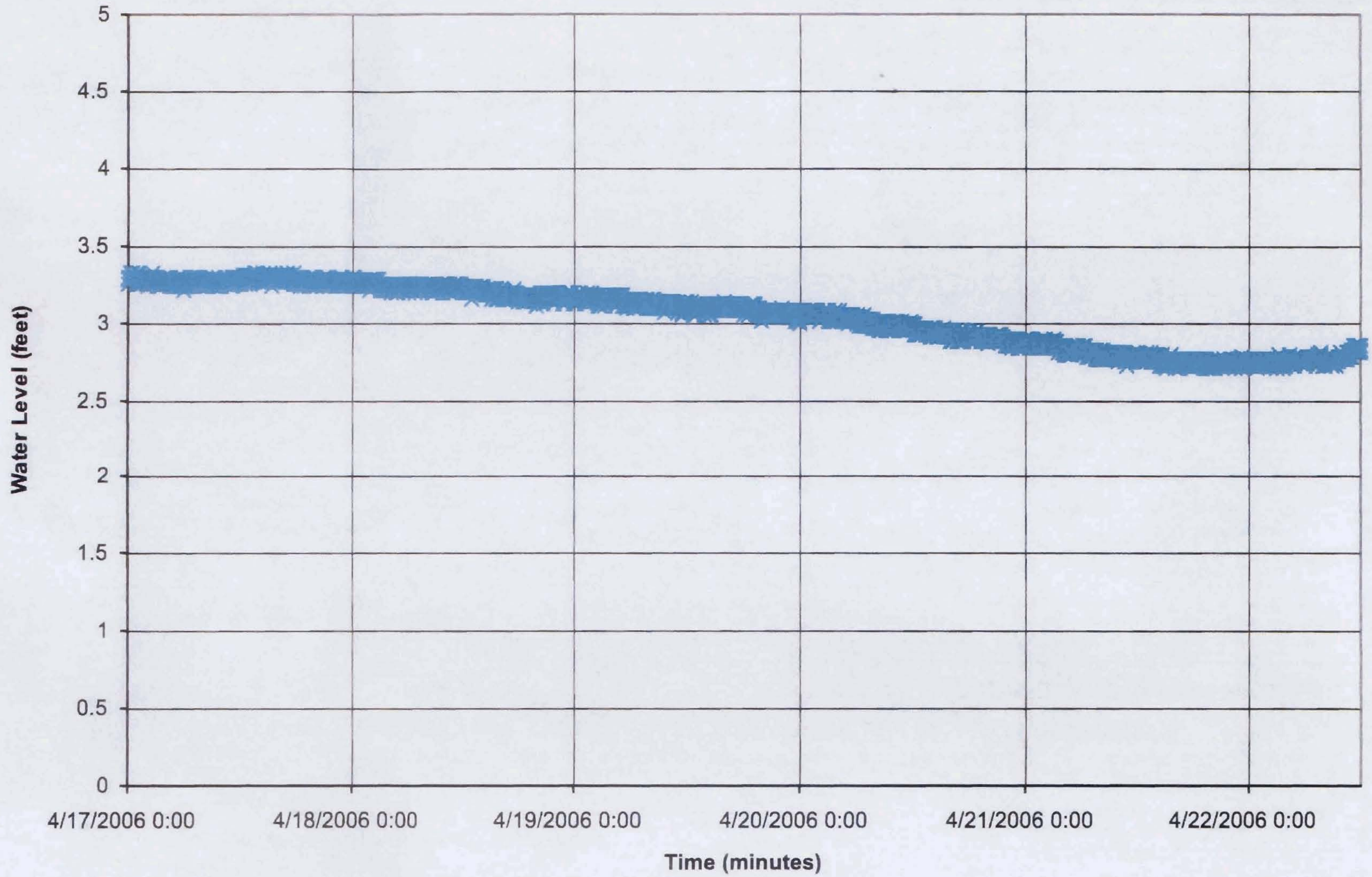


Figure 3-57 - MW16 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

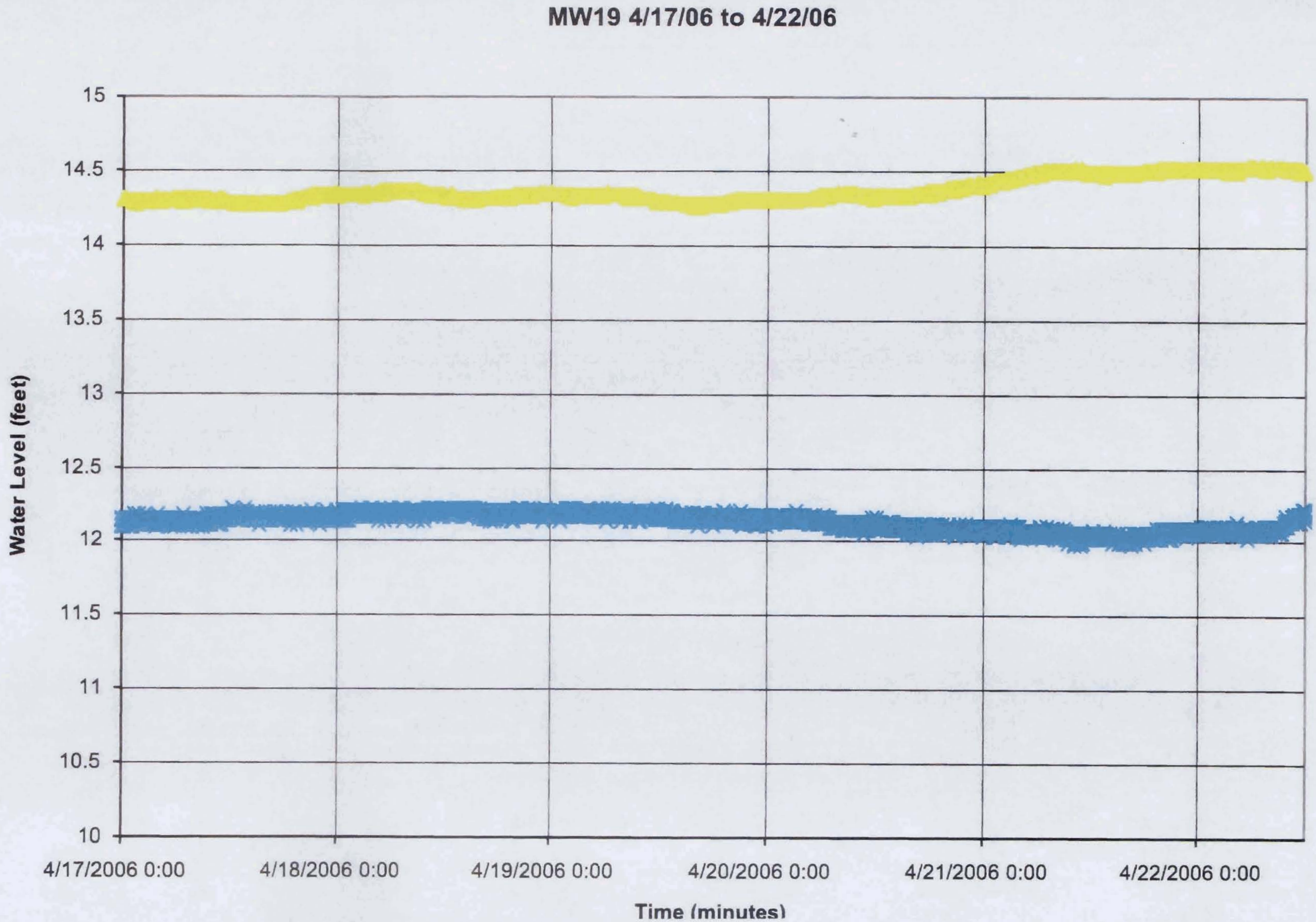


Figure 3-58 - MW19 - Water Level vs Time - April 17 to 22, 2006

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

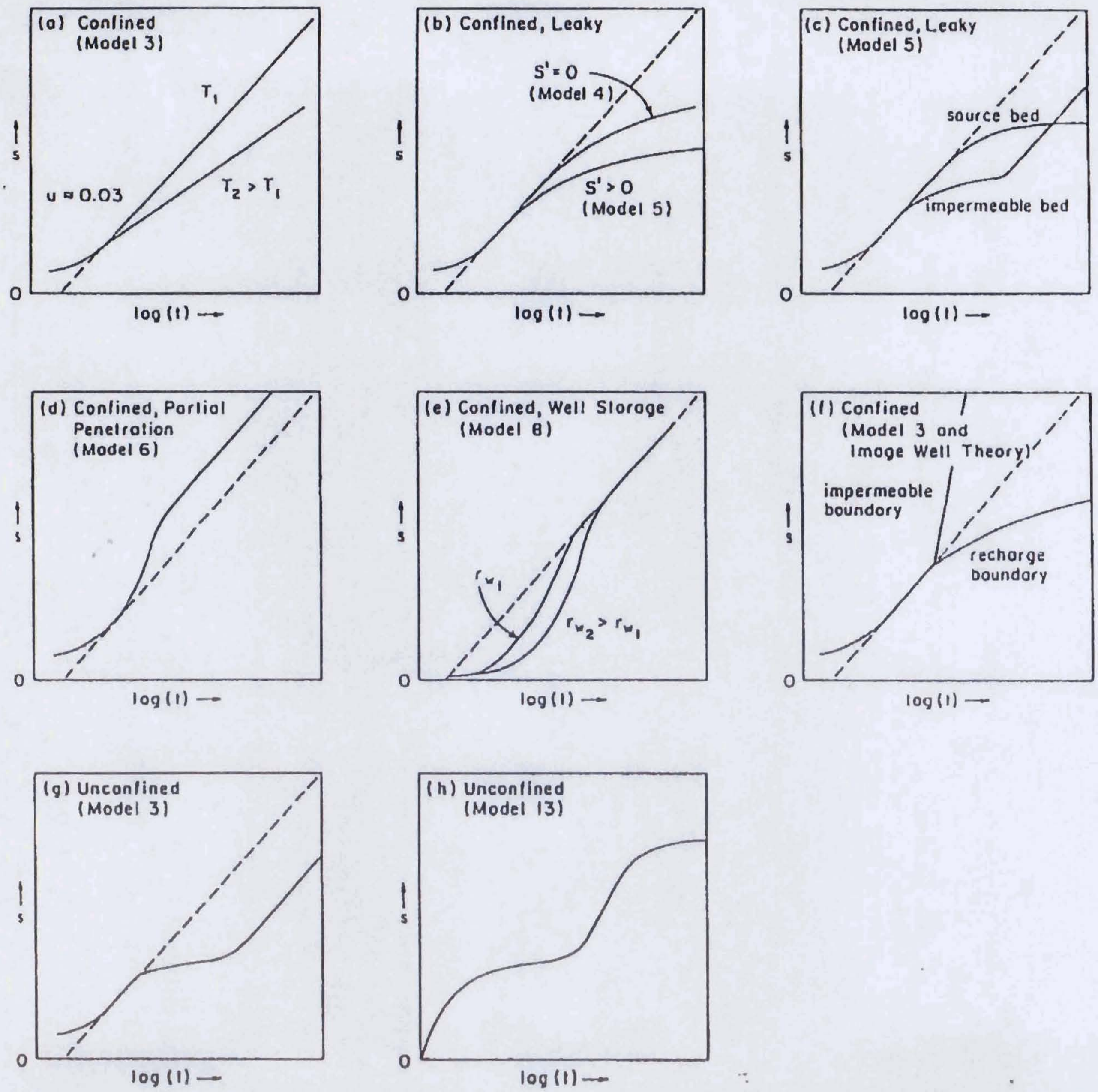


Figure 4.7 The effects of various aquifer characteristics on drawdown.

Figure 3-59 Graphic Aquifer Model Verification Methods from Dawson & Istok (1991, page 64) Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

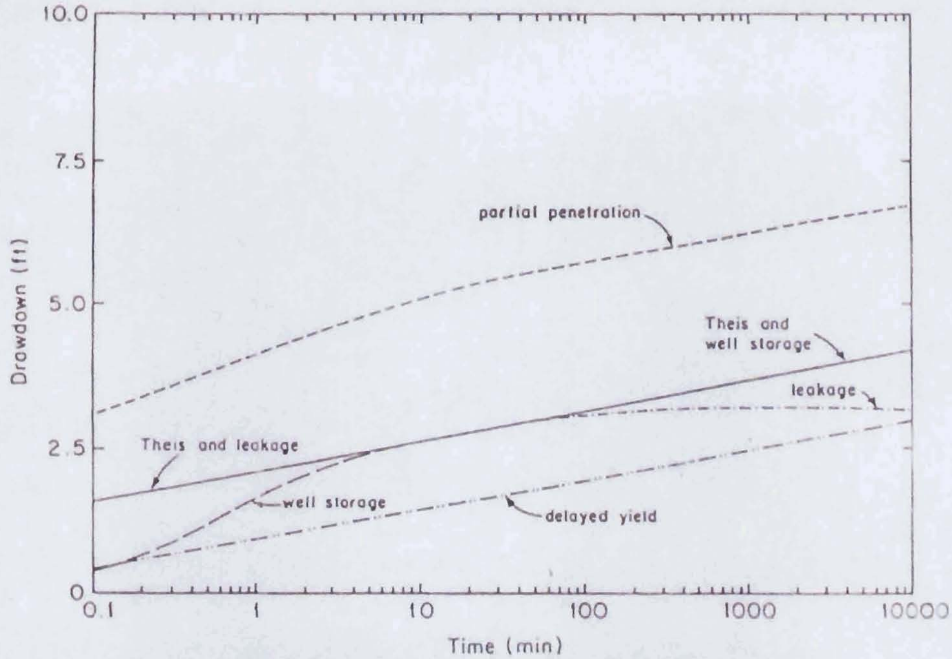


Figure 4.10 Effects on various aquifer characteristics on the semilogarithmic plot of drawdown vs. time at the pumping well.

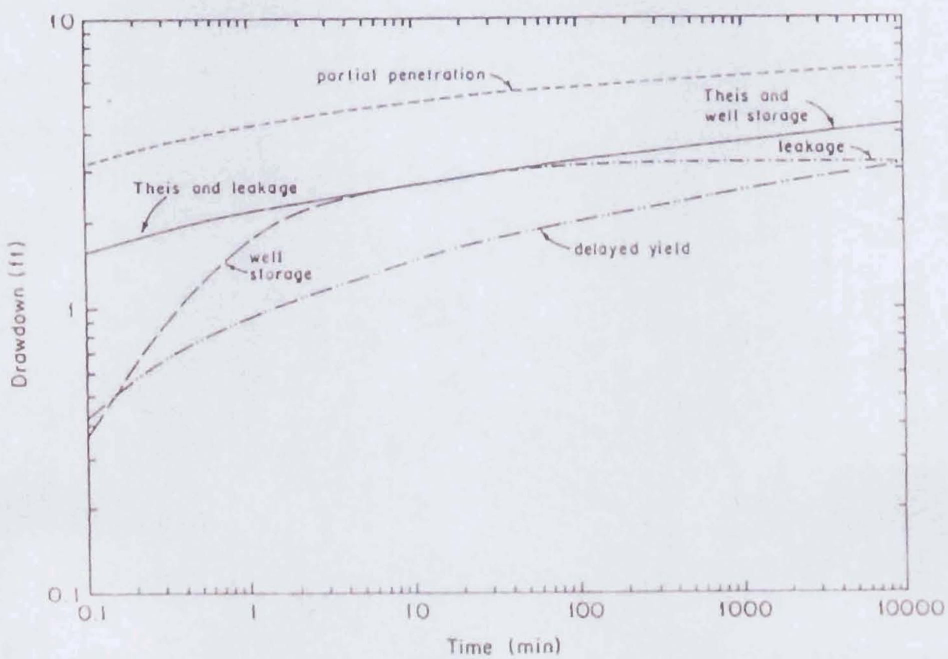


Figure 4.11 Effects of various aquifer characteristics on the logarithmic plot of drawdown vs. time at the pumping well.

Figure 3-60 Graphic Aquifer Model Verification Methods from Dawson & Istok (1991, page 70) Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

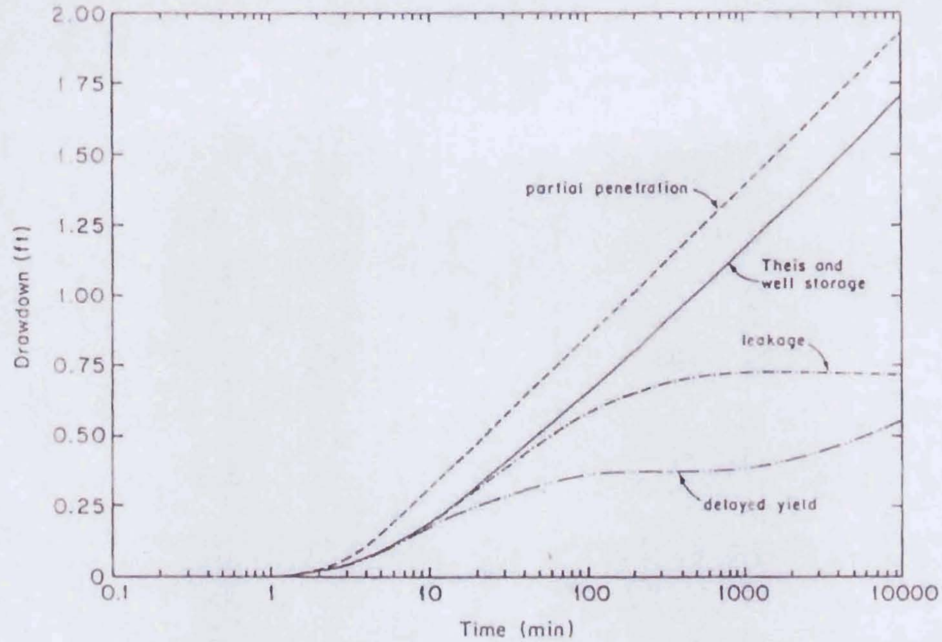


Figure 4.12 Effects of various aquifer characteristics on the semilogarithmic plot of drawdown vs. time at an observation well 250 feet from the pumping well.

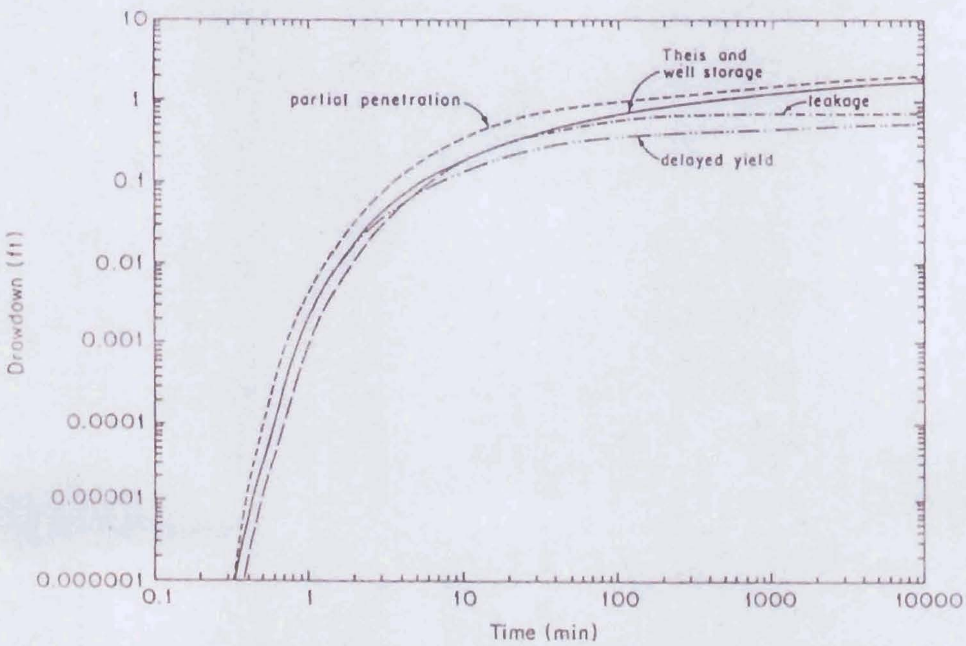


Figure 4.13 Effects of various aquifer characteristics on the logarithmic plot of drawdown vs. time at an observation well 250 feet from the pumping well.

Figure 3-61 Graphic Aquifer Model Verification Methods from Dawson & Istok (1991, page 71) Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

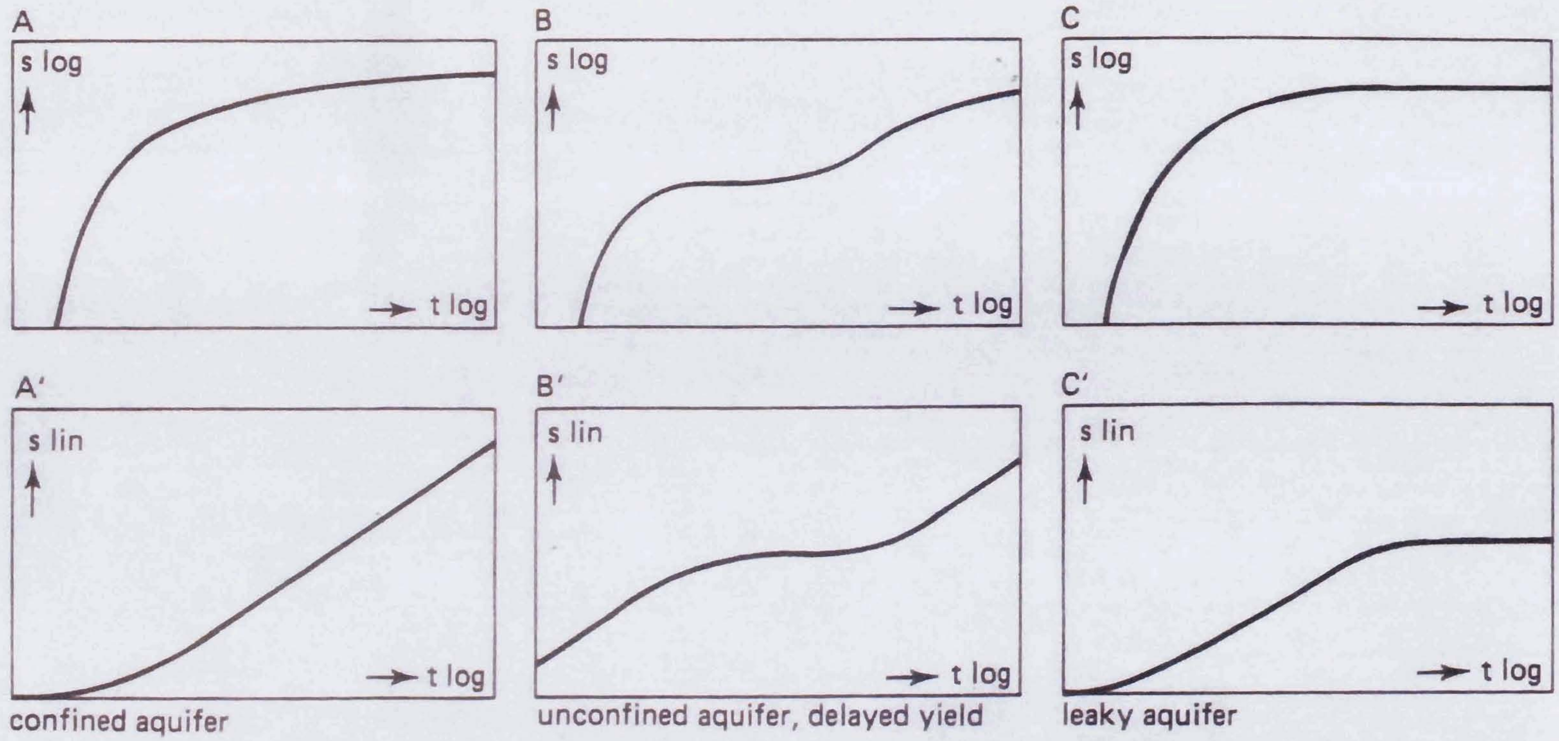


Figure 2.12 Log-log and semi-log plots of the theoretical time-drawdown relationships of unconsolidated aquifers:
Parts A and A': Confined aquifer
Parts B and B': Unconfined aquifer
Parts C and C': Leaky aquifer

Figure 3-62 - Graphic Aquifer Model Verification Methods from Kruseman & deRidder (1990, page 49) Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

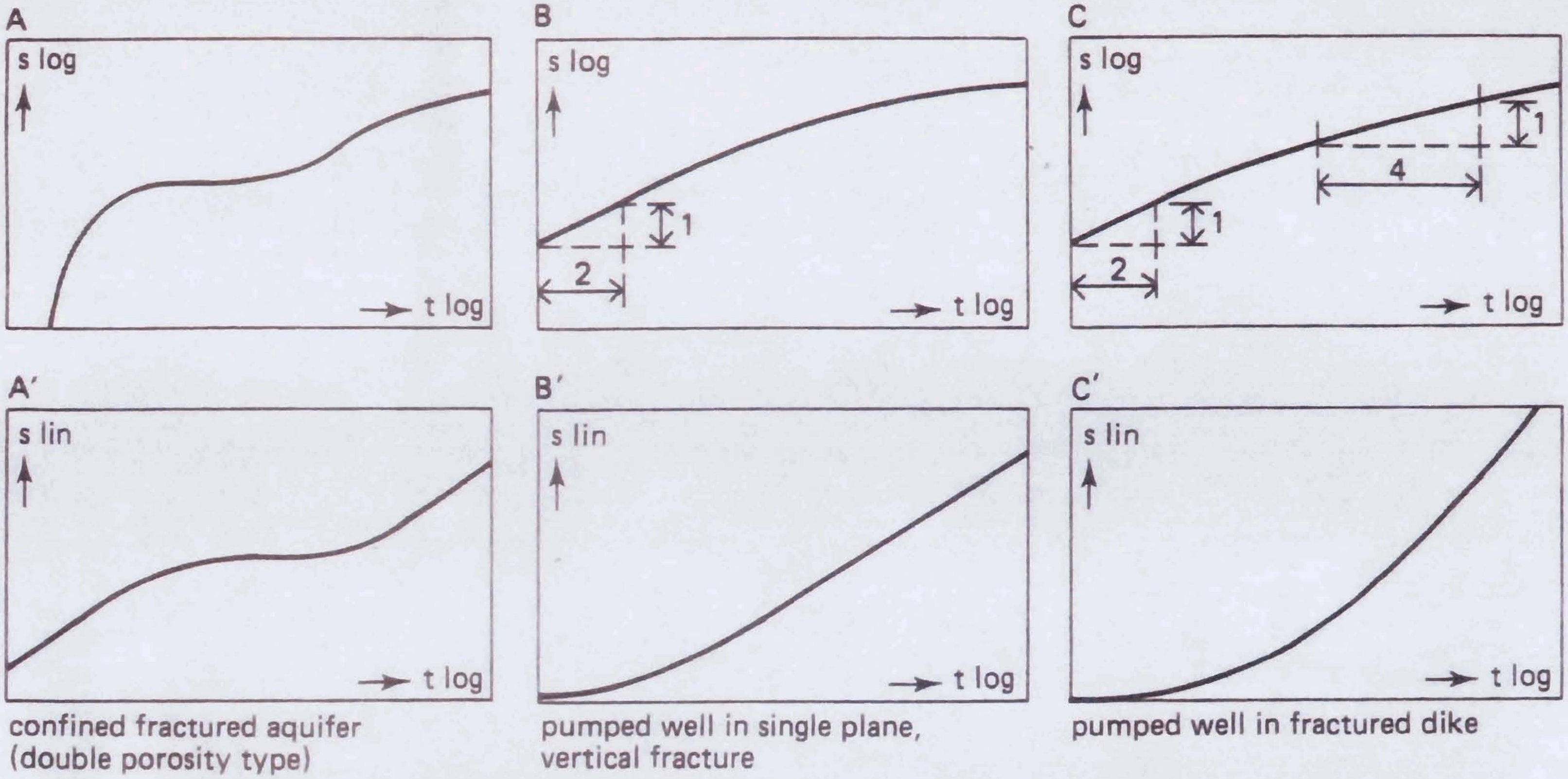


Figure 2.13 Log-log and semi-log plots of the theoretical time-drawdown relationships of consolidated, fractured aquifers:
Parts A and A′: Confined fractured aquifer, double porosity type
Parts B and B′: A single plane vertical fracture
Parts C and C′: A permeable dike in an otherwise poorly permeable aquifer

Figure 3-63 - Graphic Aquifer Model Verification Methods from Kruseman & deRidder (1990, page 50) Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

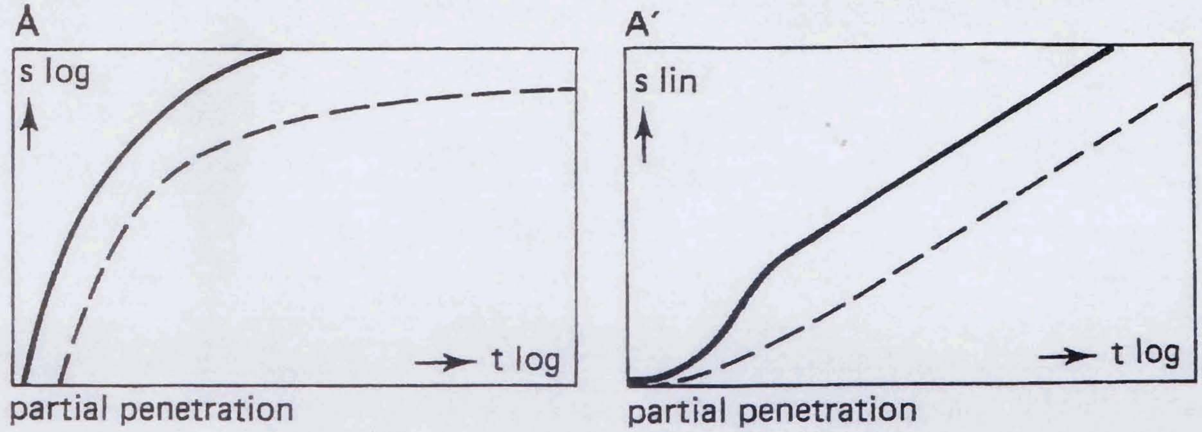


Figure 2.14 The effect of the well's partial penetration on the time-drawdown relationship in an unconsolidated, confined aquifer. The dashed curves are those of Parts A and A′ of Figure 2.12

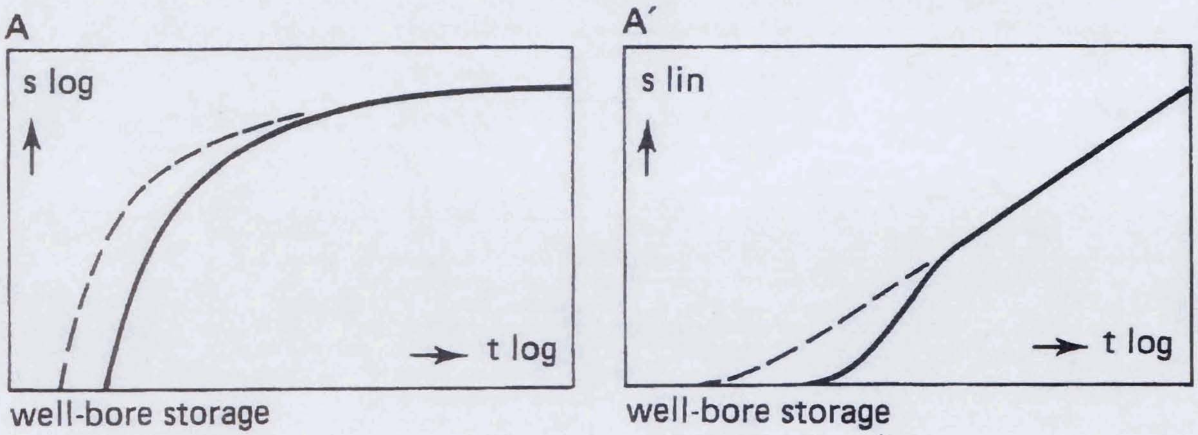


Figure 2.15 The effect of well-bore storage in the pumped well on the theoretical time-drawdown plots of observation wells or piezometers. The dashed curves are those of Parts A and A′ of Figure 2.12

Figure 3-64 - Graphic Aquifer Model Verification Methods from Kruseman & deRidder (1990, page 52)

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

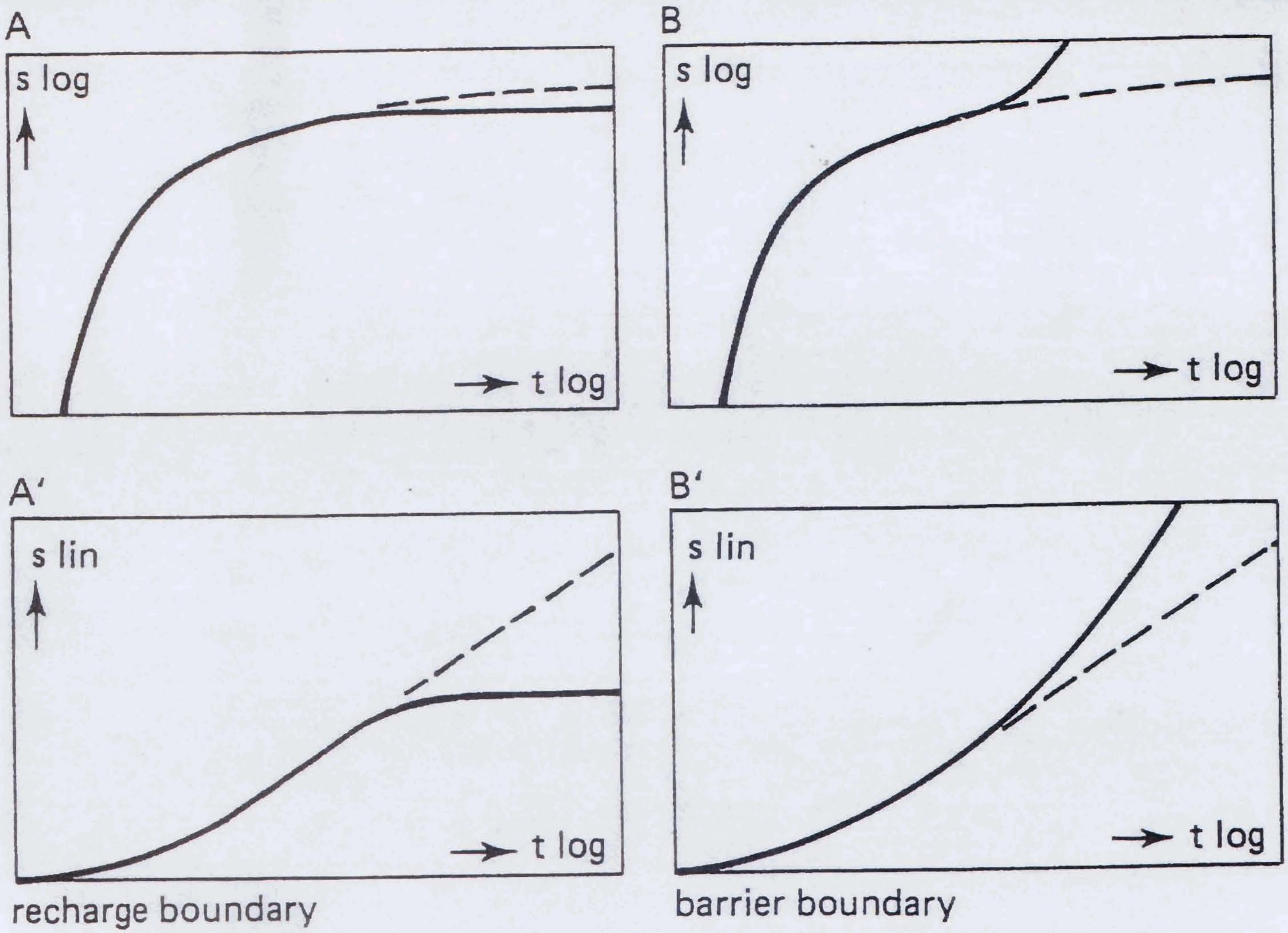


Figure 2.16 The effect of a recharge boundary (Parts A and A′) and an impermeable boundary Parts B and B′) on the theoretical time-drawdown relationship in a confined unconsolidated aquifer. The dashed curves are those of Parts A and A′ of Figure 2.12

Figure 3-65 - Graphic Aquifer Model Verification Methods from Kruseman & deRidder (1990, page 53)

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

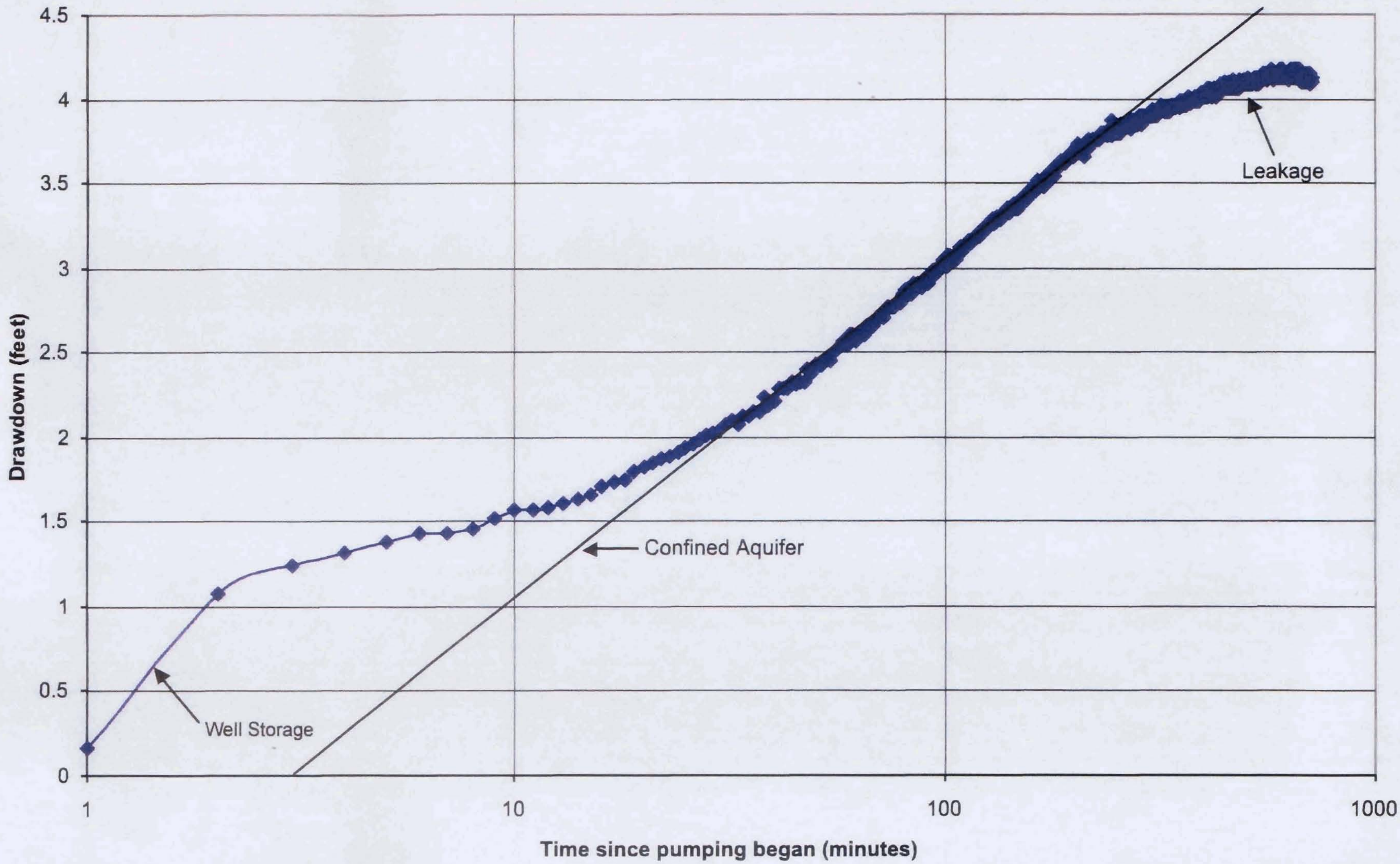


Figure 3-66 - MW211 - Pumping Well Aquifer Model Verification

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

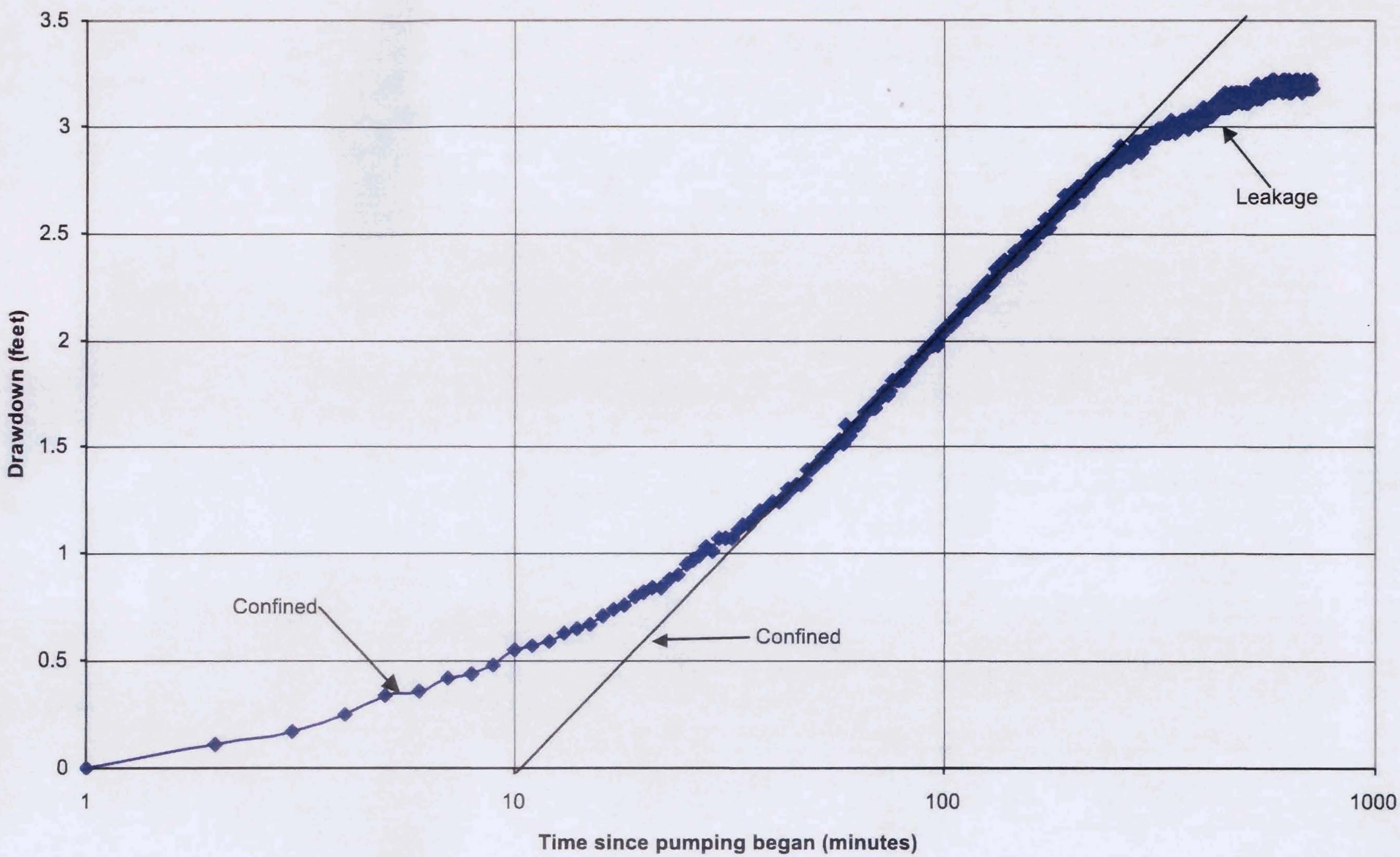


Figure 3-67 - MW204 - Observation Well Model Verification for Pumping Well 211

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

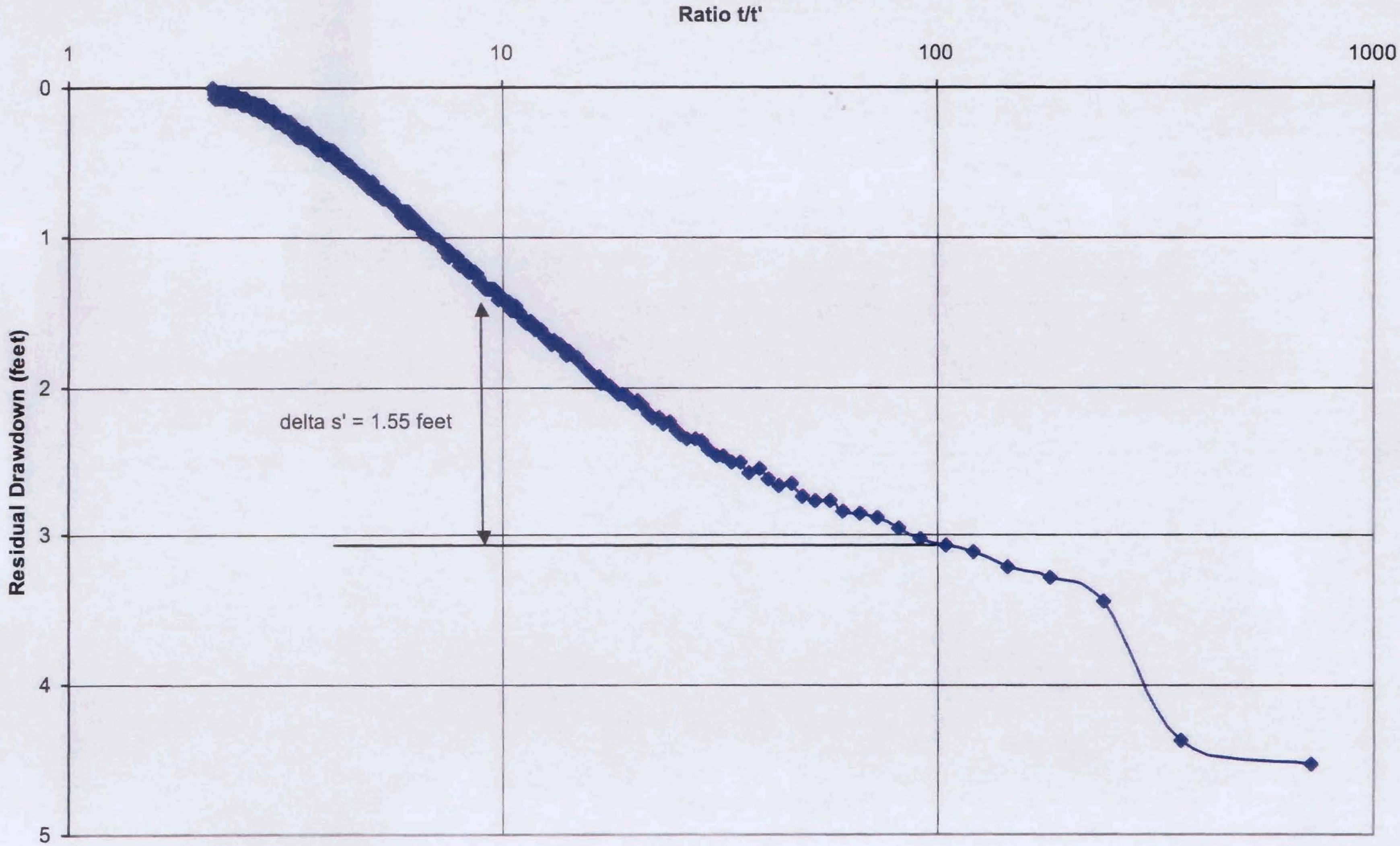


Figure 3-68 - MW211 - Recovery from Pumping

WallkillWellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

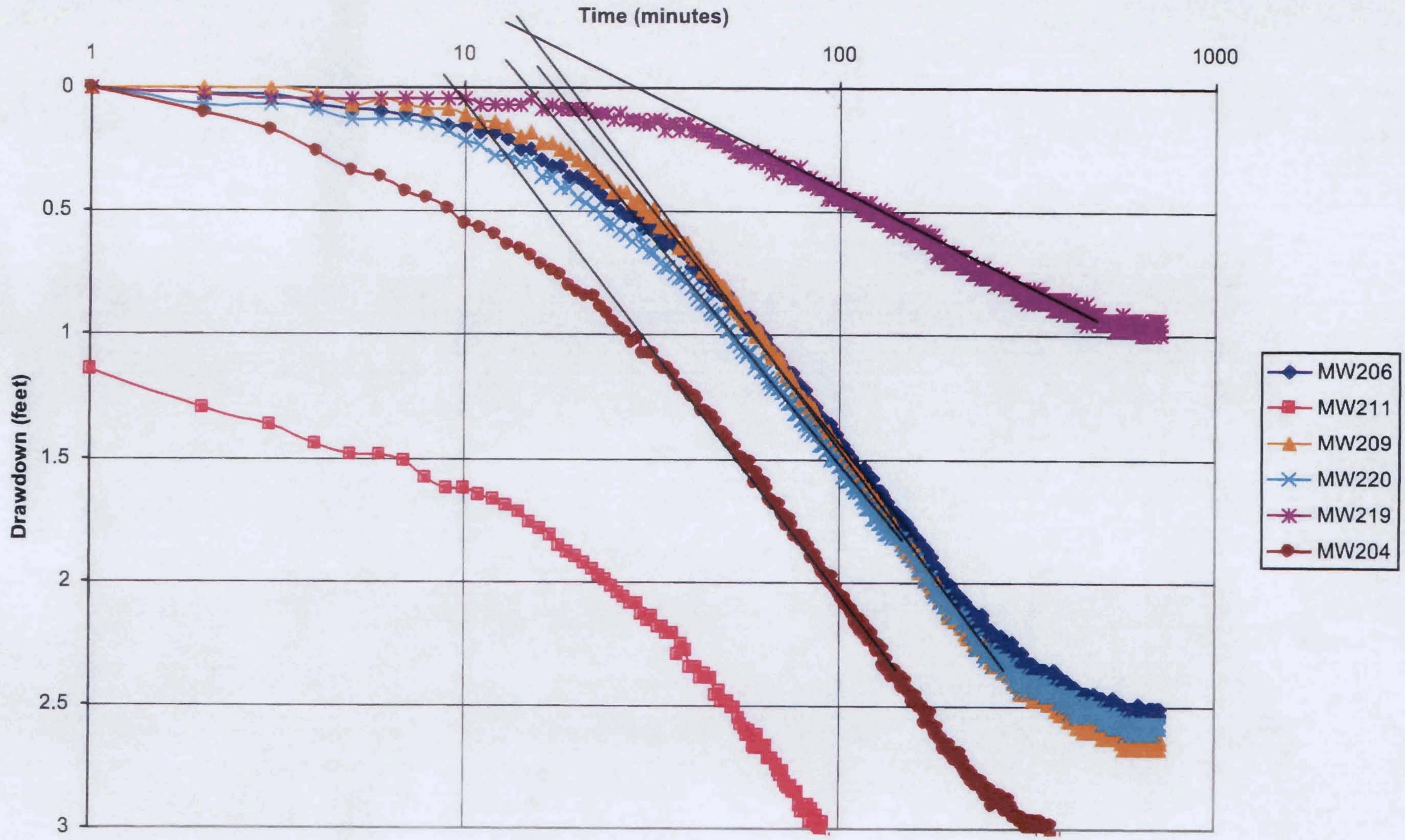


Figure 3-69 - MW211 Pumping and Observation Wells

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

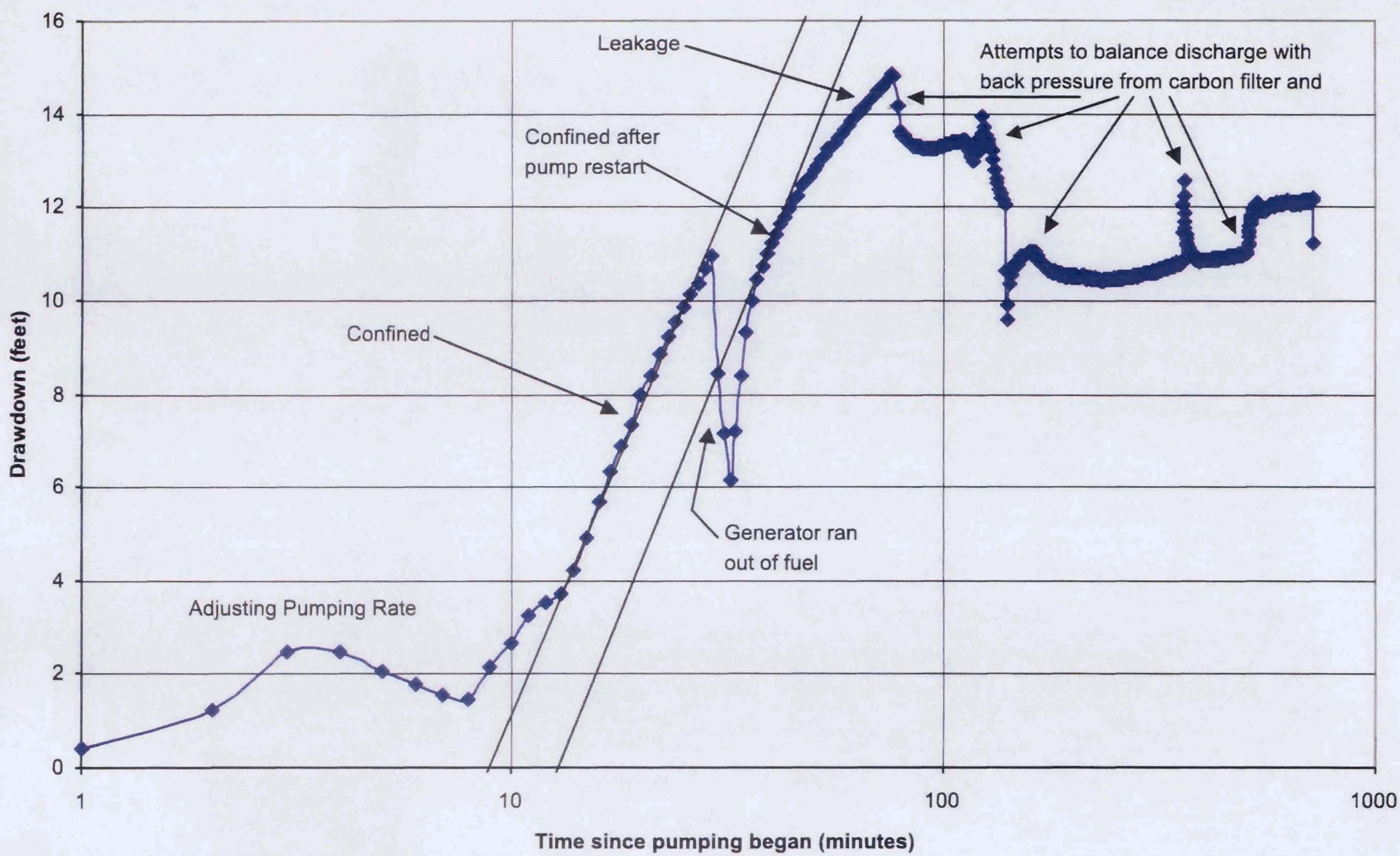


Figure 3-70 - MW206 - Pumping Well Aquifer Model Verification

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

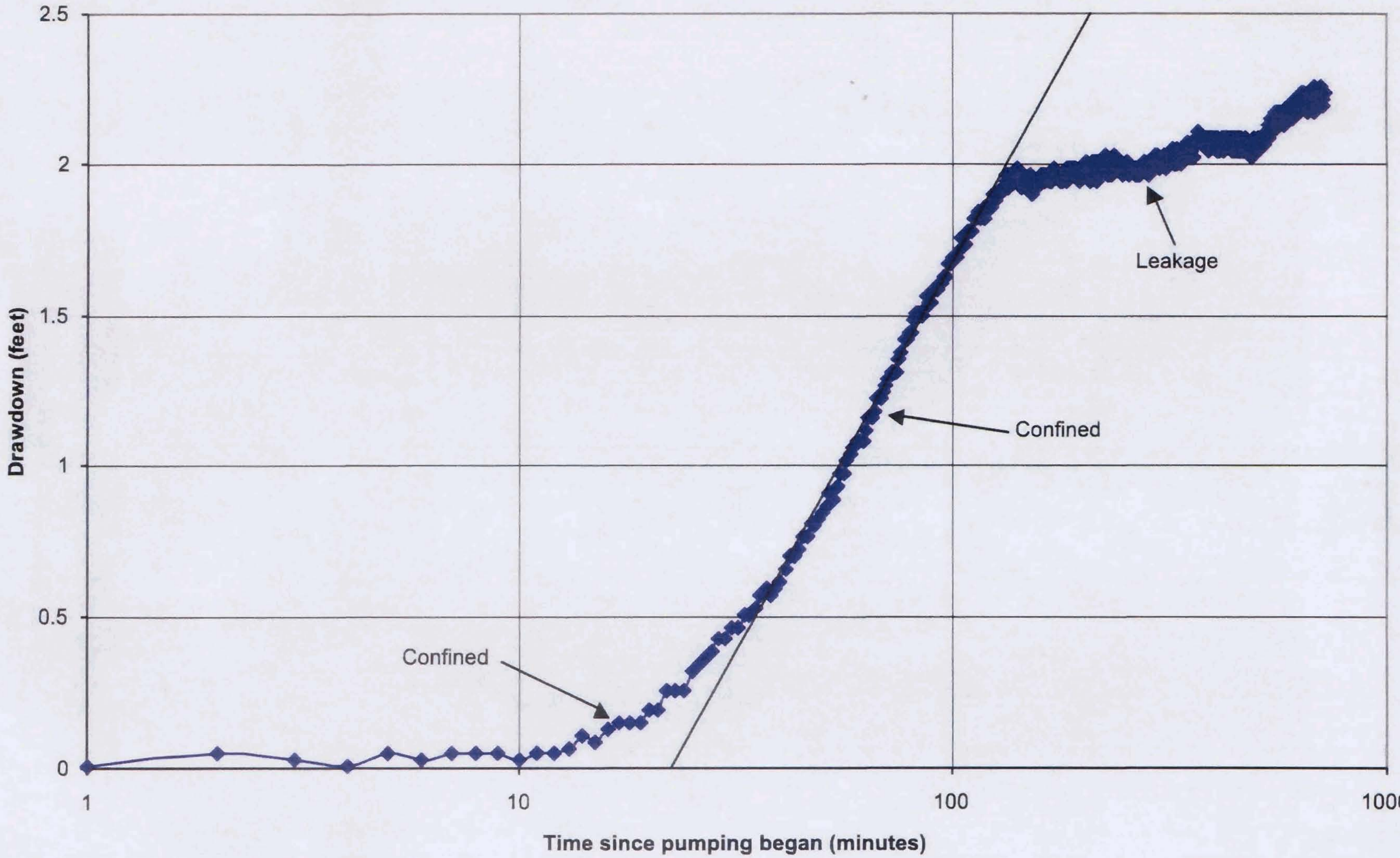


Figure 3-71 - MW204 - Observation Well Model Verification for Pumping Well 206	ESI File: LM97145.45
Wallkill Wellfield Site City of Middletown Orange County, New York	October 2007
	Appendix A

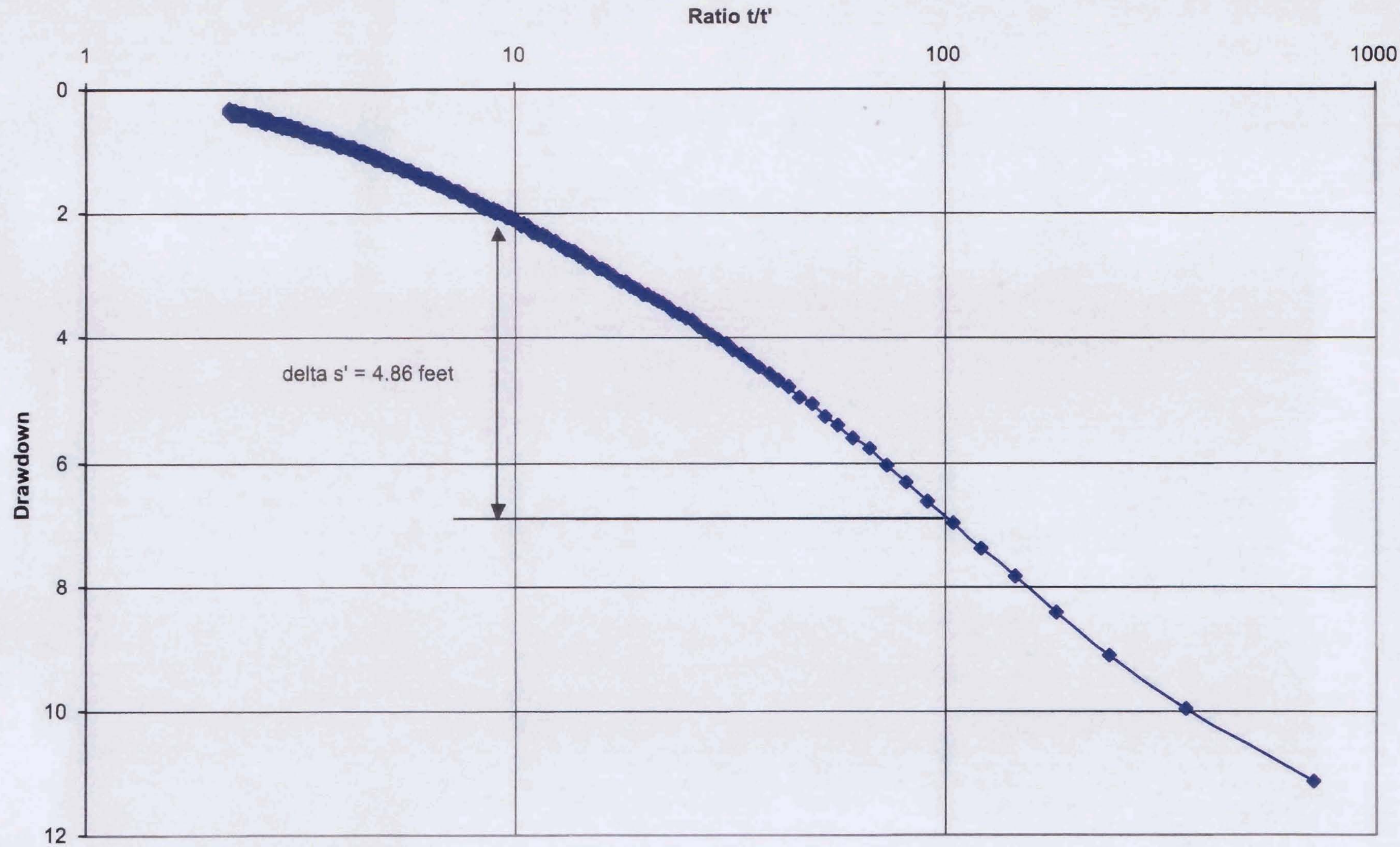


Figure 3-72 - MW206 - Recovery from Pumping

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

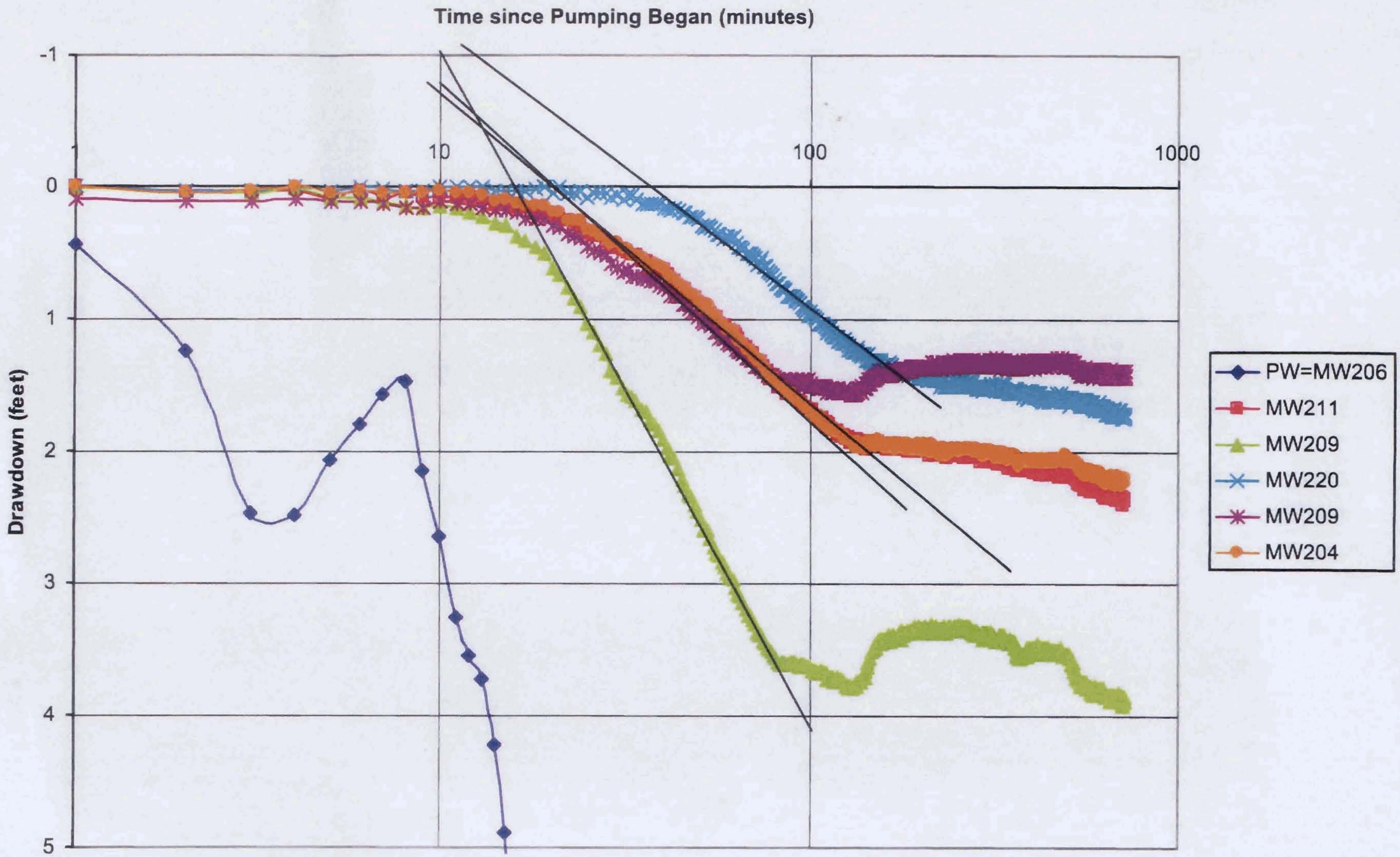


Figure 3-73 - MW206 Pumping and Observation Wells

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

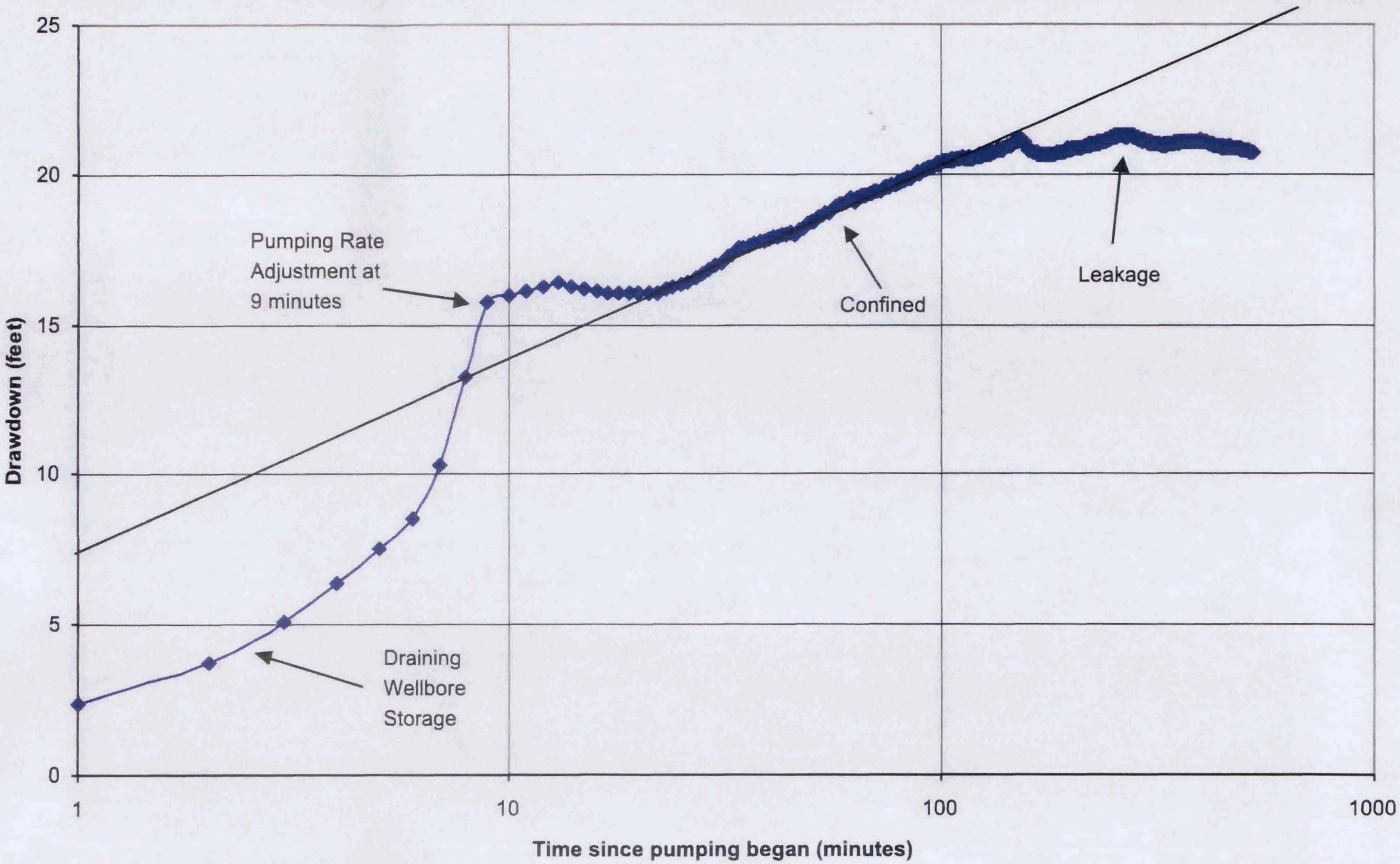


Figure 3-74 - MW209 - Pumping Well Aquifer Model Verification Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

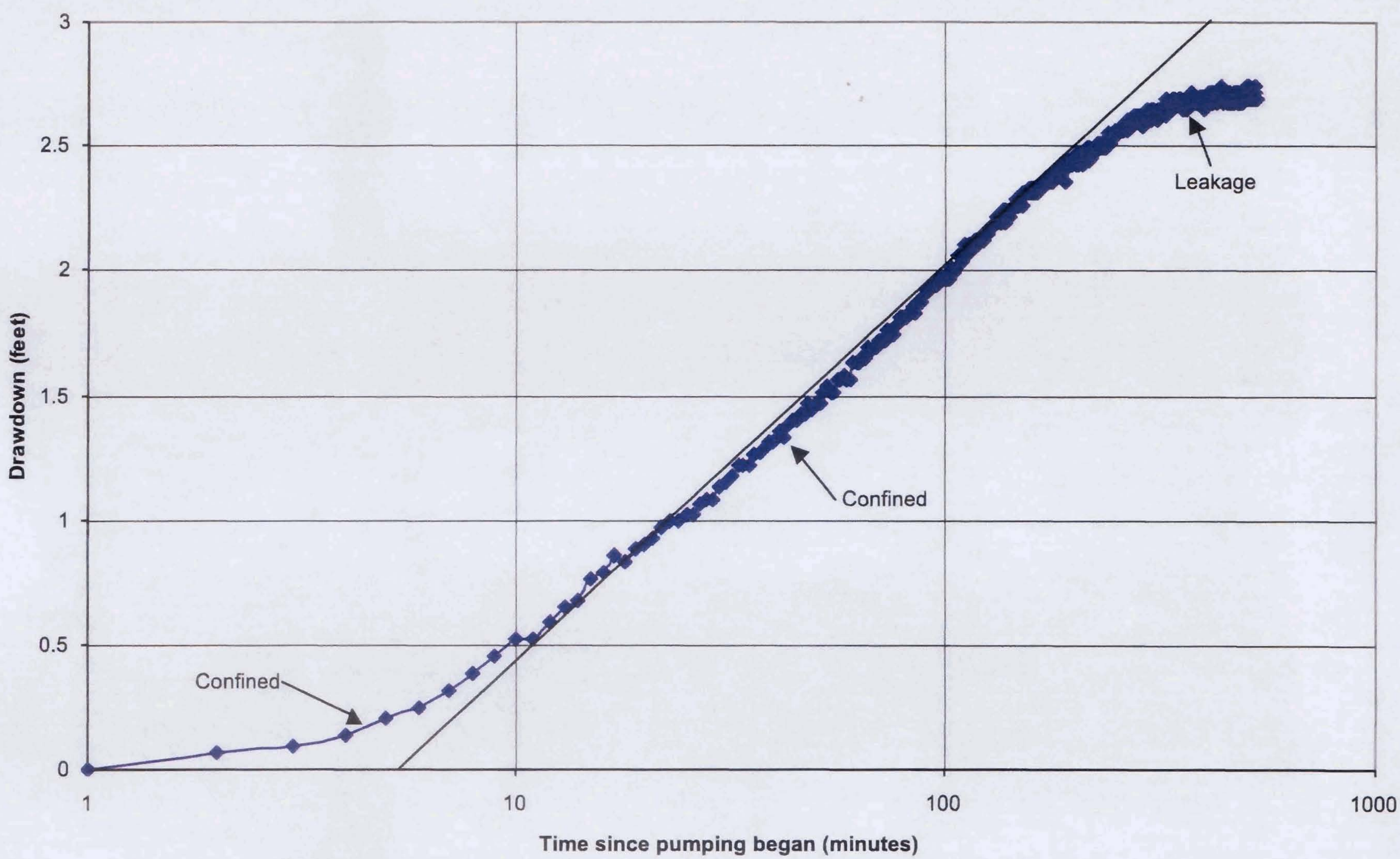


Figure 3-75 - MW211 - Pumping Well Aquifer Model Verification

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

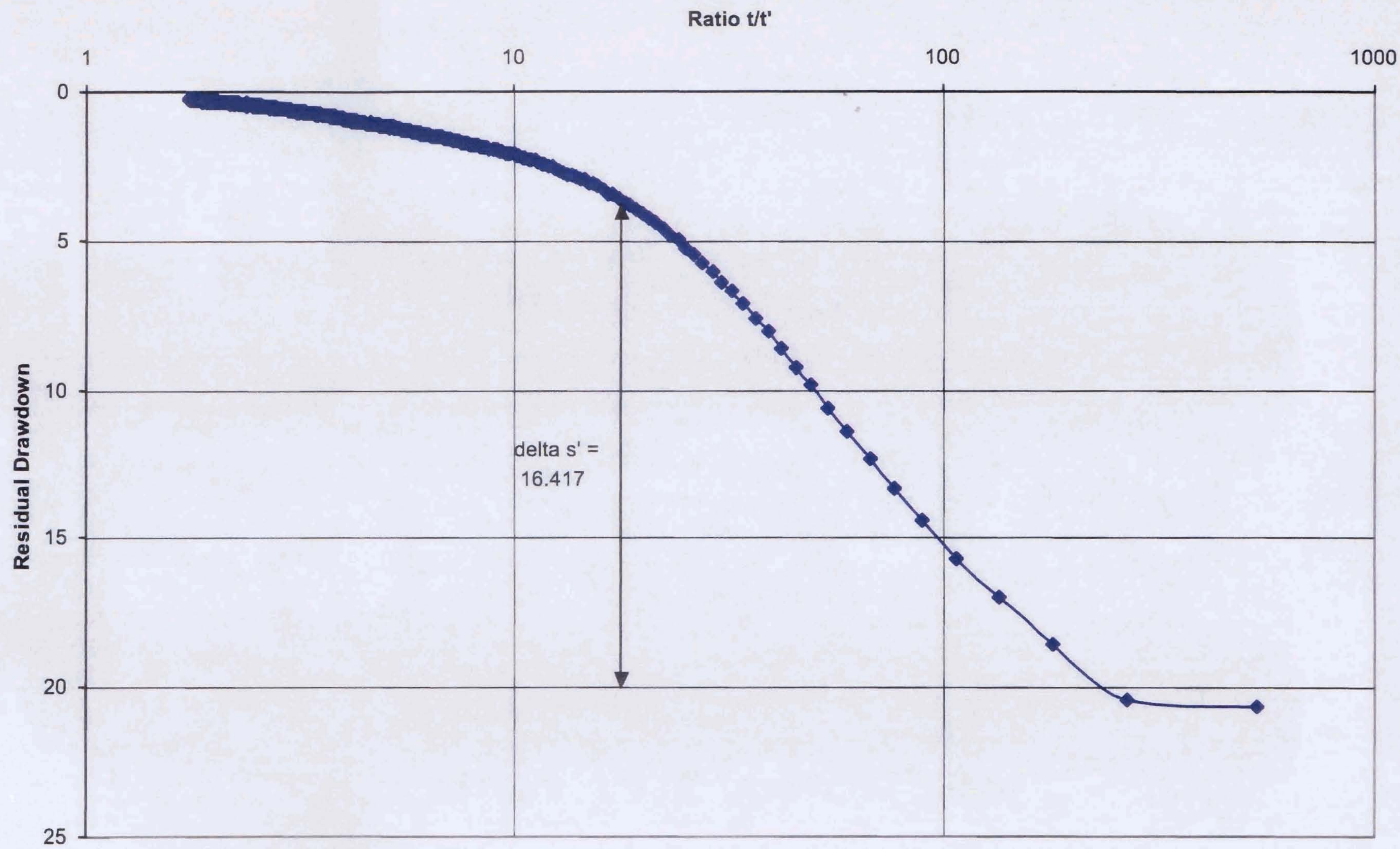


Figure 3-76 - MW209 - Recovery from Pumping

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

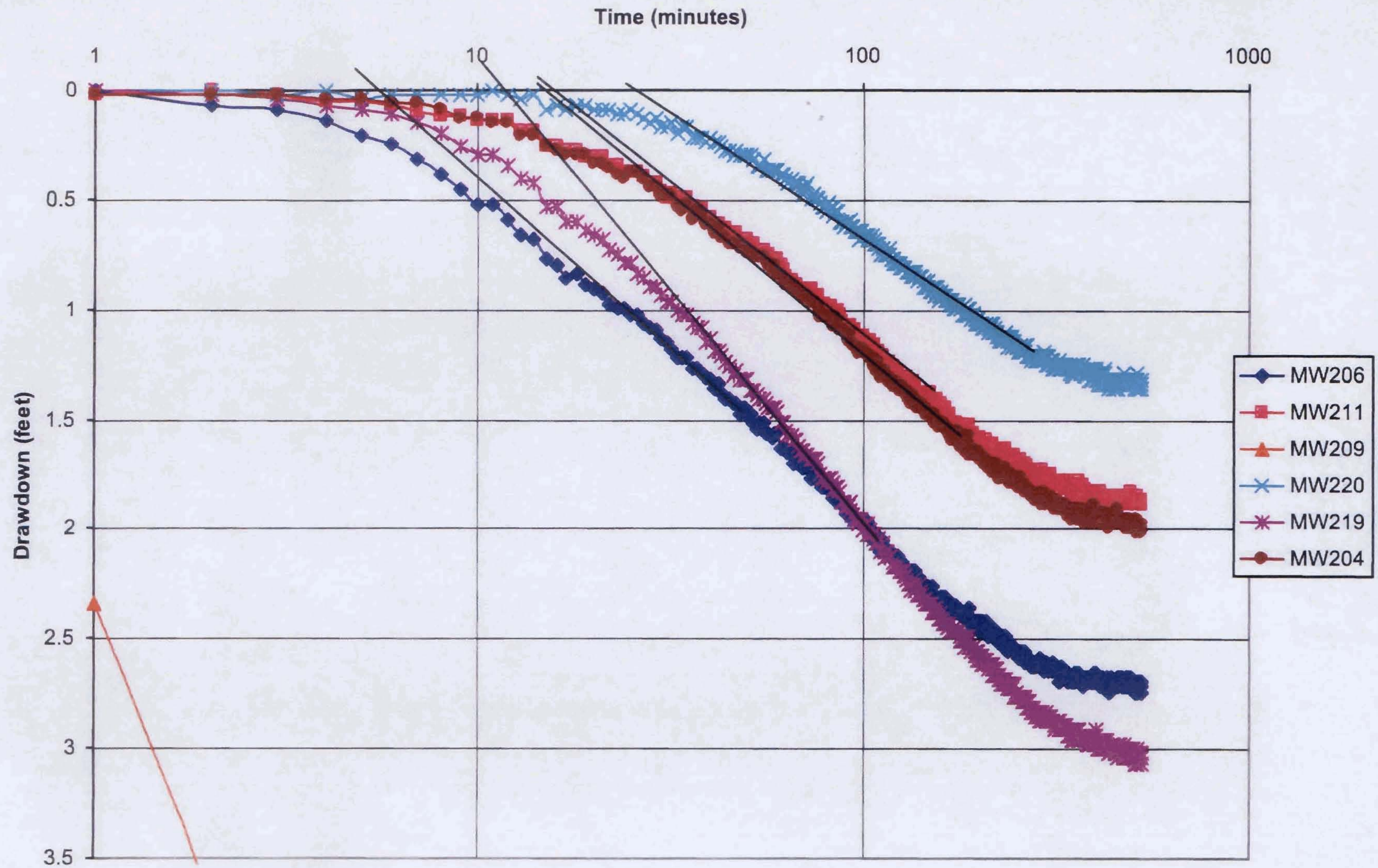


Figure 3-77 - MW209 Pumping and Observation Wells

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

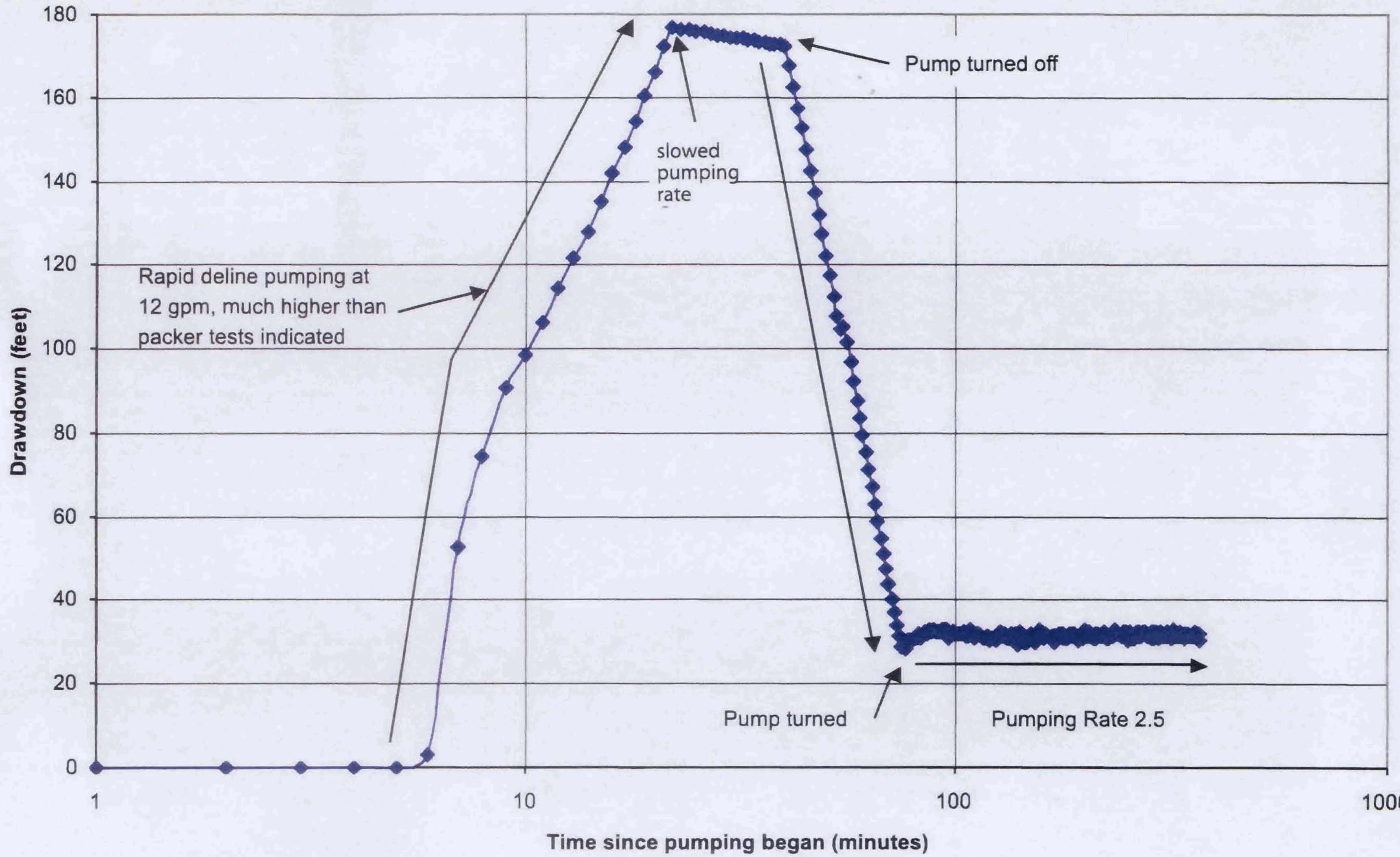


Figure 3-78 - MW220 - Pumping Well Aquifer Model Verification

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

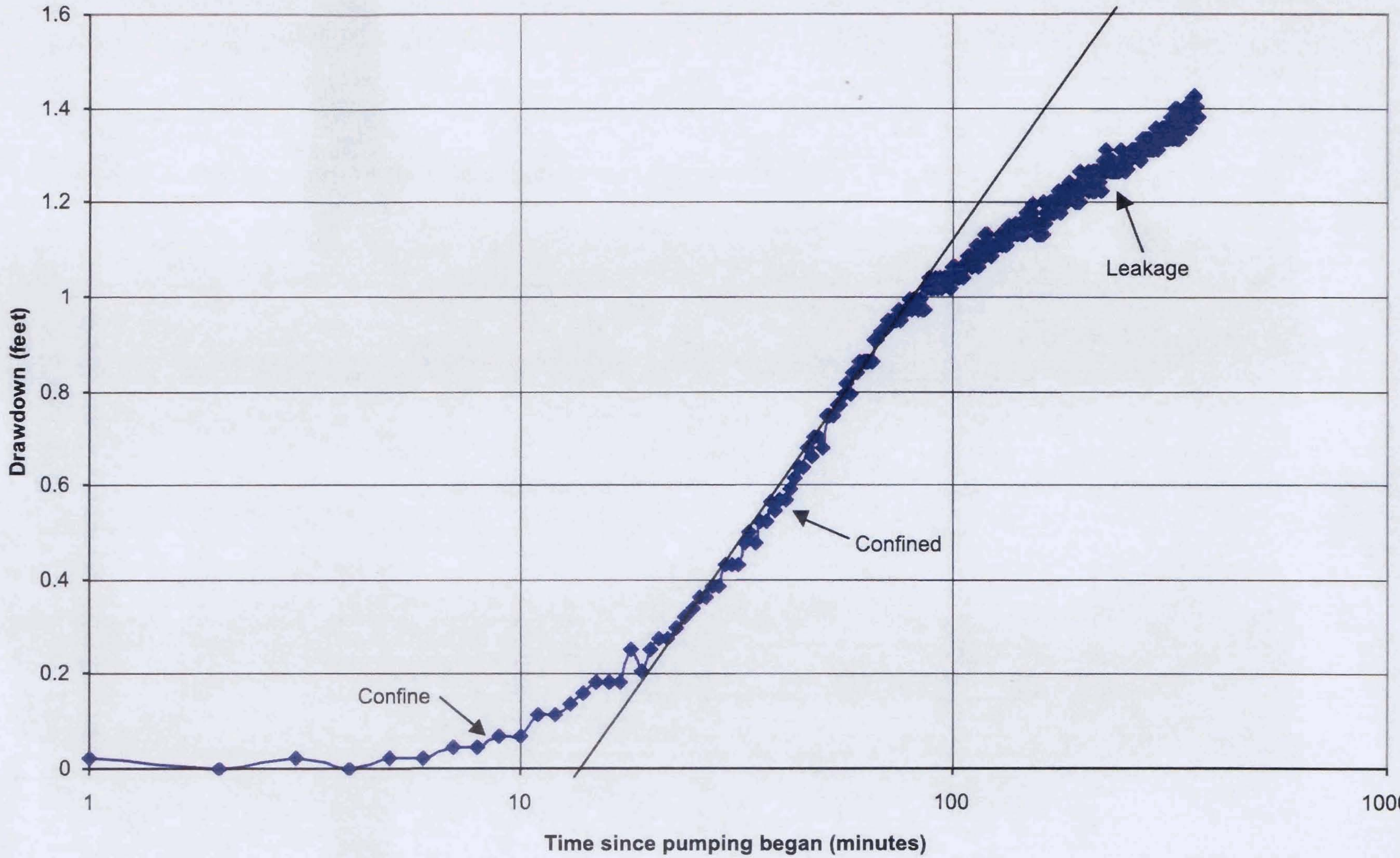


Figure 3-79 - MW206 - Observation Well Model Verification for Pumping Well 220

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

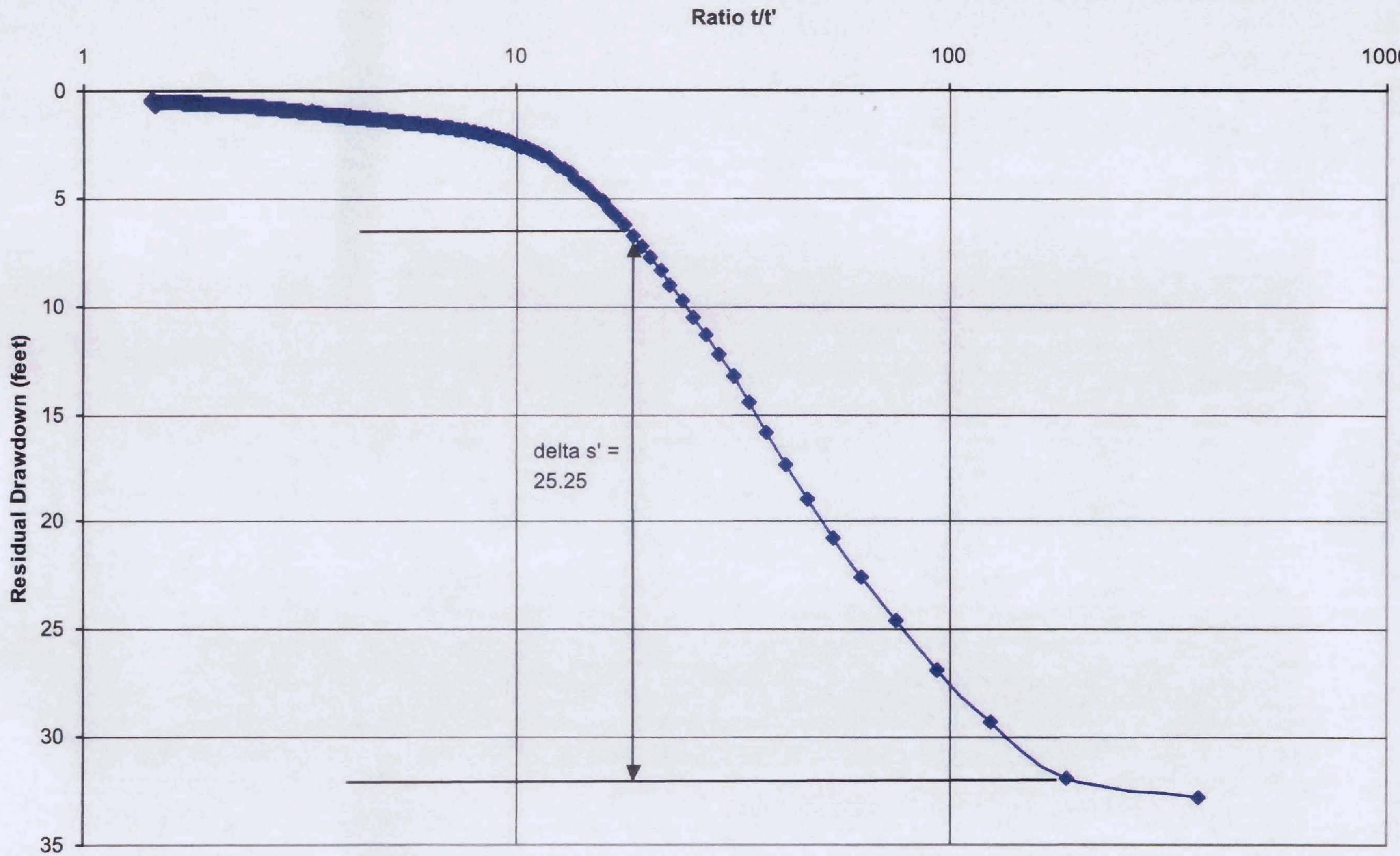


Figure 3-80 - MW220 - Recovery from Pumping

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

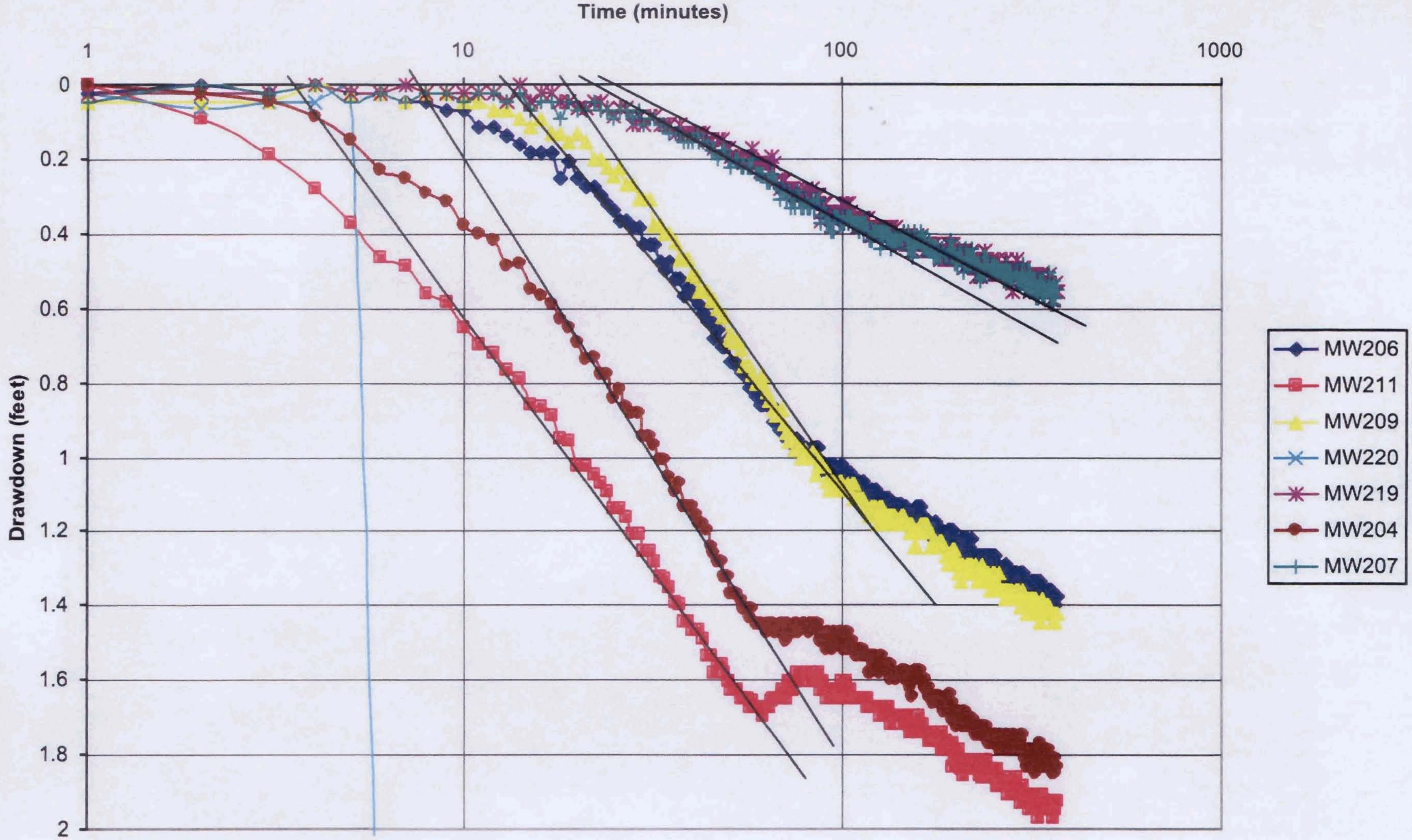


Figure 3-81 - MW220 Pumping and Observation Wells

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

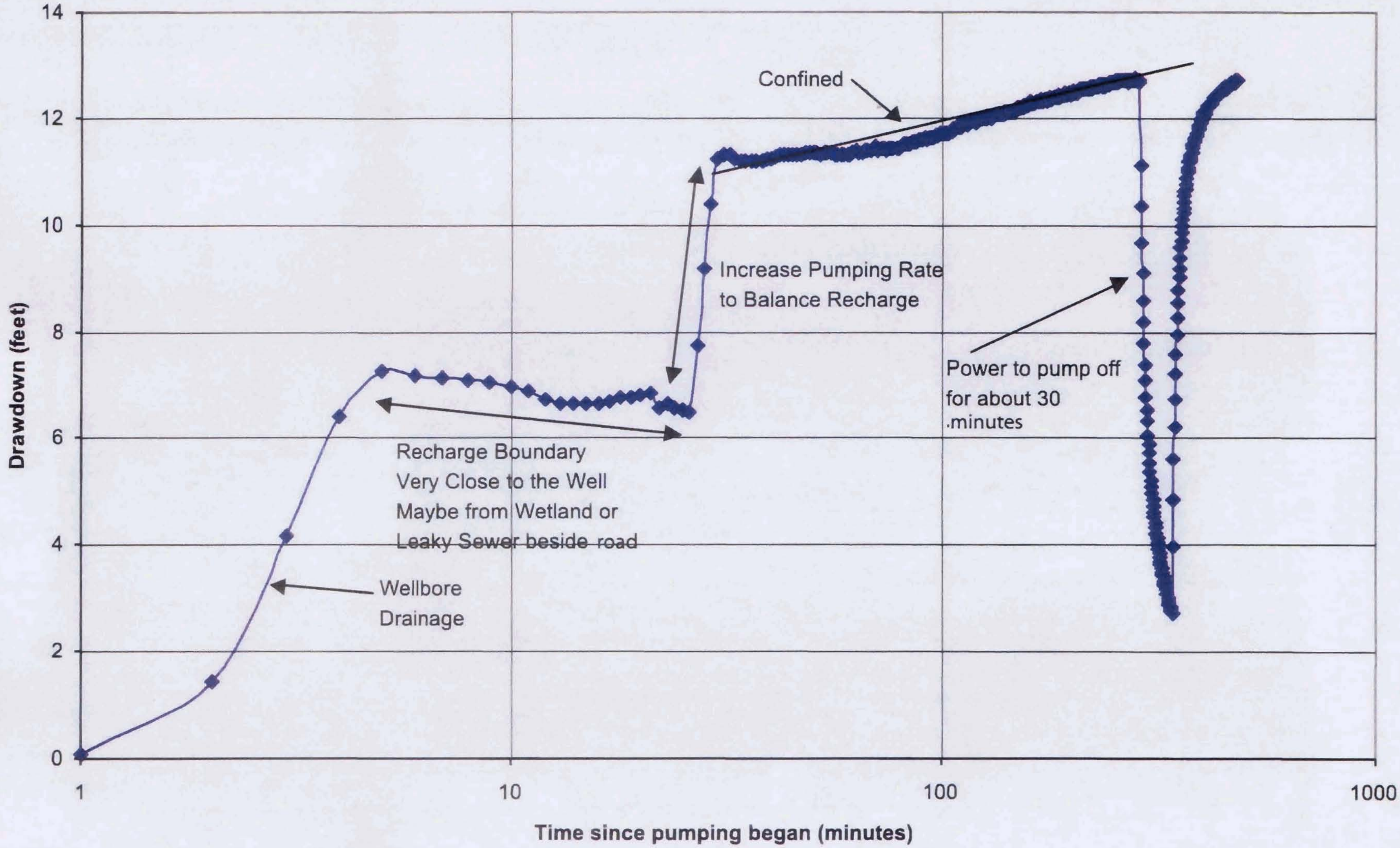


Figure 3-82 - MW219 - Pumping Well Aquifer Model Verification

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

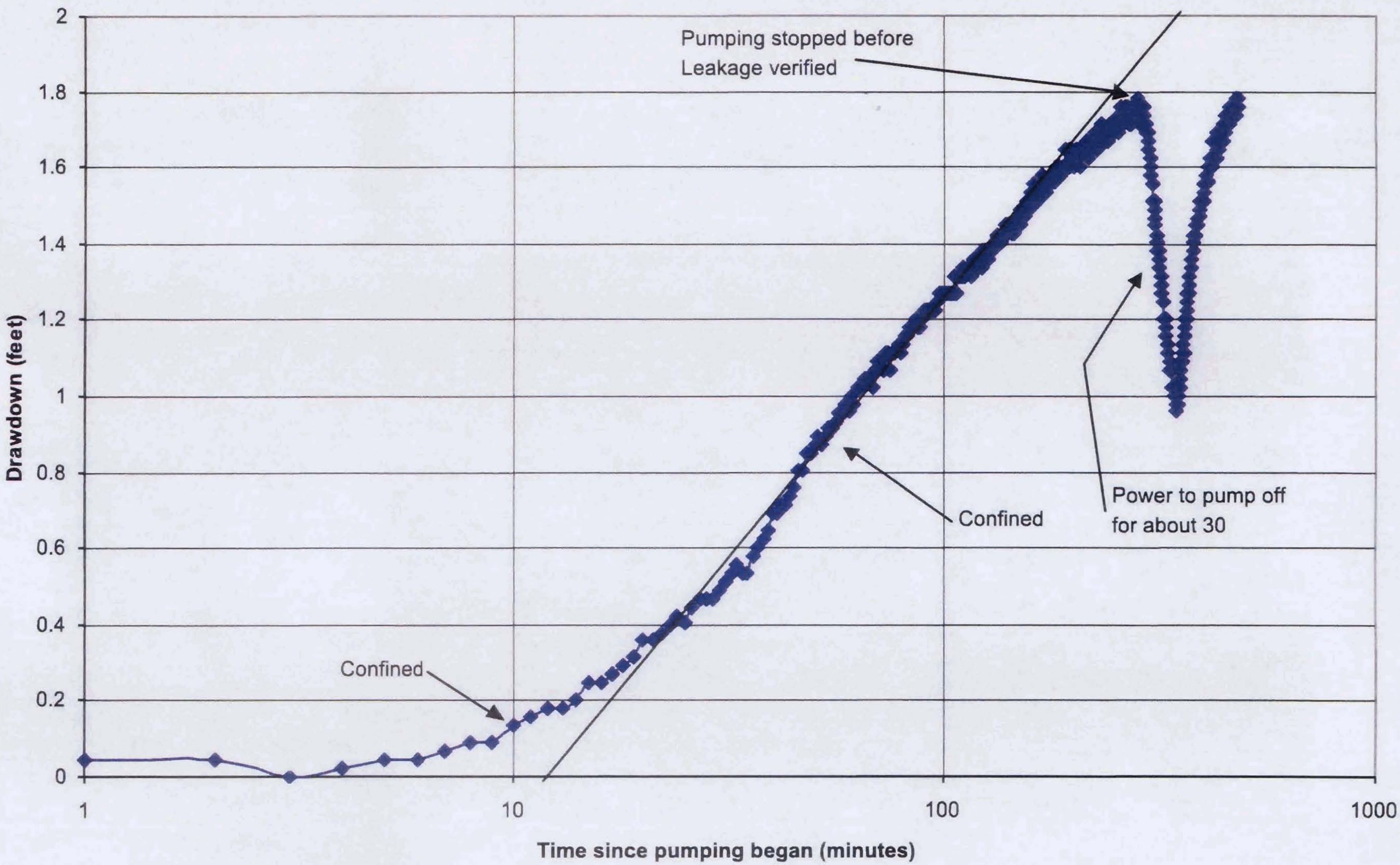


Figure 3-83 - MW209 - Observation Well Model Verification for Pumping Well 219 Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

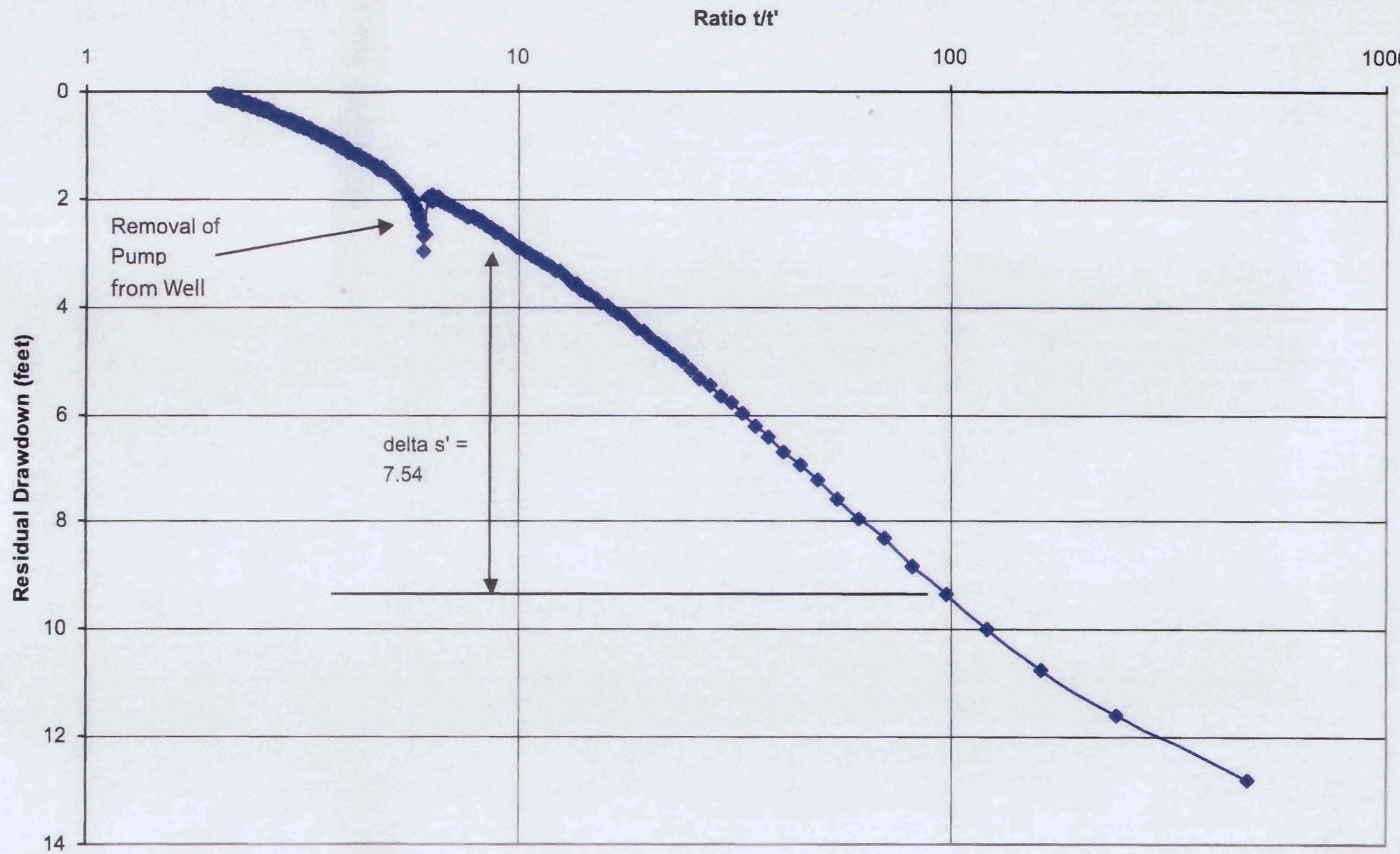


Figure 3-84 - MW219 - Recovery from Pumping Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

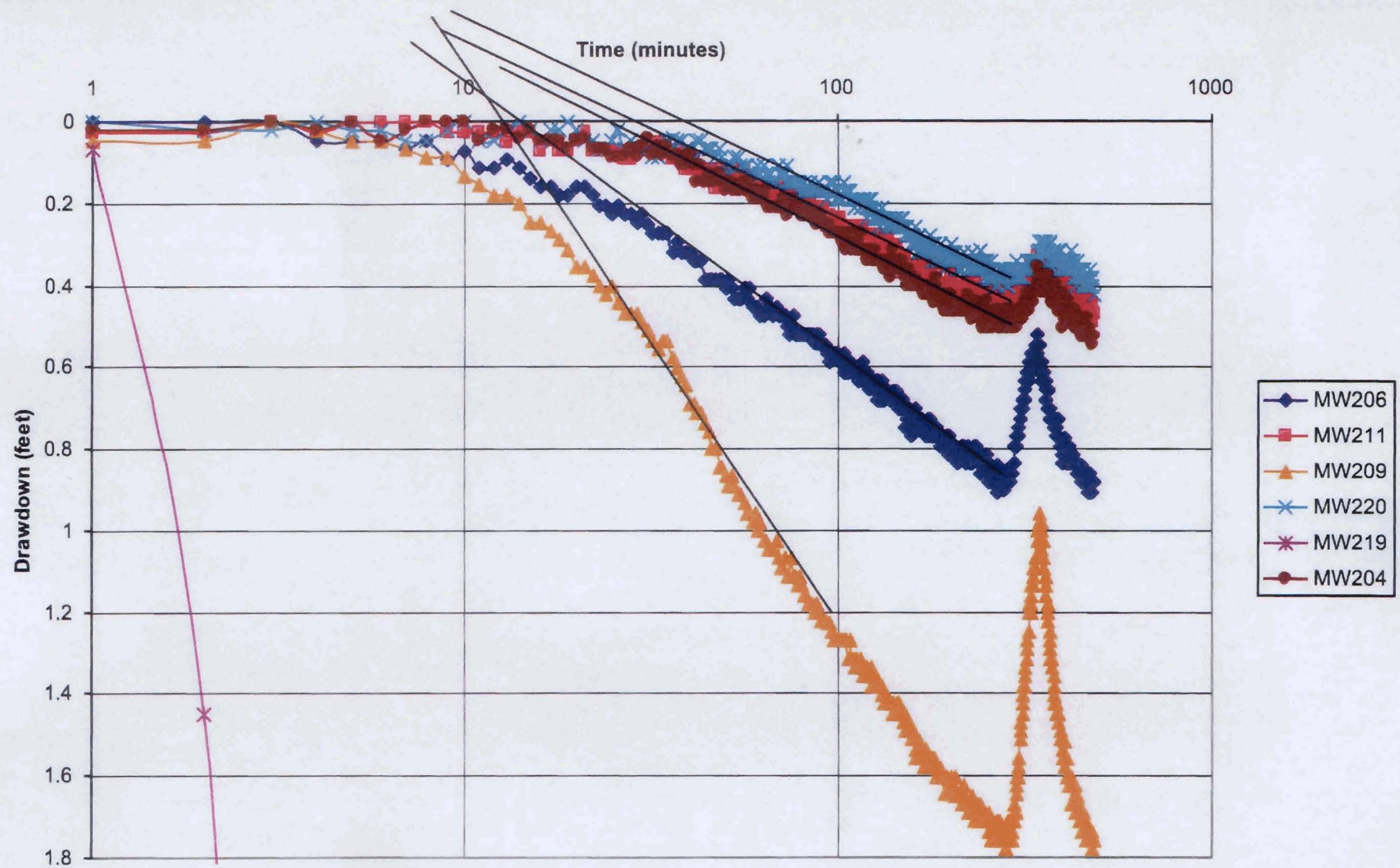


Figure 3-85 - MW219 Pumping and Observation Wells

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

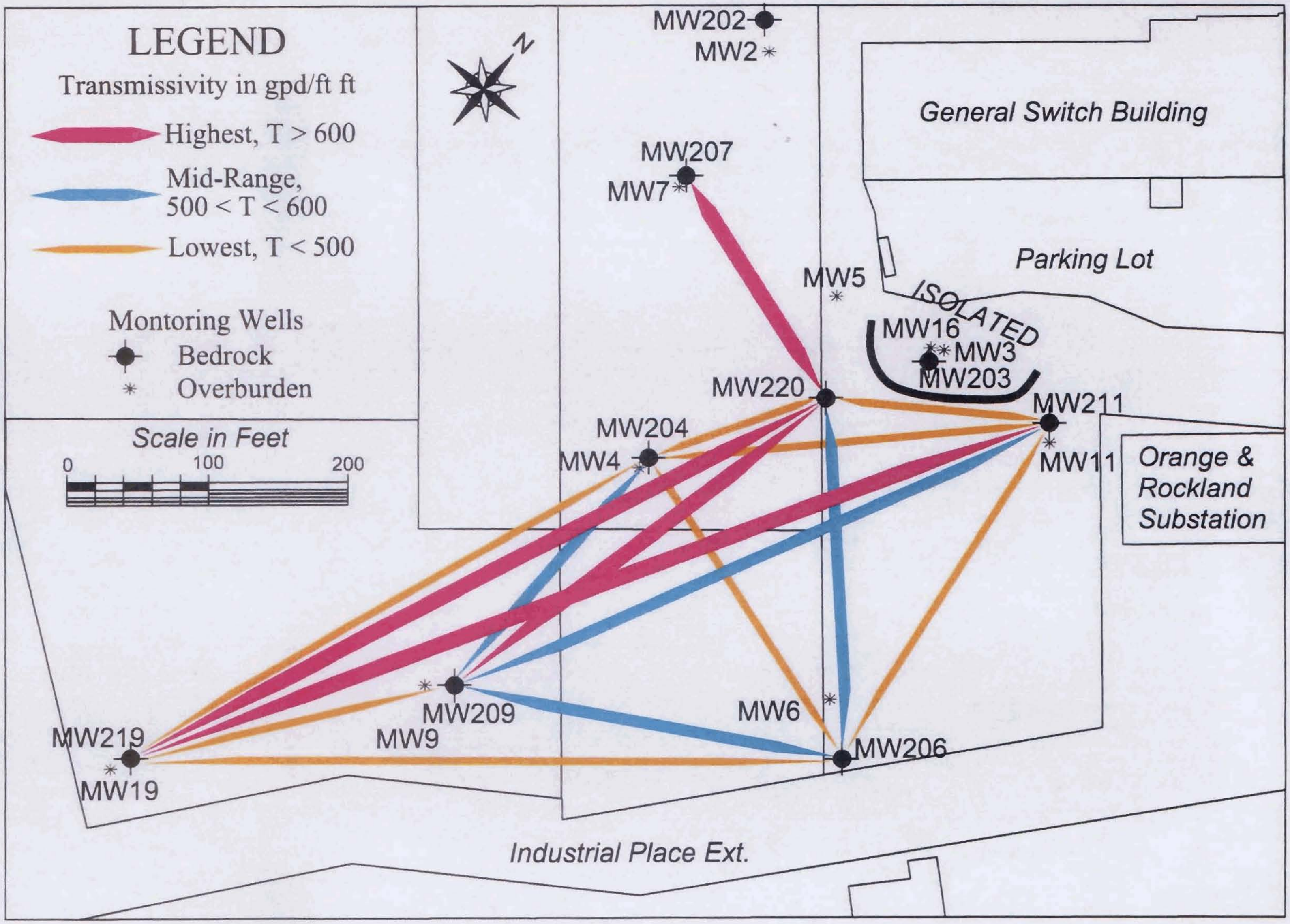


Figure 3-86 - Preferential Flow Directions
"Highest Transmissivity Chosen fom Calulation Pairs (Table 3-5)"
Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

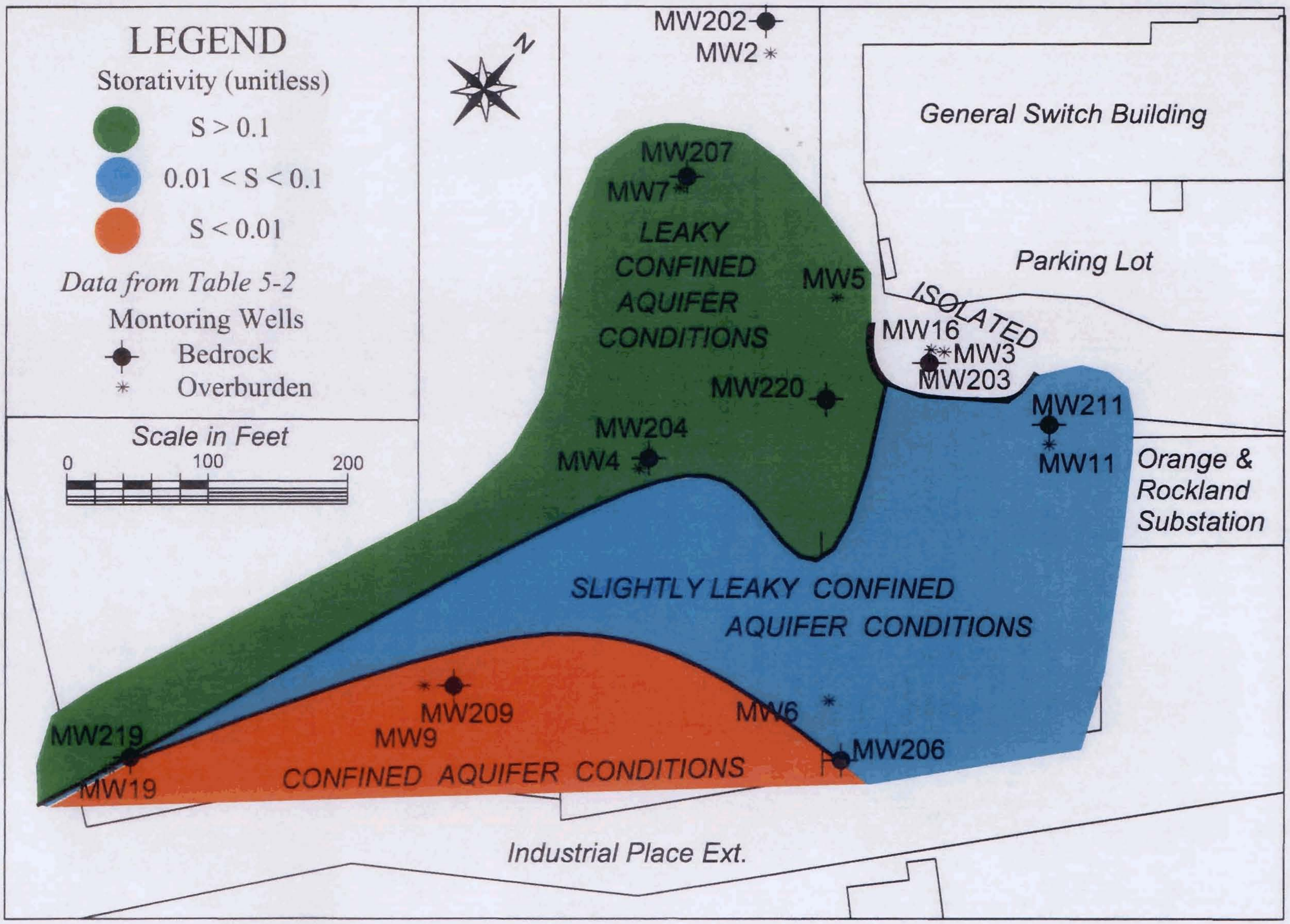


Figure 3-87 - Areal Variations in Storativity

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

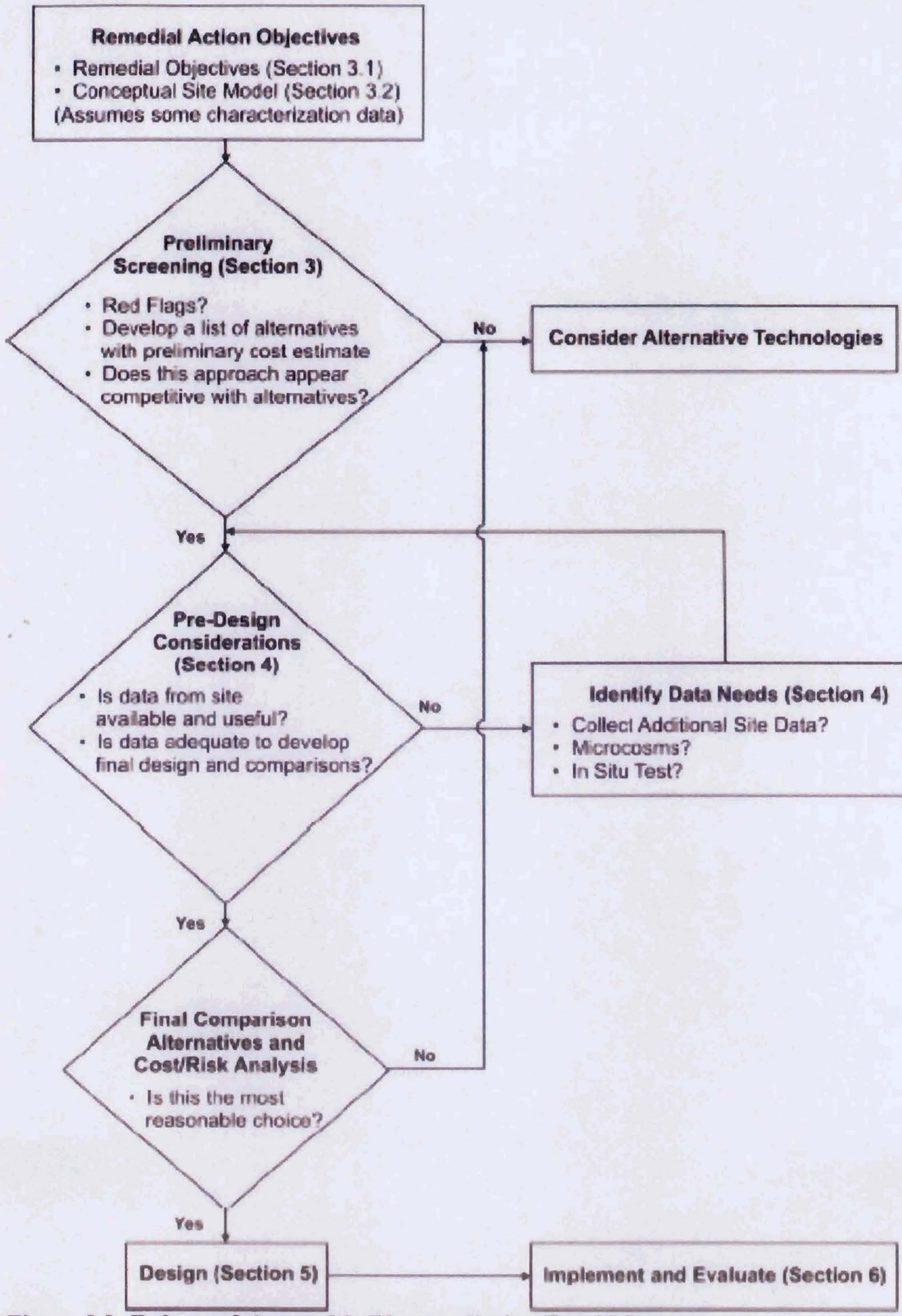


Figure 1.1 Enhanced Anaerobic Bioremediation Road Map

Figure 4-1 - Enhanced Anaerobic Bioremediation Road Map Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

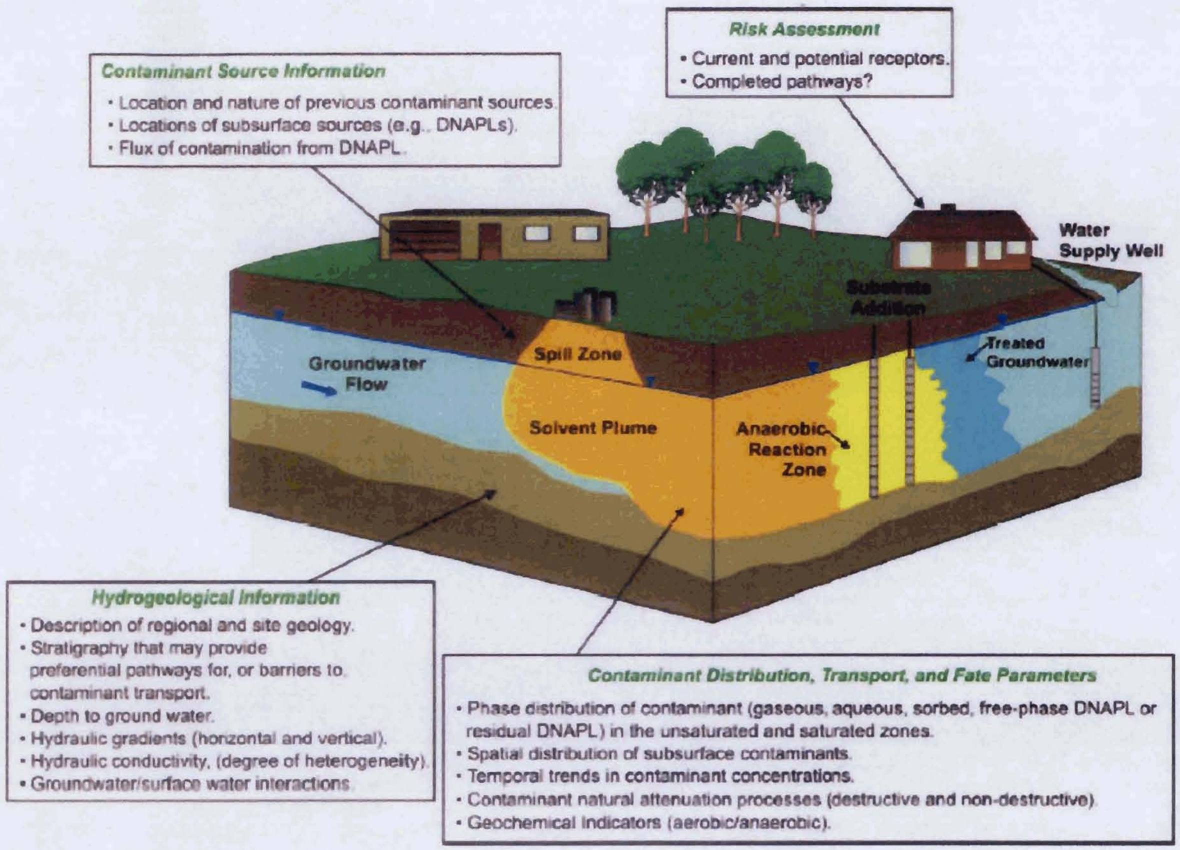
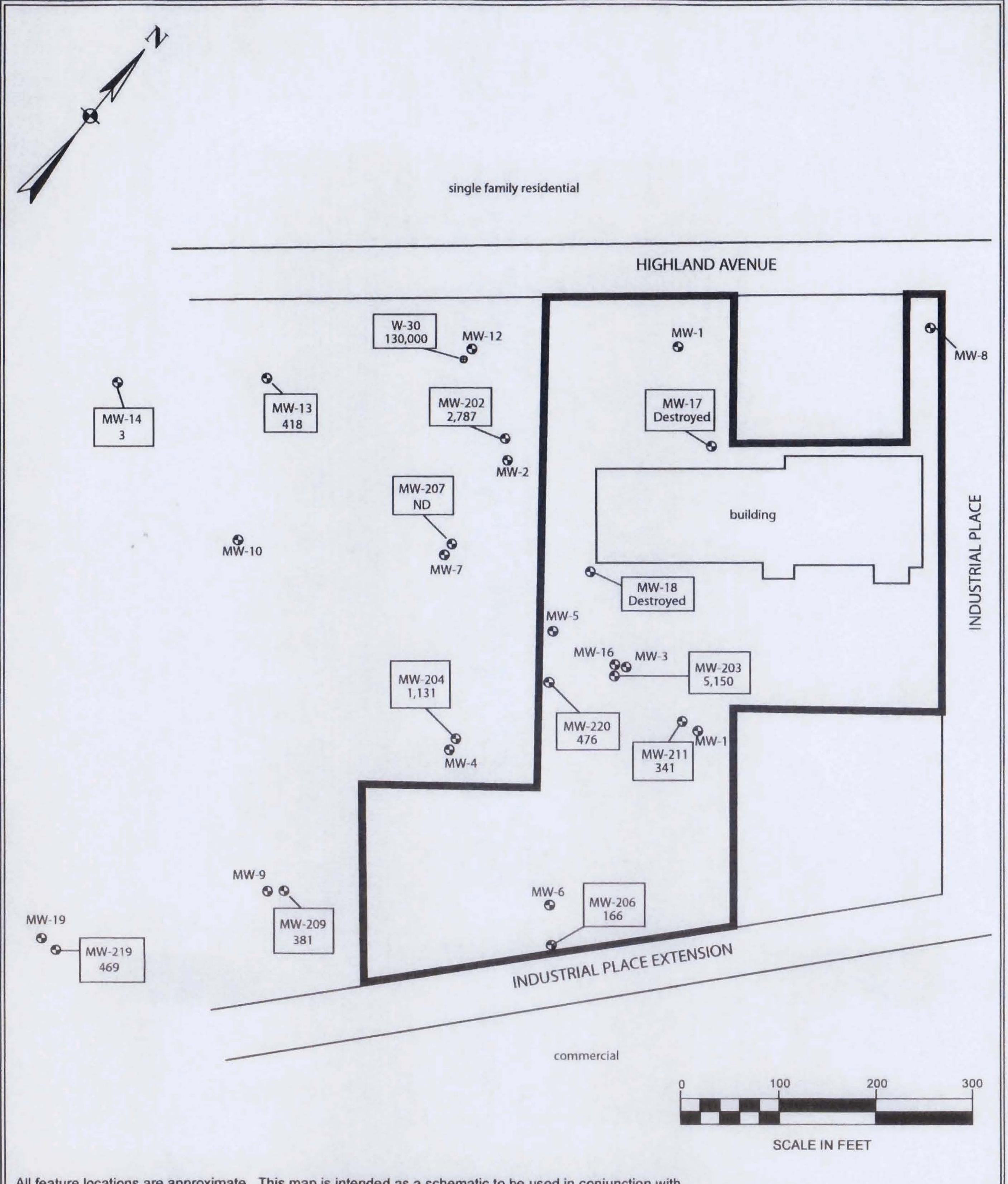


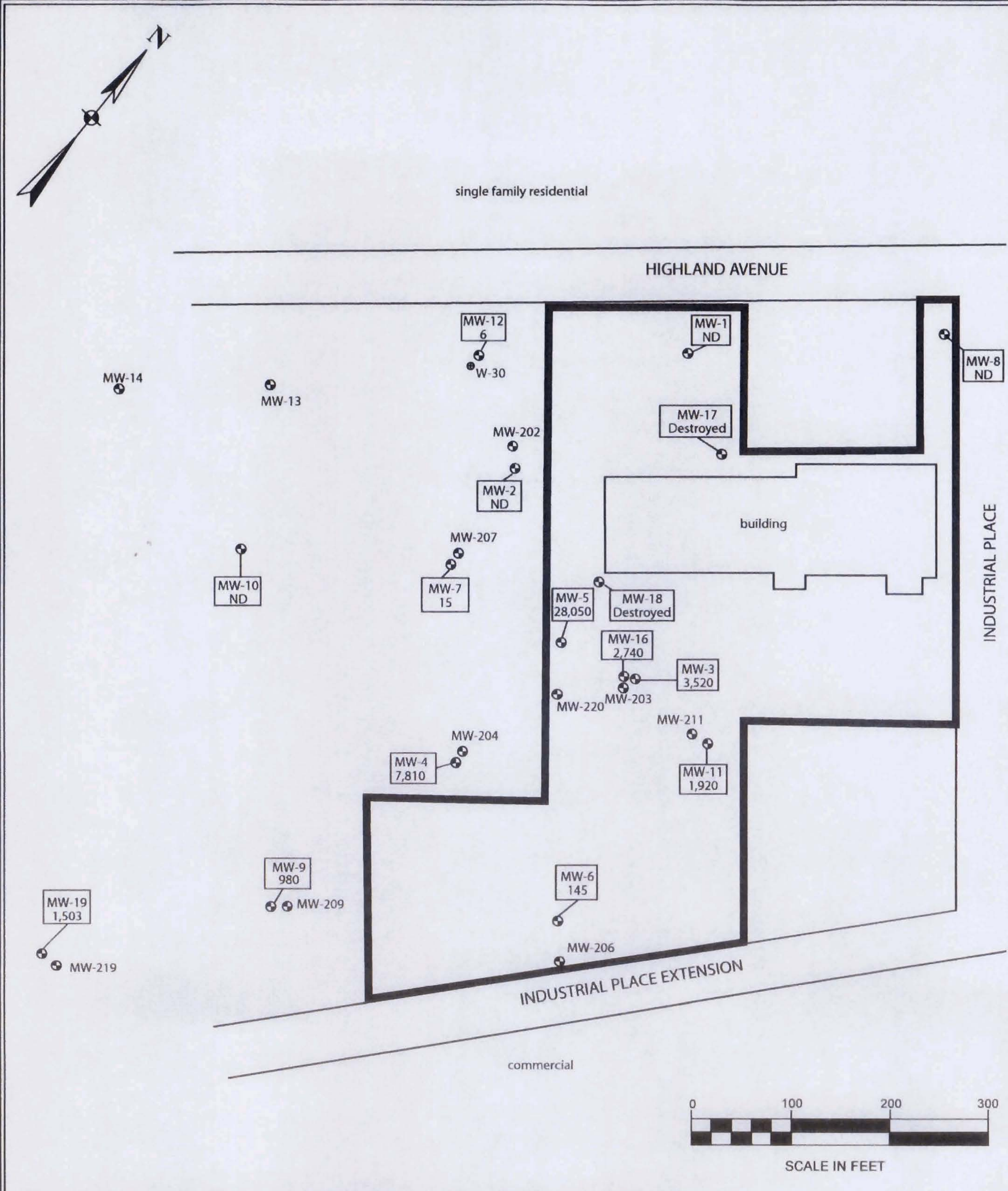
Figure 3.2 Elements of a Conceptual Site Model

Figure 4-2 - Elements of a Conceptual Site Model Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A



All feature locations are approximate. This map is intended as a schematic to be used in conjunction with the associated report, and it should not be relied upon as a survey for planning or other activities.

Figure 4-3 - Total VOCs in Deep Bedrock Monitoring Wells May 2005 Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: subject property border monitor well location ⊕ private well MW-9 — monitor well ID 980 — Total VOCs detected ND = Not detected above specified detection limit All concentrations expressed in μg/L.	ESI File: LM97145.45 October 2007 Scale as shown Appendix A



All feature locations are approximate. This map is intended as a schematic to be used in conjunction with the associated report, and it should not be relied upon as a survey for planning or other activities.

Figure 4-4 - Total VOCs in Shallow Overburden Monitoring Wells May 2005 Wallkill Wellfield Site City of Middletown Orange County, New York	Legend: ▬ subject property border monitor well location ⊕ private well MW-9 — monitor well ID 980 — Total VOCs detected ND = Not detected above specified detection limit All concentrations expressed in μg/L.	ESI File: LM97145.45 October 2007 Scale as shown Appendix A

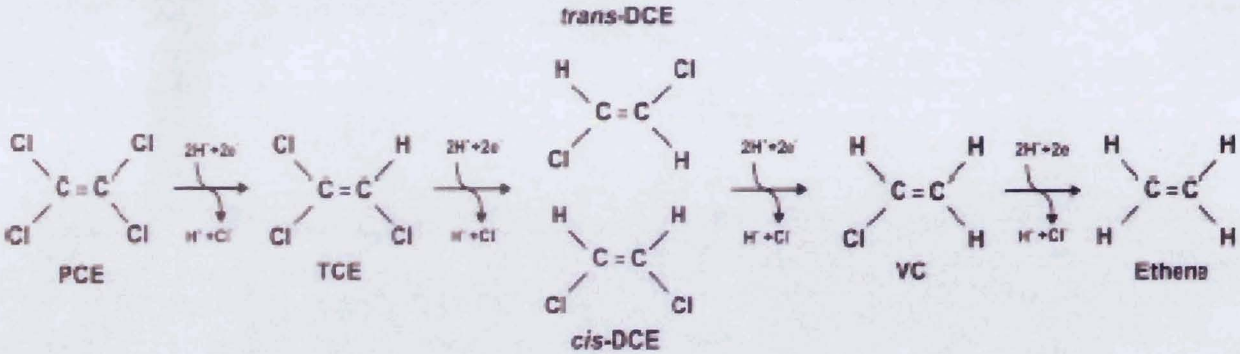


Figure 1.4 Sequential Reduction of PCE to Ethene by Anaerobic Reductive Dechlorination

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) "Principles and Practices of Enhanced Bioremediation of Chlorinated Solvents," online PDF, Figure 1.4, page 1-11.

Figure 4-5 - Sequential Reduction of PCE to Ethene by Anaerobic Reductive Dechlorination Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

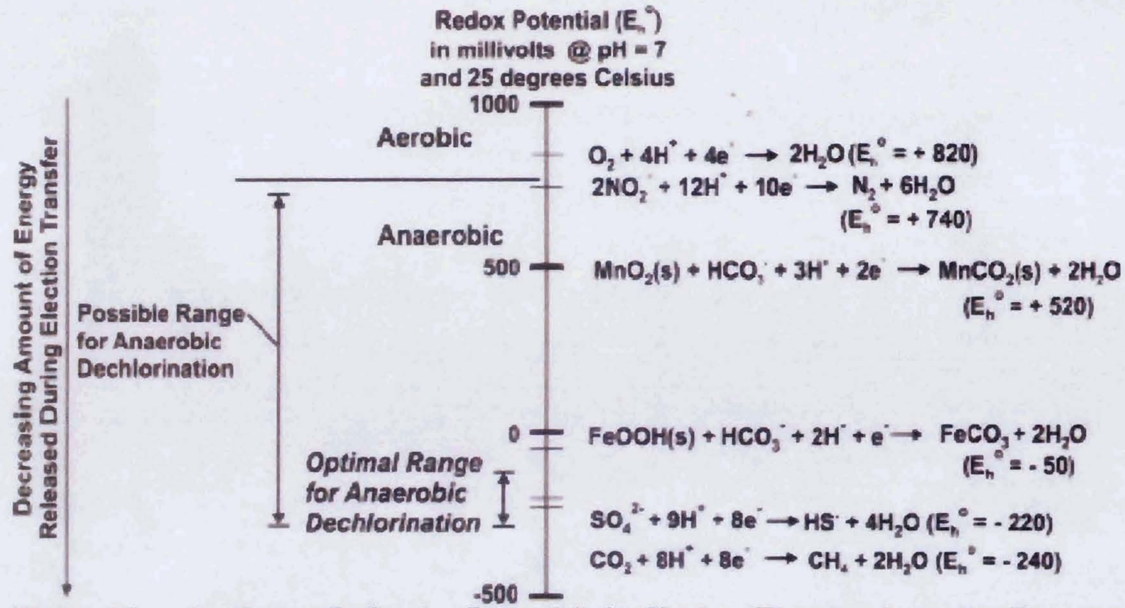
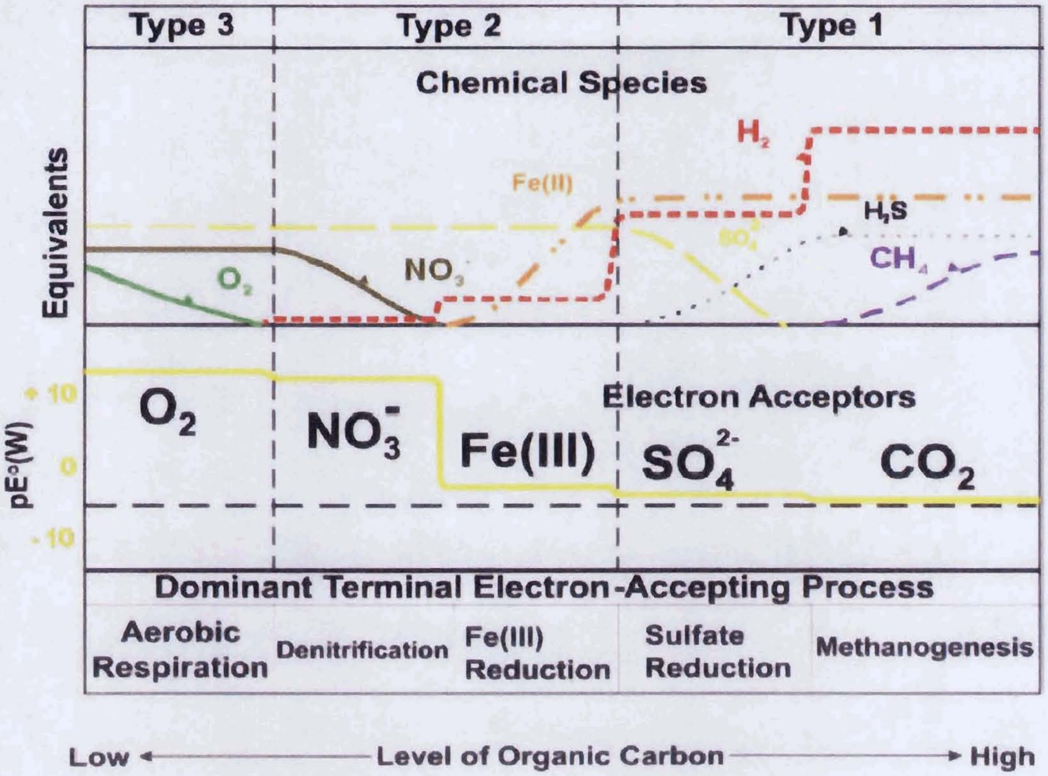


Figure 2.1 Oxidation-Reduction Potentials for Various Electron-Accepting Processes (modified from Bouwer, 1994)

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) "Principals and Practices of Enhanced Biroremediation of Chlorinated Solvents," on-line PDF, Figure 2.1, page 2-5.

Figure 4-6 - Oxidation-Reduction Potential for Various Electron-Accepting Processes Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A



Modified from: Bouwer and McCarty, 1984

Figure 3.3 Geochemical Characteristics of Three Types of Chlorinated Solvent Plumes

Type 1 Groundwater systems that are Highly Anaerobic due to High Levels of Organic Carbon
Type 2 Systems that are mildly Anaerobic due to Moderate Levels of Organic Carbon
Type 3 Aerobic Systems with Low Levels of Organic Carbon

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) "Principles and Practices of Enhanced Bioremediation of Chlorinated Solvents," online PDF, Figure 3.3, page 3-7.

Figure 4-7 - Geochemical Characteristics of Three Types of Chlorinated Solvent Plumes Wallkill Wellfield Site City of Middletown Orange County, New York	ESI File: LM97145.45 October 2007 Appendix A

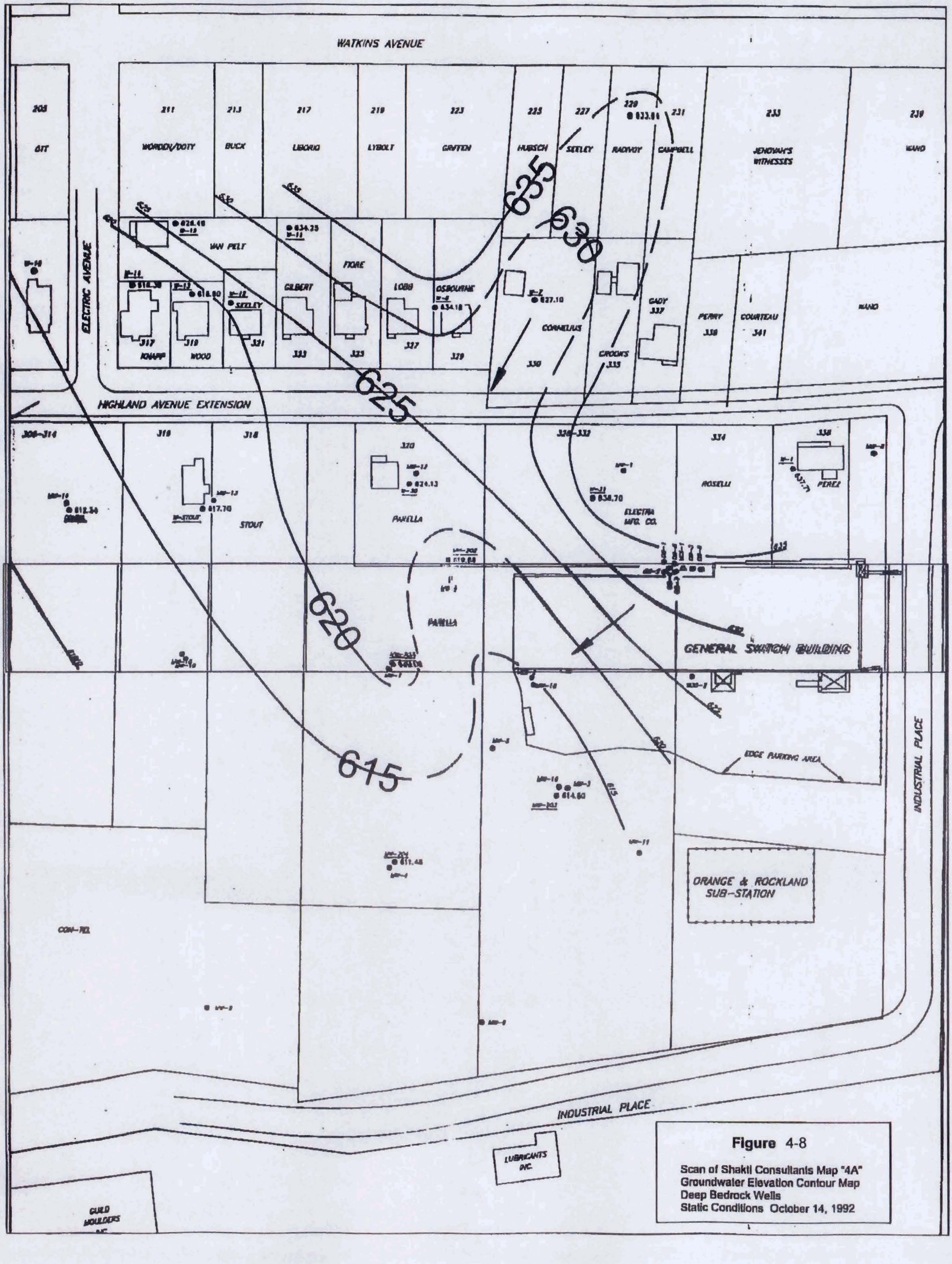


Figure 4-8

Scan of Shakti Consultants Map "4A"
Groundwater Elevation Contour Map
Deep Bedrock Wells
Static Conditions October 14, 1992

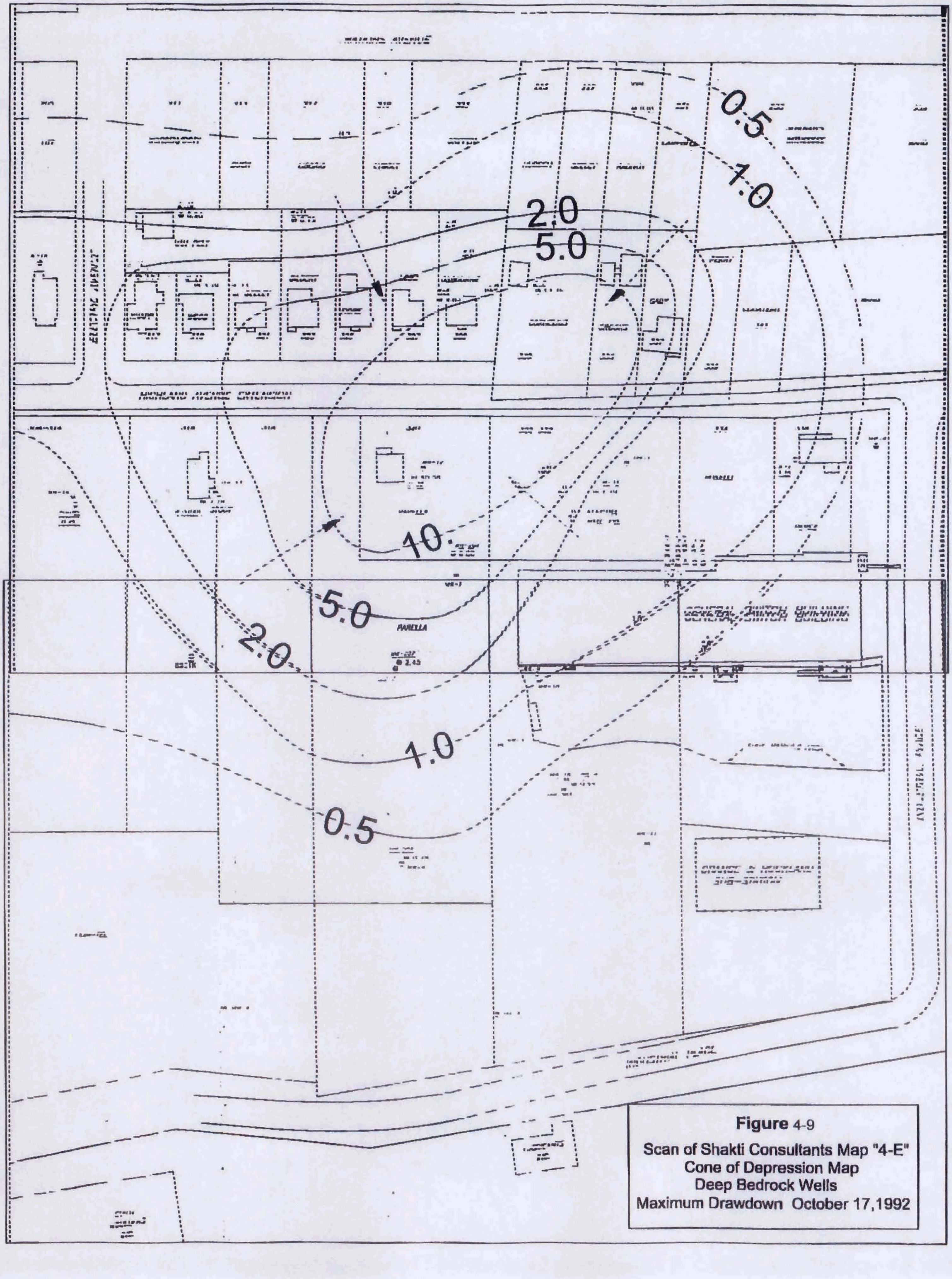


Figure 4-9

Scan of Shakti Consultants Map "4-E"
Cone of Depression Map
Deep Bedrock Wells
Maximum Drawdown October 17,1992

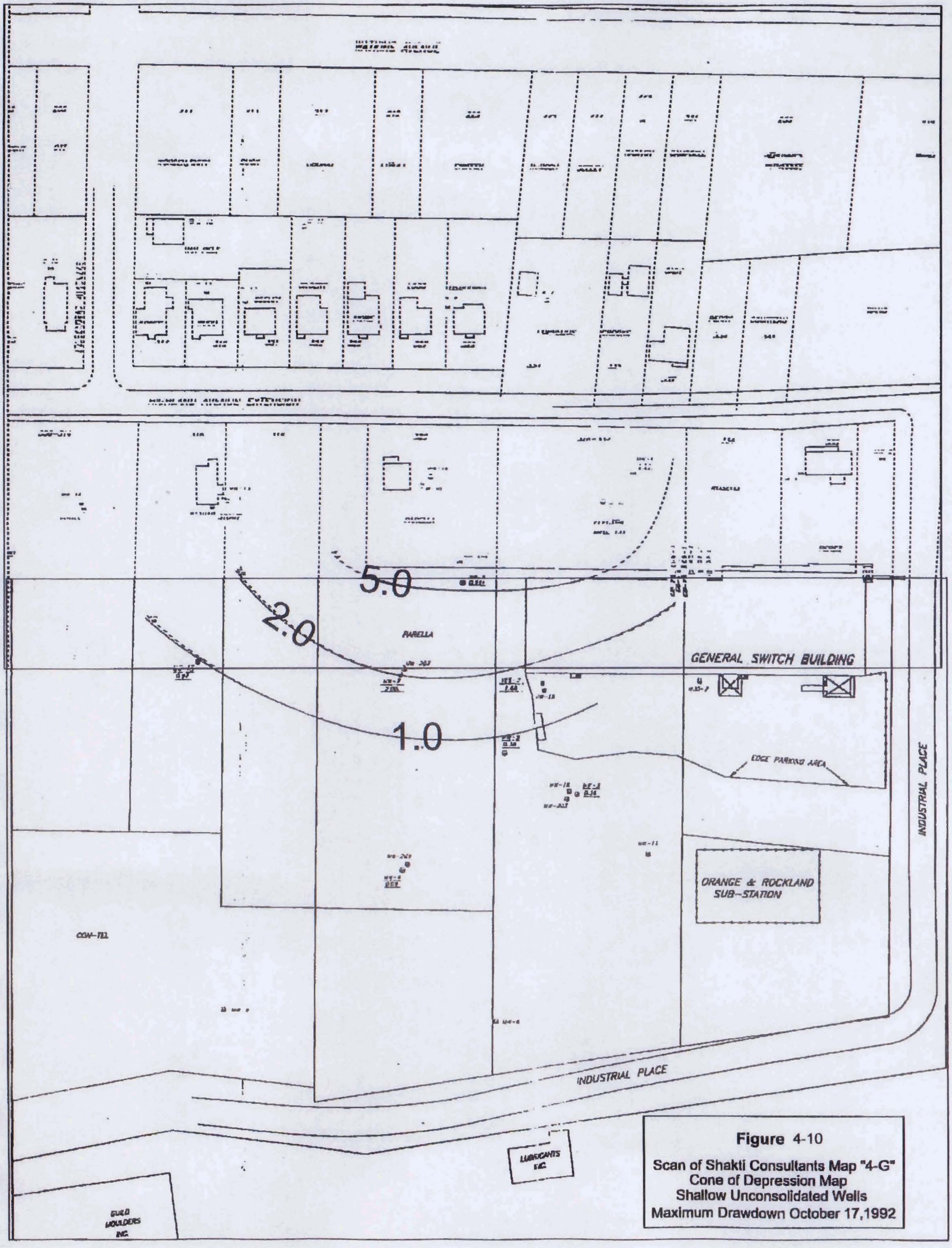


Figure 4-10

Scan of Shakti Consultants Map "4-G"
Cone of Depression Map
Shallow Unconsolidated Wells
Maximum Drawdown October 17,1992

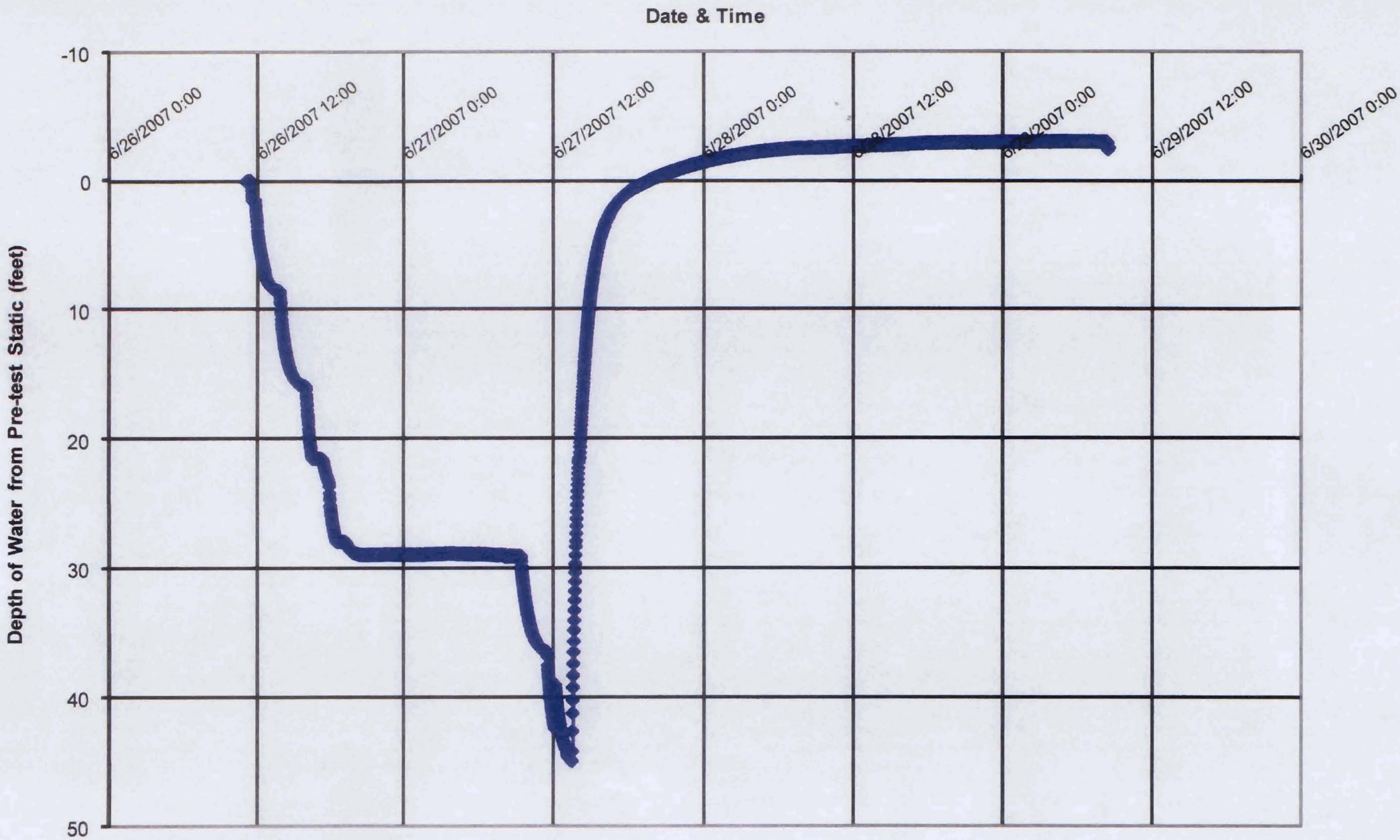


Figure 4-11 - Parella Well Pumping and Recovery

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

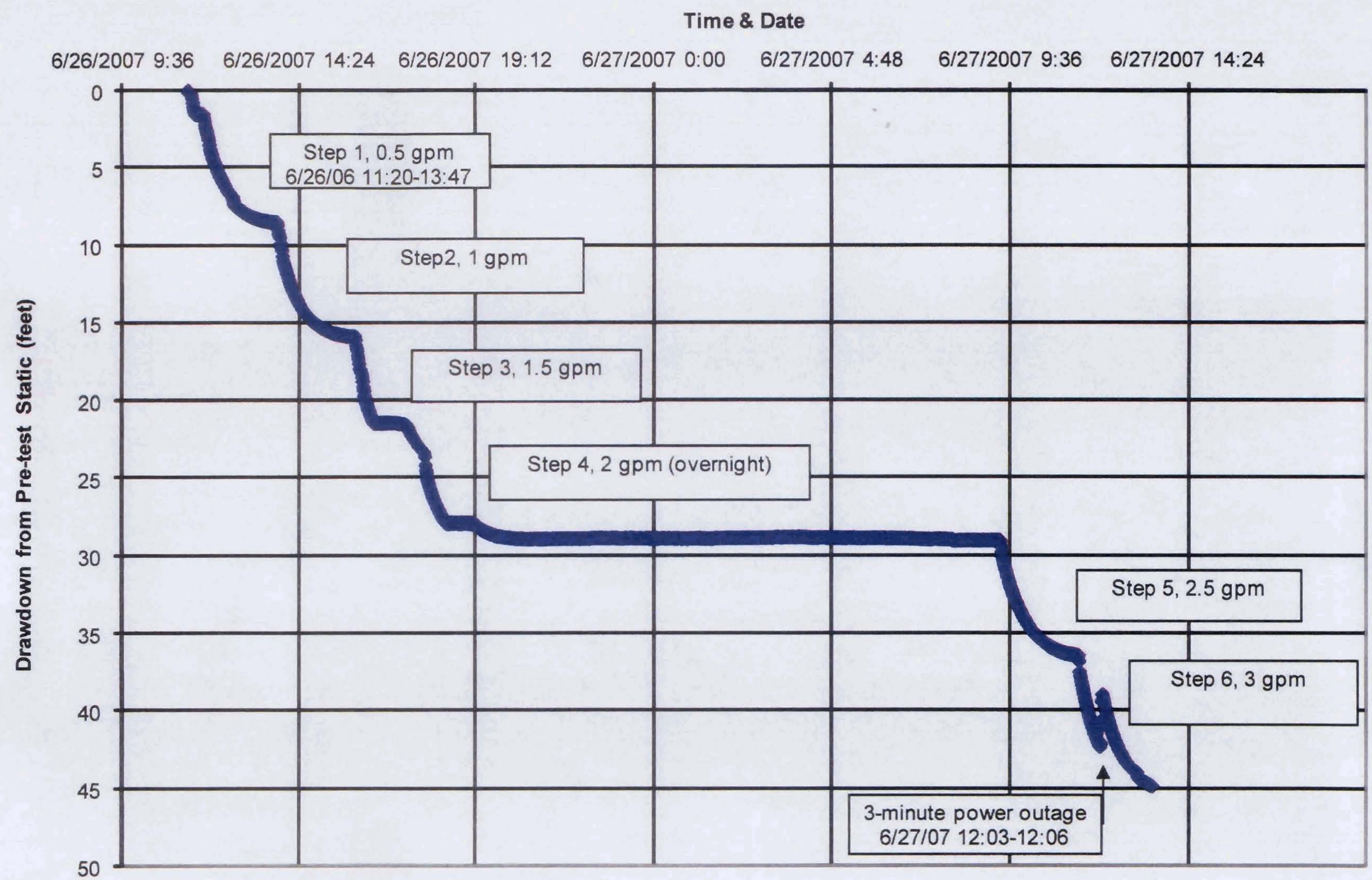


Figure 4-12 - Parella Well (W30) 24-Hour Pumping Test Drawdown in 6 Steps

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

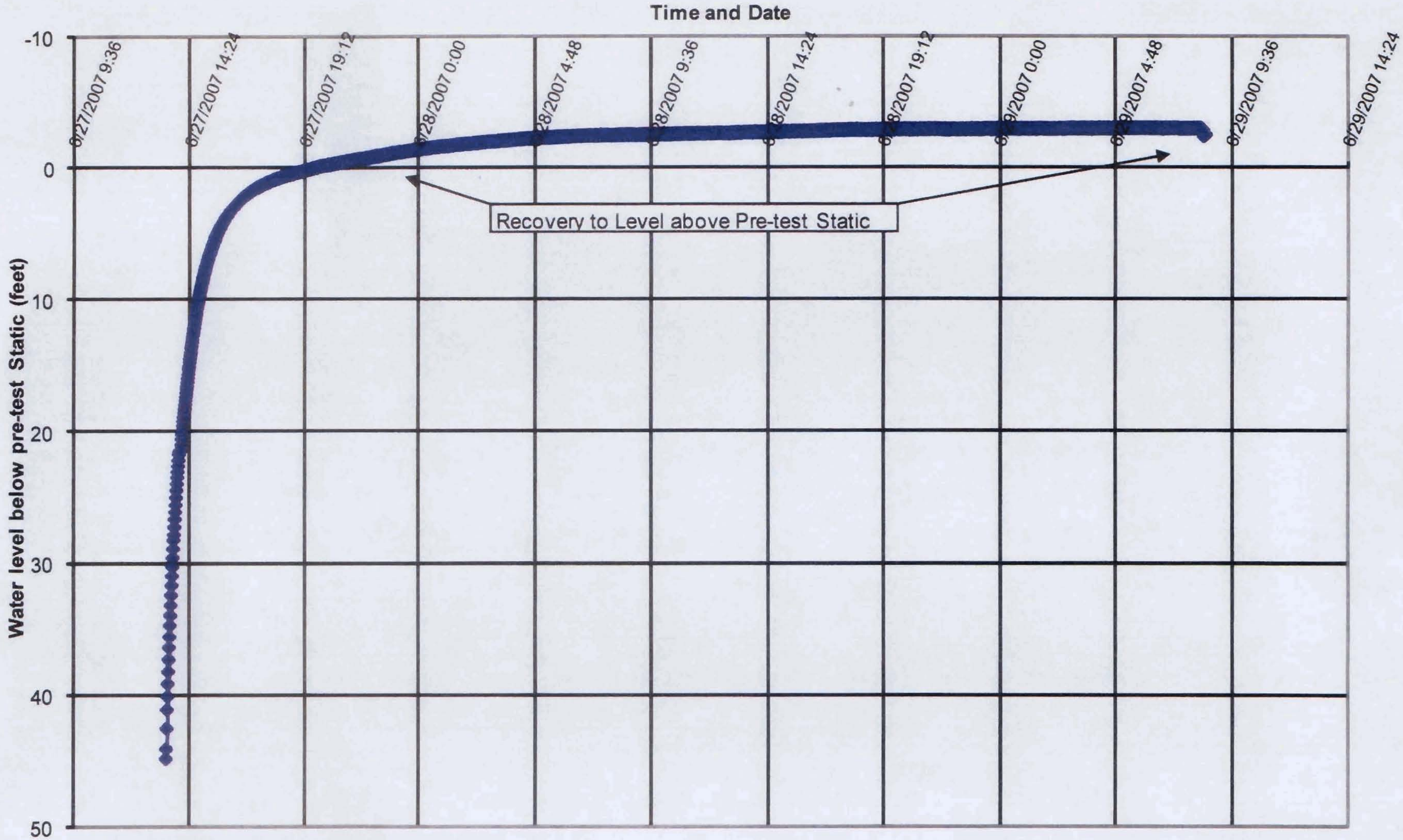


Figure 4-13 - Recovery of Parella Well (W30) after Pumping

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45
October 2007
Appendix A

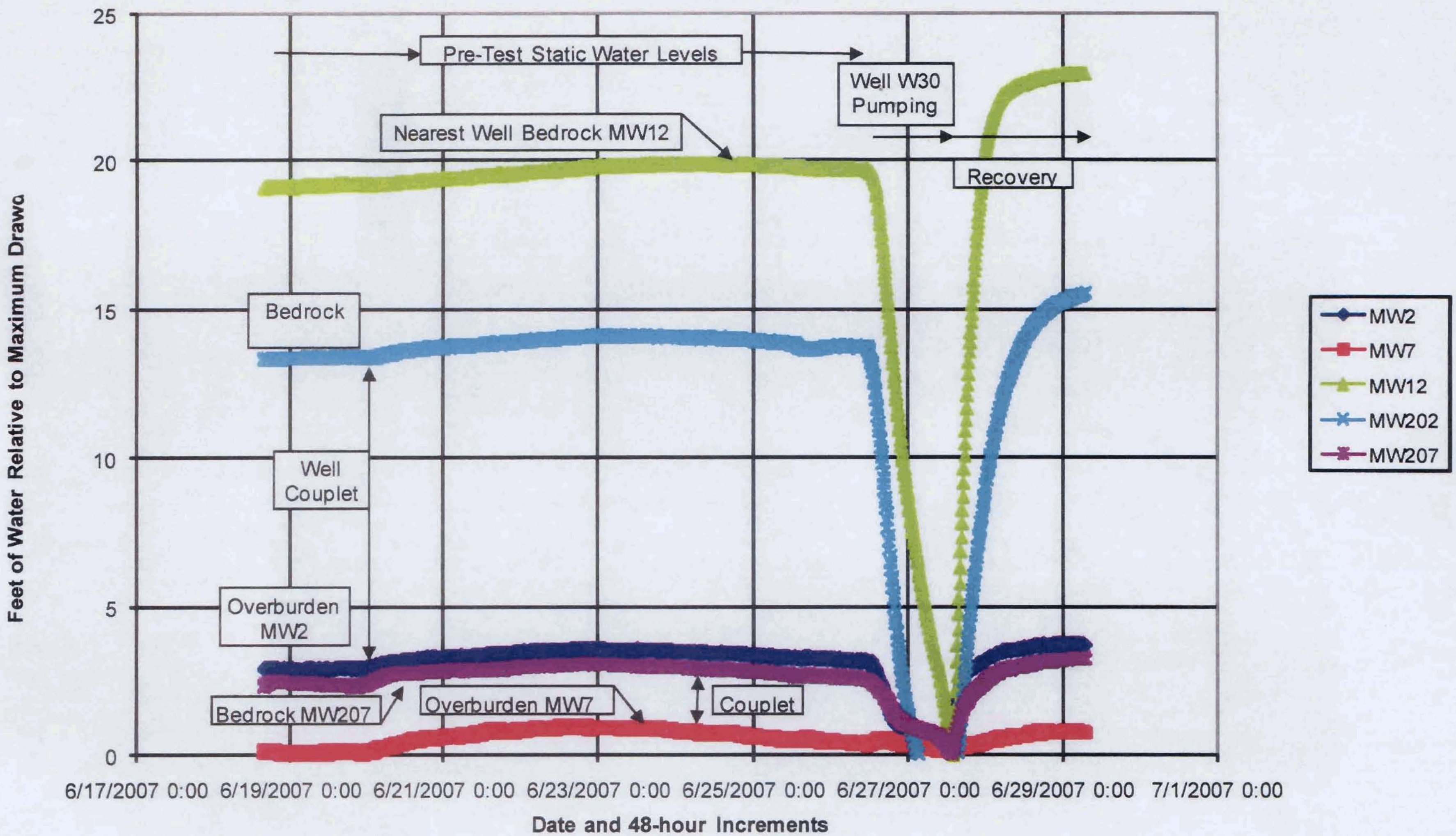


Figure 4-14 - Five Nearby Wells Showing Maximum Drawdown and Recovery from Pumping Well (W30), June 2007

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45	
October 2007	
Appendix A	

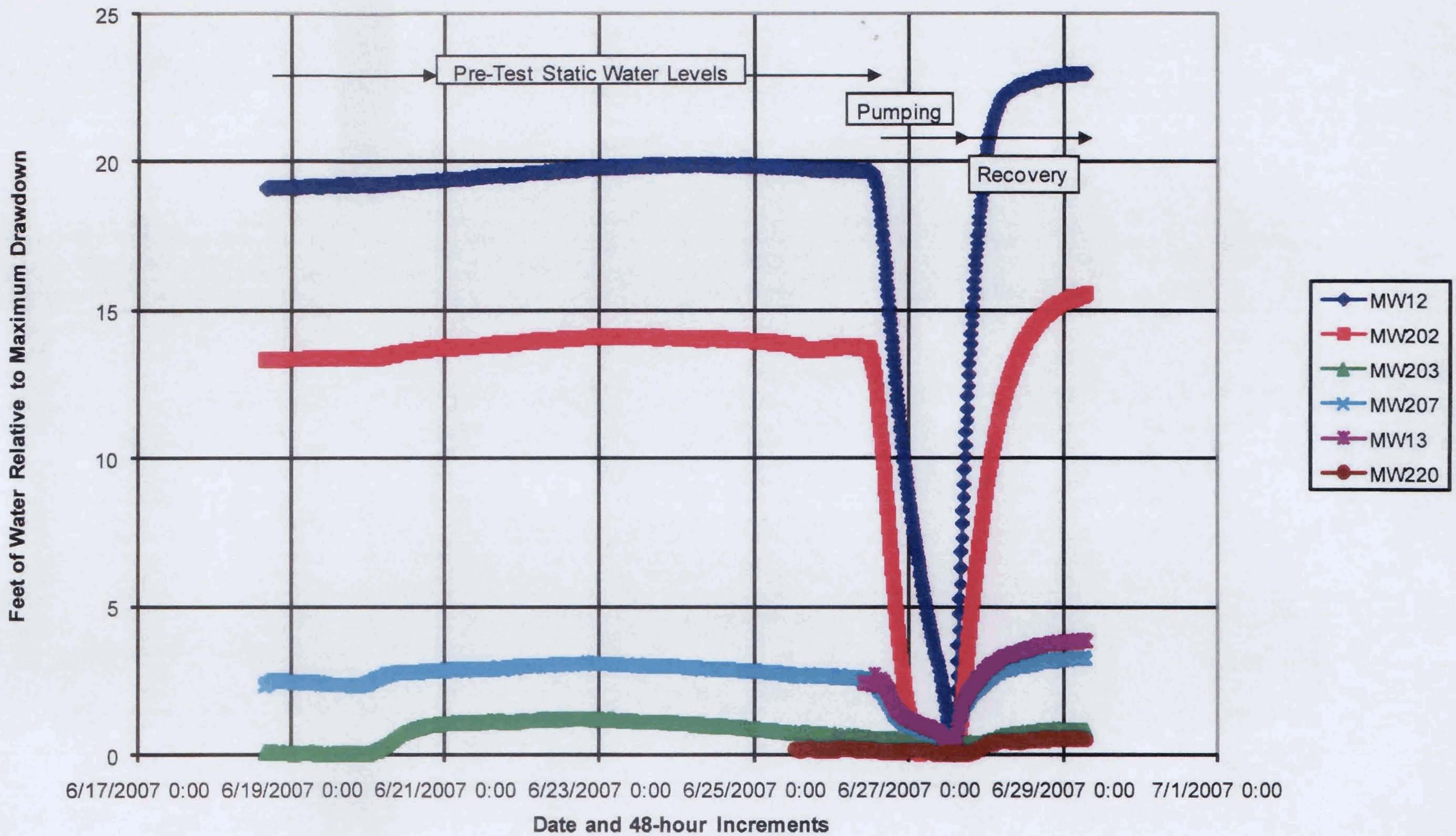


Figure 4-15 Drawdown in Bedrock Wells in Response to Pumping Well (W30), June 2007

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

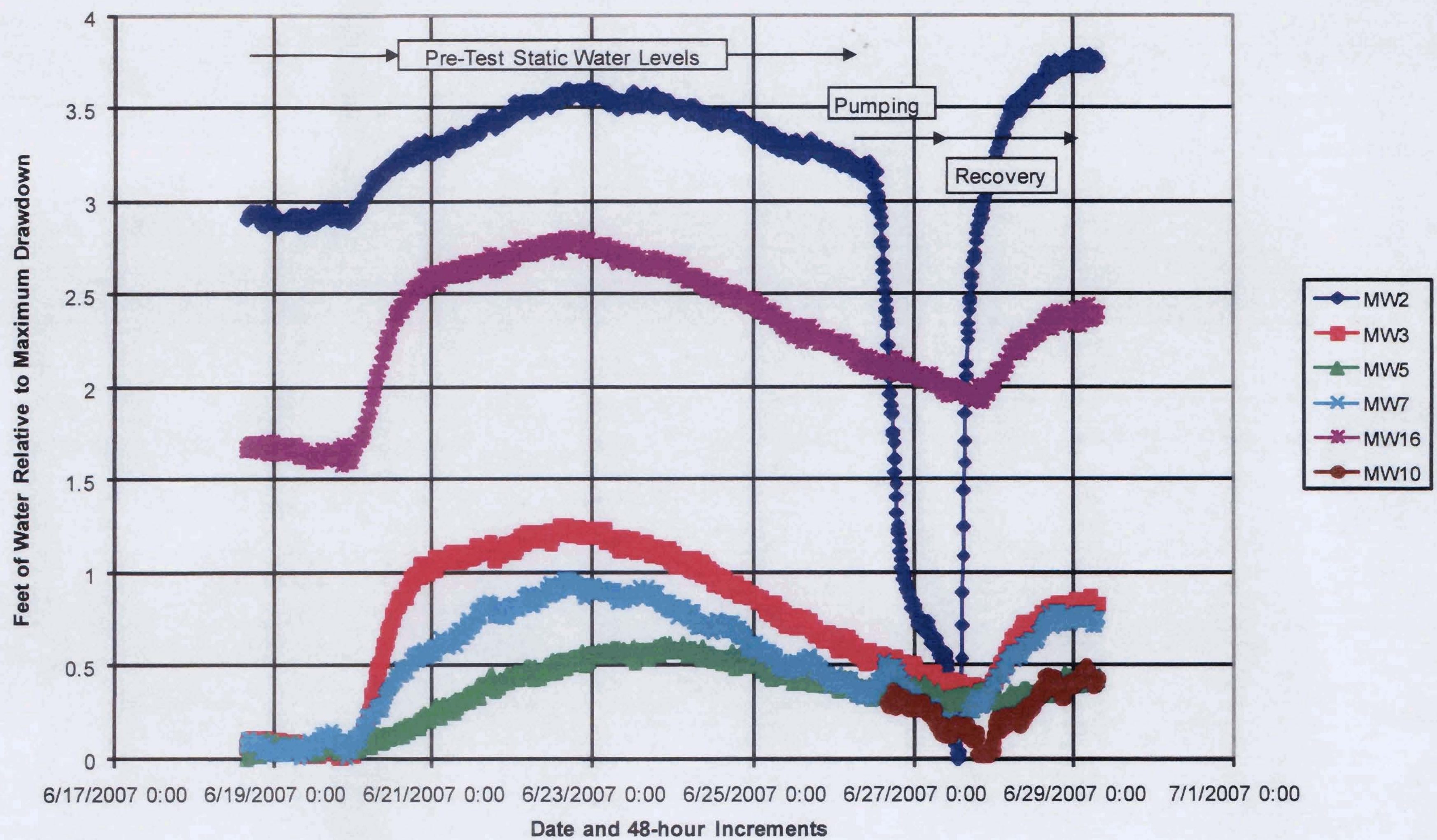


Figure 4-16 Drawdown in Overburden Wells in Response to Pumping Well (W30), June 2007

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

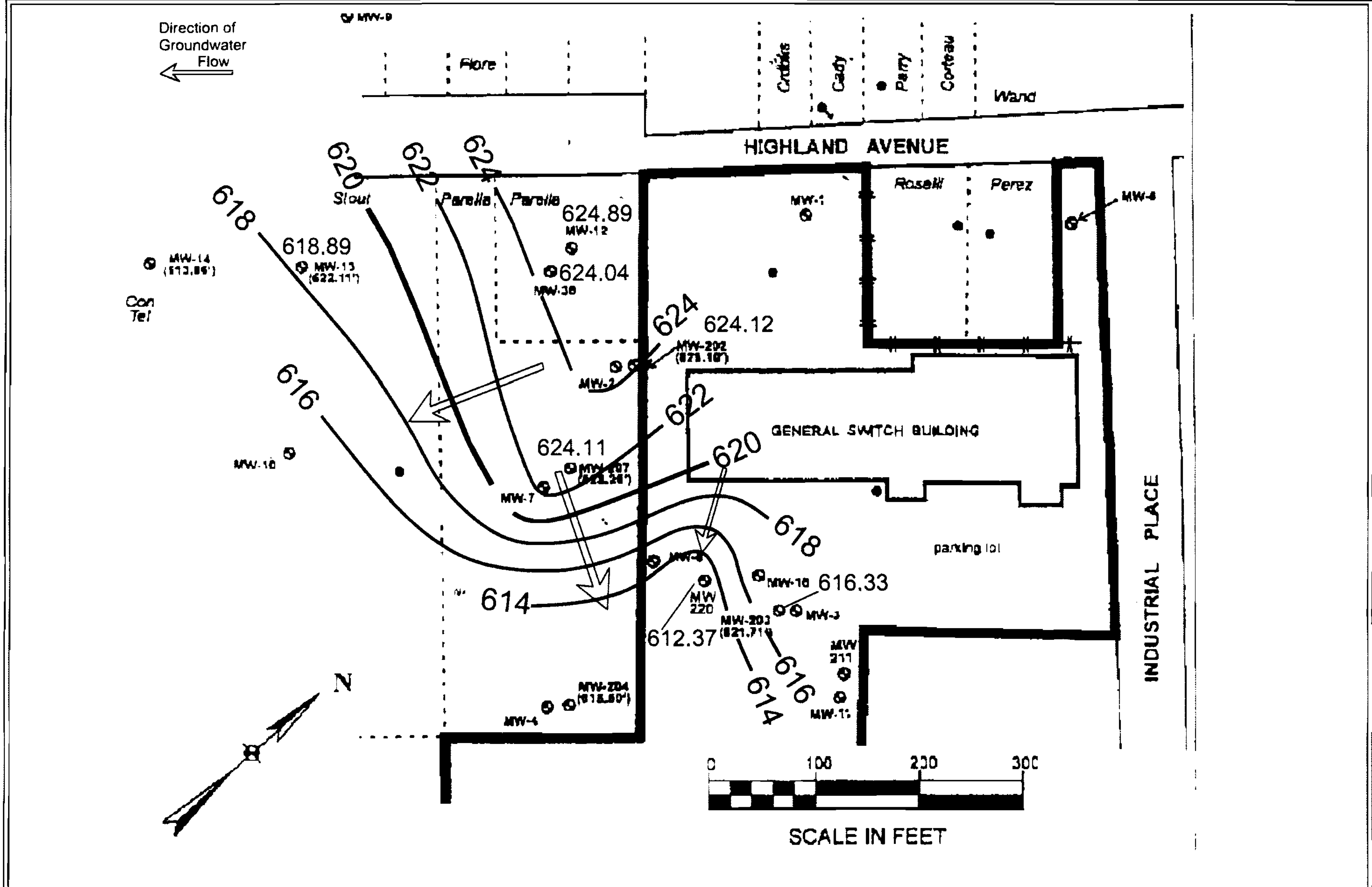


Figure 4-17 - Contour Map of Water Elevations in Bedrock Wells at start of 24-hour Pumping Test of Parella Well (W30), Tuesday June 26, 2007, 11:20 AM

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

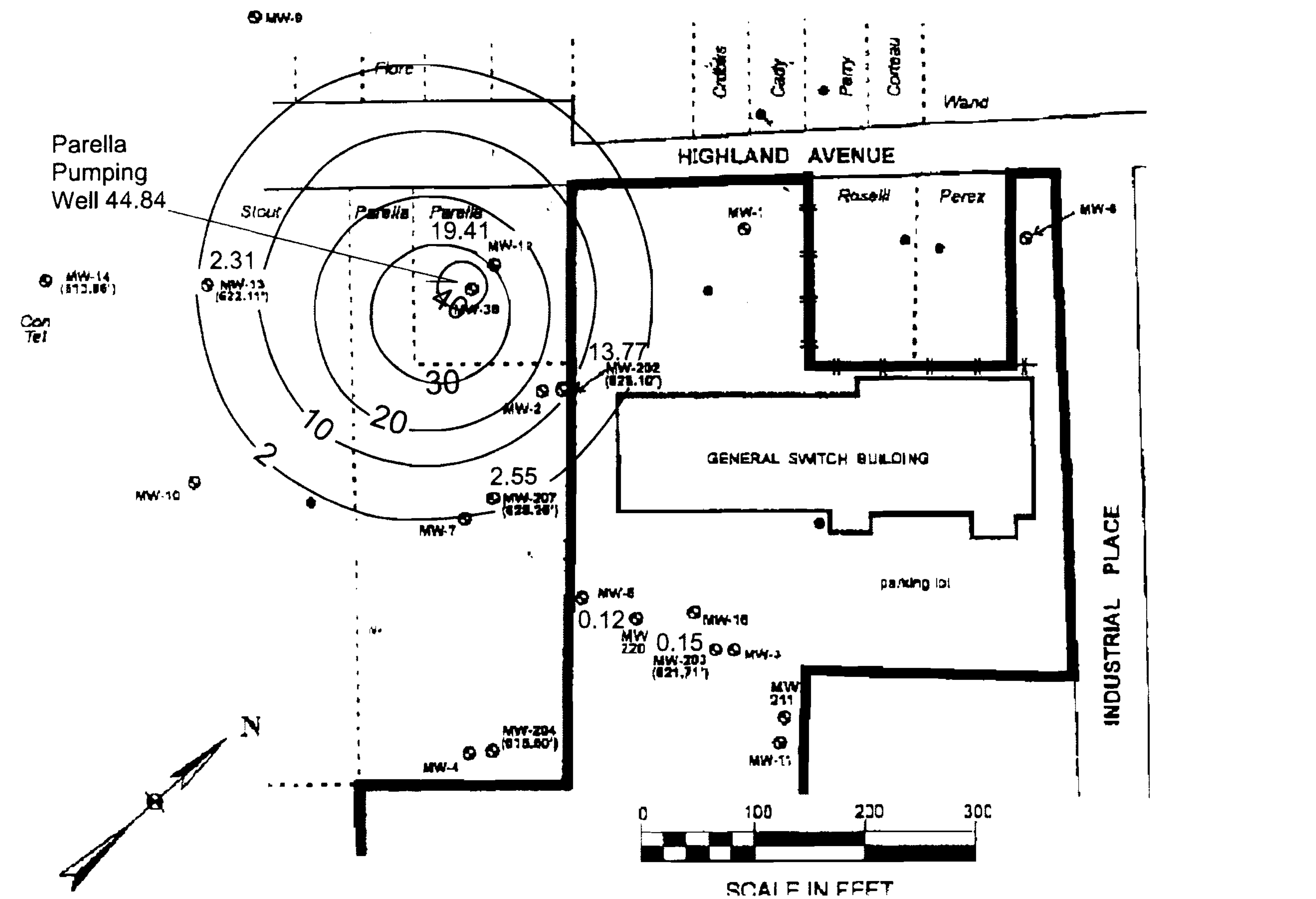


Figure 4-18 - Contour Map of Maximum Drawdown in Bedrock Wells at End of 24-hour Pumping Test on Parella Well (W30), Wednesday June 27, 2007, 1:36PM

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

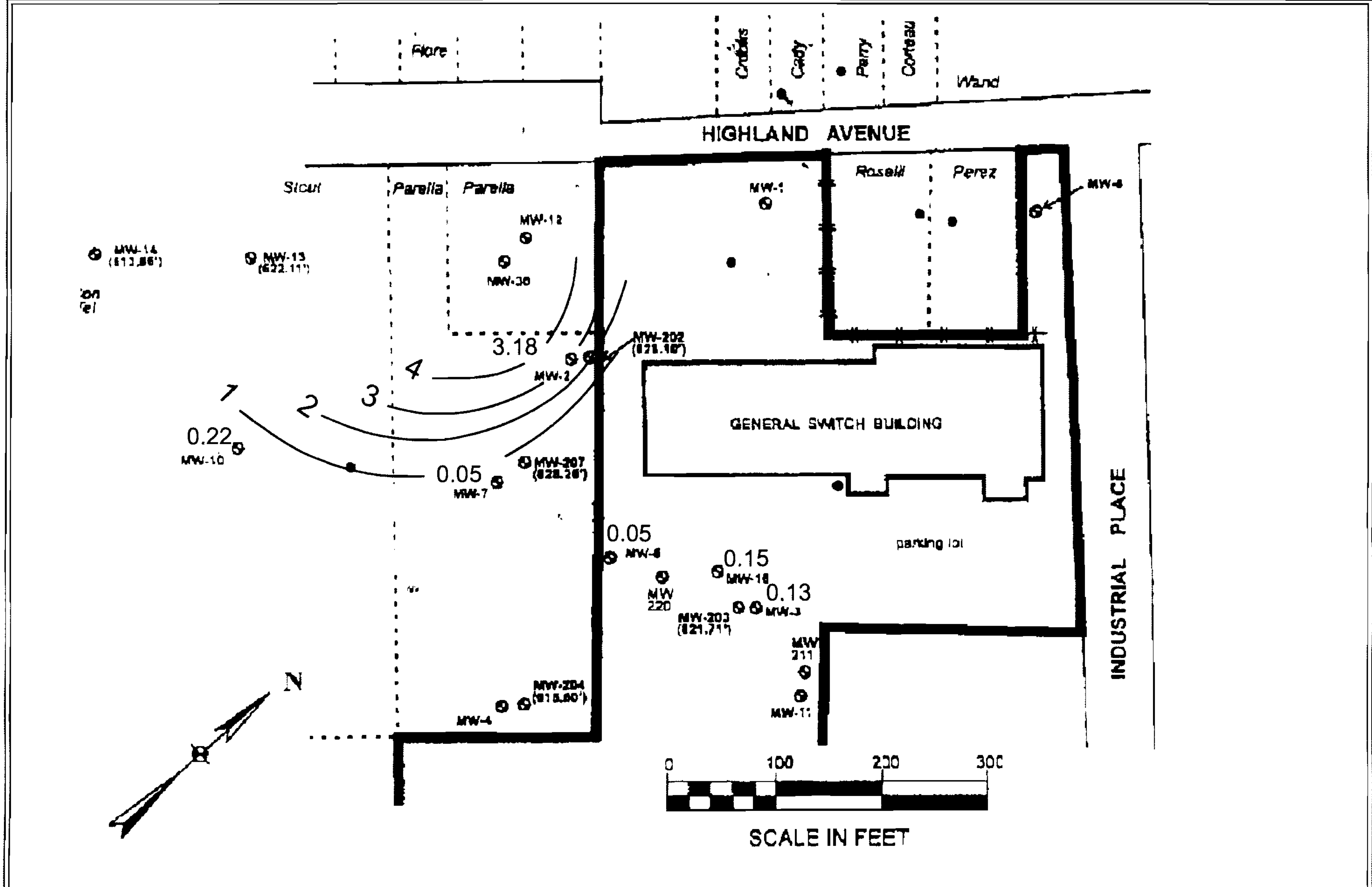


Figure 4-19 - Contour Map of Maximum Drawdown in Overburden Wells at End of 24 Hours Pumping Test on Parella Well (W30), Wednesday June 27, 2007, 1:36 PM
Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

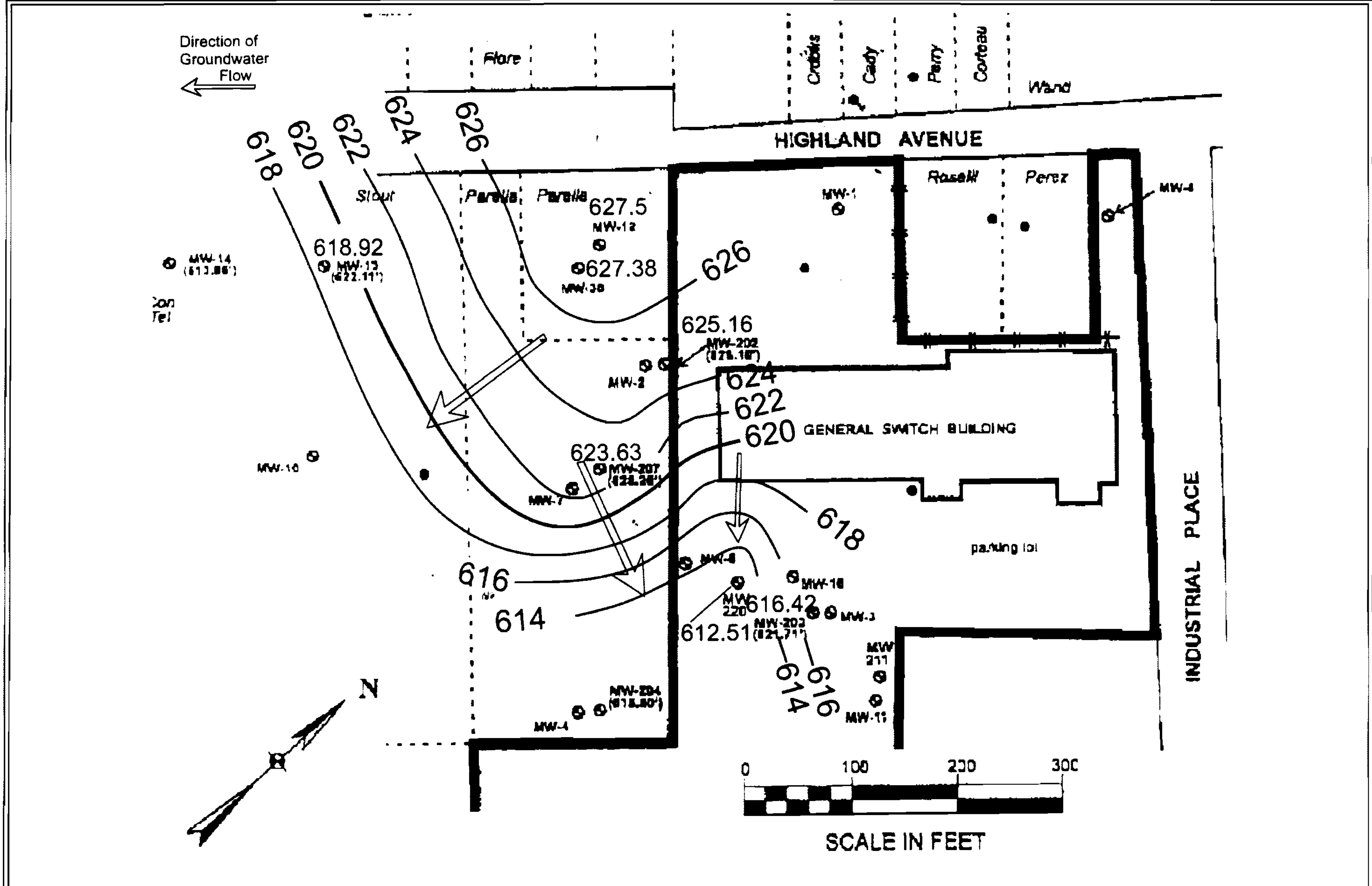


Figure 4-20 - Contour Map of Water Elevations in Bedrock Wells after Recovery from Pumping Test on Parella Well (W30), Friday June 29, 2007, 8 AM

Wallkill Wellfield Site
City of Middletown
Orange County, New York

ESI File: LM97145.45

October 2007

Appendix A

APPENDIX B

Tables

List of Tables

Table 2-1: Monitoring Well Measurements

Monitoring Well Identification	Innermost Diameter Inches	Total Depth ft from TOC	Casing Elevation ft RE: msl	Elevation High Water ft RE: msl	Elevation Low Water ft RE: msl	Depth to High Water feet	Depth to Low Water feet
MW1	2	18.6	652.08	645.97	638.15	6.11	13.93
MW2	2	38.4	639.07	629.39	622.06	9.68	17.01
MW3	2	13.17	626.22	623.22	614.18	3	12.04
MW4	2	10.92	619.35	615.9	Dry	Dry	Dry
MW5	2	13.17	627.87	624.02	Dry	Dry	Dry
MW6	2	6.84	612.30	IA	604.57	IA	7.73
MW7	2	19.92	628.68	626.41	618.47	2.27	10.21
MW8	2	14.15	655.12	647.72	Dry	Dry	Dry
MW9	4	14.56	612.83	608.21	603.66	4.62	9.17
MW10	4	31.71	626.98	624.34	615.53	2.64	11.45
MW11	4	11.08	624.73	619.93	Dry	Dry	Dry
MW12	6	65.3	646.62	628.82	621.97	17.8	24.65
MW13	6	88.9	638.12	623.47	616.03	14.65	22.09
MW14	4	80.17	635.81	615.31	611.33	20.5	24.48
MW16	4	10.92	625.7	623.1	614.37	2.6	11.33
MW19	4	18.5	608.24	603.79	600.39	4.45	7.85
MW30	6	129	644.34	IA	IA	IA	IA
MW202	6	143	640.11	628.44	621.41	11.67	18.7
MW203	6	100+	624.96	622.97	613.85	1.99	11.11
MW204	6	117.25	619.08	615.55	609.28	3.53	9.8
MW206	4	142.4	617.51	614.66	608.6	2.85	8.91
MW207	6	131	629.18	626.8	620.83	2.38	8.35
MW209	4	140.2	611.85	611.85	607.52	0	4.33
MW211	4	138.4	624.76	615.42	609.11	9.34	15.65
MW219	4	138.52	608.30	607.42	603.25	0.88	5.05
MW220	4	197.6	621.89	616.17	609.31	5.72	12.58

Notes: "ft from TOC" = feet from Top of Surface Casing,
"ft RE: msl" = feet relative to mean sea level
IA = inaccessible, Dry = water table dropped below total depth of well

13.55	63.00	55.00	8.00	59.02	52.84	6.18	0.12	53.64	52.37	1.27	14.50	6.00	8.50	0.15	Isolated	Little	No
11.70	31.50	7.50	24.00	58.68	41.53	17.15	0.41	43.18	42.26	0.92	37.00	33.50	3.50	0.26	Isolated	Little	No
11.30	71.50	45.50	26.00	80.75	27.98	52.77	1.89	30.13	29.39	0.74	27.00	22.00	5.00	0.15	Isolated	Little	No
15.27	51.50	6.50	45.00	88.73	86.28	2.45	0.03	87.69	87.18	0.51	53.00	52.50	0.50	1.02	HcAB*	Best	*
18.97	74.50	45.50	29.00	103.56	75.76	27.80	0.37	92.80	79.70	13.10	24.50	17.00	7.50	1.75	HcBelow	Good	No
15.27	46.50	12.00	34.50	116.54	107.53	9.01	0.08	115.97	107.53	8.44	52.50	46.50	6.00	1.41	HcBelow	Good	No

o. 3, slight discharge from below to Packer Zone and slight recharge from Packer Zone to above during pumping

): July 22, 2005

															Zone	Recov/Re	
terDepth	Time2	Time1	Duration	Level2	Level1	Drawdown	Ddrate	Recov2	Recov1	R2-R1	Time4	Time3	T4-T3	RecovRate	Type	Zone	Abo
5.6	62.5	51.5	11	25.66	13.55	12.11	1.10	0							Isolated	No	No
8.25	34.5	9.5	25	41.84	34.82	7.02	0.28	40.96	34.82	6.14	43.5	34.5	9	0.68	HcBelow	Good	No
	34.5	9.5	25	50.5	47.7	2.8	0.11	49.2	47.7	1.5	43.5	34.5	9	0.17			
4.95	73	36	37	94.77	31.16	63.61	1.72	41.87	35.96	5.91	33.5	20.5	13	0.45	Isolated	Good	No
8.04	39	8	31	119.73	47.5	72.23	2.33	47.39	44.24	3.15	45	39	6	0.53	Isolated	Good	No
4.77	50.5	9	41.5	133.1	18.83	114.27	2.75	32.75	19.58	13.17	68.5	51.5	17	0.77	Isolated	Best	No

): July 25-26, 2005

															Zone	Recov/Re	
terDepth	Time2	Time1	Duration	Level2	Level1	Drawdown	Ddrate	Recov2	Recov1	R2-R1	Time4	Time3	T4-T3	RecovRate	Type	Zone	Abo
1.46	47.5	25	22.5	38.98	18.95	20.03	0.89	23.98	20.61	3.37	60	48.5	11.5	0.29	HcAbove	little	to P
0.6	55	29.5	25.5	52.7	14.3	38.4	1.51	17.52	16.56	0.96	61.5	55.5	6	0.16	HcAbove	no	to P
1.4	50.05	15	35.05	70.82	19.98	50.84	1.45	22.51	21.36	1.15	57	51	6	0.19	Isolated	little	No
0.5	60.5	38.5	22	84.85	22.87	61.98	2.82	27.16	23.96	3.2	14	2	12	0.27	Isolated	little	No
1.7	77.5	43.5	34	112.36	27.34	85.02	2.50	66.42	31.3	35.12	28.5	18.5	10	3.51	HcBelow	Best	No
1.4	84	52	32	127.65	23.86	103.79	3.24	31.15	26.86	4.29	42.5	24.5	18	0.24	HcBelow	little	No
3	50	38.5	11.5	35.7	19.48	16.22	1.41	23.47	22.08	1.39	67.5	51	16.5	0.08	HcAbove	No	to P

): July 26-27, 2005

															Zone	Recov/Re	
terDepth	Time2	Time1	Duration	Level2	Level1	Drawdown	Ddrate	Recov2	Recov1	R2-R1	Time4	Time3	T4-T3	RecovRate	Type	Zone	Abo
1.05	62.5	52	10.5	30.1	13.13	16.97	1.62	14.97	13.74	1.23	16	3.5	12.5	0.10	Isolated	No	No
1.4	76.5	54.5	22	43.24	13.5	29.74	1.35	21.14	14.39	6.75	26.5	17.5	9	0.75	HcAbove	Some	to P
4.2	28.5	0	28.5	50.46	16.37	34.09	1.20	43.57	17.63	25.94	35.5	29	6.5	3.99	HcA+B	Best	to P
0.6	42.5	22.5	20	73.56	14.81	58.75	2.94	21.36	16.58	4.78	54.5	43.5	11	0.43	HcAbove	Little	to P
2.7	50	27.5	22.5	100.38	13.46	86.92	3.86	56.3	16.12	40.18	71.5	50.5	21	1.91	HcBelow	Good	No
1.65	69.5	45.5	24	123.47	14.16	109.31	4.55	22.81	16.12	6.69	14.5	9.5	5	1.34	Isolated	Some	No
6.15	84.5	51	33.5	127.7	11.9	115.8	3.46	30.9	18.42	12.48	48.5	25.5	23	0.54	Isolated	Little	No

): July 28, 2005

															Zone	Recov/Re	
terDepth	Time2	Time1	Duration	Level2	Level1	Drawdown	Ddrate	Recov2	Recov1	R2-R1	Time4	Time3	T4-T3	RecovRate	Type	Zone	Abo
8.9	57.5	50.5	7	21.92	14.35	7.57	1.08	15.22	15.18	0.04	62.5	58.5	4	0.01	Isolated	No	No
8.75	34	20	14	32.12	15.34	16.78	1.20	15.5	15.49	0.01	40.5	37.5	3	0.00	Isolated	No	No
10.5	25.5	1	24.5	42.25	16.23	26.02	1.06	22.23	16.23	6	33	25.5	7.5	0.80	Isolated	Some	No
9.45	86	58	28	58.69	13.4	45.29	1.62	27.72	13.4	14.32	94	86	8	1.79	Isolated	Good	No
8.3	68	51.5	16.5	74.77	15.91	58.86	3.57			0			0	#DIV/0!	Isolated	No	No
13.35	54	34	20	86.61	17.29	69.32	3.47	20.14	17.19	2.95	59.5	54.5	5	0.59	Isolated	Some	No
12.95	40.5	17.5	23	98.4	21.02	77.38	3.36	36.32	21.02	15.3	45.5	40.5	5	3.06	Isolated	Best	No
18.2	72	0.5	71.5	113.1	42.3	70.8	0.99	44.18	39.1	5.08	18	13	5	1.02	Isolated	Some	No
12.9	58.5	38.5	20	139.7	30.2	109.5	5.48	38.76	30.18	8.58	63	58.5	4.5	1.91	Isolated	Good	No
25	27.5	15.5	12	150	84.3	65.7	5.48	97.22	80.57	16.65	44	27.5	16.5	1.01	Isolated	Some	to P

	Guidance Level	Sample Identification							
		Valid Sample						Invalid Sample	
	Guidance Level	MW-220 (41-51')	MW-220 (57-67')	MW-220 (89-99')	MW-220 (101-111')	MW-220 (116-126')	MW-220 (141-151')	MW-220 (20-30')	MW-220 (30-40')
	5	29	52	36	39	40	39	1	1
	7	ND	ND	ND	ND	ND	ND	ND	ND
	5	ND	ND	ND	ND	ND	ND	ND	ND
	5	390	710	450	380	380	410	3	4
	5	ND	ND	52	33	21	50	8	21
	5	13	33	25	39	43	29	2	3
		433	795	560	490	384	528		
		Upper Aquifer	Upper Aquifer	Lower Aquifer	Lower Aquifer	Lower Aquifer	Lower Aquifer		

		Sample Identification					
		Valid Sample					Invalid Sample
	Guidance Level	MW-219 (35-45')	MW-219 (45-55')	MW-219 (65-75')	MW-219 (115-125')	MW-219 (127.5-134.5')	MW-219 (21-31')
	5	100	55	39	31	37	203
	7	ND	ND	ND	ND	ND	ND
	5	ND	ND	ND	ND	ND	ND
	5	340	410	220	160	200	120
	5	20	17	91	120	130	41
	5	58	50	59	45	55	26
		520	530	410	355	420	390
		Upper Aquifer	Upper Aquifer	Upper Aquifer	Lower Aquifer	Lower Aquifer	

		Sample Identification					
		Valid Sample			Invalid Sample		
	Guidance Level	MW-211 (85-95')	MW-211 (103-113')	MW-211 (113-123')	MW-211 (34-47')	MW-211 (54-60')	MW-211 (73-83')
	5	48	51	60	13	11	11
	7	ND	200	ND	ND	ND	1
	5	ND	ND	ND	3 (trip blank also)	ND	ND
	5	440	200	260	28	7	13
	5	ND	9	20	39	40	55
	5	37	120	110	13	11	12
		525	571	450			
		Lower Aquifer	Lower Aquifer	Lower Aquifer			

		Sample Identification				
		Valid Sample			Invalid Sample	
	Guidance Level	MW-206 (91-101')	MW-206 (110-120')	MW-206 (122-132')	MW-206 (22-33')	MW-206 (43-53')
	5	11	9	9	4	11
	7	ND	ND	ND	2	ND
	5	ND	ND	ND	ND	ND
	5	170	170	140	50	220
	5	110	94	120	13	1
	5	6	6	5	2	7
		297	279	274	71	239
		Lower Aquifer	Lower Aquifer	Lower Aquifer		Upper Aquifer

Division of Water Technical and Operational Guidance Series (TOGS) 1.1.1,
d Guidance Values And Groundwater Effluent Limitations (June 1988 edition)

	Guidance Level	Sample Identification						
		Valid Sample	Invalid Sample					
		MW-209 (95-105')	MW-209 (20-30')	MW-209 (28-38')	MW-209 (41-51')	MW-209 (58-68')	MW-209 (70-80')	MW-209 (108-118')
	5	45	54	110	100	73	50	38
	7	ND	ND	ND	ND	ND	ND	ND
	5	ND	ND	ND	ND	ND	ND	ND
	5	380	290	280	240	340	380	270
	5	39	63	5	23	20	16	85
	5	45	140	140	110	75	51	43
			550	435	473	508	475	436
				Upper Aquifer				Lower Aquifer

	Guidance Level	Sample Identification				
		Field Blank				
		MW-206 (F1)	MW-209 (F1)	MW-219 (F1)	MW-220 (F1)	MW-211 (F1)
	5	10	47	40	ND	19
	7	ND	ND	ND	ND	ND
	5	ND	9(trip blank also)	9(trip blank also)	2 (trip blank also)	2 (trip blank also)
	5	210	370	280	4	34
	5	ND	ND	ND	ND	ND
	5	4	35	29	3	24

ivision of Water Technical and Operational Guidance Series (TOGS) 1.1.1,
Guidance Values And Groundwater Effluent Limitations (June 1988 edition)

Table 3-3 - Fracture Descriptions Associated with Core Photographs and Packer Test Zone Recovery Rate

Well Name	Figure Number	Depth (feet)	Packer Test No.	Zone Type	Recovery Rate	Qualifiers for Recov	Fracture Description
MW211	2-1	16					weathered open fracture, elliptical surface
	2-2	39.5	1	Isolated	0.15	little	vertical fracture
	2-3	43-44	1				calcite-coated fracture surfaces
	2-4	46.5-47.	1				irregular high angle fracture
	2-5	56.5-57.	2	Isolated	0.26	little	irregular vertical fracture
	2-6	60.5-61.5	2				irregular fracture surface
	2-7	61.5-62.5	2				high angle fracture in silty fine sand
	2-8	73.5-74.5	3	Isolated	0.15	little	fractured thin shale beds above 74 ft
	2-9	75.5-76.5	3				hairline fractures with and without calcite filling
	2-10	78	3				weathered surface of bedding plane parting
	2-11	88-88.5	4	HcAB*	1.02	good	multiple fractures in fine-bedded shale
	2-12	89-89.5	4				weathered open bedding plane parting in fined-bedded shale
	2-13	90	4				45 degree open fracture with calcite linings on surfaces
	2-14	91	4				near horizontal fractures above and below white irreg calcite beds
	2-15	114-115.5	6	HcBelow	1.41	good	highly fractured zone bottom core
MW206	2-16	18	NA				open fracture cutting various-width closed calcite-filled fractures
	2-17	19	NA				low angle fractures
	2-18	26	1	Isolated	none	dry	weathered vertical fracture above bedding plane parting
	2-19	30	1				weathered high angle fracture
	2-20	31	1				near horizontal fractures and bedding plane partings
	2-21	31.5	1				irregular fracture cutting across coarse sandstone bed
	2-22	47-47.5	2	HcBelow	0.68	good	thin low-angle fracture zone
	2-23	93.5-94.5	3	Isolated	0.45	good	near vertical fractures, some with calcite lining surfaces
	2-24	94.5-95.5	3				downward continuation of near vertical fractures
	2-25	112.5	4	Isolated	0.53	good	dying water pattern showing differential permeability
MW209	2-26	22	7	HcAbove	0.08	dry	both sides of short vertical fracture, upper piece has a calcite-filled fracture offset by a microfault
	2-27	23.5	7				vertical fracture terminates at bedding plane
	2-28	45	2	HcAbove	0.16	dry	irregular high angle fracture at 45 feet
	2-29	75.5-76.	4	Isolated	0.27	little	high angle fracture at base of fracture zone
	2-30	100	5	HcBelow	3.51	best	open high-angle calcite-filled fracture broken by bedding planes
	2-31	109-110.	6	HcBelow	0.24	little	sides of open high-angle fracture lined with light gray calcite
	2-32	117	6				both surfaces of high-angle fracture cutting shale and silt beds
MW220	2-33	42	3	Isolated	0.8	some	bedding plane fractures, one with calcite lining on lower surface
	2-34	60	4	Isolated	1.79	good	high angle fracture in silty fine sand
	2-35	62.5	4				elliptical surface of high angle fracture
	2-36	63.5	4				calcite beds with fracture and slickensides on carbonaceous surface
	2-37	65	4				fracture associated with sedy flame structure with pyrite crystals
	2-38	66-67	4				high angle and vertical fractrures
	2-39	102	7	Isolated	3.06	best	elliptical high-angle fracture surface
	2-40	103	7				bedding plane parting
	2-41	116	8	Isolated	1.02	some	fresh surfaces on high-angle fracture
	2-42	120	8				fresh surfaces on high-angle fracture
	2-43	143	9	Isolated	1.91	good	high-angle fracture terminates at bedding plane
	2-44	149	9				irregular fracrtures, calcite filled fracture end in calcite beds
	2-45	174	10	Isolated	1.01	some	elliptical fracture face outlined by white calcite
	2-46	178	10				bedding parting at base of thin calcite bed with slickensides
MW219	2-47	22.5	1	Isolated	0.1	dry	high-angle fracture surface
	2-48	28	1				high-angle irregular fractures
	2-49	43	2	HcAbove	0.75	some	both sides of irregular near vertical fracture
	2-50	44.5	2				high-angle fracture
	2-51	49	3	HcA+B	3.99	best	pieces of rock from fracture zone
	2-52	70	4	HcAbove	0.43	little	surfaces of low-angle fracture
	2-53	70	4				same low-angle fracture
	2-54	118.5	6	Isolated	1.34	some	elliptical high-angle fracture surface in fine-bedded shale
	2-55	134-135	7	Isolated	0.54	little	high-angle fracrue zone
	2-56	135-136	7				downward continuation of high-angle fractures
	2-57	136-137	7				downward continuation of high-angle fractures
	2-58	137-138	7				downward continuation of high-angle fractures

Notes: Figure numbers refer to figures of core photos in this report.
Zone Type, Recovery Rate, and Qualifiers are from Table 3-1 summarizing packer test results.

Table 3-4: Summary of Timing for Pumping Tests, April 2006

Times are in 24 hour clock time.

Pumping Well	Pumping Rate gpm	Pumping Date	Pumping Start Time	Pump Off Time	End of Recovery Time	Total Pumping Duration minutes	Total Recovery Monitored minutes
MW206	2.5	April 17,2006	07:09	19:09	April 18, 05:42	722	633
MW211	2	April18,2006	07:45	19:44	April 19, 06:11	720	628
MW209	3	April 19,2006	09:14	18:02	April 20, 06:08	529	730
MW220	2.5	April 20,2006	10:52	17:00	April 21, 07:34	369	875
MW219	0.8	April 21,2006	07:46	15:46	April 21, 23:59	481	496

Table 3-5: Summary of Storativity and Transmissivity Calculations

		Recovery Interval			Pumping Interval						
Pumping Well	Pumping Rate gpm	Measurement on Figure Number	delta s' feet	Transmissivity gpd/ft	Observation Wells	Measurements on Figure Number	Distance from PW feet	delta s feet	t-zero minutes	Transmissivity gpd/ft	Storativity no units
MW206	2.5	3-72	4.86	136	MW211	5-32	278	2.5	19	264	0.0195
	2.5				MW209	5-32	300	5.1	15.5	129	0.0067
	2.5				MW220	5-32	170	2.3	35	287	0.1043
	2.5				MW219	5-32	480	2.1	19.5	314	0.0080
	2.5				MW204	5-32	222	2.5	19.5	264	0.0313
MW211	2	3-68	1.55	341	MW206	5-28	278	1.8	16.5	293	0.0188
	2				MW209	5-28	480	2.05	18.5	258	0.0062
	2				MW220	5-28	207	1.9	14.5	278	0.0282
	2				MW219	5-28	705	0.75	25	704	0.0106
	2				MW204	5-28	337	2	9.2	264	0.0064
MW209	3	3-76	16.417	48	MW206	5-36	295	1.55	5	511	0.0088
	3				MW211	5-36	480	1.4	15	566	0.0110
	3				MW220	5-36	275	1.2	24	660	0.0628
	3				MW219	5-36	215	2.2	11.5	360	0.0269
	3				MW204	5-36	155	1.45	14	546	0.0955
MW220	2.5	3-80	25.25	26	MW206	5-40	170	1.28	13.5	516	0.0723
	2.5				MW211	5-40	205	1.32	3.4	500	0.0121
	2.5				MW209	5-40	275	1.44	18.5	458	0.0336
	2.5				MW219	5-40	457	0.47	18.5	1404	0.0373
	2.5				MW204	5-40	127	1.63	7.7	405	0.0580
MW219	0.8	3-84	7.54	28	MW206	5-44	480	0.65	13.5	325	0.0057
	0.8				MW211	5-44	705	0.42	26	503	0.0079
	0.8				MW209	5-44	215	1.37	12.5	154	0.0125
	0.8				MW220	5-44	457	0.43	36	491	0.0254
	0.8				MW204	5-44	162	0.46	22	459	0.1155
MW220	2.5	3-80			MW207	5-40	250	0.75	25	880	0.1056

Notes:

Using Pumping Well Recovery Data (delta s') and Observation Well Response to Pumping (delta s and t-zero)
Pumping Well Semilog Plots of Recovery Curves (residual drawdown (s') versus t/t'
Where t is time since pumping began and t' is time since pumping stopped) are shown in Figures 3-65, 3-69, 3-73, 3-77, 3-81.
Observation Well Semilog Plots of Pumping Response (drawdown s versus time) are shown in Figures 3-66, 3-70, 3-74, 3-78, 3-82.

Table 3-6: Summary of Timing of Pumping Response in Observation Wells

Pumping Well MW211 Figure 3-66		Pumping Well MW206 Figure 3-70		Pumping Well MW209 Figure 3-74		Pumping Well MW220 Figure 3-78		Pumping Well MW219 Figure 3-82	
Observation Well	Distance from PW feet	Observation Well	Distance from PW feet	Observation Well	Distance from PW feet	Observation Well	Distance from PW feet	Observation Well	Distance from PW feet
MW204	337	MW209	300	MW206	295	MW211	205	MW209	215
MW220	207	MW219	480	MW219	215	MW204	127	MW206	480
MW206	278	MW211	278	MW204	155	MW206	270	MW204	162
MW209	480	MW204	222	MW211	480	MW209	275	MW211	705
MW219	705	MW220	270	MW220	275	MW219	457	MW220	457
						MW207	250		

Notes:

Each pumping test is represented in two columns.
For each pumping test in the first column, the observation wells are listed in order from greatest to least drawdown response.
For each pumping test in the second column, the distance from the pumping well to the observation well is recorded.
In section 3.3 of the report, this information is used to describe anisotrophy of the bedrock aquifer.
"PW" is pumping well.

Table 3-7: Hydraulic Conductivity Estimates from Packer & Pumping Test Data

				First Calculation Using Aquifer Thickness: Top of First Productive Zone to Base of Last			Second Calculation Aquifer Thickness: Lower Aquifer (top about 90 ft depth)			
Pumping Well	Estimated Aquifer Thickness feet	Observation Well	Calculated Transmissivity gpd/ft	Average Aquifer Thickness feet	Hydraulic Conductivity gpd/ft ft	Hydraulic Conductivity E-04 cm/sec	Lower Aquifer Thickness feet	Average Aquifer Thickness feet	Hydraulic Conductivity gpd/ft ft	Hydraulic Conductivity E-04 cm/sec
MW206	90	MW211	264	65	4.1	1.9	37	38	6.9	3.3
		MW209	129	75	1.7	0.8		30	4.3	2.0
		MW220	287	120	2.4	1.1		70	4.1	1.9
		MW219	314	90	3.5	1.6		37	8.5	4.0
MW211	40	MW206	293	65	4.5	2.1	38	38	7.7	3.6
		MW209	258	50	5.2	2.4		30	8.6	4.1
		MW220	278	85	3.3	1.5		70	4.0	1.9
		MW219	704	65	10.8	5.1		38	18.5	8.7
MW209	60	MW206	511	75	6.8	3.2	23	30	17.0	8.0
		MW211	566	50	11.3	5.3		30	18.9	8.9
		MW220	660	105	6.3	3.0		64	10.3	4.9
		MW219	360	75	4.8	2.3		30	12.0	5.7
MW220	150	MW206	516	85	6.1	2.9	104	70	7.4	3.5
		MW211	500	85	5.9	2.8		70	7.1	3.4
		MW209	458	105	4.4	2.1		64	7.2	3.4
		MW219	1404	122	11.5	5.4		70	20.1	9.5
MW219	90	MW206	325	90	3.6	1.7	37	37	8.8	4.1
		MW211	503	65	7.7	3.7		38	13.2	6.2
		MW209	154	75	2.1	1.0		30	5.1	2.4
		MW220	491	122	4.0	1.9		70	7.0	3.3

Notes:

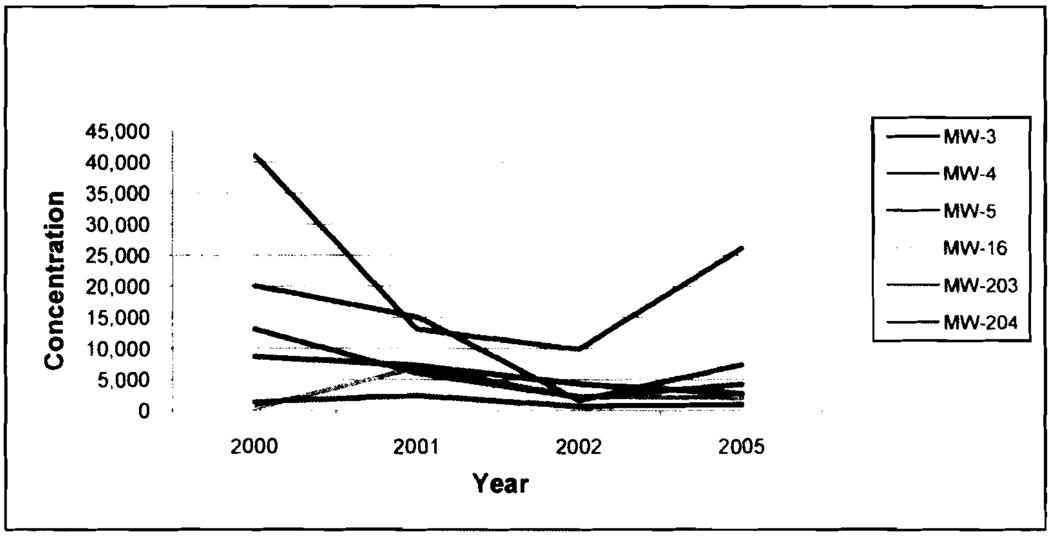
For each of the pumping tests, transmissivity was calculated in Table 3-5.
Aquifer thickness was estimated from the top of the first productive packer zone to the base of the deepest productive packer zone.
Estimated aquifer thickness is shown in the second column for each pumping well.
The average aquifer thickness for each transmissivity is the average of the aquifer thickness at the pumping well and the observation well.

Table 4-1: Calculation of Average Linear Velocity and Travel Time From Bedrock Wells to Pumping Well MW220
Conservative estimates using full vertical aquifer thickness.
Hydraulic Conductivities are from Table 3-7.

Monitoring Well	Well Casing Elevation feet msl	Water Level in Well feet	Pumping Water Level in MW220 feet	Vertical Drop delta h feet	Horizontal distance delta l feet	Hydraulic gradient dh/dl	Hydraulic conductivity gpd/ft ft	Hydraulic conductivity ft/day	Average linear velocity ft/day	Travel Time to MW220 days	Notes Natural flow is without pumping or pumping conditon
MW-202	640.11	622.97	616.17	6.8	270	0.025	6.1	0.82	0.21	1312	Natural flow, high potentiometric surface
		613.85	609.31	4.54	270	0.017	6.1	0.82	0.14	1964	Natural flow, low potentiometric surface
		622.97	575	47.97	270	0.178	6.1	0.82	1.45	186	pumping mw220 down to 575 Elevation
		613.85	550	63.85	270	0.236	6.1	0.82	1.93	140	pumping mw220 down to 575 Elevation
MW-207	629.18	626.8	616.17	10.63	250	0.043	10.35	1.39	0.59	424	Natural flow, high potentiometric surface
		620.83	609.31	11.52	250	0.046	10.35	1.39	0.64	391	Natural flow, low potentiometric surface
		626.8	575	51.8	250	0.207	10.35	1.39	2.87	87	pumping mw220 down to 575 Elevation
		620.83	550	70.83	250	0.283	10.35	1.39	3.93	64	pumping mw220 down to 550 Elevation
MW-204	619.08	615.55	575	40.55	127	0.319	3.2	0.43	1.37	93	pumping mw220 down to 575 Elevation
		609.28	550	59.28	127	0.467	3.2	0.43	2.00	63	pumping mw220 down to 550 Elevation
MW-206	617.51	614.66	575	39.66	170	0.233	6.1	0.82	1.91	89	pumping mw220 down to 575 Elevation
		608.6	550	58.6	170	0.345	6.1	0.82	2.82	60	pumping mw220 down to 550 Elevation
MW-209	611.85	611.85	575	36.85	275	0.134	5.9	0.79	1.06	260	pumping mw220 down to 575 Elevation
		607.52	550	57.52	275	0.209	5.9	0.79	1.65	166	pumping mw220 down to 550 Elevation
MW-211	624.76	615.42	575	40.42	205	0.197	4.4	0.59	1.16	176	pumping mw220 down to 575 Elevation
		609.11	550	59.11	205	0.288	4.4	0.59	1.70	121	pumping mw220 down to 550 Elevation
MW-219	608.30	607.42	575	32.42	457	0.071	11.5	1.54	1.09	418	pumping mw220 down to 575 Elevation
		603.25	550	53.25	457	0.117	11.5	1.54	1.80	255	pumping mw220 down to 550 Elevation

Table 4-2 Variation of VOCs in Four Successive Sampling Events

Year	Monitoring Well					
	MW-3	MW-4	MW-5	MW-16	MW-203	MW-204
2000	8,700	20,000	41,000	400	13,000	1,300
2001	7,300	15,000	13,000	7,000	6,000	2,400
2002	4,300	1,600	9,800	2,300	2,100	610
2005	2,700	7,300	26,000	2,100	4,200	900



Water and Static Groundwater Elevations - Wallkill Wellfield Site

DTW									Static Groundwater Elevations								
Dec-03	Mar-04	Jun-04	Sep-04	Jun-05	Oct-05	Jan-06	Mar-06	Jun-06	Dec-00	Dec-03	Mar-04	Jun-04	Sep-04	Jun-05	Oct-05	Jan-06	Ma
6.65	6.5	6.45	6.51	10.15	13.93	6.11	8.70	NF	645.57	645.43	645.58	645.63	645.57	641.93	638.15	645.97	64
10.95	11.1	11.01	11	15.45	17.01	9.68	14.07	NF	629.07	628.12	627.97	628.06	628.07	623.62	622.06	629.39	62
4.27	5.05	4.95	4.9	11.14	12.04	3	9.20	6.71	622.31	621.95	621.17	621.27	621.32	615.08	614.18	623.22	61
4.16	4.01	4	4	8.74	dry	3.45	6.11	3.65	615.46	615.19	615.34	615.35	615.35	610.61	Dry	615.9	61
5.91	5.5	5.35	5.36	11.99	dry	3.85	10.15	4.42	NR[1]	621.96	622.37	622.52	622.51	615.88	Dry	624.02	61
0.9	1.1	1.05	1.09	2.89	7.73	IA	1.90	IA	611.12	611.4	611.2	611.25	611.21	609.41	604.57	IA	61
3.25	3.41	3.35	3.33	8.18	10.21	2.27	6.24	NF	626.1	625.43	625.27	625.33	625.35	620.5	618.47	626.41	62
7.79	7.45	7.4	7.42	11.35	dry	7.4	10.25	7.42	647.56	647.33	647.67	647.72	647.7	643.77	Dry	647.72	64
5.35	5.25	5.2	5.23	8.22	9.17	4.62	6.60	4.85	608.65	607.48	607.58	607.63	607.6	604.61	603.66	608.21	60
3.44	3	3	3.02	7.51	11.45	2.64	4.36	3.21	623.92	623.54	623.98	623.98	623.96	619.47	615.53	624.34	62
6.35	6.45	6.5	6.52	Dry	dry	4.8	9.67	5.19	620.56	618.38	618.28	618.23	618.21	Dry	Dry	619.93	61
18.78	20.05	20.02	20	22.35	24.65	17.8	20.95	18.11	628.08	627.84	626.57	626.6	626.62	624.27	621.97	628.82	62
15.72	16.01	16	16.01	19.82	22.09	14.65	17.94	15.25	623.03	622.4	622.11	622.12	622.11	618.3	616.03	623.47	62
20.52	20.75	21	21.95	22.77	24.48	20.5	20.52	21.19	614.08	615.29	615.06	614.81	613.86	613.04	611.33	615.31	61
4.62	4.75	4.6	4.5	10.59	11.33	2.6	8.74	4.00	621.53	621.08	620.95	621.1	621.2	615.11	614.37	623.1	61
NC	NC	NC	NC	6.5	7.85	4.45	5.70	4.41	NC	NC	NC	NC	NC	601.74	600.39	603.79	60
12.75	11.9	12	12.01	16.69	18.7	11.67	15.12	NF	627.8	627.36	628.21	628.11	628.1	623.42	621.41	628.44	62
3.5	3.21	3.25	3.25	10.03	11.11	1.99	8.01	3.62	622.19	621.46	621.75	621.71	621.71	614.93	613.85	622.97	61
3.82	3.75	3.7	3.58	8.94	9.8	3.53	5.81	3.81	615.45	615.26	615.33	615.38	615.5	610.14	609.28	615.55	61
NC	NC	NC	NC	7.03	8.91	2.85	4.91	2.97	NC	NC	NC	NC	NC	610.48	608.6	614.66	61
3	3	2.9	2.92	6.59	8.35	2.38	5.21	NF	626.45	626.18	626.18	626.28	626.26	622.59	620.83	626.8	62
NC	NC	NC	NC	2.47	4.33	0	0.24	0.00	NC	NC	NC	NC	NC	609.38	607.52	611.85	61
NC	NC	NC	NC	13.82	15.65	9.34	11.64	9.62	NC	NC	NC	NC	NC	610.94	609.11	615.42	61
NC	NC	NC	NC	2.85	5.05	0.88	2.33	0.98	NC	NC	NC	NC	NC	605.45	603.25	607.42	60
NC	NC	NC	NC	10.63	12.58	5.72	8.29	6.27	NC	NC	NC	NC	NC	611.26	609.31	616.17	61

tructed until 2005 IA-inaccessible NF-Not Found

Table 4-3

Table 1.1 Potential Degradation Processes for CAHs

	Compound [a/]											
	Chloroethenes				Chloroethanes				Chloromethanes			
Degradation Process	PCE	TCE	DCE	VC	PCA	TCA	DCA	CA	CT	CF	MC	CM
Aerobic Oxidation	N	N	P	Y	N	N	Y	Y	N	N	Y	P
Aerobic Cometabolism	N	Y	Y	Y	P	Y	Y	Y	N	Y	Y	Y
Anaerobic Oxidation	N	N	P	Y	N	N	Y	P	N	N	Y	P
Direct Anaerobic Reductive Dechlorination	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Cometabolic Anaerobic Reduction	Y	Y	Y	Y	P	Y	Y	P	Y	Y	Y	P
Abiotic Transformation	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Modified from ITRC (1998) using references listed in Table 2.1 in Section 2 of this document.

a/ PCE = tetrachloroethene, TCE = trichloroethene, DCE = dichloroethene, VC = vinyl chloride, PCA = tetrachloroethane, TCA = trichloroethane, DCA = dichloroethane, CA = chloroethane, CT = carbon tetrachloride, CF = chloroform, MC = methylene chloride, CM = chloromethane.

N = Not documented in the literature.

Y = Documented in the literature.

P = Potential for reaction to occur but not well documented in the literature.

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) “Principles and Practices of Enhanced Bioremediation of Chlorinated Solvents,” online PDF, Table1.1, page 1-9.

Table 4-4

Table 3.1 Suitability of Site Characteristics for Enhanced Anaerobic Bioremediation

Site Characteristic	Suitable for Enhanced Bioremediation	Suitability Uncertain	Suitability Unclear - Possible Red Flag - Requires Further Evaluation
DNAPL Presence	Residual DNAPL or sorbed sources.	Poorly defined sources may require additional characterization.	**May not be appropriate for aggressive treatment of pools of DNAPL.**
Plume Size	Small, a few acres or less.	Medium to large, a few acres plus. May require concurrent technology.	**Large plumes of many acres. May require concurrent technology.**
On or Near Site Infrastructure	The risk of vapor intrusion from contaminants or biogenic gases is deemed acceptable.	Target treatment zone in close proximity to sensitive infrastructure.	**Target treatment zone in an area where known vapor intrusion or high methane problems exist.**
Evidence of Anaerobic Dechlorination	Slow or stalled dechlorination (see Table 3.2)	Limited evidence of anaerobic dechlorination.	**No evidence of any degradation.**
Depth	50 feet to water	100 feet to groundwater	**Deep groundwater and deep contamination.**
Hydraulic Conductivity	1 ft/day (3×10^{-4} cm/sec)	0.01 to 1 ft/day (3×10^{-6} to 3×10^{-4} cm/sec)	**<0.01 ft/day (<3×10^{-6} cm/sec)**
Groundwater Velocity	30 ft/yr to 5 ft/day	10 ft/yr to 30 ft/yr. 5 ft/day to 10 ft/day	**< 10 ft/yr. > 10 ft/day**
pH	6.0 – 8.0	5.0 to 6.0. 8.0 to 9.0	**< 5.0. > 9.0**
Sulfate Concentration	500 ppm	500 to 5,000 ppm (with caution)	**>5,000 ppm or presence of mineral gypsum may not be suitable**

ft/day = feet per day; ft/yr = feet per year; cm/sec = centimeters per second; mg/L = milligrams per liter

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) "Principles and Practices of Enhanced Bioremediation of Chlorinated Solvents," online PDF, Table 3.1, page 3-10.

TABLE 4-5

Table 3.2 Considerations and Red Flags for Preliminary Screening of Sites with PCE and TCE

	Site Classification		
Conditions	**Type 1**	**Type 2**	**Type 3**
No *cis*-DCE or other dechlorination products	***Red Flag*. Lack of any dechlorination products suggests the aquifer is sterile. Enhanced bioremediation not recommended.**	***Possible Red Flag*. Lack of any dechlorination products may be due to substrate limitations. Additional site evaluation (e.g., pilot test or microcosm test) recommended (Section 4).**	***Red Flag*. Potential for complete anaerobic dechlorination cannot be determined. Additional site evaluation (e.g., pilot test or microcosm test) recommended (Section 4).**
cis-DCE present, but not VC or ethene	Marginally suitable for enhanced bioremediation. Lack of VC or ethene under Type 1 conditions requires further evaluation (Section 4).	Suitable for enhanced bioremediation. Evaluate potential for complete anaerobic dechlorination (Section 4) and proceed with caution.	Presence of *cis*-DCE under Type 3 conditions may be a result of limited dechlorination at the source or in more anaerobic microenvironments. Requires further evaluation (Section 4).
VC and ethene present	Suitable for enhanced bioremediation. Consider MNA alternative first.	Suitable for enhanced bioremediation. Consider MNA alternative and whether system may become carbon limited in the absence of substrate addition	VC and ethene should not be present under Type 3 conditions, although this may sometimes occur as the result of locally reducing conditions created by the NAPL mix. For example, if the material released contained biodegradable oils, it is possible that some anaerobic dechlorination will take place, even in an aerobic aquifer.

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) "Principles and Practices of Enhanced Bioremediation of Chlorinated Solvents," online PDF, Table 3.2, page 3-12.

Table 4-6: Field Chemistry Analysis of Groundwater Samples for Indicator Parameters as Evidence of Anaerobic Biodegradation (Reductive Dechlorination) of Chlorinated Solvents (PCE Release)

December 16, 2002 to January 7, 2003 Sampling Event

Analyte	Method	MW-1 12/16/2002	MW-2 12/16/2002	MW-16 12/7/2002	MW-4 12/19/2002	MW-5 1/2/2003	MW-6 1/6/2003	MW-7 12/17/2002	MW-8 12/16/2002	MW-9 1/2/2003	MW-10 12/20/2002	MW-11 1/6/2003
CarbonDioxide	titration	N/A	N/A	70	45	25	<10	14	N/A	14	22	30
Sulfide	8131	0.274	OR>0.6	0.024	0.019	0.068	0.054	0.356	0.021	0.031	0.005	0.13
Ferrous Iron	8146	UR	2.56	0.01	0.03	0.01	UR	0.24	UR	0.01	0.03	0.21
Total Iron	8008	0.04	OR>3.0	0.11	2.08	2.26	0.22	OR>3	0.04	0.42	0.01	1.93
Sulfate	8051	30	19	34	23	14	26	36	57	14	51	11
Nitrate												
NO3--N	8039	1.1	1.3	3.6	1.5	UR	UR	2.3	1.1	UR	0.9	0.3
NO3	8039			15.9	6.8	UR	UR	10.4		UR	3.8	1.2
Nitrite												
NaNO2	8507	UR	UR	UR	0.031	UR	0.008	0.064	UR	0.022	UR	UR
NO2--N	8507	UR	UR	UR	0.006	UR	0.002	0.013	UR	0.004	UR	UR
NO2--N	8507	UR	UR	UR	0.021	UR	0.005	0.042	UR	0.015	UR	UR
Manganese												
KMnO4	8034	N/A	N/A	UR	0.4	UR	0	0	N/A	UR	UR	UR
Mn	8034	N/A	N/A	UR	0.2	UR	0	0	N/A	UR	UR	UR
MnO4-	8034	N/A	N/A	UR	0.3	UR	0	0	N/A	UR	UR	UR
Hardness												
Mg as CaCO3	8030	UR	0.12	UR	0.61	UR	0.55	UR	0.02	1.37	UR	2.67
Ca as CaCO3	3030	UR	0.42	0.11	0.1	0.01	UR	UR	UR	UR	UR	UR
Ca	8030	UR	0.17	0.04	0.04	0	UR	UR	UR	UR	UR	UR
Chloride	8113	OR>20	OR>20	17.6	14.6	17.5	OR>20	OR>20	UR	10.9	OR>20	19.6

Analyte	Method	MW-12 12/19/2001	MW-13 12/30/2002	MW-14 12/30/2002	MW-16 12/7/2002	MW-202 12/30/2002	MW-202F 1/2/2003	MW-203 12/18/2001	MW-203F 12/18/2002	MW-204 12/18/2002	MW-207 12/19/2002
CarbonDioxide	titration	14	10.5	10.2	70	18	11	60	40	30	25
Sulfide	8131	0.202	0.098	0.081	0.024	0.031	0.052	0.03	0.044	0.021	OR>0.6
Ferrous Iron	8146	1.76	0.32	0.07	0.01	0	1.69	UR	0.78	2.13	2.98
Total Iron	8008	OR>3	1.07	1.45	0.11	0.31	2.87	OR>3	OR>3	OR>3	OR>3
Sulfate	8051	27	26	30	34	11	31	34	30	40	27
Nitrate											
NO3--N	8039	UR	UR	UR	3.6	UR	UR	2.1	4.2	UR	UR
NO3	8039	UR	UR	UR	15.9	UR	UR	9.2	18.5	UR	UR
Nitrite											
NaNO2	8507	UR	UR	UR	UR	UR	UR	UR	0.009	UR	UR
NO2--N	8507	UR	UR	UR	UR	UR	UR	UR	0.002	UR	UR
NO2--N	8507	UR	UR	UR	UR	UR	UR	UR	0.006	UR	UR
Manganese											
KMnO4	8034	UR	UR	0.9	UR	2.7	0.1	0.4	0.5	2.1	0.9
Mn	8034	UR	UR	0.3	UR	1	0	0.2	0.2	0.7	0.3
MnO4-	8034	UR	UR	0.7	UR	2.1	0.1	0.3	0.4	1.6	0.7
Hardness											
Mg as CaCO3	8030	0.08	0.2	UR	UR	UR	UR	UR	0.04	UR	0.16
Ca as CaCO3	3030	0.14	UR	UR	0.11	UR	UR	0.35	UR	0.57	UR
Ca	8030	0.05	UR	UR	0.04	UR	UR	0.14	UR	0.23	UR
Chloride	8113	OR>20	N/A	N/A	17.6	OR>20	OR>20	OR>20	23.5	OR>20	OR>20

Notes: Field measurements made with Hach methods as specified except for Carbon Dioxide which is a Chemmetrics Titration method.
N/A = not analyzed, UR = under test range, OR = over test range

Table 4-7: Overburden Monitoring Well Scoring providing Evidence of Anaerobic Biodegradation

(Reductive Dechlorination) of Chlorinated Solvents (PCE Release)

December 16, 2002 to January 7, 2003 Sampling Event

	Near Source Wells								Downgradient			
	MW-5 1/2/2003		MW-16 12/17/2002		MW-3 12/17/2002		MW-11 1/6/2003		MW-4 12/19/2002		MW-9 1/2/2003	
Parameter	Mmt	Points	Mmt	Points	Mmt	Points	Mmt	Points	Mmt	Points	Mmt	Points
PID	58.3		60.0		89.1		n/a		44.4		0.0	
Sump Depth	13		10		13		11		10		14	
pH	5.19	0	5.22	0	5.28	0	4.45	-2	4.9	-2	4.63	-2
Conductivity	0.242		0.353		0.41		0.081		0.244		0.086	
Turbidity	185		40.2		62.2		226		30.7		111	
Dissolved Oxygen	5	0	6.31	-3	3.68	0	9.29	-3	5.57	-3	12.2	-3
Temperature	6.99	0	10.55	0	11.04	0	8.53	0	9.03	0	8.95	0
ORP	131	0	138	0	131	0	163	0	152	0	166	0
Carbon Dioxide	25	1	70	1	70	1	30	1	45	1	14	0
Sulfide	0.068	0	0.024	0	0.027	0	0.13	0	0.019	0	0.031	0
Ferrous Iron	0.01	0	0.01	0	0	0	0.21	0	0.03	0	0.01	0
Total Iron	2.26		0.11		OR>3		1.93		2.08		0.42	
Sulfate	14	2	34	0	34	0	11	2	23	0	14	2
Nitrate NO3-N	UR	2	3.6	0	4.2		0.3	0	1.5	2	UR	2
NO3	UR		15.9		18.7		1.2		6.8		UR	
Nitrite NaNO2	UR		UR		UR		UR		0.031		0.022	
NO2-N	UR		UR		UR		UR		0.006		0.004	
NO2-N	UR		UR		UR		UR		0.021		0.015	
Manganese KMnO4	UR		UR		0.2		UR		0.4		UR	
Mn	UR		UR		0.1		UR		0.2		UR	
MnO4-	UR		UR		0.1		UR		0.3		UR	
Hardness Mg as CaCO3	UR		UR		UR		2.67		0.61		1.37	
Ca as CaCO3	0.01		0.11		UR		UR		0.1		UR	
Ca	0		0.04		UR		UR		0.04		UR	
Chloride	17.5	2	17.6	2	23.2	2	19.6	2	14.6	2	10.9	2
Ethane	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Ethene	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Methane	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Alkaline	n/a		140	0	180	1	n/a		n/a		n/a	
Tot Org Carbon	4.3	0	2.5	0	1.8	0	1.2	0	25	2	3	0
PCE	9800	0	2300	0	4300	0	740	0	1600	0	770	0
TCE	160	2	160	2	160	2	56	2	ND	2	73	2
DCE(cis)	350	2	210	2	310	2	40	2	140	2	85	2
VC	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
methylene chloride	94B	2	ND	0	ND	0	ND	0	ND	0	ND	0
Total Points =		13		4		8		4		6		5

Notes: Each well is represented by two columns, one with field and lab measurements and the other with points based on the first column.l
"Mmt" is the heading for the well measurement columns.
"Points" is the column heading for the awarded points for the evidentiary score assessing likelihood of anaerobic biodegradation..
MW-202 and MW-202F represent two samples from the same well; the first sample was taken at the fracture depth,
for the second sample the well cover was already off and the well was "open" and therefore no PID reading was recorded.
MW-203 and MW203F also represent two samples from the same well; the first sample was taken from near the bottom of the well,
for the second sample from the fractured well, the well was "open" and therefore no PID reading was taken.
n/a = not analyzed, ND = not detected.
B = indicates a background level of analyte detected in blank

Table 4-8: Bedrock Monitoring Well Scoring providing Evidence of Anaerobic Biodegradation
(Reductive Dechlorination) of Chlorinated Solvents (PCE Release)
December 16, 2002 to January 7, 2003 Sampling Event

	Near Source Well				Upgradient Wells						Downgradient	
	MW-203 12/18/2001		MW-203F 12/18/2002		MW-202 12/30/2002		MW-202F 1/2/2003		MW-13 12/30/2002		MW-204 12/18/2002	
Parameter	Mmt	Points	Mmt	Points	Mmt	Points	Mmt	Points	Mmt	Points	Mmt	Points
PID	open		18.1		0.0		open		0.0		23.3	
Pump Depth	110		18		141		54		87		91.5	
pH	5.45	0	5.92	0	9.42	-2	9.65	-2	9.7	-2	8.72	0
Conductivity	0.375		0.367		0.591		0.611		0.766		0.632	
Turbidity	176		185		112		33.6		87.8		34.5	
Dissolved Oxygen	4.12	0	3.11	0	3.49	0	3.48	0	1.21	0	3.59	0
Temperature	10.51	0	8.18	0	10.03	0	8.69	0	10.02	0	8.6	0
ORP	120	0	81	0	-137	2	-148	2	-153	2	-94	1
CarbonDioxide	60	1	40	1	18	1	11	0	10.5	0	30	1
Sulfide	0.03	0	0.044	0	0.031	0	0.052	0	0.098	0	0.021	0
Ferrous Iron	UR	0	0.78	0	0	0	1.69	3	0.32	0	2.13	3
Total Iron	OR>3		OR>3		0.31		2.87		1.07		OR>3	
Sulfate	34	0	30	0	11	2	31	0	26	0	40	0
Nitrate												
NO3-N	2.1	0	4.2	0	UR	2	UR	2	UR	2	UR	2
NO3	9.2		18.5		UR		UR		UR		UR	
Nitrite												
NaNO2	UR		0.009		UR		UR		UR		UR	
NO2-N	UR		0.002		UR		UR		UR		UR	
NO2-N	UR		0.006		UR		UR		UR		UR	
Manganese												
KMnO4	0.4		0.5		2.7		0.1		UR		2.1	
Mn	0.2		0.2		1		0		UR		0.7	
MnO4-	0.3		0.4		2.1		0.1		UR		1.6	
Hardness												
Mg as CaCO3	UR		0.04		UR		UR		0.2		UR	
Ca as CaCO3	0.35		UR		UR		UR		UR		0.57	
Ca	0.14		UR		UR		UR		UR		0.23	
Chloride	OR>20	2	23.5	2	OR>20	2	OR>20	2	OR>20	2	OR>20	2
Ethane	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Ethene	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
Methane	ND	0	ND	0	70.6	3	59.3	3	ND	0	ND	0
Alkaline	n/a		n/a		n/a		n/a		n/a		n/a	
Tot Org Carbon	2.2	0	2.1	0	n/a		ND	0	n/a		1.5	0
PCE	2100	0	5700	0	720	0	450	0	87	0	610	0
TCE	120	2	300	2	1800	2	1000	2	190	2	64	2
DCE(cis)	280	2	590	2	440	2	230	2	780	2	98	2
VC	ND	0	ND	0	ND	0	ND	0	ND	0	ND	0
methylene chloride	600B	2	670B	2	ND	0	56B	2	ND	0	120B	2
Total Points =		9		9		14		16		8		15

Notes: Each well is represented by two columns, one with field and lab measurements and the other with points based on the first column.
"Mmt" is the heading for the well measurement columns.
"Points" is the column heading for the awarded points for the evidentiary score assessing likelihood of anaerobic biodegradation.
MW-202 and MW-202F represent two samples from the same well; the first sample was taken at the fracture depth,
for the second sample the well cover was already off and the well was "open" and therefore no PID reading was recorded.
MW-203 and MW203F also represent two samples from the same well; the first sample was taken from near the bottom of the well,
for the second sample from the fractured well, the well was "open" and therefore no PID reading was taken.
n/a = not analyzed, ND = not detected.
B = indicates a background level of analyte detected in blank

Table 4-9: pH Measurements
Sampling Events in Monitioring Wells using Horiba Low Flow Cylinder

Monitoring Well	December 2000	January 2001	December 2002	April 2005
MW1	6.6		6.37	8.15
MW2	7.51	3.9 *	8.92	7.47
MW3	6.4		5.28	6.08
MW4	6.85	6.13	4.9	5.9
MW5	6.72	6.56	5.19	6.19
MW6		4.14 *	6.85	8.53
MW7	7.61		7.37	6.93
MW8	7.85			6.53
MW9	6.37	4.66	4.63	5.36
MW10	6.94		5.17	6.52
MW11	dry		4.45	5.34
MW12	7.37		8.66	7.27
MW13	8.62	4.8 *	9.7	7.24
MW14	7.62	7.14	8.1	7.45
MW16	6.24	6.14	5.22	6.03
MW19				5.92
MW30				7.62
MW202	7.43		9.42	7.5
MW202F			9.65	
MW203	6.21	3.79 *	5.45	6.31
MW203F			5.92	
MW204	7.4	3.62 *	8.72	7.33
MW206				7.06
MW207	7.13		8.66	7.11
MW209				7.2
MW211				7.03
MW219				7.21
MW220				7.39

* indicates readings for January 2001 appear to be too high compared to other readings.

"F" indicates sample was table at fracture level in well

Table 4-10: Oxidation Reduction Potential Measurements
Sampling Events in Monitioring Wells using Horiba Low Flow Cylinder

Monitoring Well	December 2000	January 2001	December 2002	April 2005
MW1	288		55	103
MW2	n/a	233	-128	-196
MW3	242	175	131	113
MW4	238	183	152	66
MW5	236	136	131	119
MW6		220	39	101
MW7	206		-6	-34
MW8	170		97	95
MW9	220	204	166	183
MW10	244		142	29
MW11	dry		163	207
MW12	-105		-95	-107
MW13	233	183	-153	1
MW14	249	137	-47	12
MW16	237	187	138	159
MW19				173
MW30				-231
MW202	-88	246	-137	-174
MW202F			-148	
MW203	84	187	120	108
MW203F			81	
MW204	-79	204	-94	-139
MW206				-93
MW207	-8		-92	-174
MW209				16
MW211				-90
MW219				-62
MW220				-109

"F" indicates sample was table at fracture level in well

Table 4-11: Dissolved Oxygen Measurements
Sampling Events in Monitioring Wells using Horiba Low Flow Cylinder

Monitoring Well	December 2000	January 2001	December 2002	April 2005
MW1	3.29		2.05	1.74
MW2	1.74	11.97 *	1.58	1.28
MW3	1.66	11.36 *	3.68	0
MW4	3.99	6.34	5.57	1.64
MW5	5.66	10.3 *	4.99	3.13
MW6		12.79 *	2.01	2.87
MW7	2.48		2.69	0
MW8	1.79		2.88	0.89
MW9	7.71	13.24	12.2	4.7
MW10	5.49		8.3	8.95
MW11			9.29	2.61
MW12	1.98		2.99	0.18
MW13	2.88	12.83 *	1.21	0.52
MW14	2.44	9.56 *	5.06	0.84
MW16	2.06	0.91	6.31	1.75
MW19				0.08
MW30				0
MW202	0.65	12.49 *	3.49	0
MW202F			3.48	
MW203	3.84	11.39 *	4.12	0
MW203F			3.11	
MW204	1.7	11.76 *	3.59	0
MW206				0
MW207	6.4		5.53	0
MW209				0
MW211				0
MW219				0.52
MW220				0

* indicates readings for January 2001 appear to be too high compared to other readings.

"F" indicates sample was table at fracture level in well

Table 4-12

Table 3.3 Water Quality Parameters Subject to Regulatory Compliance at Enhanced Anaerobic Bioremediation Sites

Compound or Element	Molecular Formula	USEPA MCL (mg/L)[a/]	USEPA Secondary Standard[b/] (mg/L)
Chloroethenes			
Tetrachloroethene (PCE)	C_2Cl_4	0.005	--
Trichloroethene (TCE)	$C_2\,HCl_3$	0.005	--
cis-1,2-dichloroethene (*cis*-DCE)	$C_2\,H_2Cl_2$	0.070	--
trans-1,2-dichloroethene (*trans*-DCE)	$C_2\,H_2Cl_2$	0.100	--
1,1-dichloroethene (1,1-DCE)	$C_2\,H_2Cl_2$	0.007	--
Vinyl chloride (VC)	C_2H_3Cl	0.002	--
Chloroethanes			
1,1,1-trichloroethane (1,1,1-TCA)	$C_2H_3CL_3$	0.200	--
1,1,2-trichloroethane (1,1,2-TCA)	$C_2H_3CL_3$	0.005	--
1,2-dichloroethane (1,2-DCA)	$C_2H_4Cl_2$	0.005	--
Chloromethanes			
Carbon tetrachloride (CT)	CCl_4	0.005	--
Chloroform (CF)	$CHCl_3$	0.1 [c/]	--
Dichloromethane (DCM) (or methylene chloride [MC])	CH_2CL_2	0.005	--
Total trihalomethanes (includes CF)	--	0.080	--
General Water Quality Parameters			
Nitrate (as nitrogen)	NO_3^-	10	--
Nitrite (as nitrogen)	NO_2^-	1.0	--
pH	--	--	<6.5, >8.5
Chloride [d/]	Cl^-	--	250
Total dissolved solids (TDS) [d/]	--	--	500
Metals			
Arsenic [d/]	As	0.01	--
Selenium	Se	0.05	--
Iron [d/]	Fe	--	0.3
Manganese [d/]	Mn	--	0.05

[a/] USEPA MCL = USEPA Maximum Contaminant Level; mg/L = milligrams per liter.

[b/] National secondary drinking water regulations are non-enforceable guidelines. However, states may choose to adopt them as enforceable standards.

[c/] Tentative MCL (pending).

[d/] These are compounds or elements that in some cases may increase in concentrations as the result of anaerobic bioremediation

From Department of Defense Strategic Environmental Research and Development Program (SERDP) (2004) "Principles and Practices of Enhanced Bioremediation of Chlorinated Solvents," online PDF, Table 3.3, page 3-17.

Table 4-13 Hydraulic Pressure, Barometric Pressure, Depth to Water and Water Elevations in Pumping & Observation Wells At Critical Times during the Pumping Test Conducted with Pumping the Parella Well (PW30)

Well	TOC Elev	Installing Transducer						Start of Test 6/26/07 11:20AM				
		Date & Time	Depth to Water	Transducer Pressure	Barometric Pressure	Ft Water Above Tdsr	Elevation	Pressure Transducer	Barometric Pressure	Ft Water Above Tdsr	Depth to Water calculated	Elevation
PW-30	644.34	6/25/07 13:07	19.83	61.9069	14.5303	109.33	624.51	61.7105	14.5387	108.85	20.30	624.04
MW2	639.07	6/18/07 13:14	15.30	20.0651	14.4327	13.00	623.77	20.2837	14.5387	13.26	15.04	624.03
MW3	626.22	6/18/07 14:44	10.53	15.3259	14.4447	2.03	615.69	15.8915	14.5387	3.12	9.44	616.78
MW5	627.87	6/18/07 15:54	11.21	15.0033	14.4152	1.36	616.66	15.2767	14.5387	1.70	10.86	617.01
MW7	628.68	6/18/07 14:14	7.46	18.7747	14.4445	9.99	621.22	19.0004	14.5387	10.30	7.16	621.52
MW10	626.98	6/26/07 10:54	7.85	24.1174	14.5500	22.08	619.13	24.1243	14.5387	22.12	7.81	619.17
MW12	646.62	6/18/07 12:54	22.42	32.0935	14.4329	40.75	624.20	32.4983	14.5387	41.44	21.73	624.89
MW13	638.12	6/26/07 10:14	19.76	25.2173	14.5515	24.61	618.36	25.2173	14.5387	24.64	19.73	618.39
MW16	625.70	6/18/07 14:44	10.57	15.1322	14.4447	1.59	615.13	15.4748	14.5387	2.16	10.00	615.70
MW202	640.11	6/18/07 14:14	16.57	20.146	14.4445	13.16	623.54	20.4919	14.5387	13.74	15.99	624.12
MW203	624.96	6/18/07 15:04	9.20	22.2182	14.4257	17.98	615.76	22.5779	14.5387	18.55	8.63	616.33
MW207	629.18	6/18/07 14:04	6.34	22.9757	14.4257	19.73	622.84	23.2078	14.5387	20.00	6.07	623.11
MW220	621.89	6/25/07 13:04	9.52	25.2721	14.5213	24.81	612.37	25.2915	14.5387	24.81	9.52	612.37

Well	End of Pumping 6/27/07 1:26PM						Removal of Transducer 6/29/07 7-10AM						
	Transducer Pressure	Barometric Pressure	Ft Water Above Tdsr	Depth to Water Calculated	Elevation	Maximum Drawdown	Time	Transducer Pressure	Barometric Pressure	Ft Water Above Tdsr	Depth to Water Measured	Recovery* RE: Static	Elevation
PW-30	42.1748	14.4366	64.01	65.15	579.19	44.84	8:33	62.7005	14.4179	111.42	16.96	-3.34	627.38
MW2	18.8046	14.4366	10.08	18.22	620.85	3.18	8:04	20.427	14.4337	13.83	14.78	-0.26	624.29
MW3	15.7328	14.4366	2.99	9.57	616.65	0.13	7:24	15.9006	14.4436	3.36	9.68	0.24	616.54
MW5	15.155	14.4366	1.66	10.91	616.96	0.05	7:34	15.1955	14.4433	1.74	10.86	0.00	617.01
MW7	18.8027	14.4366	10.08	7.38	621.30	0.22	9:14	19.0659	14.4228	10.71	7.05	-0.11	621.63
MW10	23.9248	14.4366	21.89	8.03	618.95	0.22	9:34	24.1246	14.4417	22.34	7.75	-0.06	619.23
MW12	23.9839	14.4366	22.03	41.14	605.48	19.41	8:14	33.7899	14.4339	44.67	19.12	-2.61	627.50
MW13	24.1122	14.4366	22.33	22.04	616.08	2.31	9:24	25.7278	14.4420	26.04	19.16	-0.57	618.96
MW16	15.3095	14.4366	2.01	10.14	615.56	0.15	7:14	15.4747	14.4340	2.40	9.93	-0.07	615.77
MW202	14.4233	14.4366	-0.03	29.76	610.35	13.77	8:04	21.168	14.4337	15.54	14.95	-1.04	625.16
MW203	22.4124	14.4366	18.40	8.78	616.18	0.15	7:24	22.5876	14.4436	18.79	8.54	-0.09	616.42
MW207	22.0012	14.4366	17.46	8.61	620.57	2.55	9:14	23.3841	14.4228	20.68	5.55	-0.52	623.63
MW220	25.1361	14.4366	24.69	9.64	612.25	0.12	7:44	25.3304	14.4442	25.12	9.38	-0.14	612.51

* Negative recovery values indicate final water level is higher in elevation than pre-test static elevation.

Table 4-14: Parella Well Pumping Test, Groundwater Sampling June and July 2007

Compound (USEPA Method 8260)	Guidance Level	Sample Identification								
		MW-30 June 26, 2007 12:00PM	MW-30 Jue 26, 2007 4:00PM	MW-30 June 26, 2007 7:30PM	MW-30 June 27, 2007 8:30AM	MW-30 June 27, 2007 1:30PM	Holding Tank June 28, 2007	MW-30 June 28, 2007 9:30AM	MW-30 July 6, 2007	MW-30 July 20, 2007
1,2-Dichloroethylene (total)	5	31,000(cis-)	490(cis-)	55(cis-)	36(cis-)	19(cis-)	75(cis-)	29(cis-)	14(cis-)	14(cis-)
Tetrachloroethylene	5	ND	240	270	400	380	140	340	190	200
Trichloroethylene	5	ND	72	52	120	110	47	99	40	33

Notes:
Guidance levels based on NYSDEC Division of Water TOGS 1.1.1 (June 1998) and subsequent NYSDEC Memoranda
ND = Not Detected

APPENDIX C

Bedrock Core Descriptions/Lithologic Logs – Field Notebooks

"Rite in the Rain"®
ALL-WEATHER WRITING PAPER

HORIZONTAL LINE

All-Weather Notebook
No. 391

Book 5

General Switch
Core Descriptions
Feb - March 2005

4 5/8" x 7" - 48 Numbered Pages

MW-209
MW-219
MW-220

return to Kathie Bernkafner

"Rite in the Rain"®
ALL-WEATHER WRITING PAPER

Dr. Katherine Beinkafner
Mid-Hudson Geosciences
1003 Route 44 55
PO Box 332
Clintondale NY 12515-0332
(845) 883-5866

Name Katherine J. Beinkafner, PhD
Ecosystems Strategies, Inc

Address 24 Davis Ave
Poughkeepsie, NY

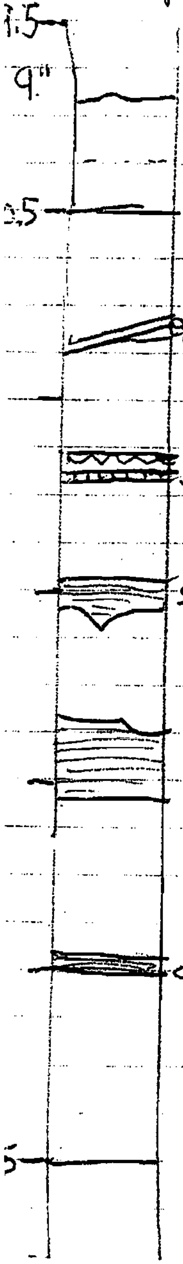
Phone (845) 452-1658
FAX 485-7083

Project Carl Kochersberger Cell 914 475 4132

Driller: Soiltesting, Inc. 800 388 4473

CONTENTS

MW-209 Box 1



graywacky indist. bed.

← 4" hairline weathered fracture

shale + siltstone lam,

graywacke

Box 1 - Core 1

Med gray graywacke

"break, no weath

Graywacke indist bed

wavey shale lam. (1")

(½" white xle calcite

Siltstone

Shale dK gray

graywacke

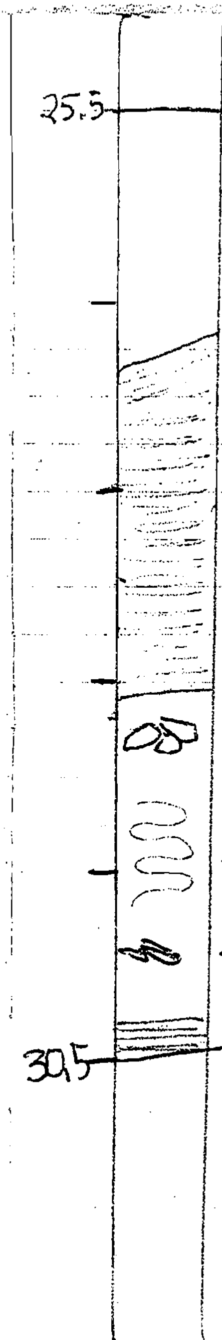
dK gray sh lam.

gray wacke

dK graysh lam.

graywacke
indist bed

MW 209



graywacke

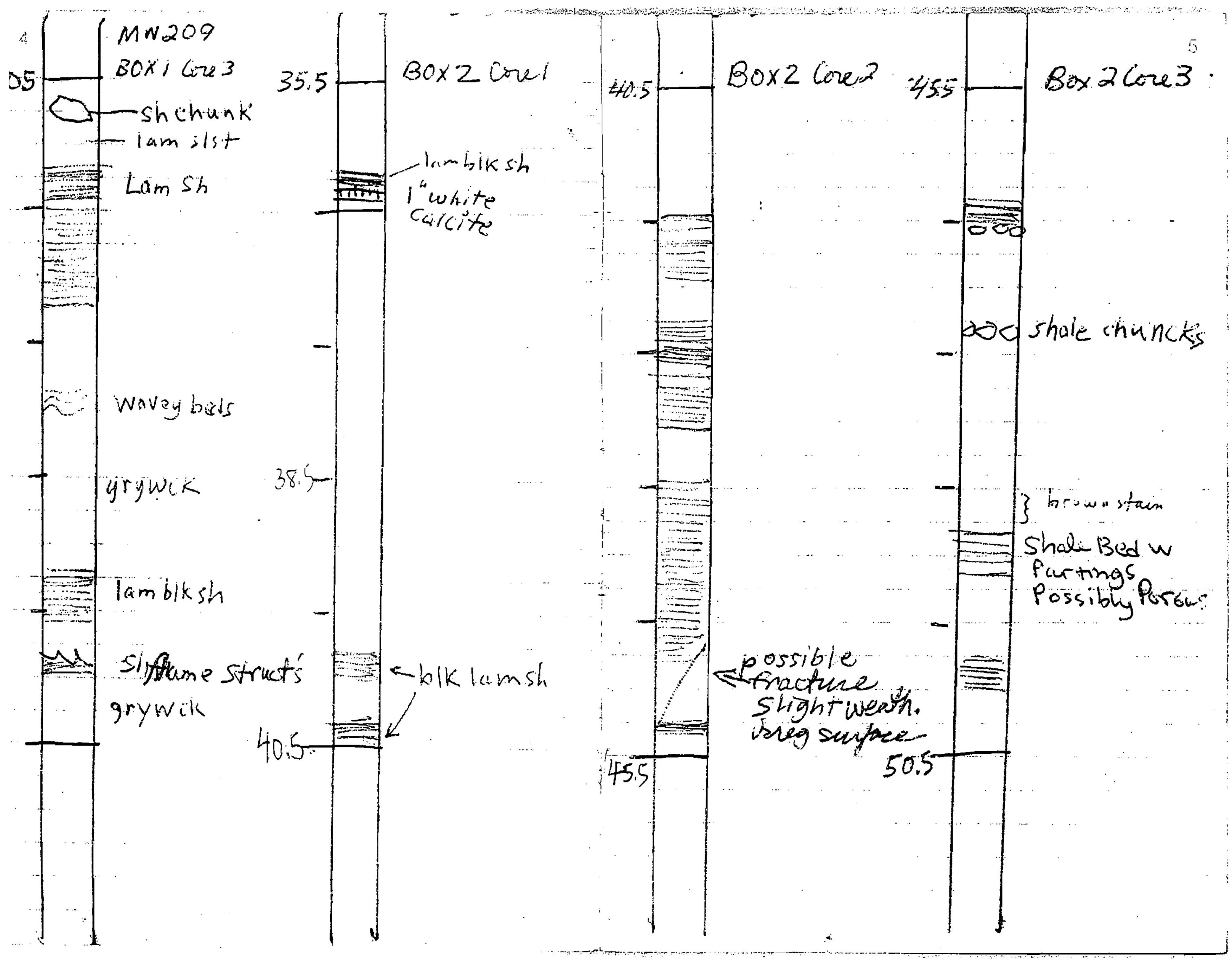
med + dK shale lam

— chuncks shale dK in Med gray shale

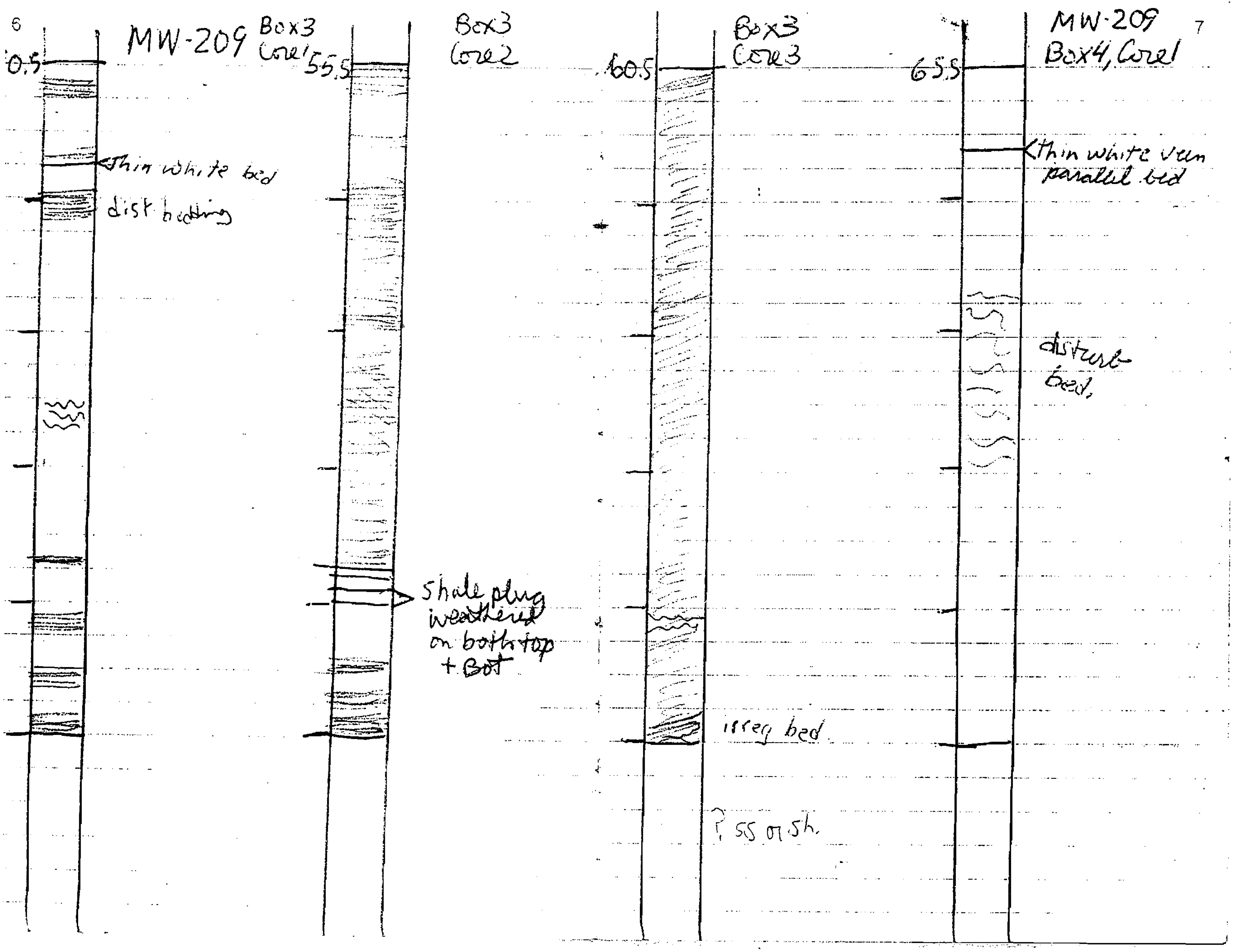
← mixed up beds

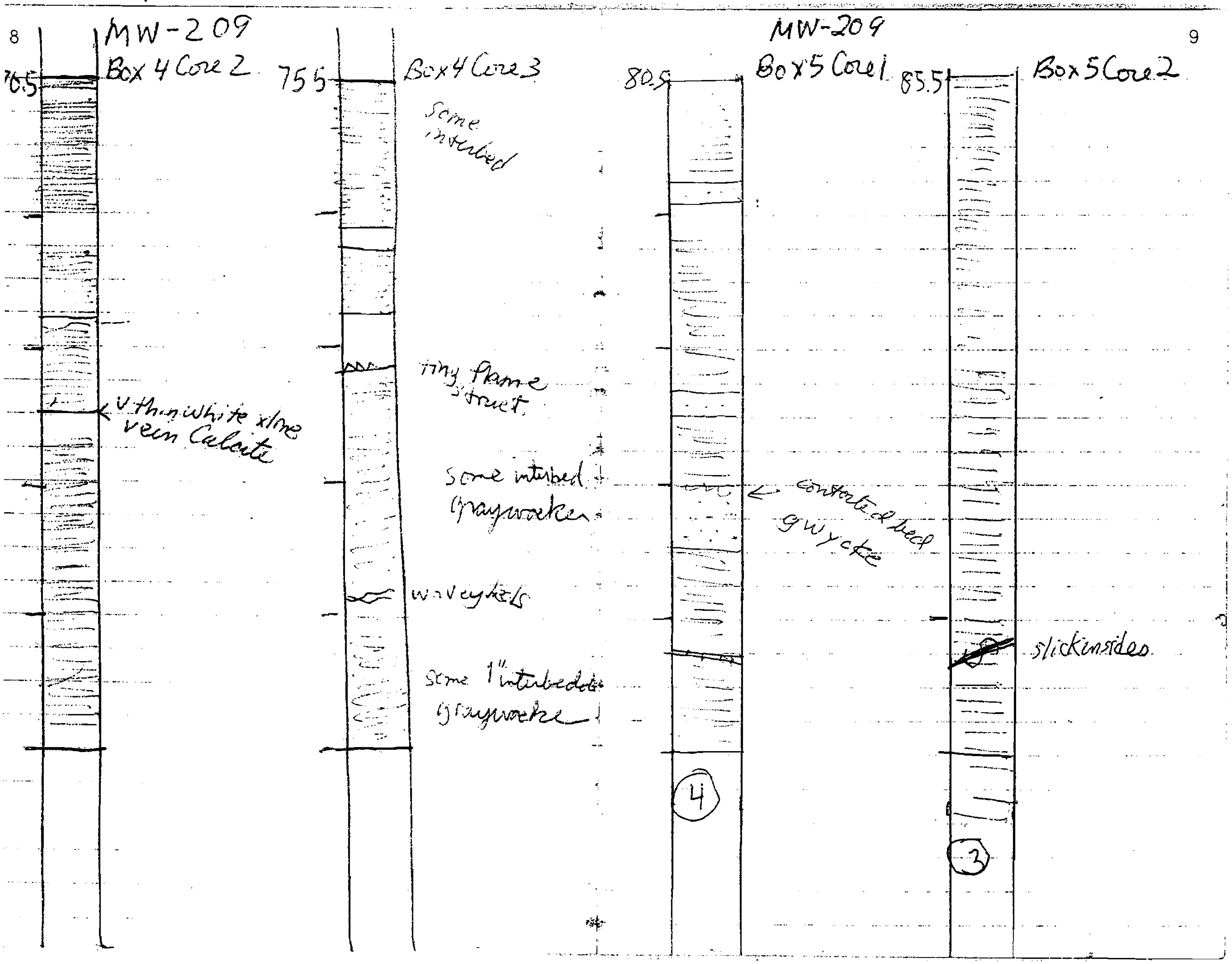
← shale chunks

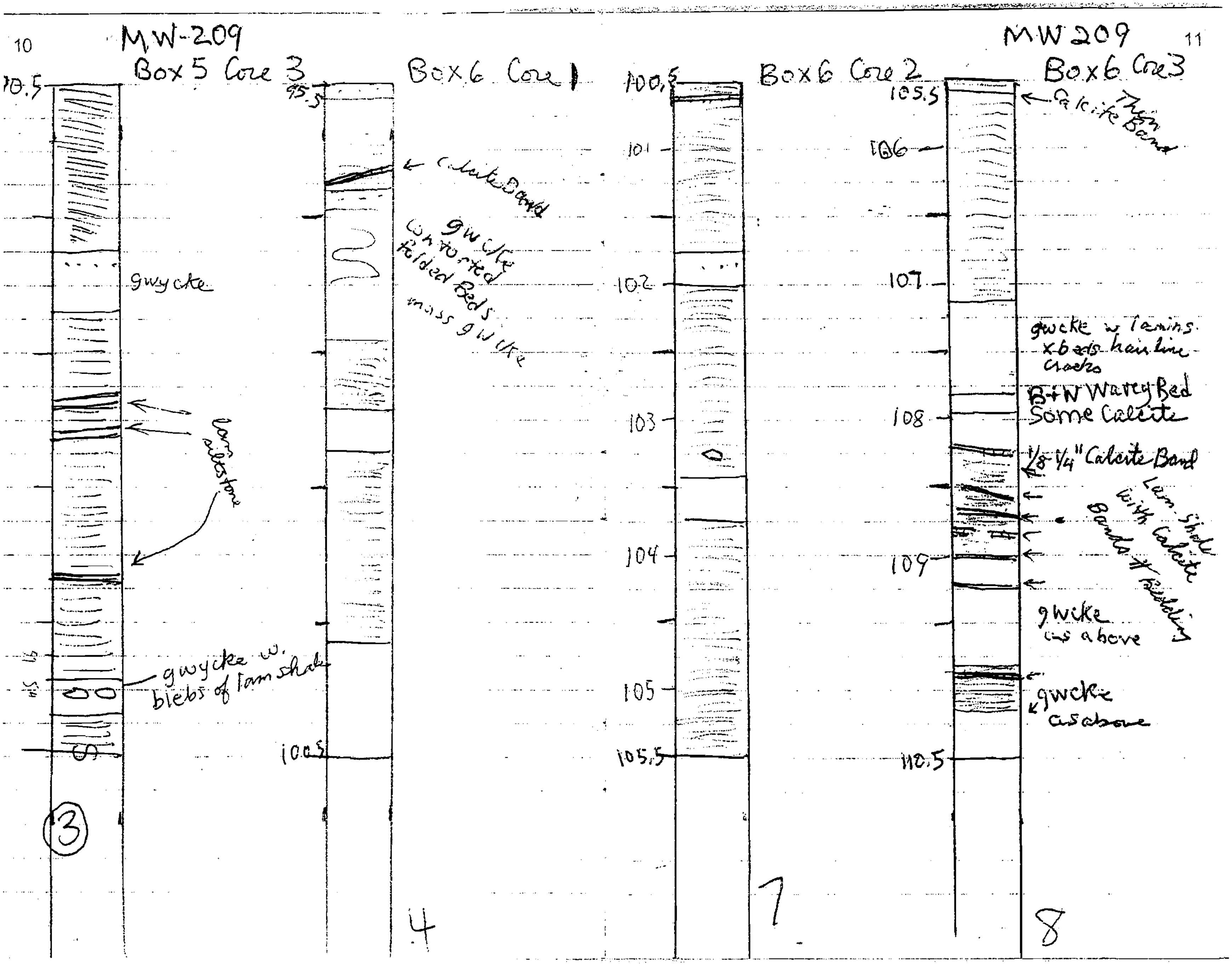
dK + med sh. lam

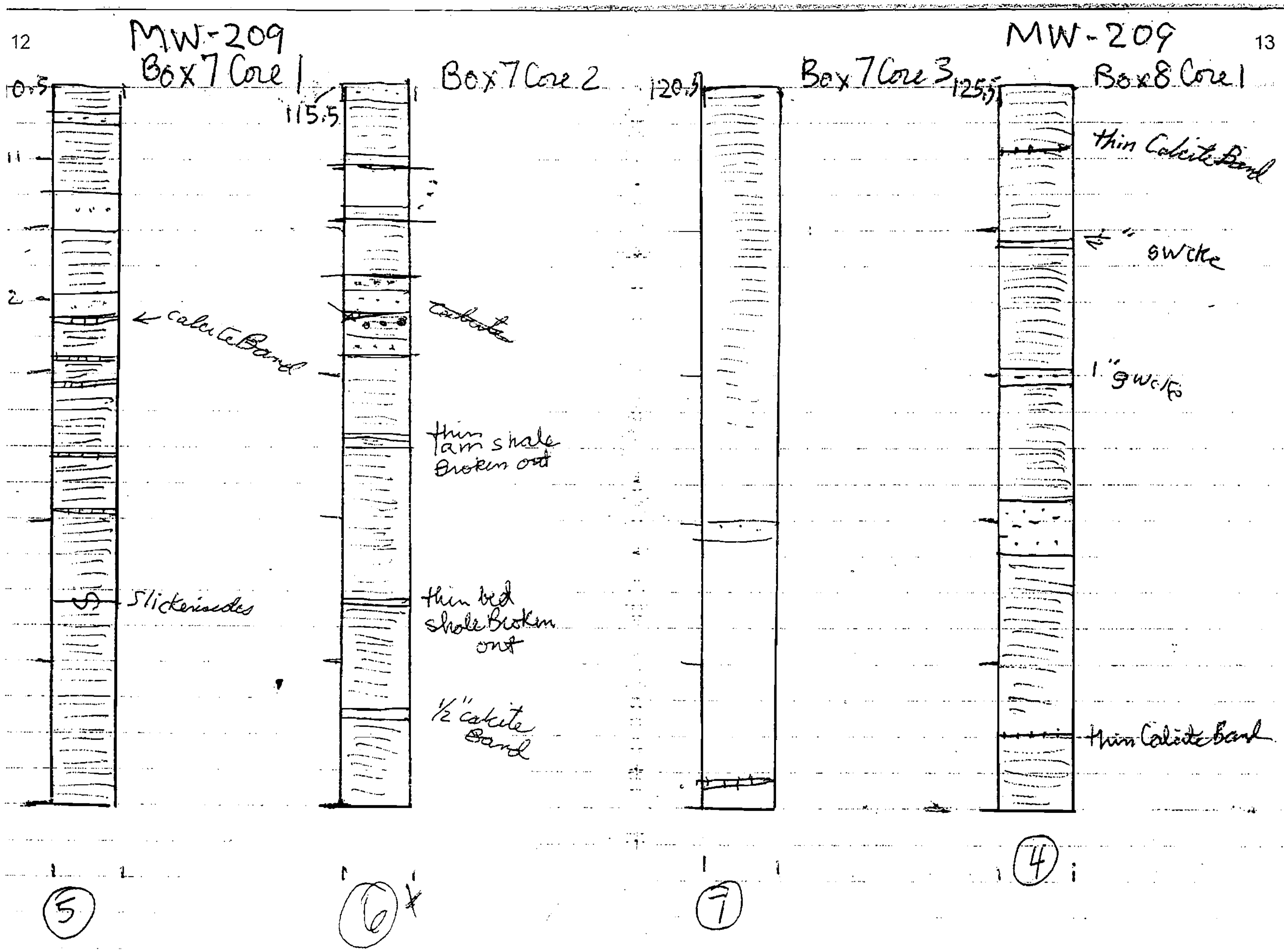


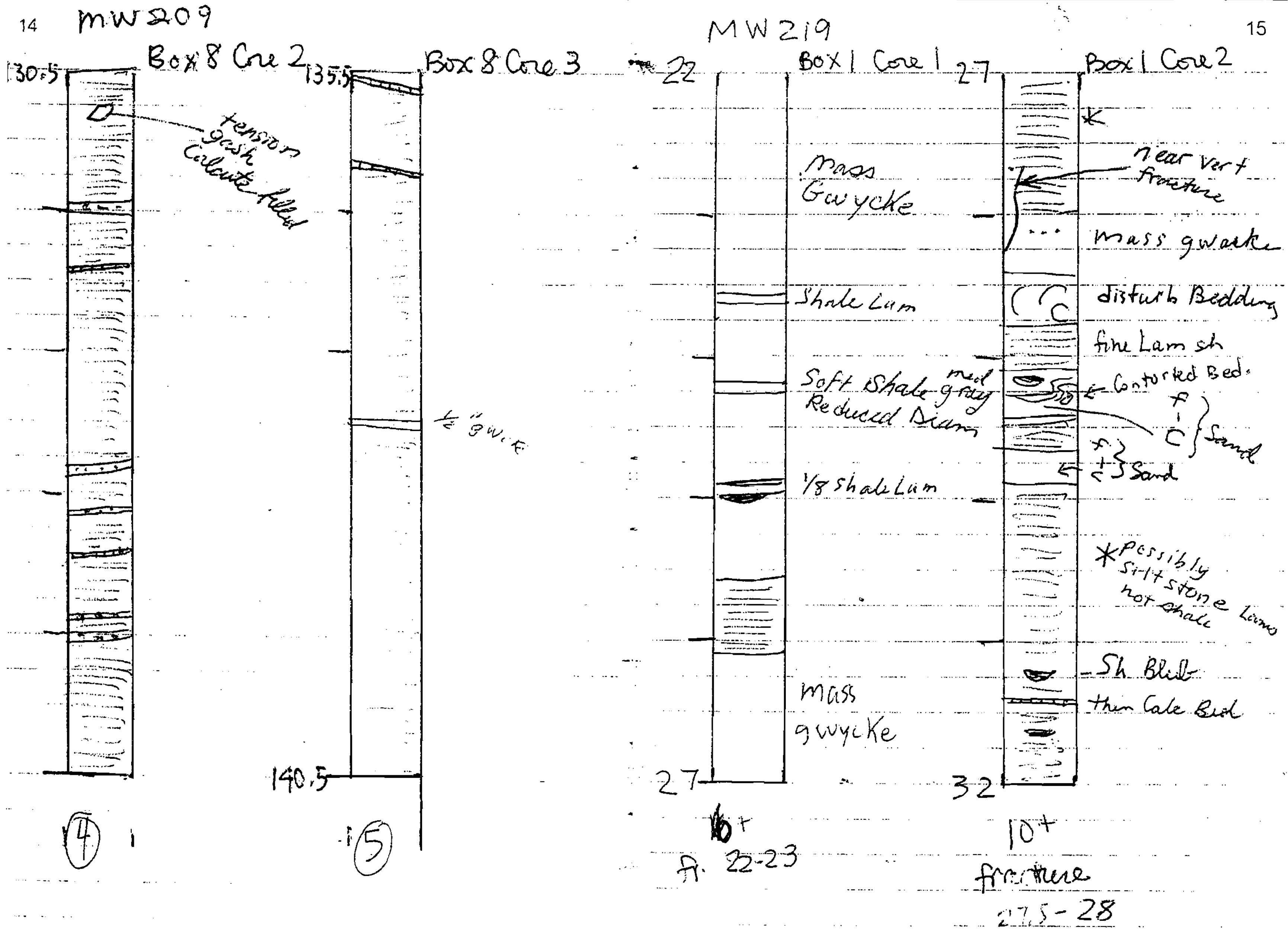
4
MN209
BOX 1 Core 3
05
sh chunk
lam slst
Lam Sh
Wavey beds
grywck
lam blk sh
Sl flame structs
grywck
35.5
BOX 2 Core 1
lam blk sh
1" white calcite
38.5
blk lam sh
40.5
40.5
Box 2 Core 2
possible fracture
Slight weath.
irreg surface
45.5
45.5
Box 2 Core 3
5
shale chuncks
brown stain
Shale Bed w partings
Possibly Porous
50.5

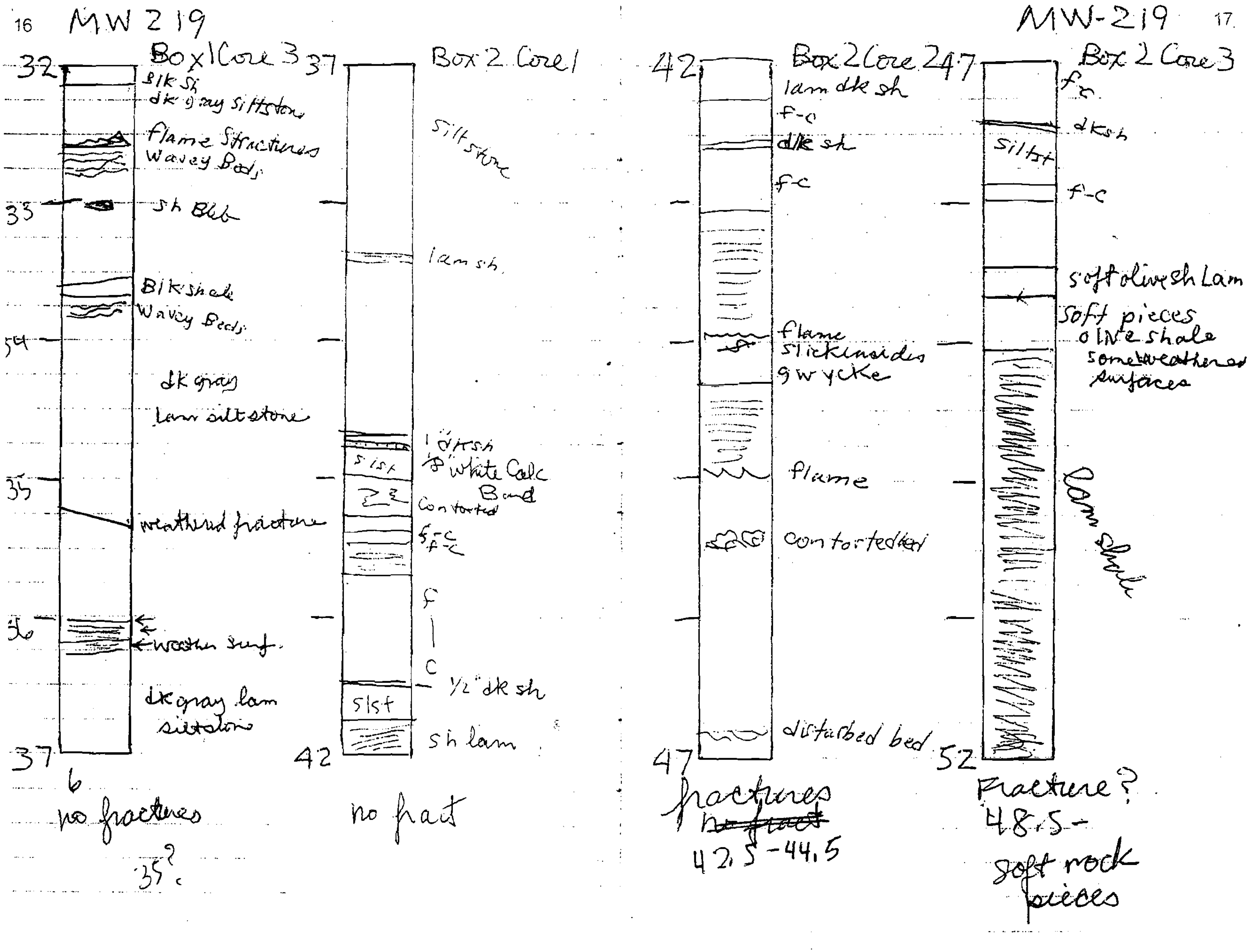

MW-209 Box3 Core1
50.5
Thin white bed
dist bedding
Box3 Core2
55.5
Shale plug weathered on both top + Bot
Box3 Core3
60.5
irreg bed
? SS or sh.
MW-209 Box4, Core1
65.5
Thin white vein parallel bed
disturb bed,


MW-209
Box 4 Core 2
76.5
v thin white xlne vein Calcite
75.5
Box 4 Core 3
Some interbed
tiny flame struct.
Some interbed graywacke
waveyktels
Some 1" interbeds graywacke
MW-209
80.5
Box 5 Core 1
contorted bed gwycke
4
85.5
Box 5 Core 2
slickensides
3


MW-209
Box 5 Core 3
90.5
gwycke
lam siltstone
gwycke w. blebs of lam shale
95.5
Box 6 Core 1
Calcite Band
gwcke contorted folded Beds
mass gwcke
100.5
Box 6 Core 2
101
102
103
104
105
105.5
MW 209
Box 6 Core 3
Thin Calcite Band
105.5
106
107
gwcke w lamins. x-beds hairline cracks
B+W Wavey Bed
108
Some Calcite
1/8-1/4" Calcite Band
Lam. Shale with Calcite Bands // Bedding
109
gwike as above
gwcke as above
110.5
3
4
7
8


MW-209
Box 7 Core 1
0.5
11
2
calcite Band
Slickensides
5
Box 7 Core 2
115.5
Calcite
thin lam shale Broken out
thin bed shale Broken out
1/2" calcite Band
6
Box 7 Core 3
120.5
7
MW-209
Box 8 Core 1
125.5
thin Calcite Band
1/2" SWCKe
1" gw c/fo
thin Calcite Band
4

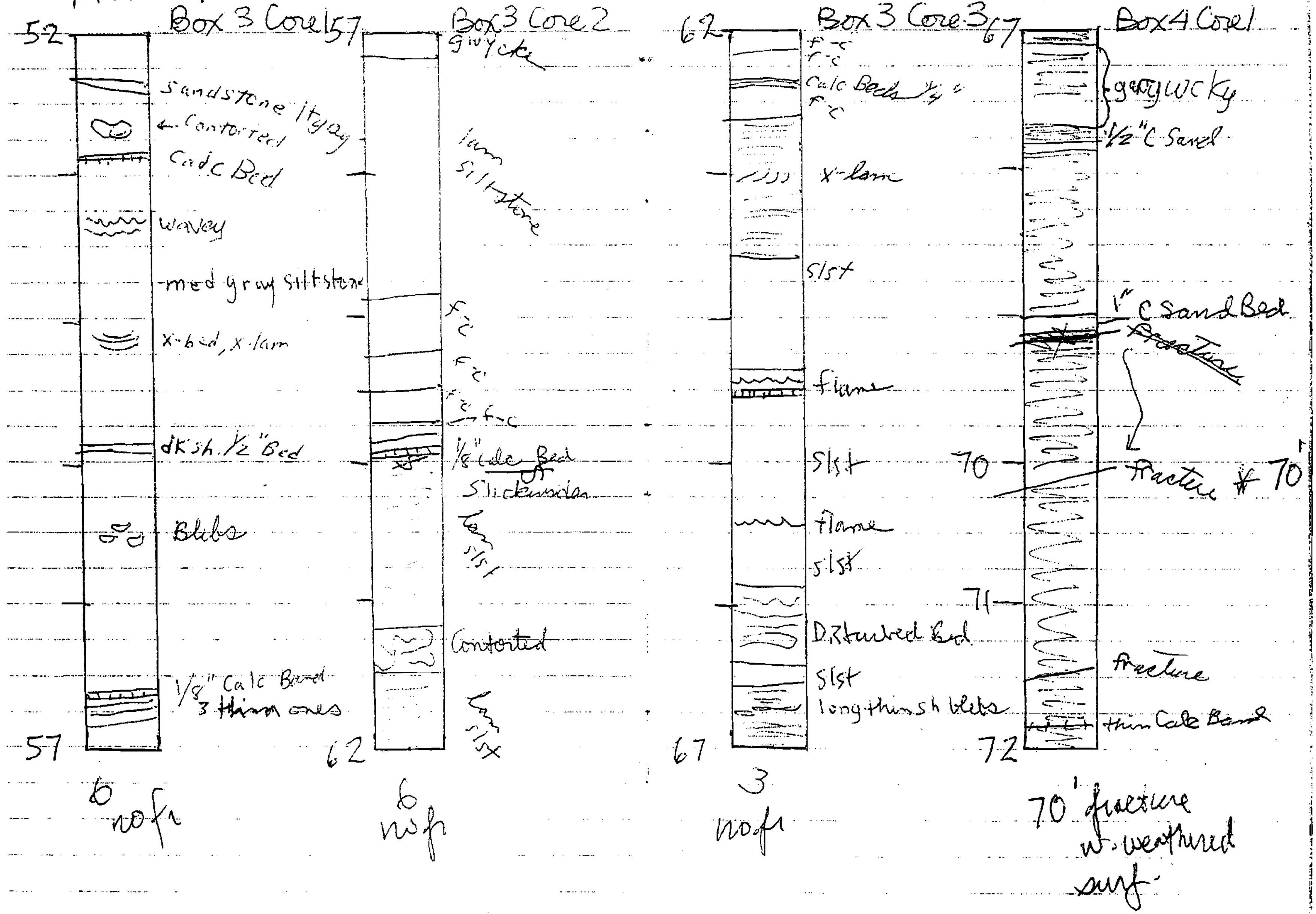

MW209
Box 8 Core 2
130.5
tension gash Calcite filled
4
Box 8 Core 3
135.5
1/2" gw.k
140.5
5
MW219
Box 1 Core 1
22
Mass Gwycke
Shale Lam
Soft Shale med gray Reduced Diam
1/8 Shale Lam
Mass gwycke
27
10+
fr. 22-23
Box 1 Core 2
27
near vert fracture
mass gwacke
disturb Bedding
fine Lam sh
Contorted Bed.
f - c Sand
f - c Sand
* Possibly Silt stone Lams not shale
Sh Bleb
thin Calc Bed
32
10+
fracture
27.5-28



MW 219
Box 1 Core 3
32
Blk Sh
dk gray siltstone
flame Structures
Wavey Beds
33
sh Bleb
Blk shale
Wavey Beds
34
dk gray
lam siltstone
35
weathered fracture
36
weather surf.
dk gray lam
siltstone
37
no fractures
35?
Box 2 Core 1
37
siltstone
lam sh.
1" dk sh
White Calc
Band
slst
Contorted
f-c
f-c
f
c
1/2" dk sh
slst
sh lam
42
no fract
Box 2 Core 2
42
lam dk sh
f-c
dk sh
f-c
flame
slickensides
gwycke
flame
contorted
disturbed bed
47
fractures
no fract
42.5-44.5
MW-219
Box 2 Core 3
47
f-c
dk sh
siltst
f-c
soft olive sh Lam
soft pieces
olive shale
some weathered
surfaces
lam shale
52
Fracture?
48.5-
soft rock
pieces

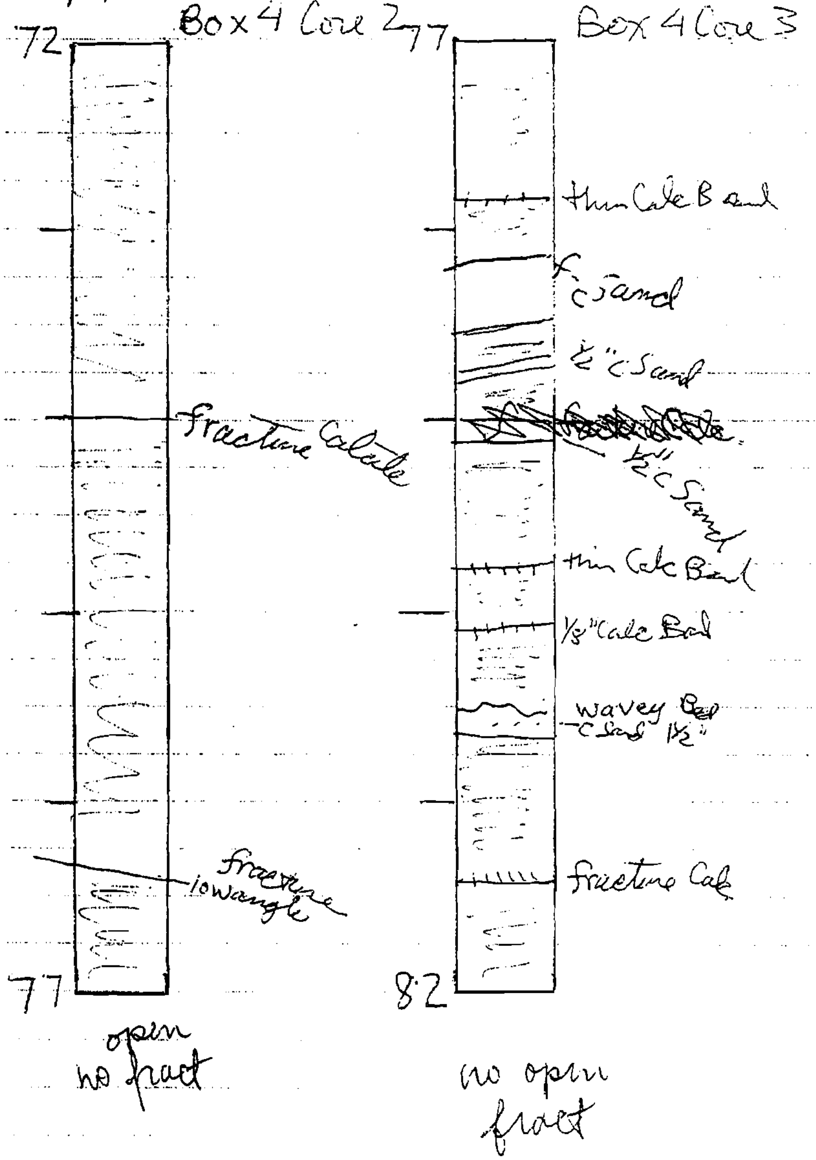
MW 219

MW 219

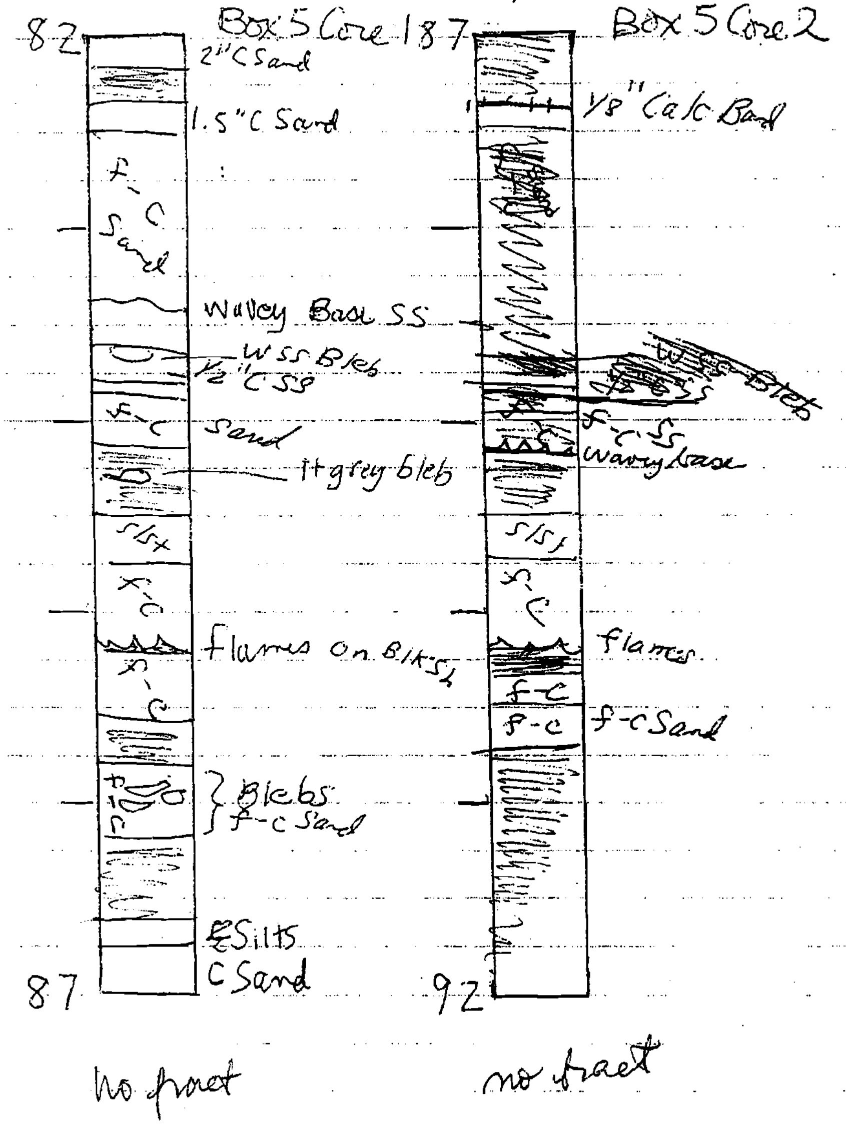


Box 3 Core 1
52
sandstone lt gray
← Contorted
Calc Bed
Wavey
med gray siltstone
x-bed, x-lam
dk sh. 1/2" Bed
Blebs
1/8" Calc Band
3 thin ones
57
6
no fr
Box 3 Core 2
57
Gwycke
lam siltstone
f-c
f-c
f-c
f-c
1/8" Calc Bed
Slickensides
lam slst
Contorted
lam slst
62
6
no fr
Box 3 Core 3
62
f-c
f-c
Calc Beds 1/4"
f-c
x-lam
slst
flame
slst
flame
slst
Disturbed Bed
slst
long thin sh blebs
67
3
no fr
Box 4 Core 1
67
graywacky
1/2" C Sand
1" C Sand Bed
Fracture
Fracture # 70'
70
71
Fracture
thin Calc Band
72
70' fracture w. weathered surf.

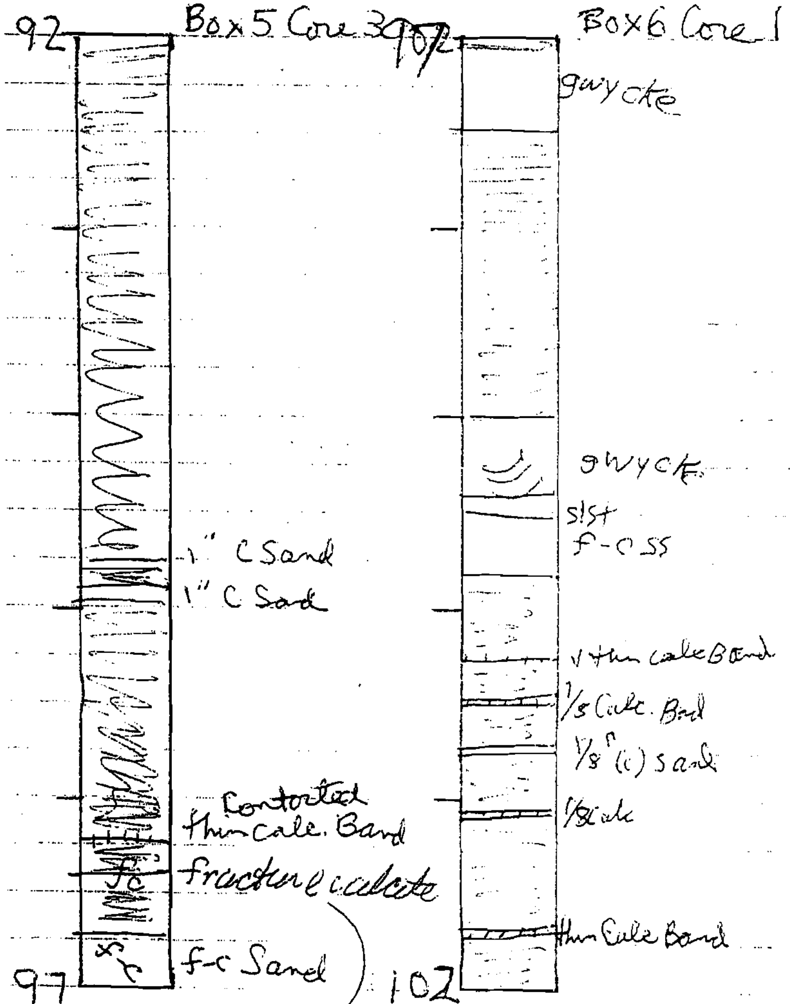
MW-219


Box 4 Core 2
72
fracture Calcite
fracture lowangle
77
open
no fract
Box 4 Core 3
77
thin Calc Band
f-c Sand
½" C Sand
½" C Sand
thin Calc Band
⅛" Calc Band
wavey Bed C Sand 1½"
fracture Calc
82
no open fract

MW-219


Box 5 Core 1
82
2" C Sand
1.5" C Sand
f-C Sand
Wavey Base SS
W SS Blebs
½" C SS
f-C
Sand
1+ grey bleb
S/St
f-C
flames on Blk St
f-C
Blebs
f-c Sand
f-c
Silts
C Sand
87
No fract
Box 5 Core 2
87
⅛" Calc Band
W SS Bleb
f-C SS
Wavy base
S/St
f-C
flames
f-c
f-c
f-c Sand
92
no fract

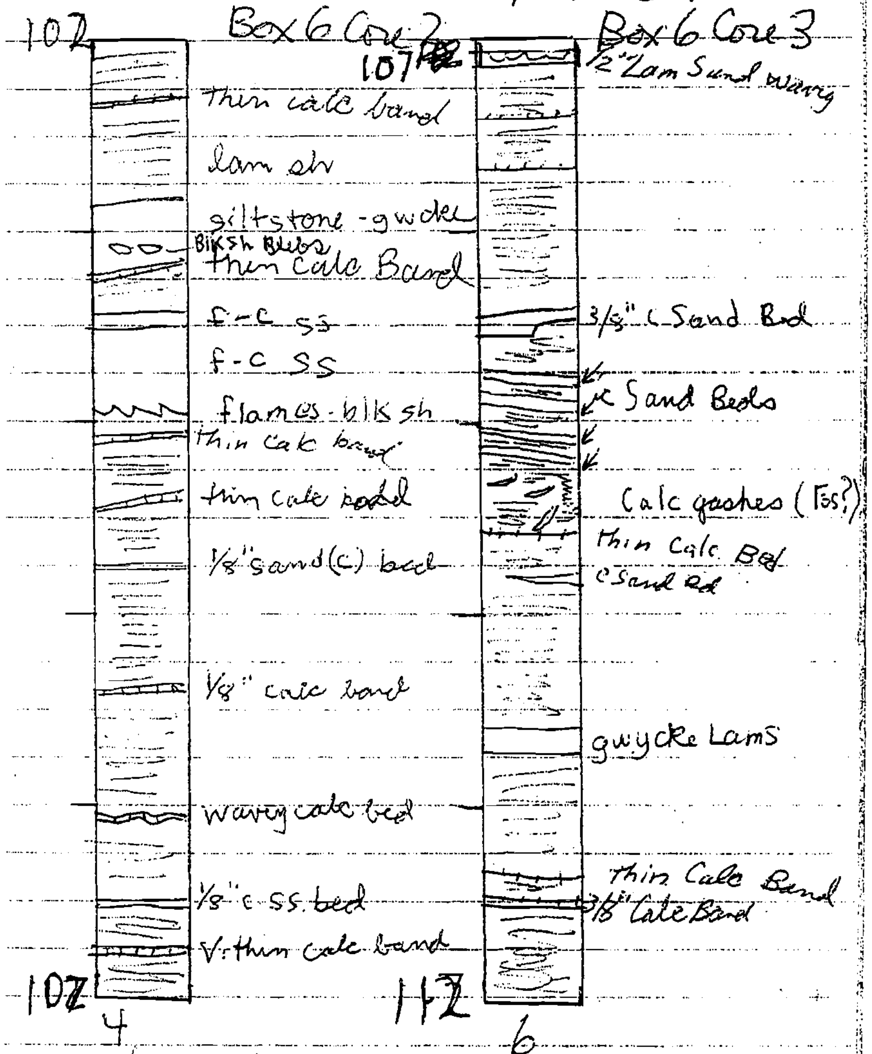
MW-219



fracture
96.5
piece out of place in box

no fract

MW-219

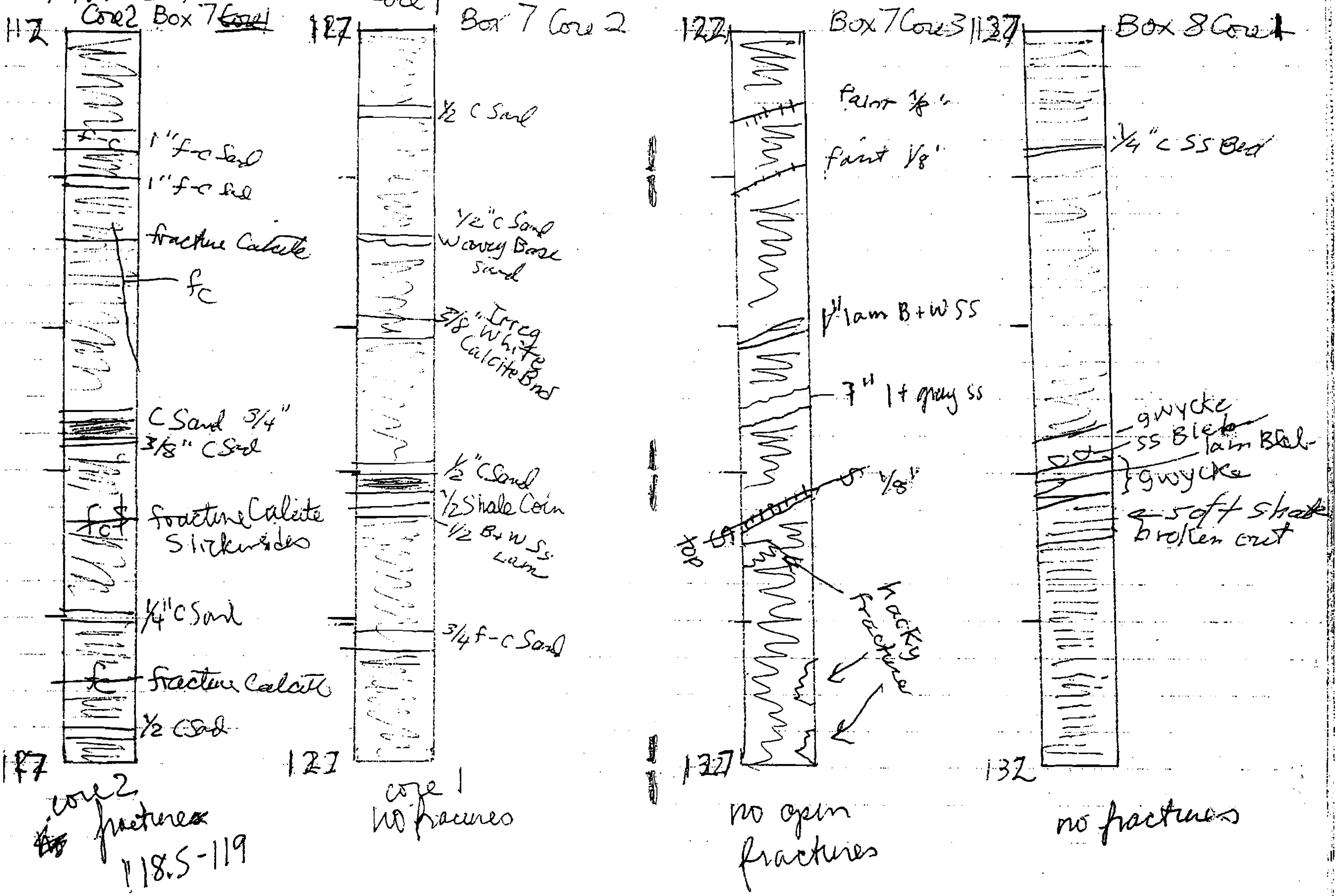


≡ typical drying pattern

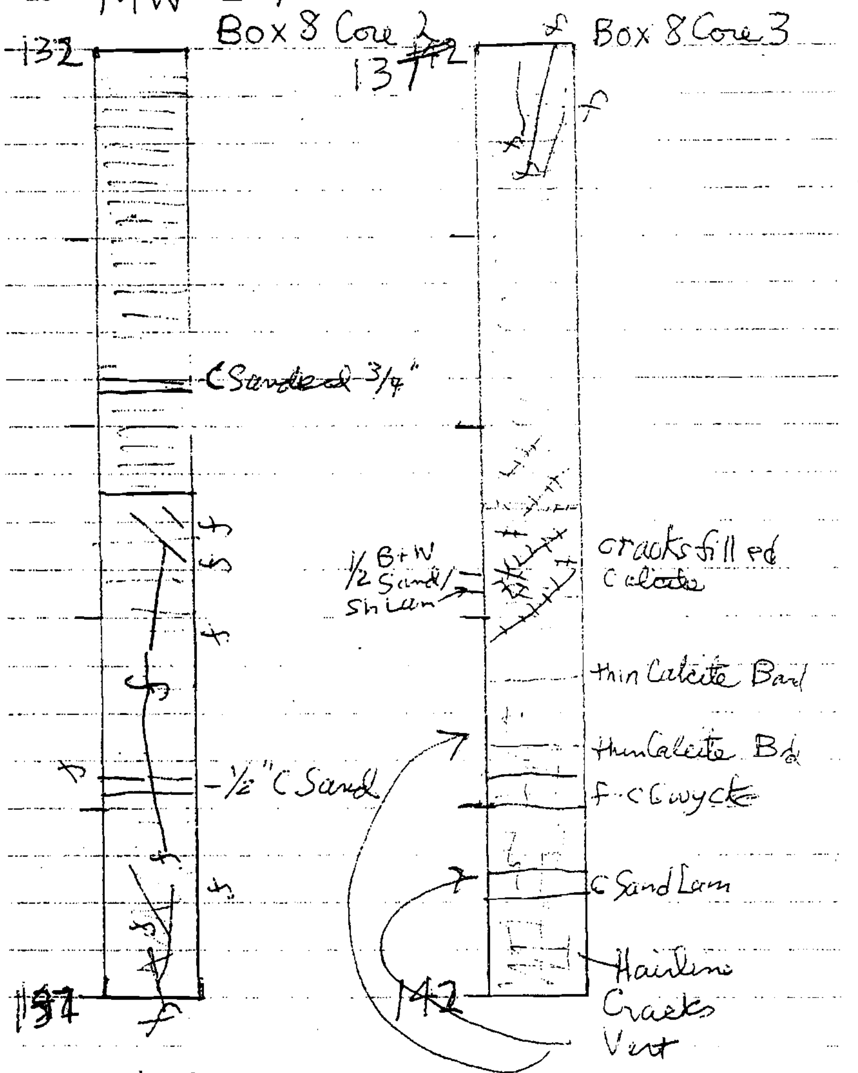
no fract

no fract

MW-219

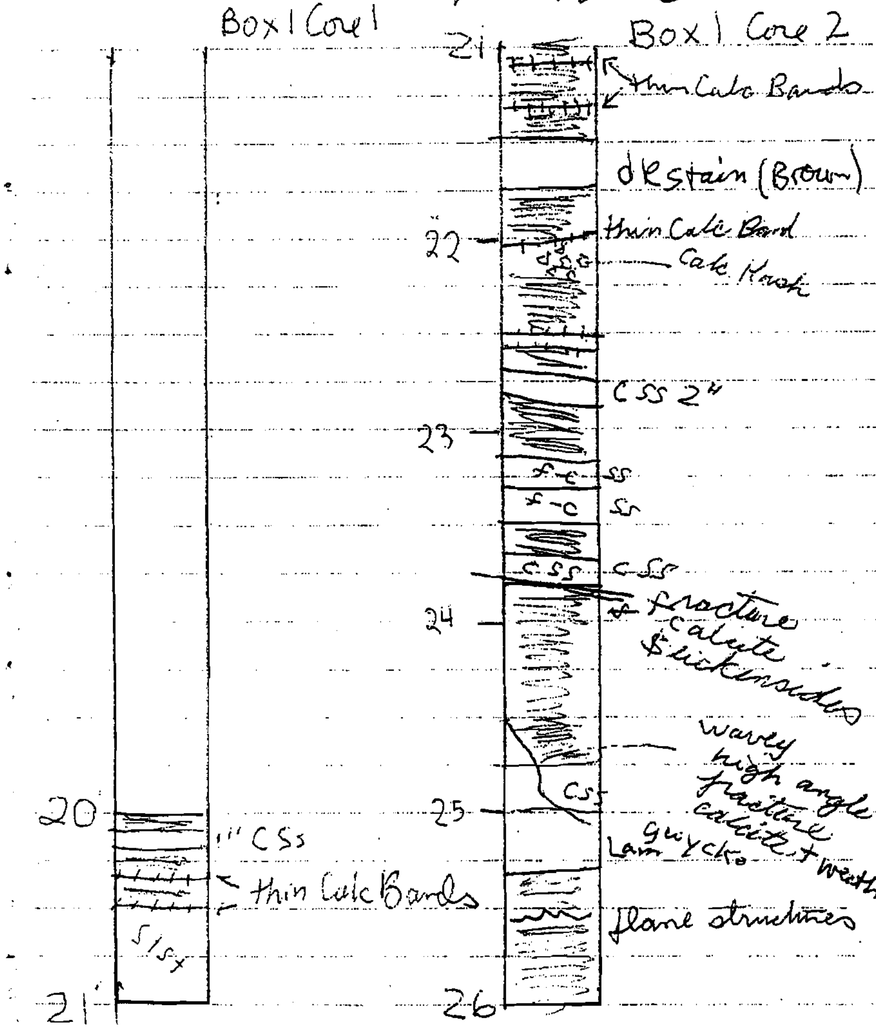

Core2 Box 7 ~~Core~~
Core 1
117
1" f-c Sand
1" f-c Sd
fracture Calcite
fc
C Sand 3/4"
3/8" C Sand
fracture Calcite Slickensides
fc
1/4" C Sand
fracture Calcite
fc
1/2 C Sand
117
core 2 fractures 118.5-119
Box 7 Core 2
127
1/2 C Sand
1/2" C Sand Wavy Base Sand
3/8" Irreg White Calcite Bnd
1/2" C Sand
1/2 Shale Coin
1/2 B+W SS Lam
3/4 f-c Sand
127
core 1 no fractures
Box 7 Core 3
127
faint 1/8"
faint 1/8"
1" lam B+W SS
3" lt gray ss
1/8"
top
hacky fracture
137
no open fractures
MW-219
Box 8 Core ~~1~~
137
1/4" C SS Bed
gwycke
SS Blebs
lam Bed
gwycke
soft shale
broken crust
132
no fractures

MW-219

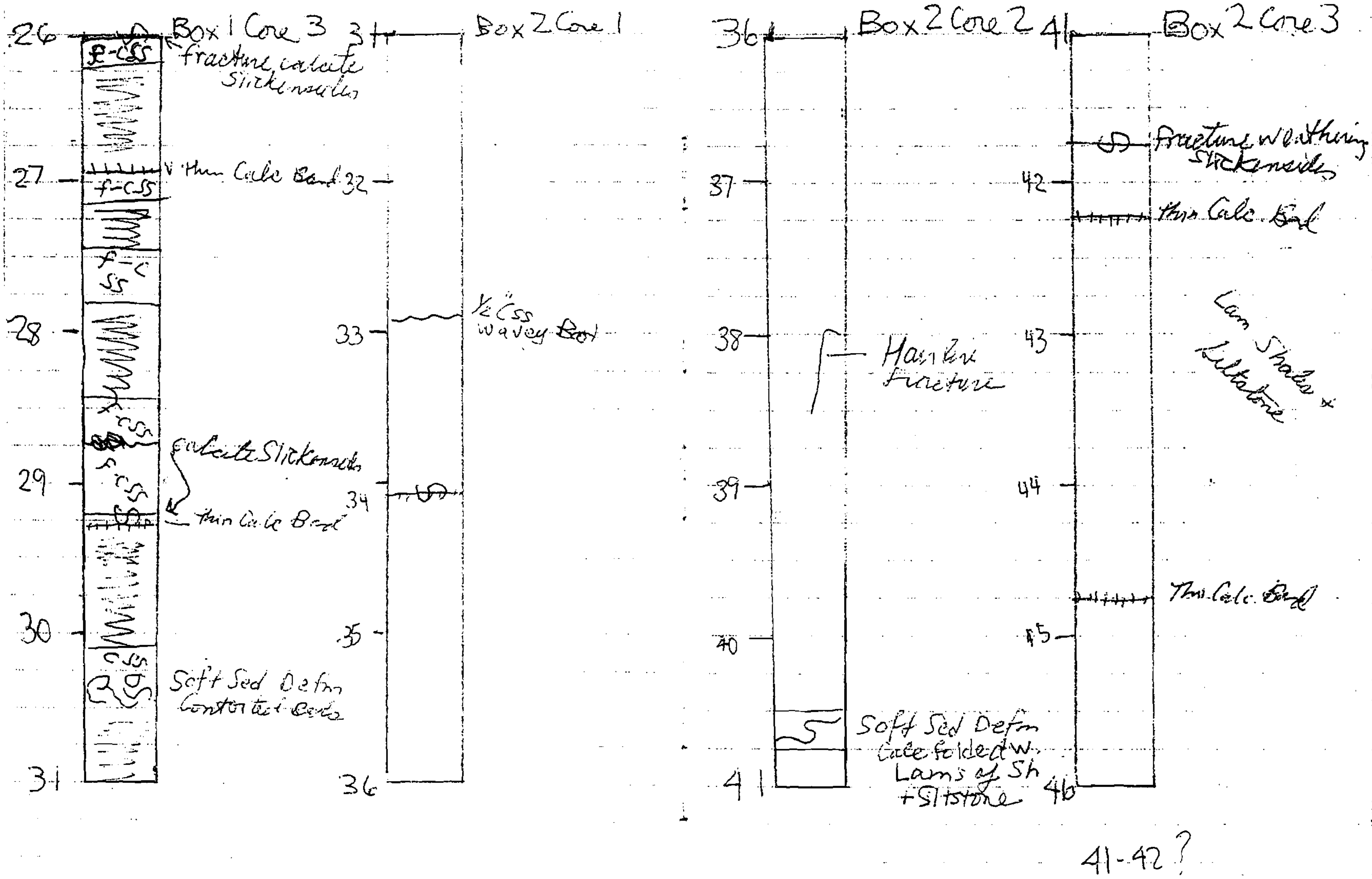


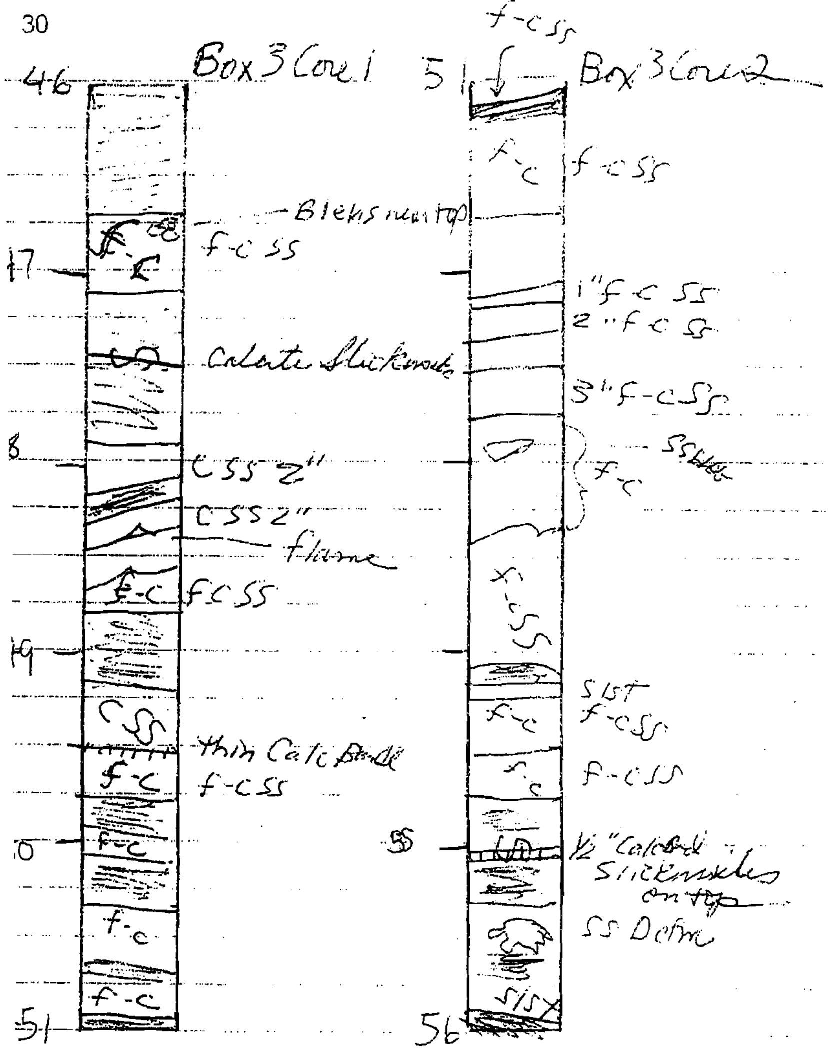
fracture
134-137

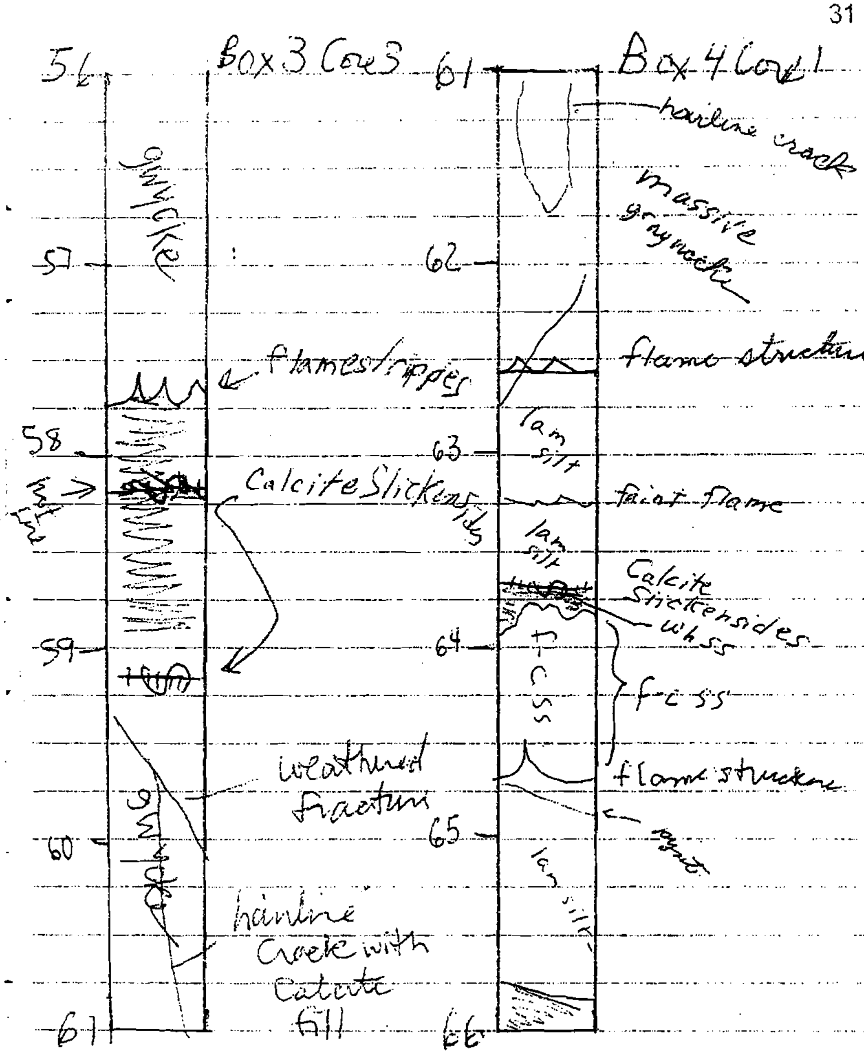
MW220



23.5-25.5

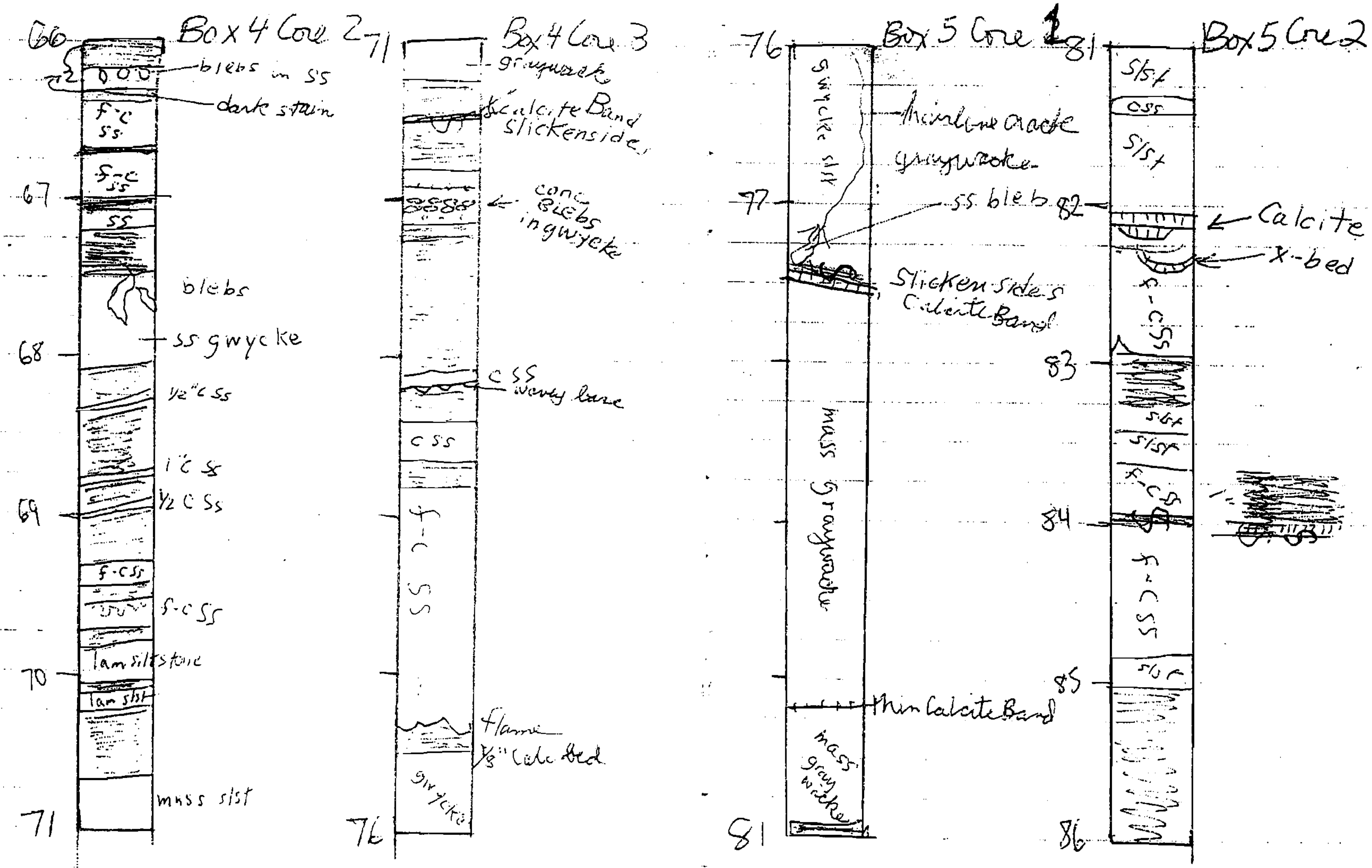

Box 1 Core 3
f-CSS
fracture calcite Slickensides
Thin Calc Band
f-CSS
f-c SS
f-CSS
f-CSS
calcite Slickensides
thin Calc Band
c SS
Soft Sed Defm Contorted Beds
26
27
28
29
30
31
Box 2 Core 1
½" CSS wavey Bed
31
32
33
34
35
36
Box 2 Core 2
Hairline Fracture
Soft Sed Defm Calc folded w. Lams of Sh + Sltstone
36
37
38
39
40
41
Box 2 Core 3
Fracture w/ Slithering Slickensides
thin Calc. Band
Lam Shales + Siltstone
Thin Calc. Band
41
42
43
44
45
46
41-42 ?

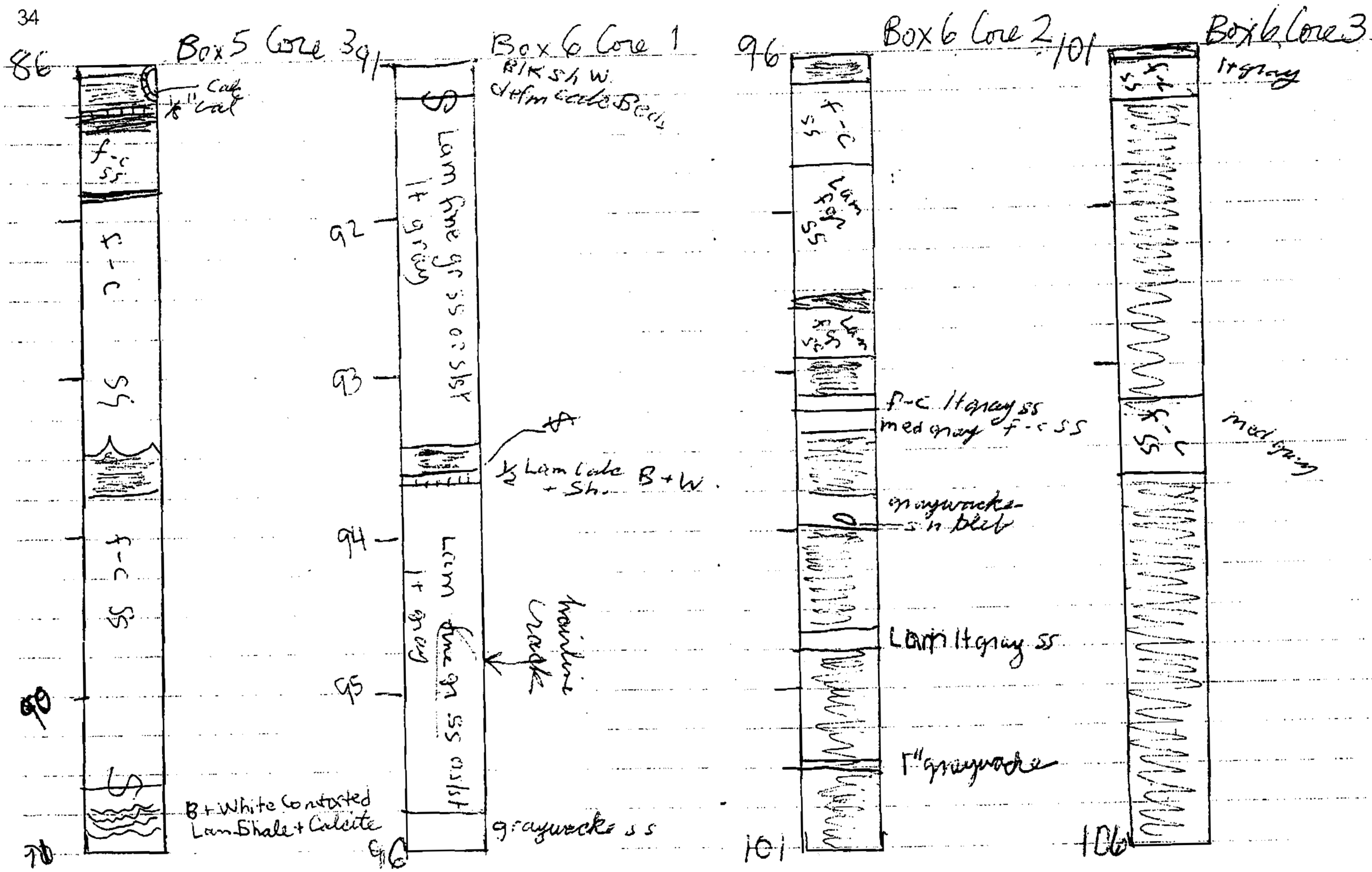




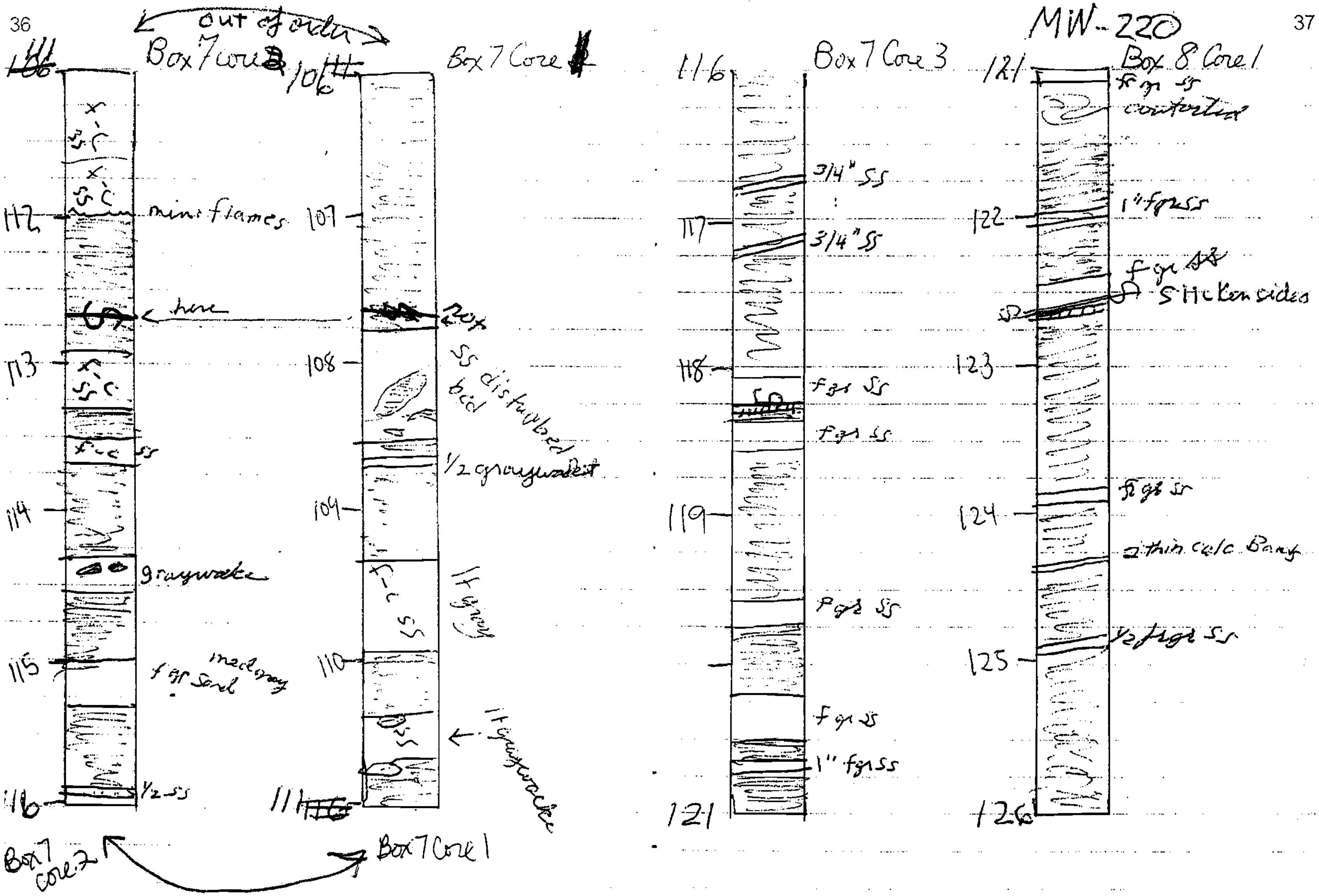
59-61 fracture

63-64

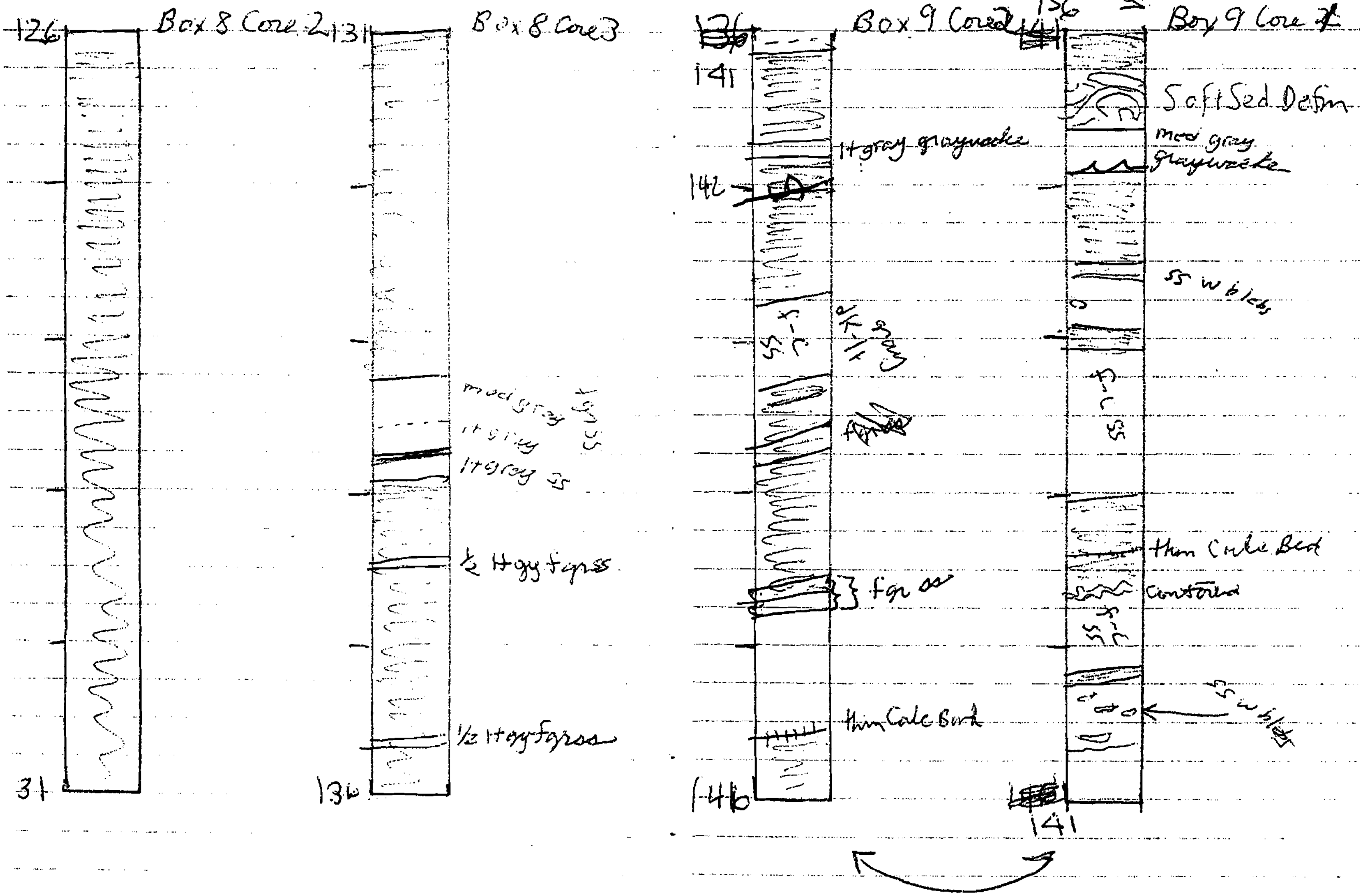

Box 4 Core 2
66
blebs in ss
dark stain
f-c ss
f-c ss
67
ss
blebs
ss gwycke
68
1/2" c ss
1" c ss
1/2 c ss
69
f-c ss
f-c ss
lam siltstone
70
lam slst
mass slst
71
Box 4 Core 3
71
graywacke
calcite Band
slickensides
conc blebs in gwycke
c ss
wavy base
c ss
f-c ss
flame
1/3" Calc Bed
grycke
76
Box 5 Core 1
76
gwycke slst
thin line cracks
graywacke
77
ss bleb
Slickensides
Calcite Band
mass graywacke
thin Calcite Band
mass gray wacke
81
Box 5 Core 2
81
slst
c ss
slst
82
Calcite
x-bed
f-c ss
83
slst
slst
f-c ss
84
1"
f-c ss
85
slst
86


Box 5 Core 3
86
Cal
1/8" Cal
f-c ss
f-c ss
f-c ss
90
B + White Contorted Lam Shale + Calcite
Box 6 Core 1
91
Blk sh w. defm calc Beds
Lam fine gr ss or slst lt gray
92
93
94
95
1/2 Lam Calc + Sh B + W.
Lam fine gr ss or slst lt grey
hairline crack
graywacke ss
Box 6 Core 2
96
101
f-c ss
Lam f-c ss
f-c lt gray ss
med gray f-c ss
graywacke ss blebs
Lam lt gray ss
1" graywacke
Box 6 Core 3
lt gray
f-c ss
med gray
106

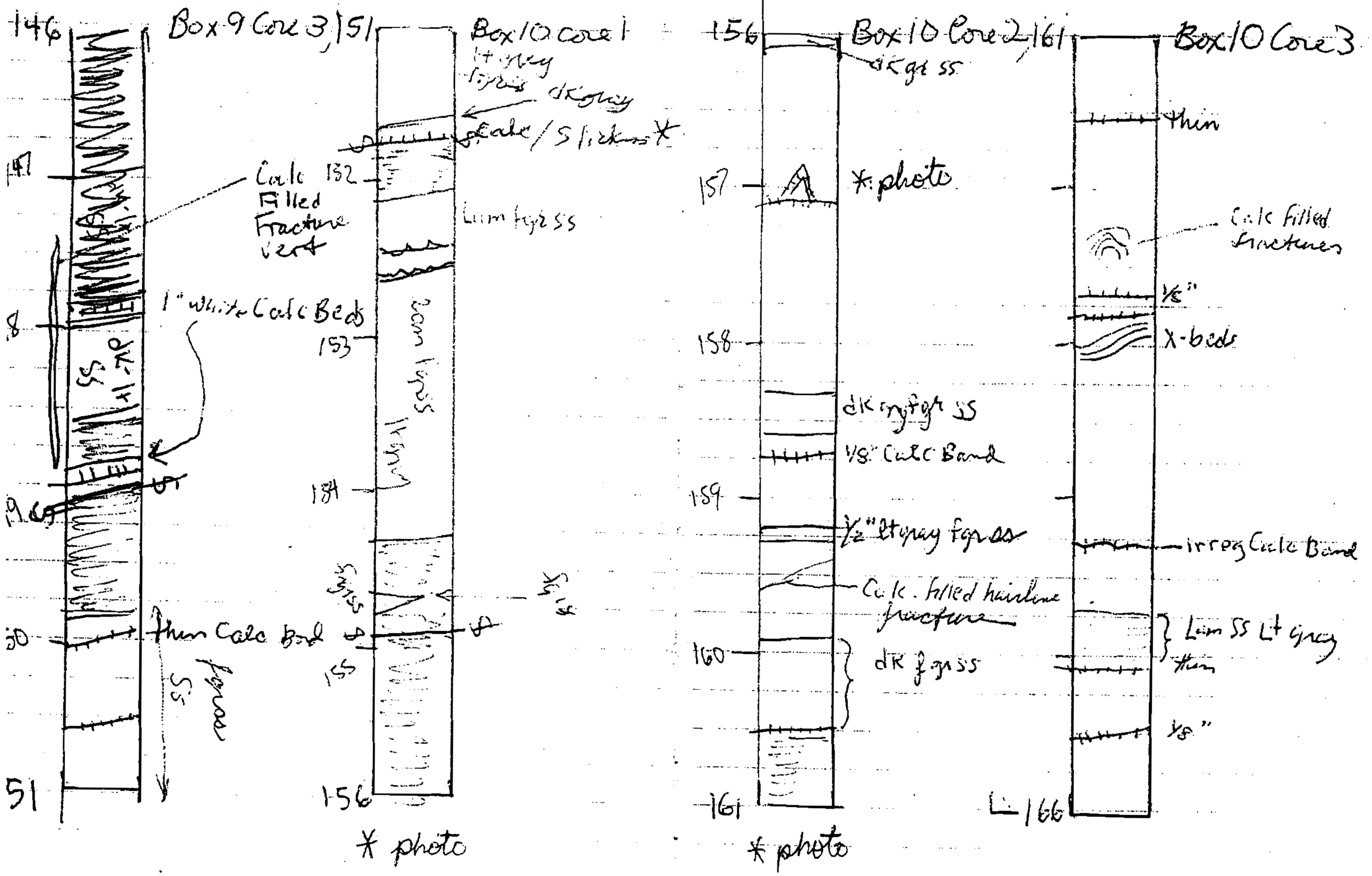
MW-220


out of order
Box 7 Core 2
Box 7 Core 1
Box 7 Core 3
Box 8 Core 1
mini flames
here
rot
SS disturbed bed
1/2 graywacke
lt gray
f-c SS
lt graywacke
graywacke
med gray f gr sand
1/2 SS
3/4" SS
3/4" SS
f gr SS
f gr SS
f gr SS
f gr SS
1" f gr SS
f gr SS contorted
1" f gr SS
f gr SS
slickensides
f gr SS
2 thin calc bands
1/2 f gr SS
111
112
113
114
115
116
106
107
108
109
110
111
116
117
118
119
121
121
122
123
124
125
126

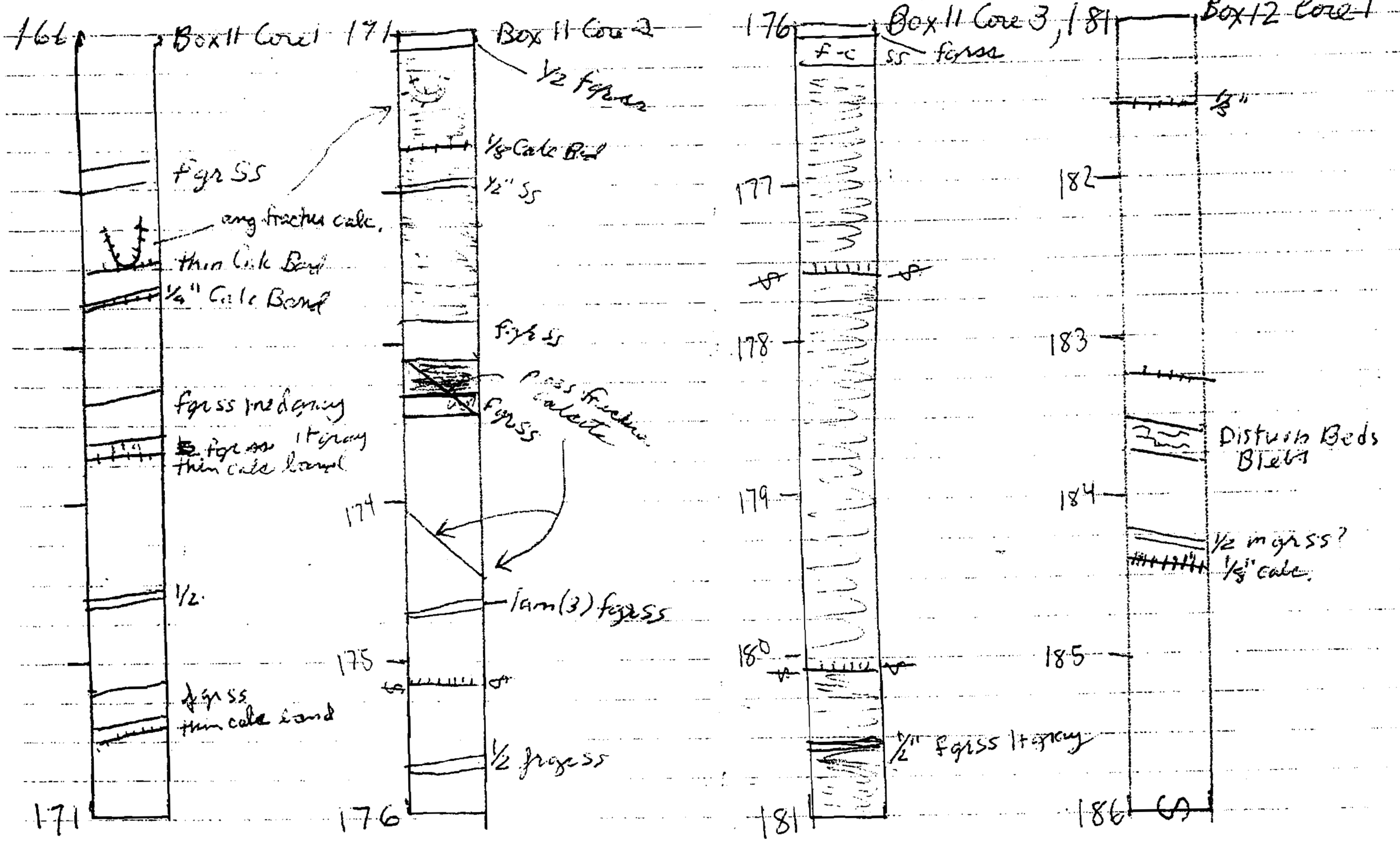
MW-220


126
Box 8 Core 2
31
131
Box 8 Core 3
med gray
lt gray
lt gray SS
fg SS
½ ltgy fgss
½ ltgy fgss
136
136
Box 9 Core 2
141
lt gray graywacke
142
dk-lt gray
f-c SS
fg ss
thin Calc Bed
146
136
Box 9 Core
Soft Sed Defm
med gray graywacke
SS w blebs
f-c SS
thin Calc Bed
Contorted
f-c SS
SS w blebs
141

MW-220

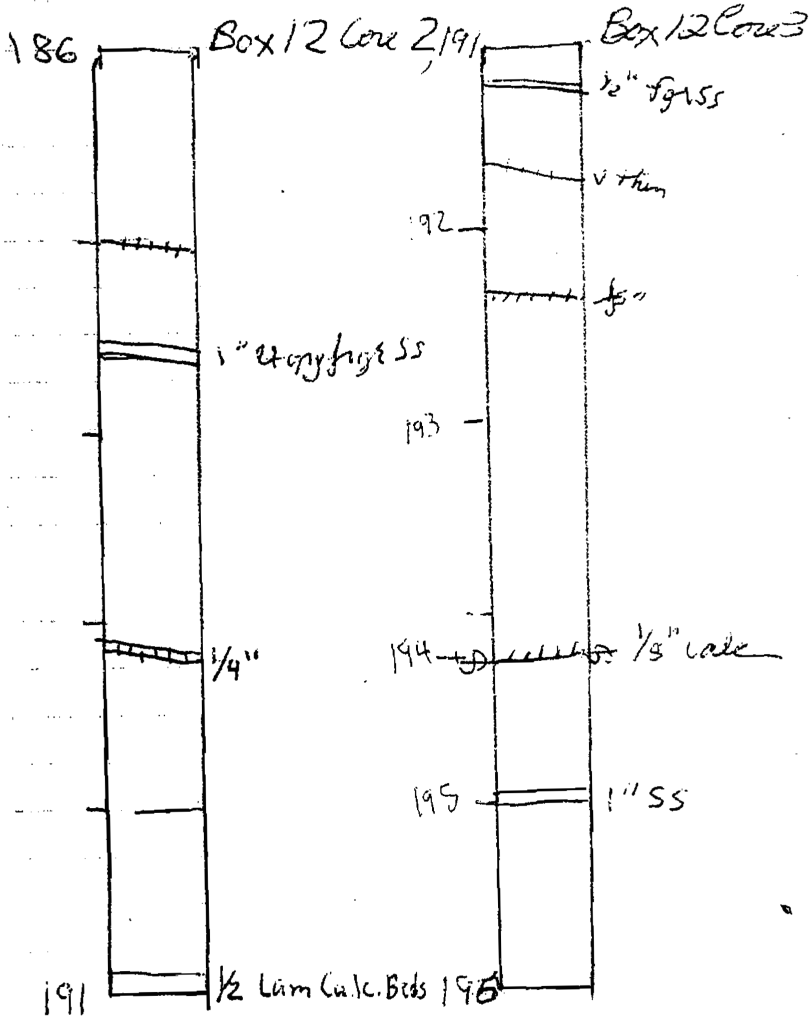

146
147
8
9
50
51
Box 9 Core 3
Calc Filled Fracture vert
1" white Calc Beds
dk-lt SS
thin Calc Band
fgrss SS
151
152
153
154
155
156
Box 10 core 1
lt grey fgrss
dk grey
scale / Slicks *
Lam fgrss
2cm fgrss
lt grey
fgrss
fg 1/8
* photo
156
157
158
159
160
161
Box 10 Core 2
dk gr ss
* photo
dk grey fgr ss
1/8" Calc Band
1/2" lt grey fgrss
Calc. filled hairline fracture
dk fgrss
* photo
161
166
Box 10 Core 3
thin
Calc filled fractures
1/8"
X-beds
irreg Calc Band
Lam SS Lt grey
thin
1/8"

MW-220



166
Box 11 Core 1
fgr SS
ang fracture calc.
thin Calc Band
1/4" Calc Band
fgr ss med gray
fgr ss lt gray thin calc band
1/2
fgr ss thin calc band
171
171
Box 11 Core 2
1/2 fgr ss
1/8 Calc Bed
1/2" SS
fgr ss
Cross fracture calcite
fgr ss
174
lam(3) fgr ss
175
1/2 fgr ss
176
176
Box 11 Core 3, 181
f-c
SS
fgr ss
177
178
179
180
1/2" fgr ss lt gray
181
Box 12 Core 1
1/8"
182
183
Disturb Beds
Blebs
184
1/2 m gr ss?
1/8" calc.
185
186

MW-220


186
Box 12 Core 2
191
1/4"
191
1/2 Lam Calc. Beds
191
Box 12 Core 3
1/2" fg tss
v thin
192
193
194
1/8" calc
195
1" SS
196

"Rite in the Rain"®
ALL-WEATHER WRITING PAPER

HORIZONTAL LINE

All-Weather Notebook
No. 391

Book 6

General Switch
Core Descriptions
Feb-March 2005

4 5/8" x 7" - 48 Numbered Pages

MW-211
MW-206

return to Kathie Beinkafner

"Rite in the Rain"®
ALL-WEATHER WRITING PAPER

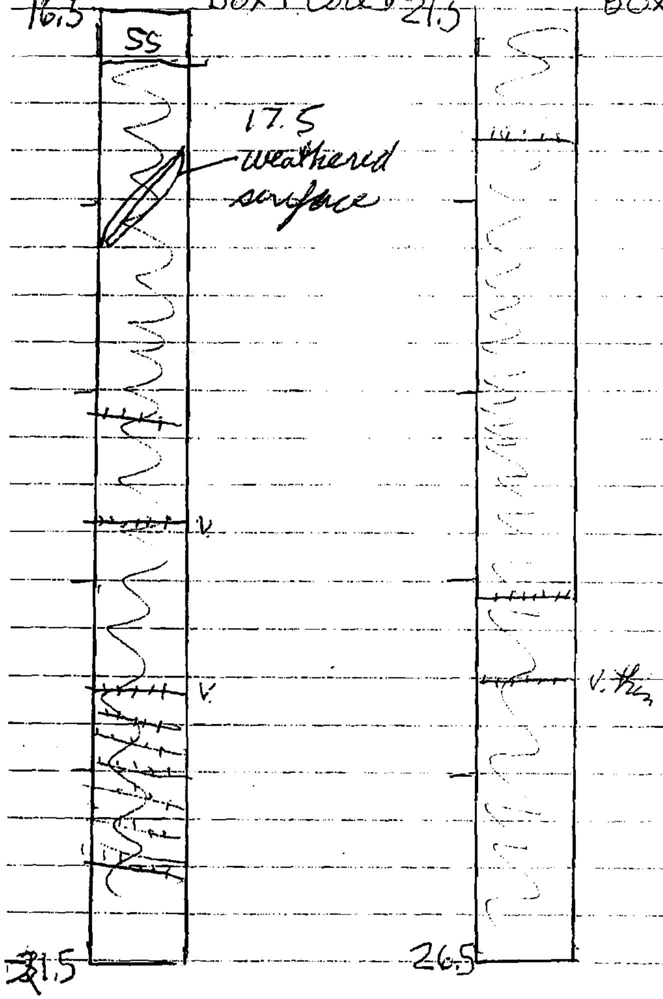
Dr. Katherine Beinkafner
Mid-Hudson Geosciences
1003 Route 44 55
PO Box 332
Clintondale NY 12515-0332
(845) 883-5866

Name Katherine J. BeinKafner, PhD
Ecosystems Strategies, Inc
Address 24 Davis Ave
Poughkeepsie, NY
Phone (845) ~~883~~ 452-1658
FAX 485-7083
Project Carl Kochersberger Cell 9144754132
Driller: Soiltesting, Inc. 800 388-4473

CONTENTS

MW-211

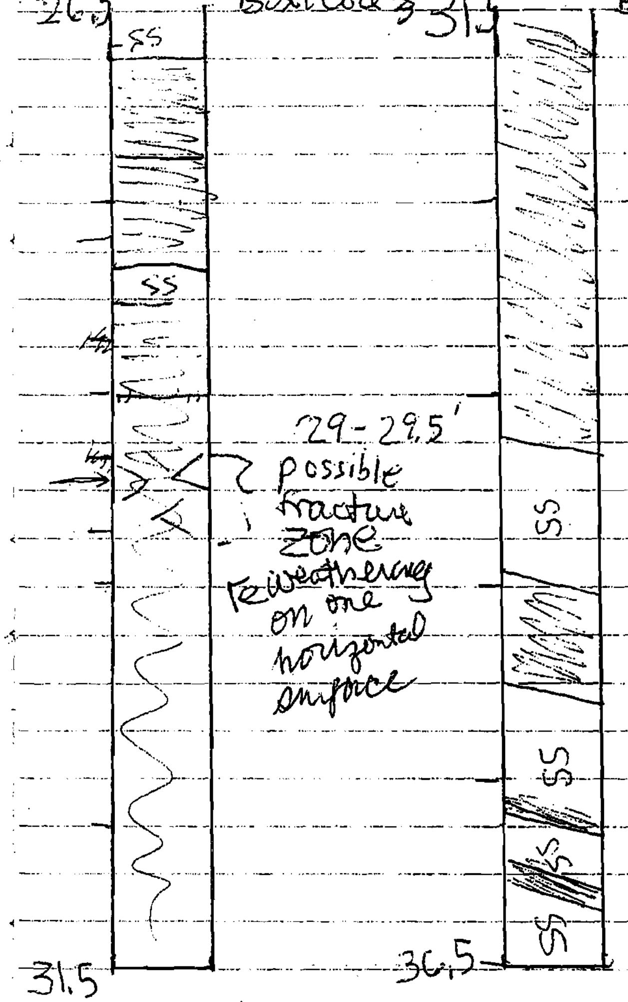
Box 1 Core 3 — Box 1 Core 2



17.5
weath
8.

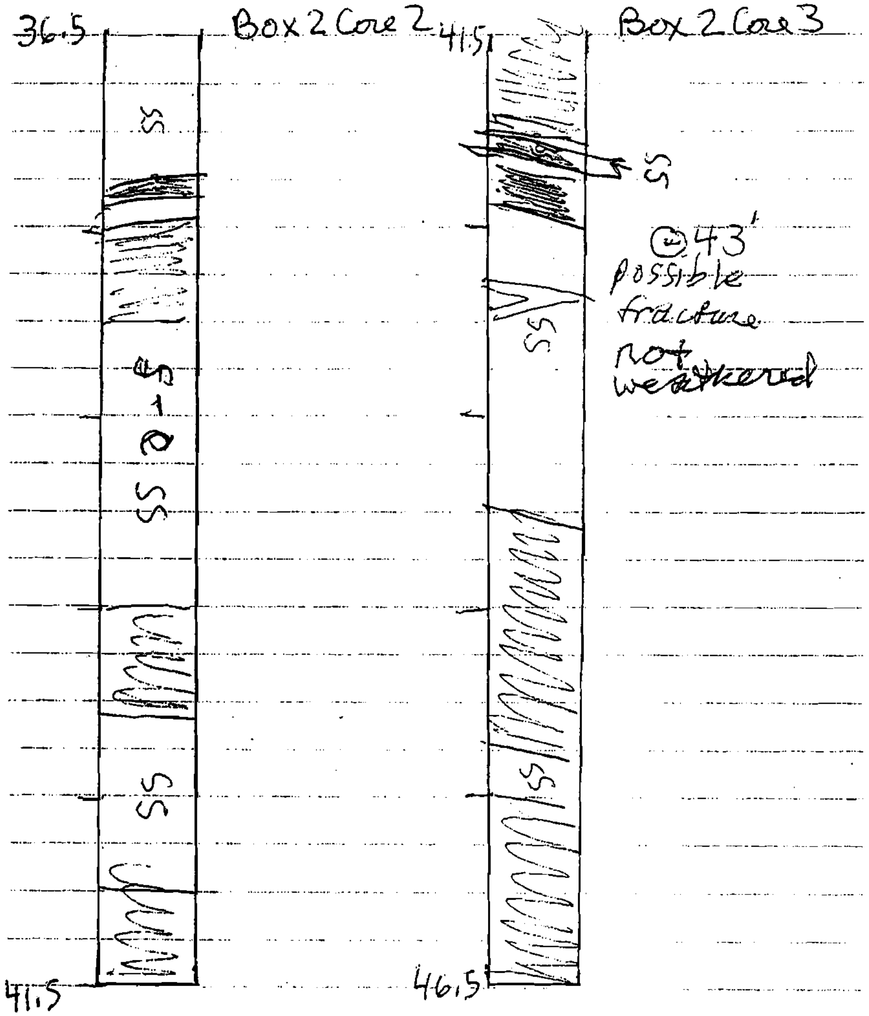
MW-211

Box 1 Core 3 — Box 2 Core 1

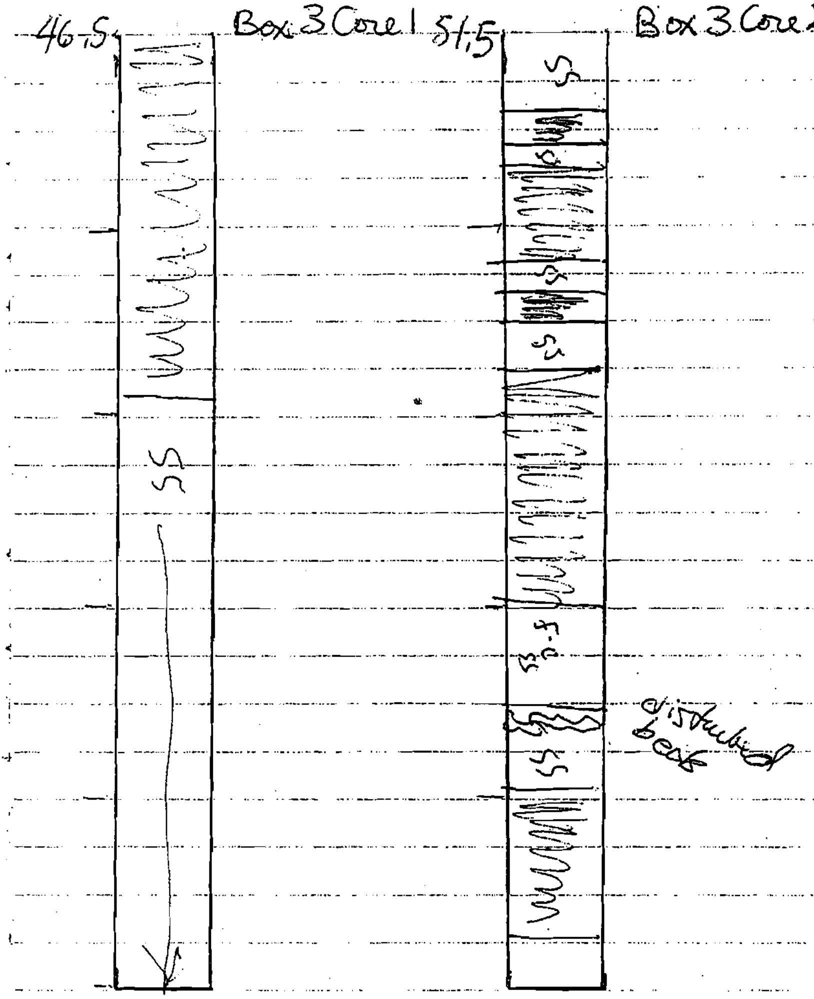


28.7

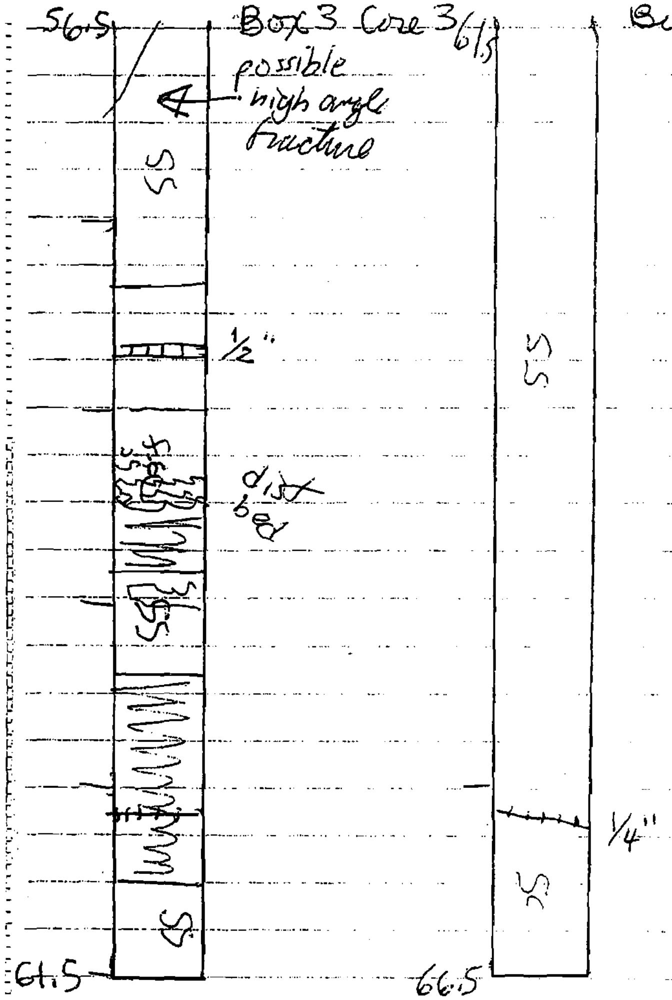
MW-211


36.5
Box 2 Core 2
41.5
Box 2 Core 3
SS
SS
f-c
SS
SS
SS
SS
@ 43'
possible
fracture
not
weathered
SS
41.5
46.5

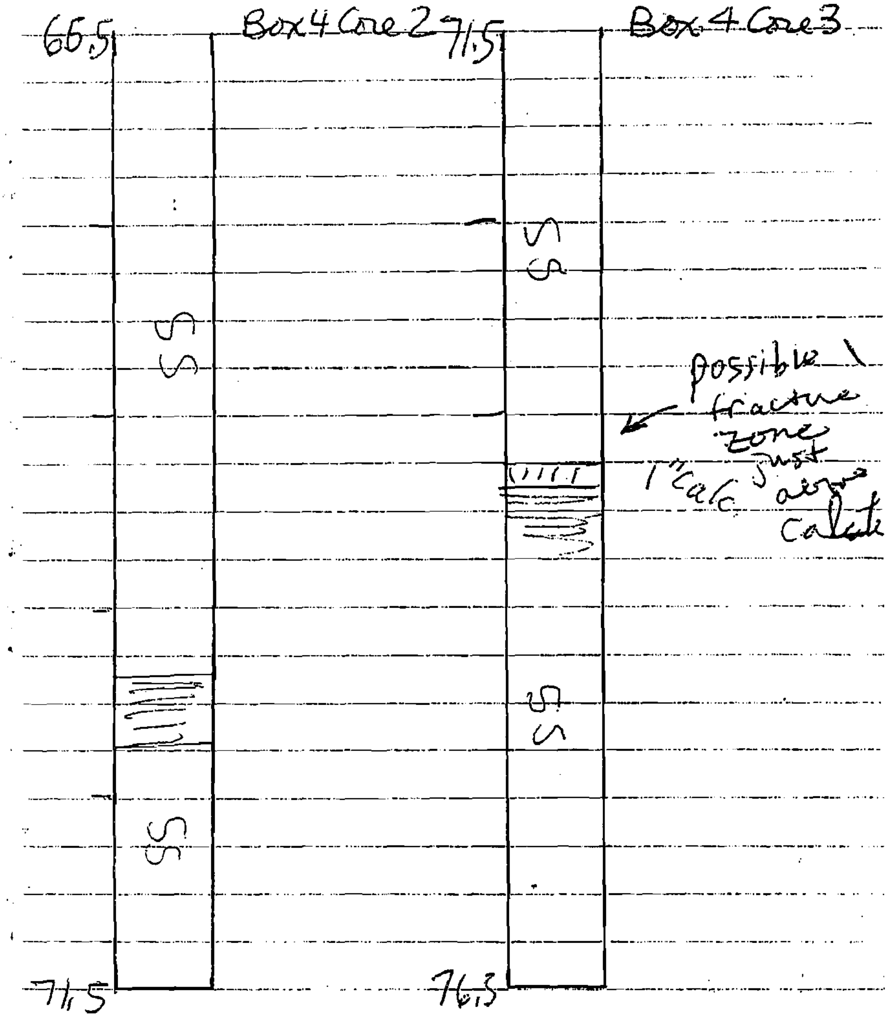
MW-211


46.5
Box 3 Core 1
SS
51.5
Box 3 Core 2
SS
SS
SS
SS
f-c
SS
disturbed
beds
SS

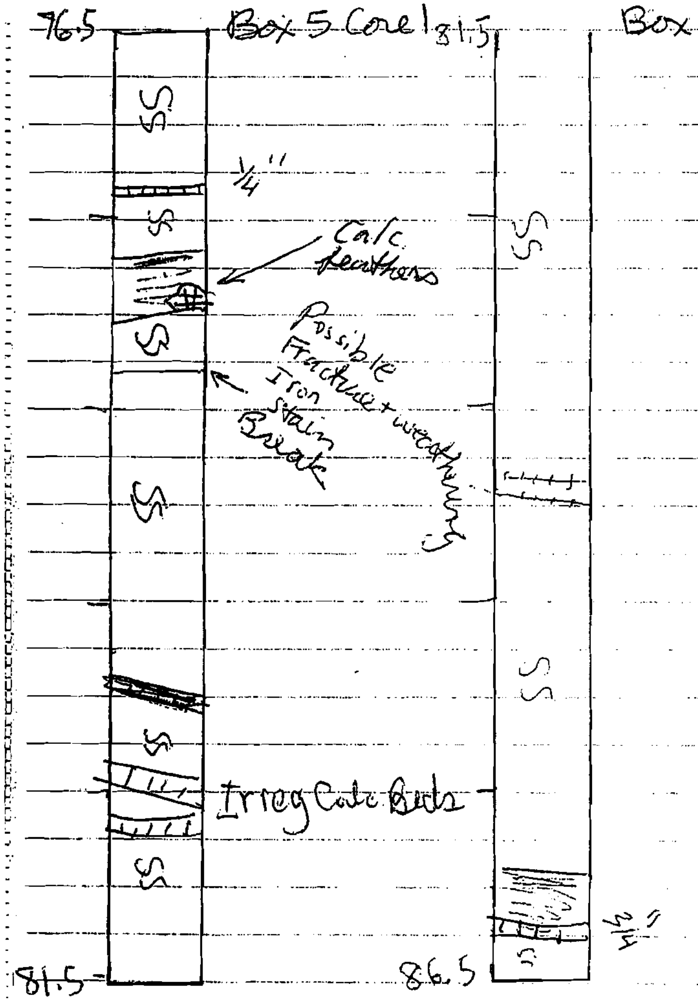
MW-211


56.5
Box 3 Core 3
possible high angle fracture
SS
1/2"
dist bed
SS
SS
61.5
61.5
Box 4 Core 1
SS
1/4"
SS
66.5

MW-211


66.5
Box 4 Core 2
SS
SS
71.5
71.5
Box 4 Core 3
SS
possible fracture zone just above calcite
1" calc
SS
76.3

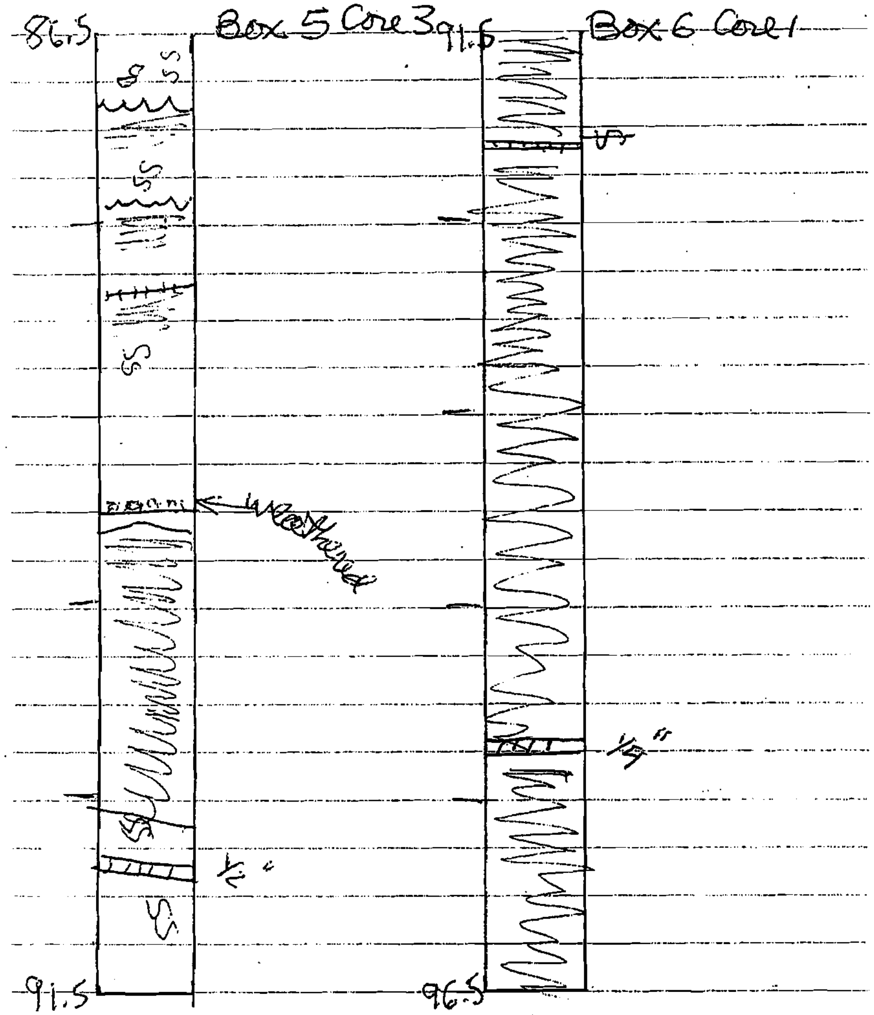
MW-211



78' - weath.

no fr

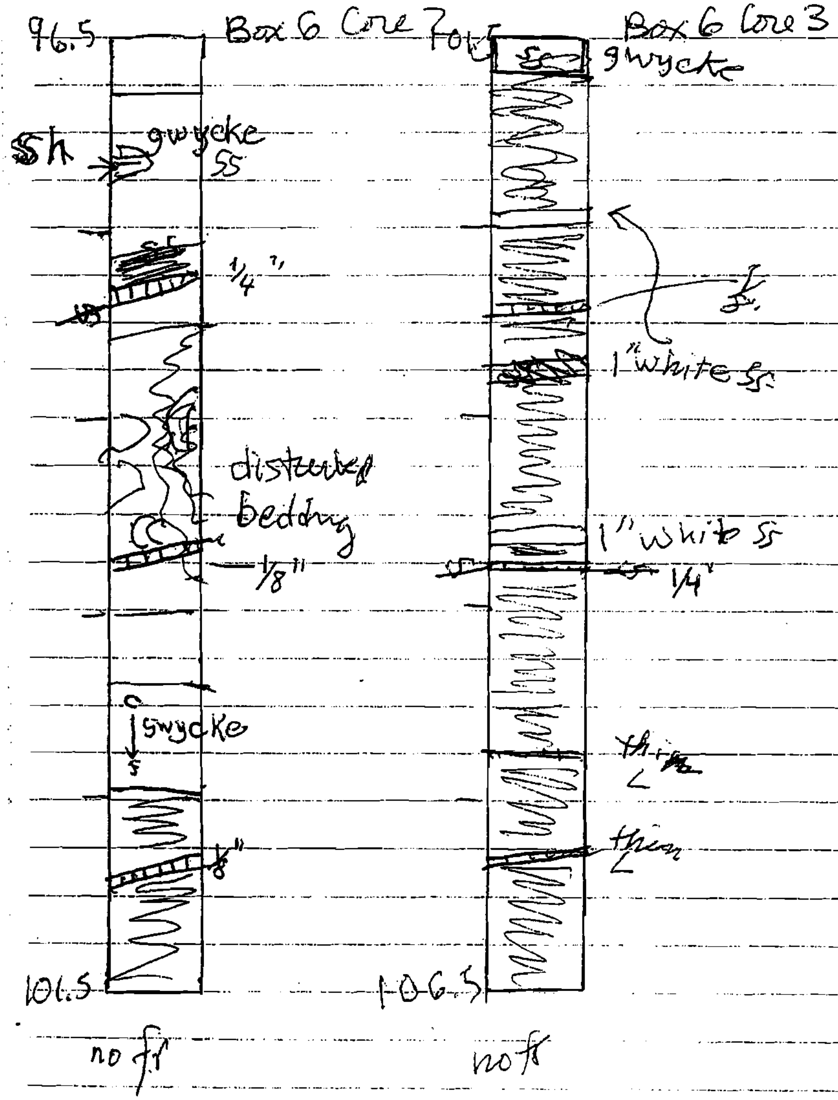
MW-211



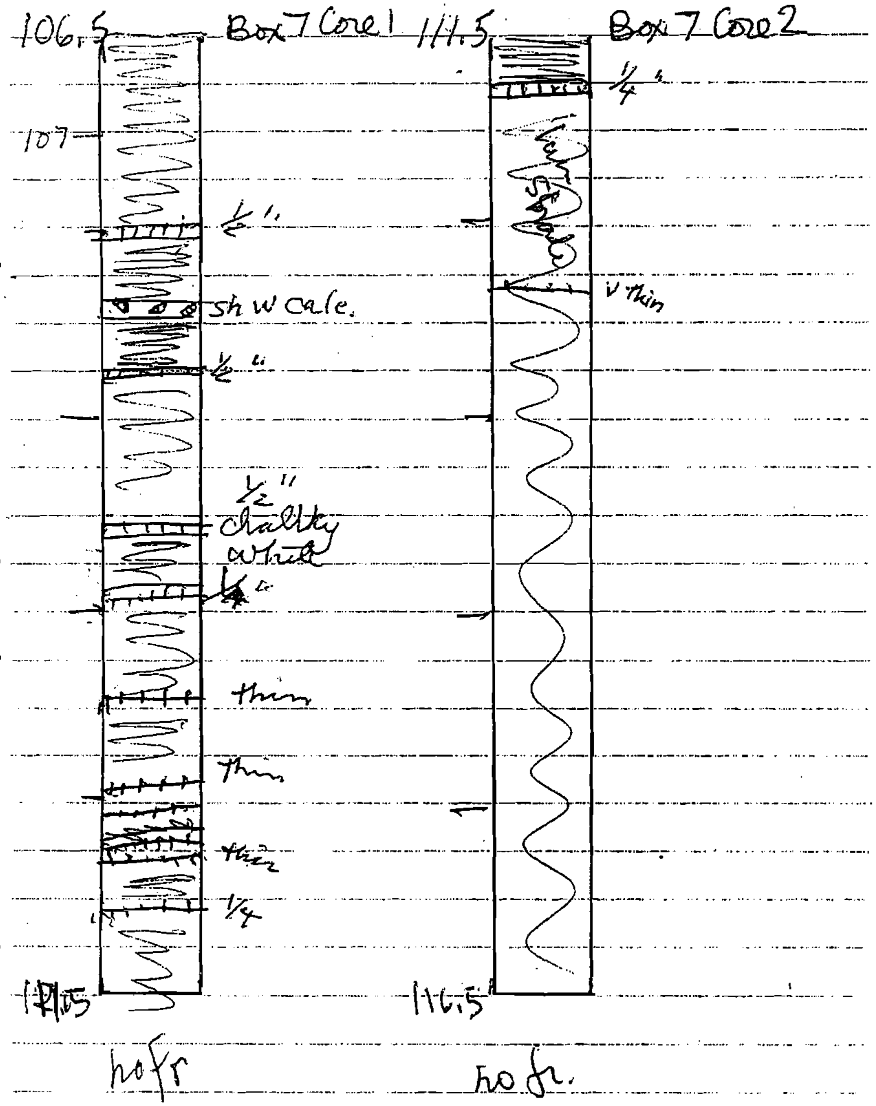
BroKenRock
88-91

no fr.

MW-211

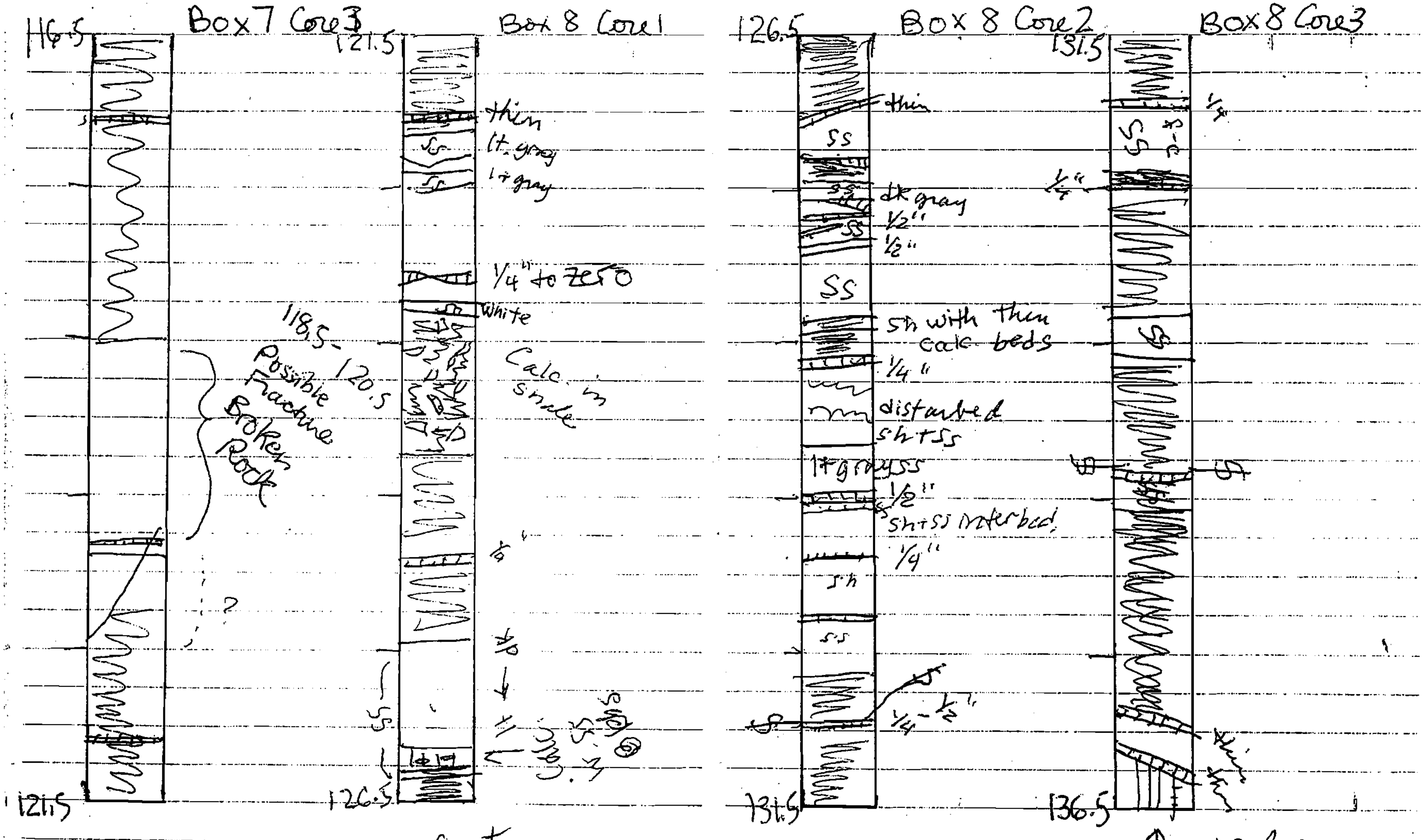

96.5
Box 6 Core 7 of
Sh
gwycke SS
1/4"
disturbed bedding
1/8"
swycke
1/8"
101.5
no fr
Box 6 Core 3
SS
gwycke
1" white SS
1" white SS
1/4"
thin
thin
106.5
no fr

MW-211


106.5
Box 7 Core 1
107
1/2"
sh w calc.
1/2"
1/2"
chalky white
1/4"
thin
thin
thin
1/4
111.5
no fr
111.5
Box 7 Core 2
1/4"
v thin
116.5
no fr.

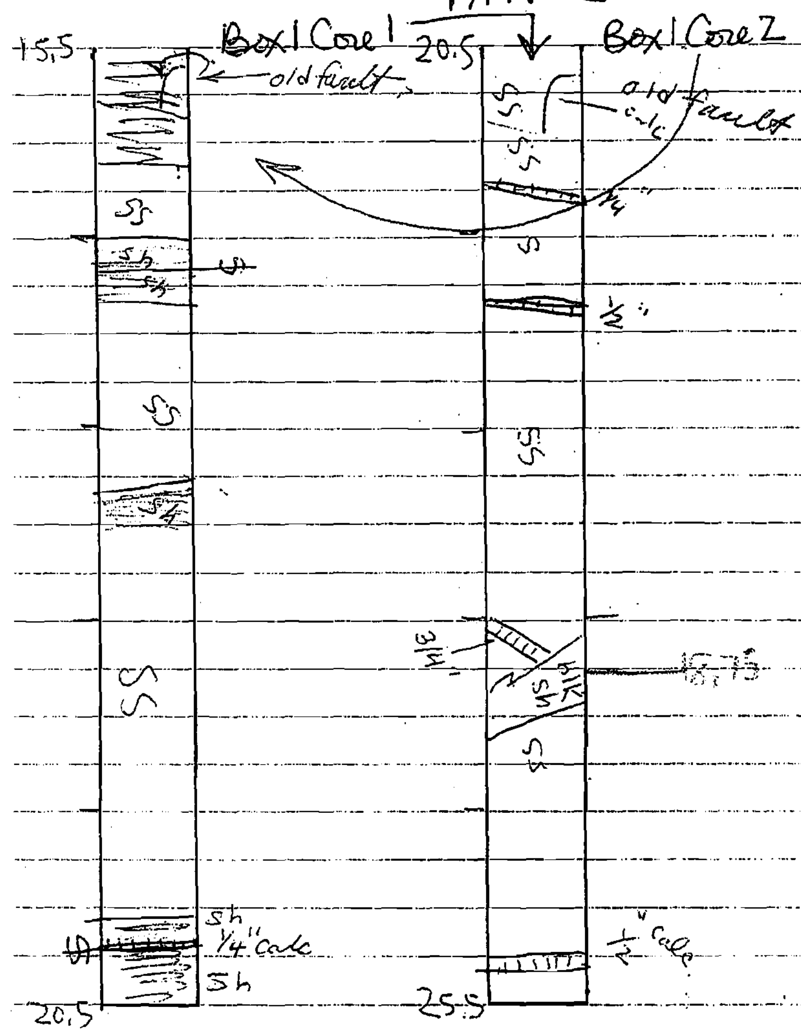
mW-211

mW-211



Broken Rock
1?8.5 - 120.5

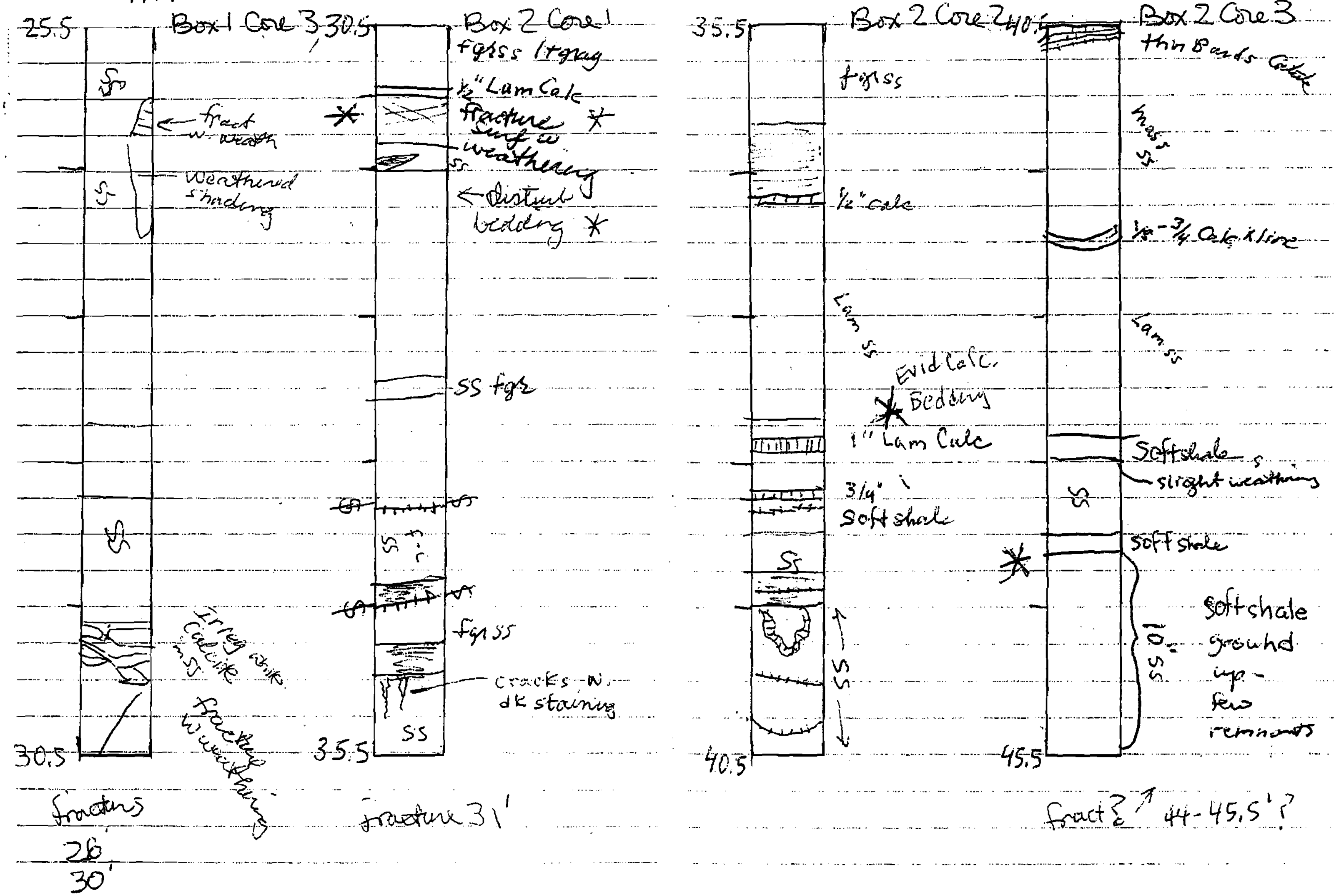
MW-206



fracture (Box 1 Core 1) → 18.75'

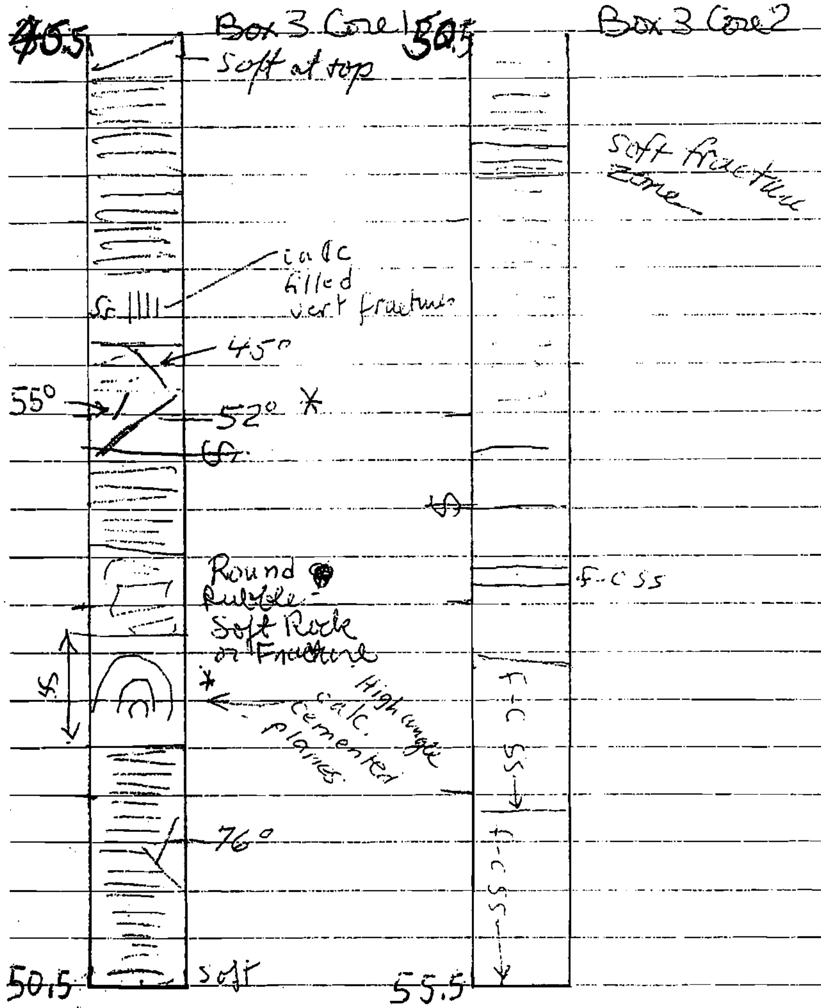
Box 1 Core 2 no definite fractures

MW-206


25.5
Box 1 Core 3 30.5
SS
← fract w. weath
Weathered shading
SS
SS
Irreg white Calcite in SS
fracture w weathering
30.5
fractures
26'
30'
Box 2 Core 1
fg ss ltgray
½" Lam Calc
fracture surf w weathering
SS
← Distur[?] bedding
SS fg[?]
f-c SS
fg SS
cracks w dk staining
SS
35.5
fracture 31'
35.5
Box 2 Core 2 40.5
fg ss
½" calc
Lam SS
Evid Calc. Bedding
1" Lam Calc
3/4" Soft shale
SS
← SS →
40.5
Box 2 Core 3
thin Bands Calc[?]
mass SS
½-¾ Calc xline
Lam SS
Softshale
slight weathering
SS
soft shale
10" SS
Softshale ground up - few remnants
45.5
fract? 44-45.5'?

MW-206

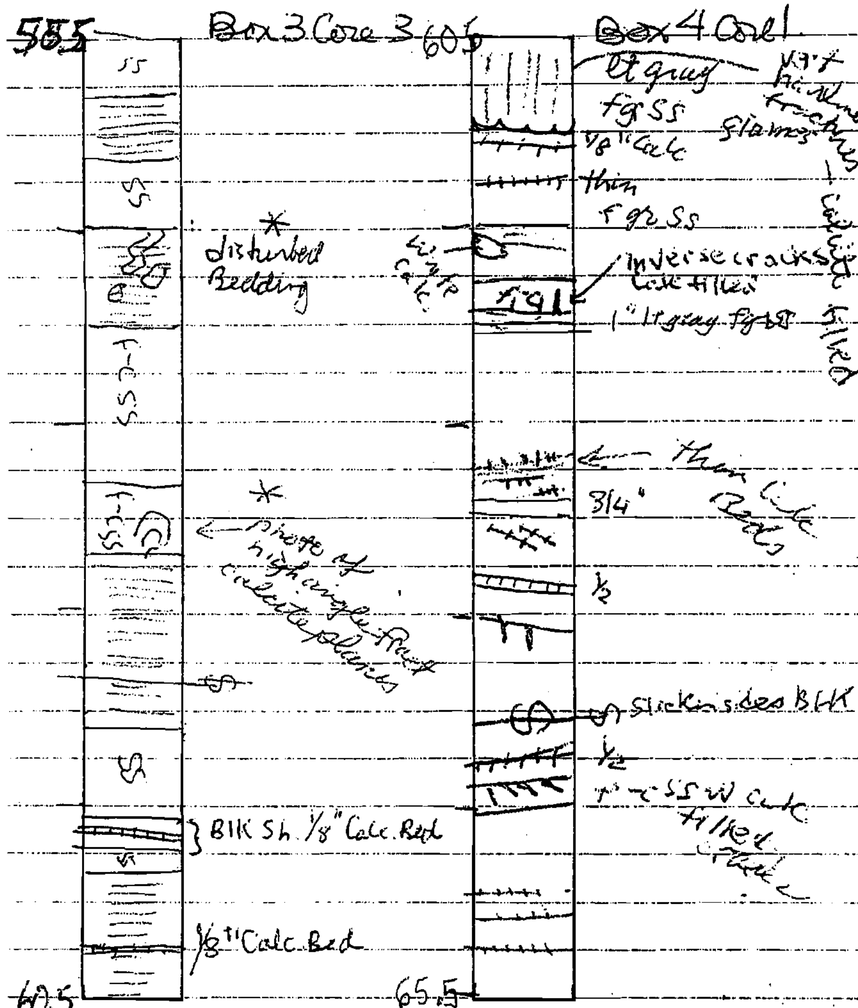
MW-206



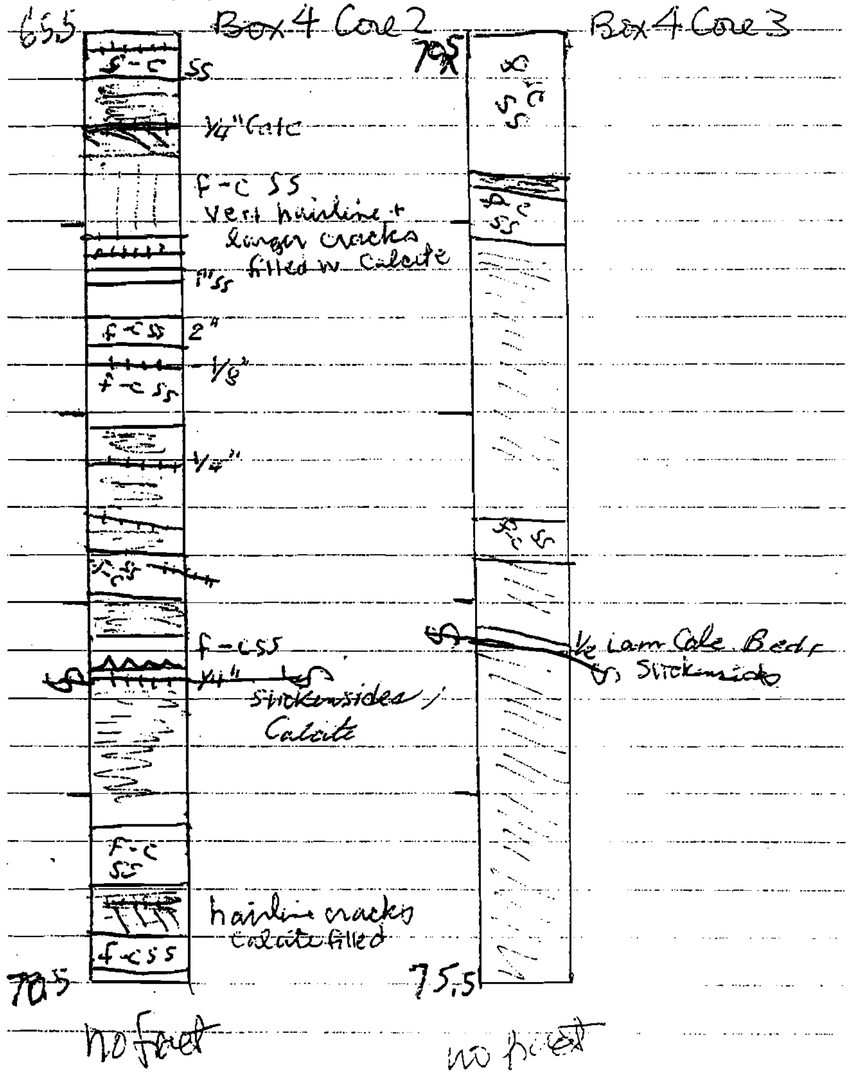
fractures @ 47.25'
@ 48.5'
49.5
possibly 45.5-

possible 60.' 1-4"

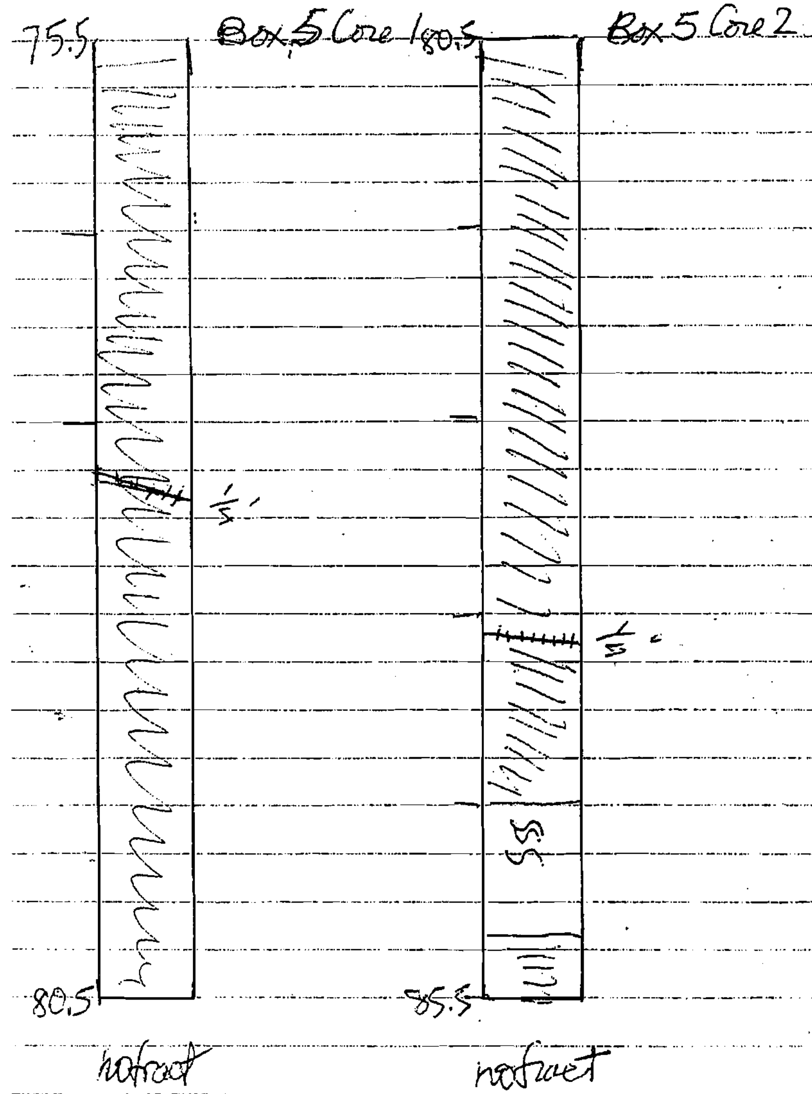
MW-206



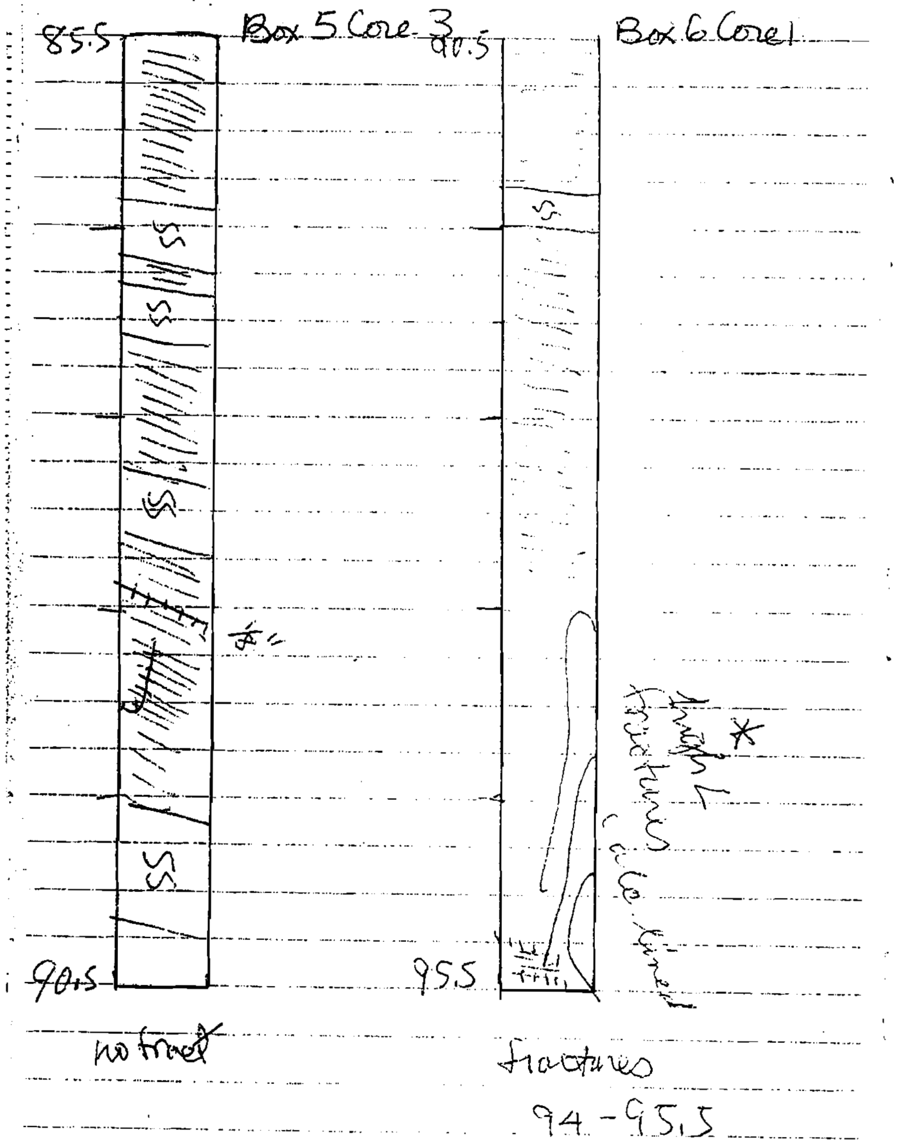
MW-206


65.5
Box 4 Core 2
f-c SS
SS
1/4" Calc
f-c SS
vert hairline + larger cracks filled w. calcite
1" SS
2"
f-c SS
1/8"
f-c SS
1/4"
f-c SS
f-c SS
1/4"
Slickensides / Calcite
f-c SS
hairline cracks calcite filled
f-c SS
70.5
no fract
70.5
Box 4 Core 3
f-c SS
f-c SS
f-c SS
1/2 lam Calc Beds Slickensides
75.5
no fract

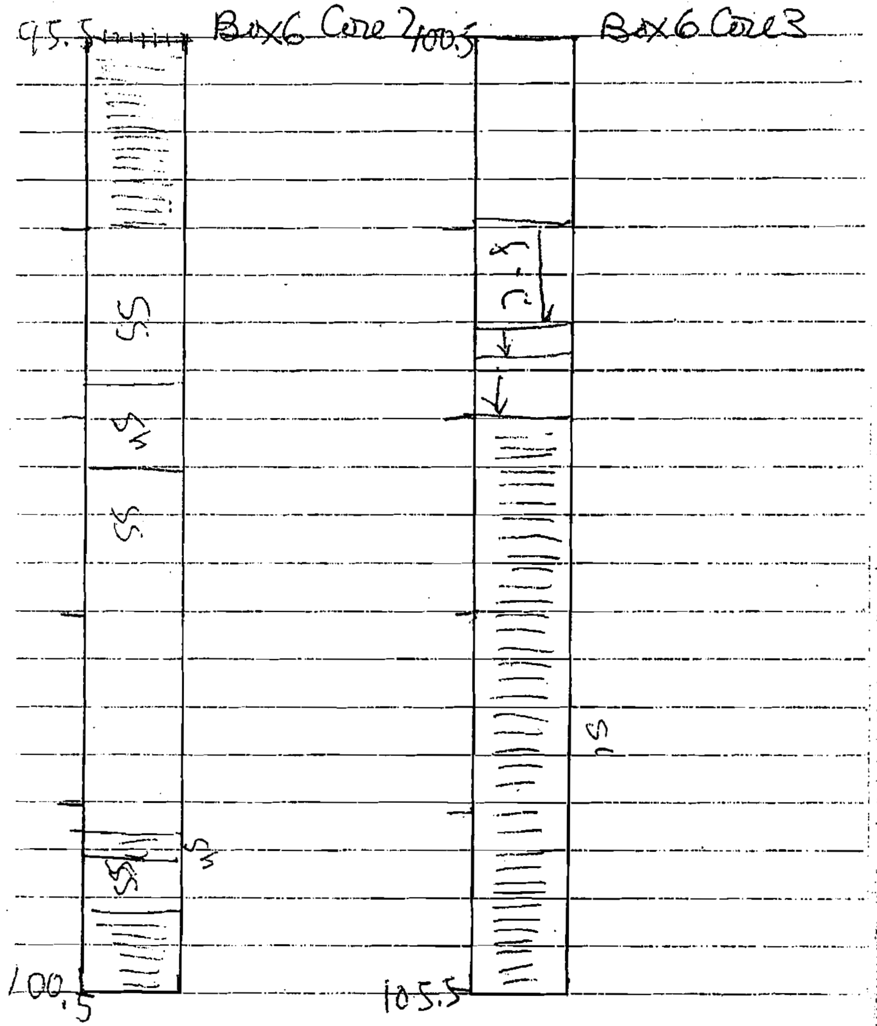
MW-206


75.5
Box 5 Core 1 80.5
1/5"
80.5
no fract
Box 5 Core 2
1/5"
SS
85.5
no fract

mW-206

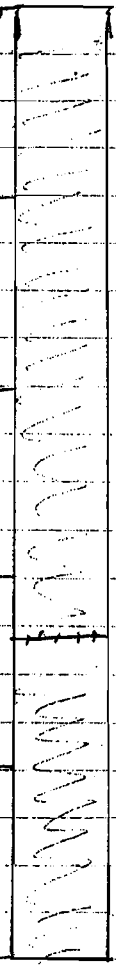

85.5
Box 5 Core 3
90.5
SS
SS
SS
SS
90.5
no fract
Box 6 Core 1
95.5
SS
high L fractures
*
calc. lined
fractures
94 - 95.5

mW-206


95.5
Box6 Core 2
100.5
SS
Sh
SS
Sh
SS
100.5
Box6 Core 3
f-c
Sl
105.5

MW-206

105.5 Box 7 Core 1 (110.5)

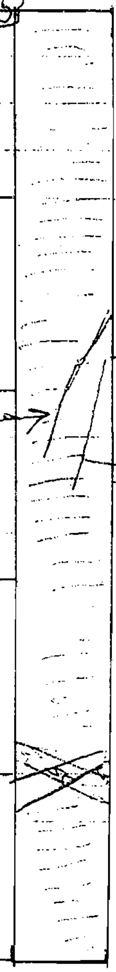


thin calc. bed

110.5

no fract

Box 7 Core 2



65°

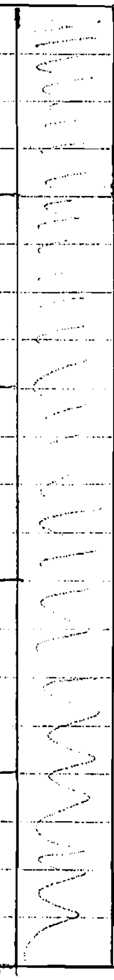
2 high angle fractures
* weathered
77° ang.

115.5

fracture
112.5 - 113'

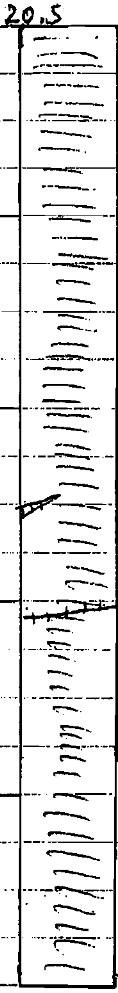
MW-206

115.5 Box 7 Core 3 120.5 Box 8 Core 1



120.5

no fract



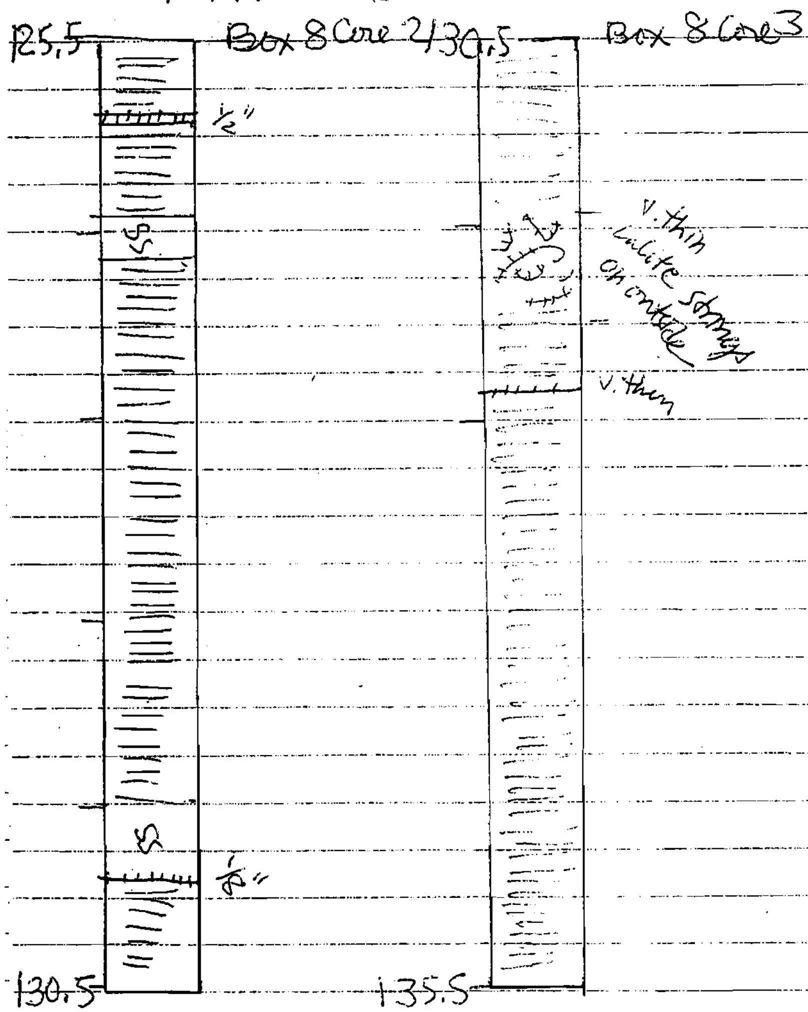
1/8

1/8"

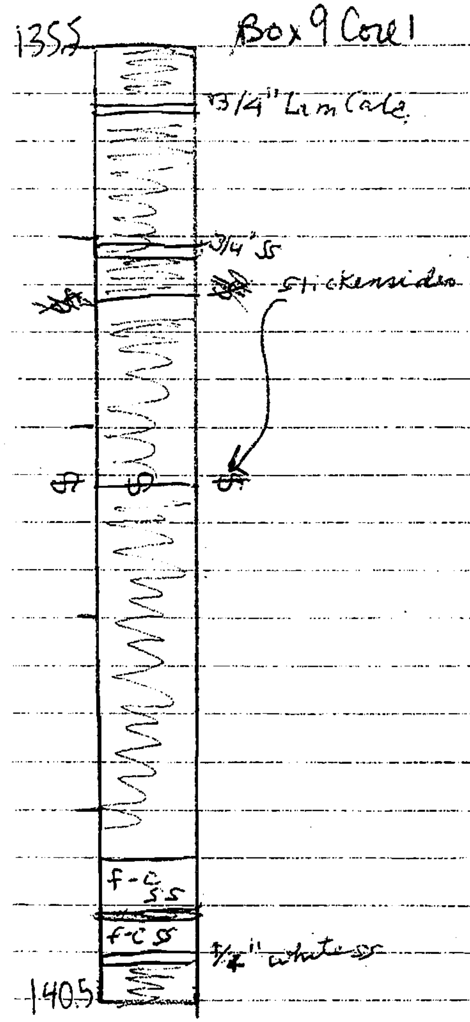
125.5

No fract.

MW-206



MW-206



no fract.

all breaks horizontal

APPENDIX D

Media – Borehole Videos on DVD for Bedrock Wells