GEI Consultants, Inc.

# INSTRUMENTATION APPENDIX TO PERIODIC INSPECTION REPORT NO. 5 WESTVILLE LAKE DAM SOUTHBRIDGE/STURBRIDGE, MASSACHUSETTS

Submitted to

Department of the Army
New England Division
Corps of Engineers

GEI Consultants, Inc.
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Project 95272
March 5, 1996

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R. Lee Wooten, P.E.
Senior Project Manager

# EXECUTIVE SUMMARY

This report provides a summary and evaluation of geotechnical instrumentation of the Westville Lake Dam in Southbridge and Sturbridge, Massachusetts. The Westville Lake Dam is a rolled-earthfill dam with a chute spillway at the north abutment, which was constructed for flood-control purposes.

Plate 1 shows the location of Westville Dam on the U.S. Geologic Survey topographic quadrangle map for Southbridge, Massachusetts, dated 1982. Plate 2 shows a plan of the dam and abutments. Plates 14 through 26 are copies of selected record drawings.

Geotechnical instrumentation at the dam consists of 6 crest monuments and 14 piezometers. Plate 3 shows the locations of the geotechnical instrumentation.

Crest Monuments - Six crest monuments (Mons. 1 through 6), two base-line, vertical control monuments (BL-2 and BL-3) and two horizontal control monuments (A and B) were installed in 1985.

The New England Division, Corps of Engineers surveyors surveyed the crest monuments in September 1988 and in July 1995. Table 1 gives the survey data and the movements computed based on differences in the survey data. Computed horizontal and vertical movements were small with a maximum horizontal movement of 0.0202 foot at Mon. 5 and a maximum vertical movement of 0.01 foot downward at Mons. 1 and 2. This range of movements is within limits of the accuracy of the survey so it is possible that no movement has occurred. Plate 10 shows 1995 baseline distances between the monuments. Plate 11 shows the computed horizontal movements of the monuments between September 1988 and July 1995. The measured movements to date are not significant.

Piezometers - The Corps of Engineers, Mobile District, installed 14 piezometers (PZ-1 through 14) on the downstream slope of Westville Dam during 1985 and 1986. Table 2 gives the stations, offsets, boring numbers, and elevations of key piezometer features. Plates 4 and 5 show the engineering logs of the piezometers. Plates 6, 7, 8, and 9 show cross sections and profiles of the embankment with piezometer locations. Appendices A and B contain the boring logs for the piezometer borings and the piezometer falling head test data, respectively.

Corps of Engineers project personnel measured piezometer pore water elevations according to the reading schedule provided in Appendix C since August 1990. Table 3 lists measured pore water elevations in the piezometers from August 1990 to August 1995. These data are plotted as time histories in Appendix D for the piezometer groups along Profile A-A at 45 feet downstream from the dam centerline (PZ-7, 8, 9, and 10), Profile B-B at 175 feet

downstream from the dam centerline (PZ-1, 2, 3, 4, 5, and 6), Section C-C at Station 5+15 (PZ-7, 8, 11, 12, and 4), and Section D-D at Station 6+00 (PZ-9, 10, 13, 14, and 3). Appendix E contains plots of piezometer time history data during the April 1993 high pool event for these same piezometer groups.

An average piezometer pore water elevation was calculated for each piezometer based on the monthly data excluding the daily data collected during high pool periods. Table 4 lists the selected piezometer data used to calculate average piezometer levels along with the calculated averages. Plate 12 shows plots of piezometer pore water elevation contours for the April 1993 high pool across the downstream area of the dam.

Pore water elevations at the piezometers were predicted with a pool level at the spillway crest, El. 572 feet, NGVD. Appendix F contains plots for each piezometer of the pore water elevations versus pool elevation. Table 5 lists these predicted pore water elevations.

Plates 13, 14, 15, and 16 show calculated average piezometer levels, maximum levels for the April 1993 high pool event, and the predicted maximum levels with the pool at the spillway crest on the various profiles and cross sections.

Conclusions and Recommendations - Based on past performance of the dam and on the performance of the instrumentation to date, the Westville Dam appears to be suitably instrumented. Existing instrumentation appear to indicate that the dam embankment is functioning adequately relative to seepage and settlement.

The crest monuments provide a suitable index for measurement and evaluation of ongoing movements. The measured movements to date are small (0.02 foot horizontal, 0.01 foot vertical) and are considered negligible. Small movements are expected to continue, most likely due to weathering, degradation, and consolidation of the downstream rock fill.

The crest monuments should be surveyed before each periodic inspection so that the inspection team can be given movement data for evaluation.

The 14 piezometers provide data to aid in evaluating seepage patterns throughout the dam. The piezometer data indicate that the combination of embankment impervious fill core, foundation grout curtain, and embankment pervious fill drain provide a relatively effective cutoff of upstream seepage pressures and drainage of downstream seepage pressures. Past observations of seepage in 1984 (Refs. 3 and 7) are probably from seepage flow down from the abutments and downstream valley sides.

Data from piezometer pairs PZ-7 and 8, PZ-11 and 12, and PZ-13 and 14 showed upward gradients. The upward gradients may indicate an effective impervious core but less effective bedrock grout curtain or they may indicate a shorter or more transmissive seepage path from

the upper piezometers to the pervious fill drain. Data from piezometer pair PZ-9 and 10 indicate higher pore water elevations in the upper PZ-9 piezometer. Apparently pore water elevations over the 23-foot-long soil and fractured bedrock zone monitored by PZ-9 are higher than in the 6.4-foot-long pervious zone set in more competent rock monitored by PZ-10.

Piezometers and pore pressure data are not available for the upstream part of the embankment and for cross sections other than at Stations 5+15 and 6+00. However, additional instrumentation does not appear necessary at this time.

Predicted piezometer pore water elevations for maximum pool should be compared with assumed phreatic surfaces used for stability evaluations of the embankment.

# PREFACE

## Purpose and Scope

This report provides a summary and evaluation of geotechnical instrumentation of the Westville Lake Dam in Southbridge and Sturbridge, Massachusetts.

GEI performed the following work:

a) Reviewed Periodic Inspection Reports 1 through 5 and data provided by the U.S. Army Corps of Engineers (USACE) on September 7, 1995. (Tasks 1 and 2)

b) Prepared an instrumentation general plan in an AutoCAD drawing file. (Task 3)

c) Prepared drafted engineering logs and piezometer logs, profiles, and cross sections in AutoCAD drawing file. (Task 4 and 5)

d) Prepared Lotus 1-2-3 plots of piezometer data. (Task 6)

e) Prepared a phreatic surface elevation plan in an AutoCAD drawing file. (Task 7)

f) Prepared survey data and horizontal and vertical movement plates in AutoCAD drawing files. (Task 8)

g) Prepared this report summarizing Tasks 1-8. (Task 9)

## Project Personnel

| | |
|---|---|
| R. Lee Wooten, P.E. | Senior Project Manager |
| Bruce I. Collingwood, P.E. | Project Engineer |
| Benjamin G. Gunther, P.E. | Project Engineer |
| Alton P. Davis Jr., P.E. | In-House Reviewer |

## Elevation Datum

All elevations in this report are referenced to National Geodetic Vertical Datum (NGVD).

## Limitations

Our professional services for this project have been performed in accordance with generally accepted engineering practices. No other warranty, expressed or implied, is made.

# TABLE OF CONTENTS

EXECUTIVE SUMMARY
PREFACE
TABLE OF CONTENTS
LIST OF TABLES
LIST OF PLATES
LIST OF APPENDICES

Page No.

1. PROJECT PERFORMANCE . . . . . 1
2. GENERAL DAM INFORMATION . . . . . 2
   2.1 Dam and Appurtenant Structures Description . . . . . 2
   2.2 Geology and Foundations . . . . . 4
   2.3 Significant Pools . . . . . 5
      2.3.1 April 1993 High Pool . . . . . 5
      2.3.2 April 1987 Flood . . . . . 6
      2.3.3 June 1984 Flood . . . . . 6

3. INSTRUMENTATION . . . . . 7
   3.1 Crest Monuments . . . . . 7
   3.2 Piezometers . . . . . 7

4. DATA COLLECTION, INTERPRETATION AND EVALUATION . . . . . 8
   4.1 Crest Monuments . . . . . 8
      4.1.1 Interpretation and Evaluation . . . . . 8
   4.2 Piezometers . . . . . 8
      4.2.1 Data Collection . . . . . 8
      4.2.2 Interpretation and Evaluation . . . . . 9
      4.2.3 Individual Piezometer Evaluation . . . . . 10
         4.2.3.1 Piezometer PZ-1 . . . . . 10
         4.2.3.2 Piezometer PZ-2 . . . . . 10
         4.2.3.3 Piezometer PZ-3 . . . . . 11
         4.2.3.4 Piezometer PZ-4 . . . . . 11
         4.2.3.5 Piezometer PZ-5 . . . . . 12
         4.2.3.6 Piezometer PZ-6 . . . . . 12
         4.2.3.7 Piezometer PZ-7 . . . . . 13
         4.2.3.8 Piezometer PZ-8 . . . . . 13
         4.2.3.9 Piezometer PZ-9 . . . . . 14
         4.2.3.10 Piezometer PZ-10 . . . . . 14
         4.2.3.11 Piezometer PZ-11 . . . . . 15
         4.2.3.12 Piezometer PZ-12 . . . . . 15
         4.2.3.13 Piezometer PZ-13 . . . . . 16
         4.2.3.14 Piezometer PZ-14 . . . . . 16

**TABLE OF CONTENTS**
(continued)


4.2.4 Profile and Section Interpretation and Evaluation . . . . . 17
4.2.4.1 Profile A-A at 45 Feet Downstream From Dam Centerline . 17
4.2.4.2 Profile B-B at 175 Feet Downstream From Dam Centerline 18
4.2.4.3 Section C-C at Station 5+15 . . . . . 18
4.2.4.4 Section D-D at Station 6+00 . . . . . 19
4.2.5 Phreatic Surface Elevation Plan Interpretation and Evaluation . . . . . 20

5. CONCLUSIONS AND RECOMMENDATIONS . . . . . 21
5.1 General . . . . . 21
5.2 Crest Monuments . . . . . 21
5.3 Piezometers . . . . . 21

TABLES
PLATES
APPENDICES

## LIST OF TABLES

1. Crest Monument Survey Data
2. Piezometer Construction Data
3. Piezometer Data From August 9, 1990, to August 18, 1995
4. Piezometer Data Used to Calculate Average Water Levels for Each Piezometer
5. Predicted Piezometer Pore Water Elevations for Pool Level at Spillway Crest (El. 572.0)

## LIST OF PLATES

1. Site Location Plan
2. Site Plan
3. Instrumentation General Plan
4. Engineering Logs For Piezometers PZ-1 Through PZ-6
5. Engineering Logs For Piezometers PZ-7 Through PZ-14
6. Profile A-A - 45 Feet Downstream From Dam Centerline
7. Profile B-B - 175 Feet Downstream From Dam Centerline
8. Section C-C at Sta. 5+15
9. Section D-D at Sta. 6+00
10. Crest Monument Survey Data
11. Horizontal and Vertical Movement of Crest Monuments
12. Phreatic Surface Plan of Maximum Porewater Levels for April 1993 High Pool
13. Profile A-A With Piezometer Pore Water Levels
14. Profile B-B With Piezometer Pore Water Levels
15. Section C-C With Piezometer Pore Water Levels
16. Section D-D With Piezometer Pore Water Levels
17. Record Drawing: Plan of Foundation Explorations
18. Record Drawing: Log Profile 1-1 and Geologic Sections 2-2, 3-3, and 4-4
19. Record Drawing: Geologic Sections 5-5 and 6-6
20. Record Drawing: Record of Foundation Explorations No. 1
21. Record Drawing: Record of Foundation Explorations No. 2
22. Record Drawing: Record of Foundation Explorations No. 3
23. Record Drawing: General Plan
24. Record Drawing: Embankment Profile and Sections No. 1
25. Record Drawing: Embankment Profile and Sections No. 2
26. Record Drawing: Spillway and Outlet Works Channel Sections

## LIST OF APPENDICES

A. Boring Logs
B. Falling Head Test Data
C. Reading Schedule for Piezometers
D. Piezometer Data, Time History Plots
E. Piezometer Data, April 1993 Event Plots
F. Piezometer Elevations vs. Pool Elevations Plots
G. Standards and Procedures for Settlement Surveys

# 1. PROJECT PERFORMANCE

Based on past performance of the dam and on the performance of the instrumentation to date, the performance of the Westville Lake Dam is rated as good. The dam is suitably instrumented. The existing instrumentation indicate that the dam embankment is functioning suitably relative to seepage and crest movements. The crest monument data indicate little or no settlement (0.12 inch maximum) from September 1988 to July 1995. A maximum horizontal movement in the downstream direction of 0.24 inch was calculated for the same time period. No movement data were available for Mon. 4 because the monument was damaged and replaced between the 1988 and 1995 surveys. A total of 14 piezometers had been installed in 1985 and 1986 to monitor pore water pressures and seepage patterns in the dam embankment, foundation, and through the right abutment. The piezometers appear to be in good working condition.

# 2. GENERAL DAM INFORMATION

## 2.1 Dam and Appurtenant Structures Description

The following descriptions of Westville Dam are taken from the Periodic Inspection Report No. 1 (April 1976, Ref. 1):

> Westville Lake is one of a system of six dams and lakes that have been constructed in the Thames River Basin for flood control purposes. The Westville Lake is regulated in series with East Brimfield Lake whenever necessary to maintain downstream flows within safe channel capacities. The critical damage point is in the Town of Southbridge immediately downstream, but the lake is also regulated for the Town of Putnam, Connecticut and for all downstream communities in the Quinebaug River.
>
> ...Westville Lake is located in south-central Massachusetts on the Quinebaug River 1.3 miles west of the center of the Town of Southbridge. The lake occupies portions of both Southbridge and Sturbridge, Massachusetts. Construction of the project started in 1960 and it became operational in 1962.
>
> ...Westville Dam is a rolled-earth fill dam with rock fill as slope protection; a downstream rock fill toe, a chute spillway founded on bedrock in the left (north abutment) and an outlet works incorporated in the spillway weir. A control house between the embankment and the weir houses operating equipment and provides entry to the spillway gallery. Access to the control house is by means of an access bridge supported by a non-overflow section between the control house and the embankment. ...The permanent pool is set at elevation 525.0. Principal recreation activities at the site are picnicking, boating and swimming.

Plate 1 shows the location of Westville Dam on the local U.S. Geologic Survey topographic quadrangle map. Plate 2 shows a simplified plan of the dam and abutments. Plates 17 through 26 are copies of record drawings - Plate 17 (Plan of Foundation Explorations), Plate 18 (Log Profile 1-1 and Geologic Sections 2-2, 3-3, and 4-4), Plate 19 (Geologic Sections 5-5 and 6-6), Plate 20 (Record of Foundation Explorations No. 1), Plate 21 (Record of Foundation Explorations No. 2), Plate 22 (Record of Foundation Explorations No. 3), Plate 23 (General Plan), Plate 24 (Embankment Profile and Sections No. 1), Plate 25

(Embankment Profile and Sections No. 2), and Plate 26 (Spillway and Outlet Works Channel Sections).

The following data (Ref. 1) summarize the important features of the dam:

Summary of Pertinent Data, Westville Dam

Location: Quinebaug River, Southbridge and Sturbridge, Massachusetts
Drainage Area: 99.5 square miles

Dam

Type ..... Rolled earth and rock fill
Length ..... 560 feet
Maximum height above streambed ..... 78 feet
Top elevation ..... 587 feet
Top width ..... 25 feet
Embankment slopes
Upstream ..... 2.5H:1V
Downstream ..... 2.5H:1V

Outlet Works

Type ... Upstream intake weir and outlet conduits in rock, located below spillway
Service gates ..... Three electric slide gates
Sill elevation ..... 515 feet
Maximum discharge capacity ..... 3,750 cfs
Tunnel size ..... Three tunnels, each 4.0 feet wide x 6.0 feet high
There are no emergency gates. Stop-log slots are provided up-stream of service gates.

A "U" (in plan) shaped concrete weir upstream of the center gate contains five 4 feet wide x 6 feet high stop-log openings to control a pool varying from elevation 524.0 to elevation 527.0.

Spillway

Type ..... Uncontrolled, concrete ogee weir and unlined channel in rock
Crest elevation ..... 572 feet
Crest length ..... 200 feet

Reservoir Data

| | Elevation (feet) | Area (Acres) | Cumulative Capacity (Acre feet) | Cumulative Equivalent Run-off (inches) |
|---|---|---|---|---|
| Conduit Invert | 515.0 | - | - | - |
| Permanent Pool | 525.0 | 23 | 100 | - |
| Flood Control Storage | 525.0-572.0 | 1,220 | 11,000 | 6.4 |
| Spillway Crest | 572.0 | 1,220 | 11,100 | - |
| Maximum Surcharge | 582.1 | 1,650 | 24,300 | 14.2 |

## 2.2 Geology and Foundations

The following descriptions of site geology at Westville Dam are taken from the Periodic Inspection Report No. 1 (April 1976, Ref. 1):

> General. The Westville Lake Project area lies in the northward continuation of the eastern upland area of Connecticut, which is a portion of the New England upland physiographic province. The Quinebaug River at the dam site flows easterly in a narrow partly filled pre-glacial valley. Relief of the area presents a strong north-northeast - south-southwest orientation reflecting a structural control modified by glacial erosion and deposition. The bedrock of the immediate area consists of folded metamorphic rocks with extensive granitic intrusions. The overburden consists predominantly of clayey glacial till in the uplands with minor deposits of outwash and ice contact sands and gravels in lower areas.
>
> Dam. Overburden consisting of thick uniform clayey till forms the steep south (right) abutment and a portion of the valley bottom adjacent to the south (right) bank of the river. The central and northern (left) portions of the river bottom are underlain by a thin blanket up to ten feet thick of alluvial sands and gravels over glacial till. The till layer is also thin, in the order of 2 to 5 feet thick, and directly overlies bedrock. A cut-off wall was constructed to bedrock in this area from Station 5+25 and extending up the north (left) abutment to the south (right) training wall of the emergency spillway. Bedrock is exposed at the ground surface adjacent to the river on the north (left) abutment, but is buried

further up the abutment to depths of up to 25 feet with deposits of poorly sorted till which had been locally reworked to varying degrees of permeability. Bedrock was exposed prior to construction on the north (left) abutment between the river and the abandoned railroad cut approximately 150 feet from the river's edge. The rock is weathered and fractured to varying degrees throughout the area, and was highly weathered and fractured between the abandoned railroad cut and the river. Structure locations were avoided in this area insofar as was possible. High water losses during drilling and pressure testing indicated the need for a grout curtain beneath the structures. This grout curtain was constructed from the southern (right) end of the cutoff wall at 5+25 to the north (left) wall of the spillway weir at approximately Station 11+00. A predominance of steeply dipping, open joints combined with frequent bedding joints occurs in the upper rock zones.

Spillway and Outlet Works. The foundations of the control house, outlet structure and spillway weir were all carried to sound rock. The major portions of the intake and outlet channels from approximately Station 6+00 to Station 14+00 are predominately in rock cut, with slopes of about 4 on 1 [1H:4V]. The lower portion of the spillway discharge channel is also in rock. Line drilling on vertical slopes was performed here as this section will be subject to strong turbulent flow during spillway discharge. The spillway approach channel is cut in glacial till.

## 2.3 Significant Pools

Three significant storm events have occurred during April 1993, April 1987, and June 1984. Each event is described below.

### 2.3.1 April 1993 High Pool

During the last two weeks in March 1993, rainstorms combined with snowmelt generated high pool elevations at Westville Lake Dam. The pool peaked at elevation 558.9 feet (NGVD) (a 43.9-foot pool stage) on April 2. No problems or abnormalities were reported from the Project Manager.

### 2.3.2 April 1987 Flood

During April 1987, the embankment was subjected to its second highest impoundment to date with a maximum water surface elevation of 564.2 feet (NGVD), 49.2-foot stage, 48% full. The highest impoundment occurred in June 1984 with a maximum water surface elevation of 565.5 feet (NGVD), 50.5-foot stage, 56% full.

An emergency inspection team from Geotechnical Engineering Branch observed conditions during the April 1987 flood. The embankment was seen to be performing satisfactorily under the high pool condition. Seepage was observed flowing in an area of the old river channel located approximately 100 feet from the downstream toe. The flow was clear and runoff from the right abutment seemed to be contributing to the flow. There was no evidence of boils.

### 2.3.3 June 1984 Flood

During June 1984, the embankment was subjected to its highest impoundment to date with a maximum water surface elevation of 565.5 feet (NGVD), 50.5-foot stage, 56% full.

Two seepage areas were observed at the downstream toe. Seepage area 1 was located approximately 75 feet downstream from the toe at about Station 6+00. Active sand boils were observed. Seepage area 2 was located approximately 100 feet downstream from the toe between Stations 6+50 and 8+50. Water flow was observed from three to four locations at 1/3 to 1 gallon per minute. In addition, five depressions from 1.5 to 4 feet in diameter and 0.5 to 1 foot deep were observed in the rock waste area located about 20 feet downstream of the toe at approximately Station 6+00. Recommendations included continued visual observations and installation of nine piezometers to determine the source of seepage.

# 3. INSTRUMENTATION

## 3.1 Crest Monuments

Six crest monuments (Mon. 1 through 6), two base-line, vertical control monuments (BL-2 and BL-3), and two horizontal control monuments (A and B) were installed in 1985. The crest monuments consist of 4-inch-diameter, concrete-filled steel pipes. The tip of the steel pipes are 10 feet below the ground surface. A brass disk is set in the top of each monument at the ground surface, and concrete is placed around the upper section of the pipe. The current standards and procedures employed by Corps of Engineers surveyors for crest monument surveys at Westville Lake Dam are provided in Appendix G. Plate 3 shows the locations of the monuments. Table 1 gives the survey data for the monuments from September 1988 and July 1995.

## 3.2 Piezometers

A total of fourteen piezometers, six single piezometers, and four double piezometers (PZ-1 through 14) were installed on the downstream slope and along the downstream toe of Westville Dam during 1985 and 1986 in borings FD-85-1 through 4 and FD-86-6 through FD-86-11. Plate 3 shows the locations of the piezometers. Table 2 gives the stations, offsets, boring number, and elevations of key piezometer features.

The piezometers are Casagrande-type piezometers constructed with sand filters and 2-foot-slotted lengths of PVC pipe sealed at selected elevations over filtered lengths ranging from 3.8 to 34.0 feet. Depths of piezometer sand filters range from 10.2 feet to 92.0 feet below ground surface. Piezometer risers are 1-inch-outer-diameter by 3/4-inch-inner-diameter PVC pipes. Piezometer seals are either concrete (PZ-1 through 4) or bentonite (PZ-5 through 14).

Plates 4 and 5 show the engineering logs of the piezometers. Plates 6, 7, 8, and 9 show cross sections and profiles of the embankment with piezometer locations. Appendices A and B contain the boring logs for the piezometer borings and the piezometer falling head test data, respectively.

# 4. DATA COLLECTION, INTERPRETATION AND EVALUATION

## 4.1 Crest Monuments

The New England Division, Corps of Engineers surveyors surveyed the crest monuments in September 1988 and in July 1995. Crest Mon. 4 was damaged and replaced between the 1988 and 1995 surveys. Table 1 gives the survey data and the movements computed based on differences in the survey data. Computed horizontal and vertical movements were small with a maximum horizontal movement of 0.0202 foot at Mon. 5 and a maximum vertical movement of 0.01 foot downward at Mons. 1 and 2. Plate 10 shows 1995 baseline distances between the monuments. Plate 11 shows the computed horizontal movements of the monuments between September 1988 and July 1995.

### 4.1.1 Interpretation and Evaluation

The surveys indicate the total settlement of all monuments from 1988 to 1995 is limited to 0.01 foot (0.12 inch). This range of movement is within the limits of the accuracy of the survey so it is possible that no settlement has occurred. However, minor settlement of the embankment or settlement of the monuments within the embankment could have occurred. This small amount of recorded settlement is considered negligible.

The two horizontal movement surveys, performed using a combination of trilateration and angles, show the range of movement of monuments between 1988 and 1995 ranged from 0.0019 to .0202 foot (0.0228 to 0.2424 inch). The net horizontal movement of the monuments is in the downstream direction. Additionally, there was no physical evidence of movement at any monument, such as slumps, scarps, cracks, or depressions that would indicate any movement is taking place in the embankment. The overall downstream direction of movement of the monuments indicates the embankment may be experiencing some very minor deformations. Based on the data that has been acquired to date, it is concluded that there has been insignificant horizontal movement within the embankment.

## 4.2 Piezometers

### 4.2.1 Data Collection

The project personnel measured piezometer pore water elevations on a monthly basis since August 1990. Daily measurements of piezometers have been made during periods of high pool levels when the pool level was greater than El. 535.0. Appendix

C contains the "Reading Schedule for Piezometers" that provides instructions for piezometer data collection.

Table 3 lists measured pore water elevations in the piezometers from August 1990 to August 1995. These data are plotted as time histories in Appendix D for the piezometer groups along Profile A-A (PZ-7, 8, 9, and 10), Profile B-B (PZ-1, 2, 3, 4, 5, and 6), Section C-C at Station 5+15 (PZ-7, 8, 11, 12, and 4), and Section D-D at Station 6+00 (PZ-9, 10, 13, 14, and 3). Appendix E contains plots of piezometer time history data during the April 1993 high pool event for these same piezometer groups.

### 4.2.2 Interpretation and Evaluation

The piezometer data provide a means to determine phreatic surfaces across the dam embankment for historic pool levels and to predict phreatic surfaces for maximum pool levels.

An average piezometer pore water elevation was calculated for each piezometer based on the monthly data excluding the daily data collected during high pool periods. Table 4 lists the selected piezometer data used to calculate average piezometer levels along with the calculated averages. Plates 13, 14, 15, and 16 show these average piezometer pore water elevations on the profiles and cross sections.

For the April 1993 high pool, the maximum piezometer pore water elevations measured at each piezometer during the April 1993 high pool are shown in Plates 12, 13, 14, 15, and 16. Plate 12 shows plots of piezometer pore water elevation contours for the April 1993 high pool across the downstream area of the dam. No piezometer pore water elevation measurements were made during the previous higher impoundments during June 1984 and April 1987 since establishment of the piezometer reading schedule did not begin until 1990.

The responses of pore water elevations were estimated at the piezometers to a pool level at elevation 572.0, the crest level of the emergency spillway. Appendix F contains plots for each piezometer of the pore water elevations versus pool elevation. These plots were used to extrapolate a predicted pore water elevation at each piezometer for a pool elevation of 572. Table 5 lists these predicted pore water elevations. Plates 13, 14, 15, and 16 also show these predicted maximum piezometer pore water elevations on the profiles and sections.

The predicted piezometer pore water levels are typically higher than, but consistent with past measurements. In general, pore pressures at the piezometers indicate that the steepest downstream pressure gradients (see Plate 12) occur from the abutment and

downstream valley sides to the river channel. The downstream gradients perpendicular to the dam axis (see Plates 8 and 9) at the Station 5+15 and 6+00 sections are relatively flat, indicating that the embankment provides a relatively effective cutoff of upstream seepage pressures and adequate drainage for downstream seepage.

### 4.2.3 Individual Piezometer Evaluation

#### 4.2.3.1 Piezometer PZ-1

PZ-1 is located 150 feet downstream of the dam centerline at Station 8+05, about 25 feet downstream of the toe of the dam. The tip is located at El. 532.5 feet (NGVD), in bedrock. The tip is surrounded by filter sand that extends from El. 531.1 to El. 538.6 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick concrete seal that extends to the ground surface. The pervious zone of PZ-1 extends through bedrock with a rock core recovery 70 to 75 percent.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. Based on these plots and the piezometer data in Table 3, PZ-1 is typically dry during normal pools but appears to react within one day to a rising or falling pool level above El. 545 feet (NGVD). Below a pool level of El. 545 (NVGD), the piezometer data (See Appendix F) show no strong correlation with pool level. Discharge through the adjacent spillway channel or perched water levels due to heavy rainfall may be the major factors influencing PZ-1 levels. The maximum water level recorded for PZ-1 during the April 1993 event was El. 540.0 feet (NGVD), which occurred on the same day as the highest pool level for the April 1993 event. The extrapolated piezometer level in Appendix F for a pool level at the spillway crest, El. 572 feet (NGVD), is El. 541.6 feet (NGVD), ground surface level.

#### 4.2.3.2 Piezometer PZ-2

PZ-2 is located 185 feet downstream of the dam centerline at Station 7+10. PZ-2 is located downstream of the toe of the dam. The tip is located at El. 530.7 feet (NGVD), in bedrock. The tip is surrounded by filter sand that extends from El. 530.6 to El. 537.8 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick concrete seal that extends to the ground surface. The pervious zone of PZ-2 extends through bedrock with a rock core recovery 43 to 88 percent.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. Based on these plots and the piezometer data in Table 3, PZ-2 is typically dry during normal pools. The maximum water level recorded for PZ-2 during the April 1993 event was El. 537.2 feet (NGVD) four days before the maximum pool level. The data collected to date, shown on the plot in Appendix F, displayed no correlation with pool levels. PZ-2 levels probably indicate perched water levels from heavy rainfall. Therefore, the median piezometer level, El. 535.8 feet (NGVD), was used as the predicted level when the pool reaches the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.3 Piezometer PZ-3

PZ-3 is located 220 feet downstream of the dam centerline at Station 6+00, slightly upstream from the toe of the dam. The tip is located at El. 498.0 feet (NGVD). The top of bedrock is located at El. 498.8 feet (NGVD). The tip is surrounded by filter sand that extends from El. 494.8 to El. 514.8 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick concrete seal that extends to the ground surface. The pervious zone of the piezometer extends through boulders and the sandy gravel (GP)/gravelly sand (SP) foundation drain into bedrock.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 512.8 feet (NGVD). The piezometer water level appears to react within a day over a small range of about 3 feet to a rising or falling pool level (see Appendix F). The maximum water level recorded for PZ-3 during the April 1993 event was 2.6 feet above average at El. 515.4 feet (NGVD). The extrapolated piezometer level shown in Appendix F is 3.3 feet above average at El. 516.1 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.4 Piezometer PZ-4

PZ-4 is located 200 feet downstream of the dam centerline at Station 5+00 in the rock waste area, slightly downstream from the toe of the dam. The tip is located at El. 504.4 feet (NGVD). The tip is surrounded by filter sand that extends from El. 501.1 to El. 518.9 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick concrete seal that extends to the ground surface. The pervious zone of PZ-4 extends through silty sand (SP), clayey silt (till, MH), sandy gravel (GP), and one boulder.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 514.6 feet (NGVD). The piezometer water level appears to react within a day over a small range of about 4 feet to rising or falling pool levels (see Appendix F). The maximum water level recorded for PZ-4 during the April 1993 event was 3.9 feet above average at El. 518.5 feet (NGVD). The extrapolated piezometer level shown in Appendix F is 5.1 feet above average at El. 519.7 feet (NGVD), for a pool level at the spillway crest El. 572 feet (NGVD).

#### 4.2.3.5 Piezometer PZ-5

PZ-5 is located 160 feet downstream of the dam centerline at Station 4+00, slightly downstream from the toe of the dam. The tip is located at El. 521.0 feet (NGVD). The tip is surrounded by filter sand that extends from El. 517.1 to El. 538.4 feet (NGVD). Immediately overlying the filter sand is a 4-foot-thick bentonite seal that extends to the ground surface. The pervious zone of PZ-5 extends through glacial till-lean clay with gravel (CL) and clayey silty sand with gravel (SC).

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 539.3 feet (NGVD). Water levels in PZ-5 are typically higher than the pool level, indicating seepage from the right abutment controls the water level at PZ-5. The maximum water level recorded for PZ-5 during the April 1993 event occurred four days before maximum pool level and was 2.1 feet above average at El. 541.4 feet (NGVD). The extrapolated piezometer level shown in Appendix F is 2.0 feet above average at El. 541.3 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.6 Piezometer PZ-6

PZ-6 is located 120 feet downstream of the dam centerline at Station 3+00, at the toe of the dam. The tip is located at El. 545.7 feet (NGVD). The tip is surrounded by filter sand that extends from El. 542.7 to El. 557.9 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick bentonite seal that extends to the ground surface. The pervious zone of PZ-6 extends through glacial till-cobbles, and boulders; clayey, silty sand with gravel; and lean clay with sand and gravel (CL).

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 557.6 feet (NGVD). Water levels in PZ-6 are typically higher than the pool level, indicating seepage from the right abutment controls the water level at PZ-6. The maximum water level recorded for PZ-6 during the April 1993 event occurred one day before maximum pool level and was 3.0 feet above average at El. 560.6 feet (NGVD). The extrapolated piezometer level shown on the plot in Appendix F is 2.8 feet above average at El. 560.4 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.7 Piezometer PZ-7

PZ-7 is located 45 feet downstream of the dam centerline at Station 5+15. The tip is located at El. 493.8 feet (NGVD) in the subgrade soil below the embankment dam. The tip is surrounded by filter sand that extends from El. 488.6 to El. 500.7 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick bentonite seal. The pervious zone of PZ-7 extends through glacial till-sandy lean clay (CL).

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 516.5 feet (NGVD). The piezometer water level appears to react within one day to a rising or falling pool level. The maximum water level recorded for PZ-7 during the April 1993 event was 6.4 feet above average at El. 522.9 feet (NGVD). PZ-7 typically shows an upward gradient from the lower piezometer PZ-8 set in rock. The upward gradient is consistent with seepage gradients expected from an embankment with an effective impervious core but less effective bedrock cutoff system or a shorter or more transmissive seepage path from the upper piezometer to the pervious fill drain. The extrapolated piezometer level shown in Appendix F is 8.6 feet above average at El. 525.1 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.8 Piezometer PZ-8

PZ-8 is located in the same borehole as PZ-7. The tip is located at El. 480.3 feet (NGVD). The tip is surrounded by filter sand that extends from El. 479.0 to El. 485.6 feet (NGVD). Immediately overlying the filter sand is a 3-foot-thick bentonite seal. The pervious zone of PZ-8 extends through bedrock with a rock core recovery of 69 to 82 percent.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 516.2 feet (NGVD). The piezometer water level appears to react within one day to a rising or falling pool level. The maximum water level recorded for PZ-8 during the April 1993 event was 8.0 feet above average at El. 524.2 feet (NGVD). The extrapolated piezometer level shown in Appendix F is 10.8 feet above average at El. 527.0 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.9 Piezometer PZ-9

PZ-9 is located 45 feet downstream of the dam centerline at Station 6+00. The tip is located at El. 511.3 feet (NGVD). The tip is surrounded by filter sand that extends from El. 494.2 to El. 517.2 feet (NGVD). Immediately overlying the filter sand is a 4.7-foot-thick bentonite seal. The pervious zone of PZ-9 extends through pervious embankment fill-silty fine sand (SM) into bedrock with recoveries of 91% and 36%.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 518.2 feet (NGVD). The piezometer water level appears to react within one day to a rising or falling pool level. The maximum water level recorded for PZ-9 during the April 1993 event was 6.5 feet above average at El. 524.7 feet (NGVD). Data from piezometer pair PZ-9 and PZ-10 indicate higher pore water elevations in the upper piezometer. PZ-9 was constructed with a 23-foot-long pervious zone that spans soil and rock zones with very poor recovery. Apparently, pore water elevations over this upper zone monitored by PZ-9 are higher than in the lower 6.4-foot-long pervious zone set in more competent rock monitored by PZ-10. Factors that could cause these pore water elevation differences would be higher transmissivity between the pool and the PZ-9 pervious zone and/or higher transmissivity between PZ-10 and downstream water pressures. The extrapolated piezometer level shown on the plot in Appendix F is 8.6 feet above average at El. 526.8 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

#### 4.2.3.10 Piezometer PZ-10

PZ-10 is located in the same borehole as PZ-9. The tip is located at El. 485.9 feet (NGVD). The tip is surrounded by filter sand that extends from

El. 495.6 to El. 505.5 feet (NGVD). Immediately overlying the filter sand is a 3.4-foot-thick bentonite seal. The pervious zone of PZ-14 extends through bedrock with a rock core recovery 70 to 100 percent.

A history of the piezometer's response to pool fluctuations for all available data collected to date is presented on plots located in Appendices D, E, and F. The average water level in the piezometer is El. 515.3 feet (NGVD). The piezometer water level appears to react within one day over a small range of about 4 feet to rising or falling pool levels (see Appendix F). The maximum water level recorded for PZ-14 during the April 1993 event was 4.3 feet above average at El. 519.6 feet (NGVD). The extrapolated piezometer level shown on the plot in Appendix F is 5.5 feet above average at El. 520.8 feet (NGVD) for a pool level at the spillway crest, El. 572 feet (NGVD).

### 4.2.4 Profile and Section Interpretation and Evaluation

#### 4.2.4.1 Profile A-A at 45 Feet Downstream From Dam Centerline

Piezometers located along Profile A-A include PZ-7, PZ-8, PZ-9, and PZ-10 as shown in Plates 6 and 13. Several preconstruction borings are also included in Plate 6. Plate 13 includes (1) average piezometer pore water levels for normal pool, (2) maximum piezometer pore water levels for the April 1993 high pool (El. 558.9), and (3) projected piezometer pore water levels for a pool level at the spillway crest (El. 572).

Time history plots of water level data for these piezometers are included in Appendix D. Time history water level data recorded for these piezometers during the April 1993 high pool are included in Appendix E.

These four piezometers appear to be influenced mainly by the elevation of the pool. The plots of individual piezometer responses versus pool level for these four piezometers (Appendix F) show a strong correlation between pool level and the piezometer levels. Piezometer levels along A-A peaked on the same day as maximum pool during the April 1993 event.

The pore water levels shown on Plate 13 for average, April 1993, and projected piezometer levels are significantly below corresponding pool levels. This drop in pore water levels across the dam indicates that the combination of embankment impervious fill core, foundation grout curtain, and embankment pervious fill drain provide a relatively effective cutoff of upstream seepage pressures and drainage of downstream seepage pressures.

Pore pressure gradients for high pool levels across the two piezometer couplets along Profile A-A differ from each other. The PZ-7,8 couplet has a downward gradient for high pool levels, while the PZ-9,10 couplet has an upward gradient. The differences reflect the variability of transmissivities across the width and height of the dam.

#### 4.2.4.2 Profile B-B at 175 Feet Downstream From Dam Centerline

Piezometers located along Profile B-B include PZ-1, PZ-2, PZ-3, PZ-4, PZ-5 and PZ-6 as shown in Plates 7 and 14. Several preconstruction borings are also included in Plate 7. Plate 14 includes (1) average piezometer pore water levels for normal pool, (2) maximum piezometer pore water levels for the April 1993 high pool (El. 558.9), and (3) projected piezometer pore water levels for a pool level at the spillway crest (El. 572).

Time history plots of water level data for these piezometers are included in Appendix D. Time history plots of water level data recorded for these piezometers during the April 1993 high pool are included in Appendix E.

Profile B-B include four abutment piezometers - PZ-5 and PZ-6 on the right abutment and PZ-1 and PZ-2 on the right abutment. Average pore water levels in PZ-5 and PZ-6 are above normal pool level, indicating that seepage from the right abutment controls these piezometer levels. PZ-1 and PZ-2 are typically dry and typically do not show a correlation with pool level during high pool events. Perched water levels due to heavy rainfall may be the primary factor influencing PZ-1 and PZ-2 levels.

PZ-3 and PZ-4 are set at the toe of the dam in the valley floor area. Both piezometers appear to react within one day over a relatively small range (3 to 4 feet) to rises or falls in pool level. The reactions of PZ-3 and PZ-4 probably reflect the effective drainage of the pervious fill embankment drain to the toe area.

#### 4.2.4.3 Section C-C at Station 5+15

Piezometers located along Section C-C at Station 5+15 include PZ-4, PZ-7, PZ-8, PZ-11, and PZ-12 as shown in Plates 8 and 15. Several preconstruction borings are also included in Plate 8. Plate 15 includes (1) average piezometer pore water levels for normal pool, (2) maximum piezometer pore water levels for the April 1993 high pool (El. 558.9), and (3) projected piezometer pore water levels for a pool level at the spillway crest (El. 572).

Time history plots of water level data for these piezometers are included in Appendix D. Time history plots of water level data recorded for these piezometers during the April 1993 high pool are included in Appendix E.

The piezometer levels in Section C-C appear to be influenced mainly by the elevation of the pool. The plots of individual piezometer responses versus pool level for these five piezometers (Appendix F) show a strong correlation between pool level and the piezometer levels. Piezometer levels along C-C peaked on the same day as maximum pool during the April 1993 event.

The pore water levels shown in Plate 15 and inferred phreatic surfaces show a steep gradient across the impervious fill core of the dam. This drop in pore water levels across the core of the dam indicates that the combination of embankment impervious fill core, foundation grout curtain, and embankment pervious fill drain provide a relatively effective cutoff of upstream seepage pressures and drainage of downstream seepage pressures.

Pore pressure gradients for high pool levels across the two piezometer couplets along Section C-C indicate upward gradients. The upward gradients may indicate an effective impervious core but less effective bedrock grout curtain, or they may indicate a shorter or more transmissive seepage path from the upper piezometers to the pervious fill drain.

#### 4.2.4.4 Section D-D at Station 6+00

Piezometers located along Section D-D include PZ-3, PZ-9, PZ-10, PZ-13, and PZ-14 as shown in Plates 9 and 16. Several preconstruction borings are also included in Plate 9. Plate 16 includes (1) average piezometer pore water levels for normal pool, (2) maximum piezometer porewater levels for the April 1993 high pool (558.9), and (3) projected piezometer pore water levels for a pool level at the spillway crest (E1.572).

The piezometer levels in Section D-D appear to be influenced mainly by the elevation of the pool. The plots of individual piezometer responses versus pool level for four of these five piezometers (Appendix F) show a strong correlation between pool level and the piezometer levels. PZ-13, however, appears to be non-responsive to changes in pool levels, probably due to the effectiveness of the pervious fill drain in which it is set. Except for PZ-13, piezometer levels along D-D peaked on the same day as maximum pool during the April 1993 event.

The pore water levels shown in Plate 15 and inferred phreatic surfaces show a steep gradient across the impervious fill core of the dam. This drop in pore water levels across the core of the dam indicates that the combination of embankment impervious fill core, foundation grout curtain, and embankment pervious fill drain provide a relatively effective cutoff of upstream seepage pressures and drainage of downstream seepage pressures.

Pore pressure gradients for high pool levels across the two piezometer couplets along Section D-D differ from each other. The PZ-13,14 couplet has a downward gradient for high pool levels, while the PZ-9,10 couplet has an upward gradient. The differences reflect the variability of transmissivities across the section.

### 4.2.5 Phreatic Surface Elevation Plan Interpretation and Evaluation

The piezometer pore water elevation contours for the April 1993 high pool event are shown in Plate 12. The pool reached a maximum height of El. 558.9 on April 2, 1993. In general, pore pressure at the piezometers indicate that the steepest downstream pressure gradients (~0.20 feet/feet) occur from the abutment and downstream valley sides of the river channel.

# 5. CONCLUSIONS AND RECOMMENDATIONS

## 5.1 General

Based on past performance of the dam and on the performance of the instrumentation to date, the Westville Dam appears to be suitably instrumented. Existing instrumentation indicates that the dam embankment is functioning suitably relative to seepage and crest movements.

## 5.2 Crest Monuments

The crest monuments provide a suitable index for measurement and evaluation of ongoing creep movements. The measured horizontal and vertical movements to date are small, typically less than 0.02 foot (0.24 inch) and do not appear to indicate problems. Small movements will probably continue, most likely due to weathering, degradation, and consolidation of the downstream rock fill. The crest monuments should be surveyed before each periodic inspection so that the inspection team can be given movement data for evaluation.

## 5.3 Piezometers

The 14 piezometers (6 single and 4 double) provide data to aid in evaluating seepage and pore pressure concerns. The piezometer data indicate that the embankment provides a relatively effective cutoff of upstream seepage pressures and drainage for downstream seepage. Past observations of seepage in 1984 (Refs. 3 and 7) appear to indicate seepage flow down from the abutments and downstream valley sides because of the steep gradients from those areas.

Piezometers and pore pressure data are not available for the upstream part of the embankment and for cross sections other than at Station 5+15 and 6+00. No additional instrumentation is recommended.

Predicted piezometer pore water elevations for maximum pool should be compared with assumed phreatic surfaces used for stability evaluations of the embankment.

## REFERENCES


1. "Periodic Inspection Report No. 1," Westville Lake, Quinebaug River, Massachusetts, April 1976, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

2. "Periodic Inspection Report No. 2," Westville Lake, Quinebaug River, Massachusetts, June 1980, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

3. "Periodic Inspection Report No. 3," Westville Lake, Quinebaug River, Massachusetts, November 1984, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

4. "Periodic Inspection Report No. 4," Westville Lake, Quinebaug River, Massachusetts, November 1989, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

5. "Periodic Inspection Report No. 5," Westville Lake, Quinebaug River, Massachusetts, May 1995, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

6. "Intermediate Inspection Report No. 2-1," Westville Lake, Quinebaug River, Massachusetts, July 1983, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

7. "After Action Report No. 5," Westville Lake, Quinebaug River, Massachusetts, June 1984, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

8. "Supplemental Data For Periodic Dam Inspection Report No. 4," Westville Lake, Quinebaug River, Massachusetts, August 1991, Department of the Army, New England Division, Corps of Engineers, Waltham, Massachusetts.

Table 1 - CREST MONUMENT SURVEY DATA
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| MON. # | September 1988 | | | July 1995 | | | Difference | | Total Horizontal Movement (feet) | | Total Vertical Mvmnt. (feet) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Northing (feet) | Easting (feet) | Elevation (feet, NGVD) | Northing (feet) | Easting (feet) | Elevation (feet, NGVD) | Northing (feet) | Easting (feet) | | | |
| MON 1 | 394528.9240 | 448592.5321 | 586.79 | 394528.9326 | 448592.5267 | 586.78 | 0.0086 | -0.0054 | 0.0102 | NW | -0.01 |
| MON 2 | 394592.6635 | 448521.9411 | 586.98 | 394592.6700 | 448521.9548 | 586.97 | 0.0065 | 0.0137 | 0.0152 | NE | -0.01 |
| MON 3 | 394673.5912 | 448462.5721 | 587.11 | 394673.6029 | 448462.5773 | 587.11 | 0.0117 | 0.0052 | 0.0128 | NE | 0.00 |
| MON 4 | 394754.5577 | 448403.0429 | 586.98 | 394754.5581 | 448403.0539 | 587.00 | - | - | - | - | - |
| MON 5 | 394839.9550 | 448351.5036 | 587.12 | 394839.9745 | 448351.5089 | 587.12 | 0.0195 | 0.0053 | 0.0202 | NE | 0.00 |
| MON 6 | 394933.7631 | 448309.9096 | 586.47 | 394933.7641 | 448309.9080 | 586.47 | 0.0010 | -0.0016 | 0.0019 | NW | 0.00 |
| A | | | | 394588.9178 | 448669.9859 | | | | | | |
| B | | | | 394928.6040 | 448491.4685 | | | | | | |
| BL- 2 | 394925.2000 | 448284.0100 | 586.03 | 394925.2000 | 448284.0100 | 586.02 | 0.0000 | 0.0000 | 0.0000 | NA | -0.01 |
| BL- 3 | 394477.8200 | 448582.3200 | 588.32 | 394477.8200 | 448582.3200 | 588.32 | 0.0000 | 0.0000 | 0.0000 | NA | 0.00 |

Note: Crest Monument 4 was damaged and replaced between the 1988 and 1995 surveys.

Table 2 - PIEZOMETER CONSTRUCTION DATA
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| Zone of Influence for Piezometer Response | Piezometer Number | Approximate Dam Stationing | Approximate Centerline Offset Downstream (feet) | Boring Number | Top of Riser Elevation (feet) NGVD | Ground Elevation (feet) NGVD | Elevations of Piezometer Seals, Upper/Lower (feet) NGVD | | Elevations of Piezometer Tip, (feet) NGVD |
|---|---|---|---|---|---|---|---|---|---|
| Bedrock | PZ-1 | 8+05 | 150 | FD 85-1 | 543.6 | 541.6 | 538.6 | 531.1 | 532.5 |
| Bedrock | PZ-2 | 7+10 | 185 | FD 85-2 | 542.4 | 540.8 | 537.8 | 530.6 | 530.7 |
| Rock Waste & Pervious Fill | PZ-3 | 6+00 | 220 | FD 85-3 | 520.1 | 517.8 | 514.8 | 494.8 | 498.0 |
| Rock Waste & Glacial Till | PZ-4 | 5+00 | 200 | FD 85-4 | 524.9 | 521.9 | 518.9 | 501.1 | 504.4 |
| Abutment Glacial Till | PZ-5 | 4+00 | 160 | FD 86-1 | 545.7 | 542.4 | 538.4 | 517.1 | 521.0 |
| Abutment Glacial Till | PZ-6 | 3+00 | 120 | FD 86-1 | 564.1 | 560.9 | 557.9 | 542.7 | 545.7 |
| Foundation Glacial Till | PZ-7 | 5+15 | 45 | FD 86-9 | 574.3 | 571.0 | 500.7 | 488.6 | 493.8 |
| Bedrock | PZ-8 | 5+15 | 45 | FD 86-9 | 574.1 | 571.0 | 485.6 | 479.0 | 480.3 |
| Pervious Fill & Bedrock | PZ-9 | 6+00 | 45 | FD 86-8 | 577.5 | 574.6 | 517.2 | 494.2 | 511.3 |
| Bedrock | PZ-10 | 6+00 | 45 | FD 86-8 | 577.5 | 574.6 | 491.2 | 484.8 | 485.9 |
| Foundation Glacial Till | PZ-11 | 5+15 | 125 | FD 86-6 | 544.6 | 541.4 | 510.1 | 476.1 | 479.3 |
| Bedrock | PZ-12 | 5+15 | 125 | FD 86-6 | 544.6 | 541.4 | 470.8 | 464.7 | 466.8 |
| Pervious Fill | PZ-13 | 6+00 | 125 | FD 86-7 | 543.8 | 541.1 | 512.7 | 508.9 | 510.2 |
| Bedrock | PZ-14 | 6+00 | 125 | FD 86-7 | 544.1 | 541.1 | 505.5 | 495.6 | 500.2 |

TABLE 3 - PIEZOMETER DATA FROM AUGUST 9, 1990 TO AUGUST 18, 1995
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| | | | POREWATER ELEVATION, FT-NGVD | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | STAGE | POOL EL | PZ-1 | PZ-2 | PZ-3 | PZ-4 | PZ-5 | PZ-6 | PZ-7 | PZ-8 | PZ-9 | PZ-10 | PZ-11 | PZ-12 | PZ-13 | PZ-14 |
| 09-Aug-90 | 10.6 | 525.6 | DRY | DRY | 512.2 | 512.7 | 538.2 | 559.1 | 515.4 | 515.3 | 516.8 | 515.4 | 515.1 | 515.5 | 514.4 | 514.6 |
| 17-Aug-90 | 10.9 | 525.9 | DRY | DRY | 512.5 | 514.1 | 539.0 | 557.2 | 516.0 | 515.8 | 517.6 | 516.0 | 515.4 | 515.9 | 514.6 | 515.1 |
| 18-Sep-90 | 10.2 | 525.2 | DRY | DRY | 512.1 | 513.6 | 537.4 | 555.6 | 515.4 | 515.1 | 516.9 | 515.3 | 514.8 | 515.3 | 514.3 | 514.5 |
| 26-Oct-90 | 16.0 | 531.0 | DRY | DRY | 513.4 | 515.6 | 540.2 | 559.7 | 517.9 | 517.9 | 519.8 | 518.0 | 517.3 | 518.0 | 514.8 | 516.5 |
| 26-Nov-90 | 11.0 | 526.0 | DRY | DRY | 512.4 | 514.3 | 539.2 | 557.5 | 515.9 | 515.7 | 517.7 | 515.9 | 515.4 | 515.9 | 514.5 | 515.0 |
| 26-Dec-90 | 11.6 | 526.6 | DRY | DRY | 512.9 | 515.0 | 540.1 | 559.9 | 516.8 | 516.5 | 518.6 | 516.7 | 516.5 | 516.7 | 514.3 | 515.6 |
| 04-Feb-91 | 11.4 | 526.4 | DRY | DRY | 512.6 | 514.7 | 540.1 | 557.7 | 516.5 | 516.3 | 518.0 | 516.3 | 515.8 | 516.4 | 514.5 | 515.3 |
| 05-Mar-91 | 14.5 | 529.5 | DRY | DRY | 513.9 | 516.1 | 540.9 | 557.0 | 518.0 | 517.9 | 519.8 | 518.0 | 517.5 | 518.0 | 514.9 | 516.7 |
| 18-Apr-91 | 10.8 | 525.8 | DRY | DRY | 510.6 | 514.4 | 539.9 | 555.2 | 516.2 | 515.9 | 517.8 | 516.0 | 516.4 | 516.1 | 514.5 | 515.1 |
| 21-May-91 | 11.2 | 526.2 | DRY | DRY | 512.5 | 514.4 | 539.6 | 557.1 | 516.3 | 516.1 | 518.1 | 516.2 | 515.8 | 516.3 | 514.5 | 515.1 |
| 26-Jun-91 | 10.1 | 525.1 | DRY | DRY | 512.1 | 513.4 | 538.0 | 555.6 | 515.4 | 515.4 | 517.0 | 515.5 | 515.1 | 515.6 | 514.4 | 514.7 |
| 24-Jul-91 | 9.1 | 524.1 | DRY | DRY | 511.9 | 513.3 | 536.3 | 554.7 | 515.0 | 514.9 | 515.9 | 514.9 | 514.5 | 514.9 | 514.3 | 514.2 |
| 20-Aug-91 | 22.6 | 537.6 | 536.8 | 534.9 | 514.8 | 516.6 | 540.4 | 560.0 | 519.0 | 519.1 | 520.6 | 519.2 | 518.5 | 519.2 | 515.5 | 517.7 |
| 21-Aug-91 | 28.5 | 543.5 | 539.1 | 536.7 | 515.0 | 517.3 | 540.8 | 560.4 | 520.3 | 520.6 | 522.0 | 520.6 | 519.9 | 520.8 | 515.3 | 518.6 |
| 22-Aug-91 | 29.1 | 544.1 | 536.7 | DRY | 514.5 | 517.0 | 540.5 | 559.8 | 520.2 | 520.7 | 521.9 | 520.5 | 519.9 | 520.9 | 515.0 | 518.1 |
| 23-Aug-91 | 29.7 | 544.7 | 535.8 | DRY | 514.0 | 516.5 | 540.1 | 559.5 | 519.9 | 520.4 | 521.7 | 520.1 | 519.7 | 520.8 | 514.9 | 517.8 |
| 26-Aug-91 | 11.0 | 526.0 | DRY | DRY | 512.7 | 514.5 | 539.7 | 558.1 | 516.7 | 516.4 | 518.7 | 516.7 | 516.0 | 516.5 | 514.7 | 515.5 |
| 27-Aug-91 | 11.1 | 526.1 | DRY | DRY | 512.6 | 514.4 | 539.5 | 557.9 | 516.5 | 516.2 | 518.5 | 516.5 | 515.8 | 516.4 | 514.7 | 515.4 |
| 28-Aug-91 | 10.9 | 525.9 | DRY | DRY | 512.5 | 514.3 | 539.4 | 557.6 | 516.3 | 516.0 | 518.4 | 516.3 | 515.7 | 516.2 | 514.7 | 515.3 |
| 29-Aug-91 | 10.8 | 525.8 | DRY | DRY | 512.4 | 514.2 | 539.2 | 557.3 | 516.2 | 515.9 | 518.3 | 516.2 | 515.6 | 516.0 | 514.6 | 515.2 |
| 30-Aug-91 | 10.6 | 525.6 | DRY | DRY | 512.4 | 514.1 | 539.2 | 557.3 | 516.0 | 515.8 | 518.1 | 516.1 | 515.4 | 515.9 | 514.5 | 515.1 |
| 01-Oct-91 | 11.5 | 526.5 | DRY | DRY | 512.7 | 514.7 | 539.9 | 559.1 | 516.6 | 516.3 | 518.6 | 516.5 | 515.9 | 516.5 | 514.7 | 515.4 |
| 04-Nov-91 | 11.1 | 526.1 | DRY | DRY | 512.4 | 514.2 | 539.4 | 556.5 | 516.1 | 515.9 | 517.9 | 516.0 | 515.6 | 516.1 | 514.5 | 515.1 |
| 01-Dec-91 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 07-Jan-92 | 11.2 | 526.2 | DRY | DRY | 512.6 | 514.6 | 540.0 | 558.2 | 516.3 | 516.0 | 517.9 | 516.2 | 515.7 | 516.2 | 514.4 | 515.2 |
| 20-Feb-92 | 11.4 | 526.4 | DRY | DRY | 512.6 | 514.5 | 540.1 | 559.7 | 516.2 | 516.1 | 517.9 | 516.1 | 515.7 | 516.3 | 514.4 | 515.2 |
| 12-Mar-92 | 17.0 | 532.0 | DRY | DRY | 513.6 | 515.9 | 540.7 | 560.1 | 517.9 | 517.9 | 519.7 | 517.9 | 517.4 | 518.2 | 514.8 | 516.5 |
| 22-Jun-92 | 10.7 | 525.7 | DRY | DRY | 512.3 | 514.0 | 538.7 | 555.9 | 516.0 | 515.8 | 517.8 | 515.9 | 515.5 | 515.9 | 514.5 | 515.0 |
| 27-Jul-92 | 10.5 | 525.5 | DRY | DRY | 512.4 | 514.1 | 538.5 | 555.8 | 516.0 | 515.8 | 518.0 | 515.9 | 515.4 | 515.9 | 514.5 | 515.0 |
| 03-Sep-92 | 10.4 | 525.4 | DRY | DRY | 512.4 | 514.2 | 538.7 | 556.5 | 516.0 | 515.7 | 518.0 | 515.9 | 515.4 | 515.9 | 514.5 | 515.0 |
| 06-Nov-92 | 7.3 | 522.3 | DRY | DRY | 512.5 | 514.3 | 540.1 | 559.9 | 515.5 | 515.1 | 516.9 | 515.3 | 514.9 | 515.2 | 514.4 | 514.6 |
| 07-Jan-93 | 17.0 | 532.0 | DRY | DRY | 513.8 | 516.2 | 541.0 | 560.5 | DRY | 518.2 | 520.5 | 518.2 | 517.7 | 518.4 | 515.2 | 516.7 |
| 29-Mar-93 | 26.3 | 541.3 | DRY | 537.2 | 515.1 | 517.3 | 541.4 | 560.4 | 520.1 | 520.3 | 521.7 | 520.1 | 520.0 | 519.7 | 515.3 | 518.3 |
| 30-Mar-93 | 37.1 | 552.1 | DRY | 536.3 | 514.9 | 517.7 | 541.2 | 560.4 | 521.7 | 522.2 | 523.2 | 521.8 | 521.4 | 522.8 | 515.0 | 518.8 |
| 31-Mar-93 | 40.6 | 555.6 | DRY | 534.6 | 514.9 | 517.9 | 541.2 | 560.2 | 522.2 | 523.2 | 523.7 | 522.4 | 522.0 | 523.5 | 515.0 | 519.1 |
| 01-Apr-93 | 42.4 | 557.4 | DRY | 536.9 | 515.4 | 518.4 | 541.3 | 560.5 | 522.6 | 523.7 | 524.3 | 522.9 | 522.7 | 524.3 | 515.1 | 519.5 |

TABLE 3 - PIEZOMETER DATA FROM AUGUST 9, 1990 TO AUGUST 18, 1995
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| | | | POREWATER ELEVATION, FT-NGVD | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | STAGE | POOL EL | PZ-1 | PZ-2 | PZ-3 | PZ-4 | PZ-5 | PZ-6 | PZ-7 | PZ-8 | PZ-9 | PZ-10 | PZ-11 | PZ-12 | PZ-13 | PZ-14 |
| 02-Apr-93 | 43.9 | 558.9 | 540.0 | 535.8 | 515.3 | 518.5 | 541.1 | 560.4 | 522.9 | 524.2 | 524.7 | 523.3 | 523.1 | 524.7 | 515.0 | 519.6 |
| 03-Apr-93 | 43.2 | 558.2 | 539.5 | 534.4 | 515.2 | 518.5 | 541.0 | 560.3 | 522.8 | 524.1 | 524.7 | 523.2 | 523.0 | 524.6 | 515.0 | 519.6 |
| 04-Apr-93 | 40.8 | 555.8 | 538.9 | 533.4 | 515.1 | 518.3 | 540.9 | 560.3 | 522.4 | 523.6 | 524.4 | 522.9 | 522.5 | 524.1 | 514.9 | 519.3 |
| 05-Apr-93 | 37.7 | 552.7 | 538.1 | DRY | 515.0 | 518.0 | 540.9 | 560.3 | 521.9 | 522.9 | 524.0 | 522.3 | 521.9 | 523.4 | 515.0 | 519.0 |
| 06-Apr-93 | 38.8 | 553.8 | 537.3 | DRY | 514.8 | 517.7 | 540.9 | 560.3 | 521.4 | 522.2 | 523.5 | 521.7 | 521.2 | 522.6 | 514.9 | 518.6 |
| 07-Apr-93 | 31.3 | 546.3 | 536.5 | DRY | 514.6 | 517.5 | 540.8 | 560.2 | 520.9 | 521.6 | 523.1 | 521.1 | 520.7 | 521.9 | 514.9 | 518.2 |
| 08-Apr-93 | 28.2 | 543.2 | 535.9 | DRY | 514.4 | 517.2 | 540.8 | 560.3 | 520.4 | 520.9 | 522.7 | 520.6 | 520.2 | 521.3 | 514.9 | 518.0 |
| 09-Apr-93 | 24.5 | 539.5 | 535.0 | DRY | 514.2 | 516.9 | 540.8 | 560.4 | 519.8 | 520.1 | 522.0 | 519.8 | 519.3 | 520.4 | 514.9 | 517.5 |
| 10-Apr-93 | 25.4 | 540.4 | 534.2 | DRY | 513.8 | 516.5 | 541.0 | 560.6 | 519.5 | 519.9 | 521.9 | 519.7 | 519.1 | 520.1 | 514.8 | 517.4 |
| 11-Apr-93 | 27.7 | 542.7 | 536.6 | DRY | 514.2 | 513.7 | 541.1 | 560.6 | 520.0 | 520.3 | 522.3 | 520.0 | 519.6 | 520.7 | 515.0 | 517.7 |
| 12-Apr-93 | 28.0 | 543.0 | 535.8 | DRY | 514.3 | 517.0 | 541.0 | 560.5 | 520.1 | 520.5 | 522.4 | 520.2 | 519.7 | 520.8 | 515.0 | 517.7 |
| 13-Apr-93 | 25.5 | 540.5 | 536.8 | DRY | 514.4 | 517.0 | 541.0 | 560.5 | 519.9 | 520.2 | 522.2 | 520.0 | 519.5 | 520.5 | 515.0 | 517.7 |
| 14-Apr-93 | 19.4 | 534.4 | 535.0 | DRY | 514.0 | 516.5 | 540.8 | 560.3 | 518.9 | 519.0 | 521.4 | 518.9 | 518.4 | 519.2 | 514.9 | 517.1 |
| 15-Apr-93 | 18.4 | 533.4 | 533.5 | DRY | 513.7 | 516.1 | 540.7 | 560.2 | 518.5 | 518.4 | 520.9 | 518.4 | 517.9 | 518.6 | 514.9 | 516.7 |
| 16-Apr-93 | 15.0 | 530.0 | DRY | DRY | 513.5 | 515.7 | 540.7 | 560.2 | 517.9 | 517.8 | 520.4 | 517.9 | 517.3 | 517.9 | 514.8 | 516.3 |
| 17-Apr-93 | 15.0 | 530.0 | 537.2 | 536.8 | 513.7 | 516.0 | 541.3 | 560.6 | 517.9 | 517.7 | 520.3 | 518.0 | 517.3 | 517.9 | 514.8 | 516.3 |
| 18-Apr-93 | 15.9 | 530.9 | 534.1 | DRY | 513.6 | 516.0 | 540.9 | 560.3 | 517.9 | 517.8 | 520.5 | 518.0 | 518.3 | 517.9 | 514.9 | 516.5 |
| 19-Apr-93 | 15.0 | 530.0 | DRY | DRY | 513.4 | 515.7 | 540.6 | 560.1 | 517.8 | 517.6 | 520.3 | 517.8 | 517.1 | 517.7 | 514.9 | 516.3 |
| 20-Apr-93 | 14.3 | 529.3 | DRY | DRY | 513.3 | 515.5 | 540.6 | 560.0 | 517.6 | 517.4 | 520.0 | 517.5 | 516.9 | 517.5 | 514.8 | 516.1 |
| 21-Apr-93 | 13.6 | 528.6 | DRY | DRY | 513.2 | 515.4 | 540.6 | 560.0 | 517.4 | 517.1 | 519.9 | 517.3 | 516.7 | 517.2 | 514.8 | 516.0 |
| 22-Apr-93 | 12.8 | 527.8 | DRY | DRY | 513.2 | 515.3 | 540.8 | 560.3 | 517.3 | 517.0 | 519.7 | 517.1 | 516.5 | 517.0 | 514.8 | 515.8 |
| 23-Apr-93 | 12.8 | 527.8 | DRY | DRY | 513.2 | 515.4 | 540.8 | 560.3 | 517.2 | 516.9 | 519.6 | 517.1 | 516.5 | 517.0 | 514.8 | 515.8 |
| 24-Apr-93 | 12.4 | 527.4 | DRY | DRY | 513.1 | 515.2 | 540.6 | 560.0 | 516.9 | 516.7 | 519.3 | 516.8 | 516.2 | 516.7 | 514.7 | 515.7 |
| 25-Apr-93 | 12.2 | 527.2 | DRY | DRY | 513.1 | 515.2 | 540.6 | 559.9 | 517.0 | 516.6 | 519.4 | 516.9 | 516.2 | 516.7 | 514.7 | 515.7 |
| 26-Apr-93 | 11.9 | 526.9 | DRY | DRY | 513.0 | 515.0 | 540.5 | 559.8 | 516.8 | 516.5 | 519.3 | 516.8 | 516.1 | 516.6 | 514.7 | 515.6 |
| 27-Apr-93 | 12.3 | 527.3 | 535.9 | 533.8 | 513.5 | 515.7 | 541.2 | 560.5 | 517.2 | 516.9 | 519.6 | 517.1 | 516.5 | 516.9 | 514.8 | 515.9 |
| 28-Apr-93 | 12.2 | 527.2 | 532.8 | DRY | 513.3 | 515.5 | 540.8 | 560.2 | 517.2 | 516.9 | 519.7 | 517.1 | 516.4 | 516.9 | 514.9 | 515.9 |
| 14-Jun-93 | 10.8 | 525.8 | DRY | DRY | 512.2 | 514.9 | 538.8 | 556.5 | 515.7 | 515.3 | 517.5 | 515.7 | 515.1 | 515.1 | 514.4 | 514.7 |
| 16-Jul-93 | 10.3 | 525.3 | DRY | DRY | 511.9 | 513.5 | 536.8 | 555.0 | 515.2 | 515.1 | 516.3 | 515.2 | 514.7 | 515.1 | 514.3 | 514.1 |
| 22-Sep-93 | 10.6 | 525.6 | DRY | DRY | 512.3 | 513.8 | 538.1 | 557.8 | 515.6 | 515.3 | 516.6 | 515.6 | 515.0 | 515.4 | 514.5 | 514.7 |
| 18-Oct-93 | 11.2 | 526.2 | DRY | DRY | 512.7 | 514.5 | 539.5 | 557.9 | 516.3 | 516.0 | 517.8 | 516.2 | 515.7 | 516.1 | 514.6 | 515.2 |
| 16-Nov-93 | 11.2 | 526.2 | DRY | DRY | 512.7 | 514.0 | 539.3 | 556.7 | 516.2 | 515.9 | 518.1 | 516.1 | 515.6 | 516.0 | 514.6 | 515.1 |
| 14-Dec-93 | 13.8 | 528.8 | DRY | DRY | 513.1 | 515.4 | 540.2 | 560.0 | 517.4 | 517.3 | 519.4 | 520.6 | 516.8 | 517.4 | 514.7 | 516.0 |
| 12-Mar-94 | 19.7 | 534.7 | 536.7 | DRY | 513.5 | 516.0 | 540.8 | 559.9 | 518.4 | 518.4 | 520.0 | 518.3 | 517.9 | 518.7 | 514.7 | 516.6 |
| 13-Mar-94 | 18.2 | 533.2 | 535.0 | DRY | 513.4 | 516.0 | 540.9 | 559.9 | 518.3 | 518.3 | 521.6 | 518.2 | 517.8 | 518.6 | 514.7 | 516.6 |
| 14-Mar-94 | 17.3 | 532.3 | 536.3 | DRY | 513.6 | 516.0 | 541.0 | 560.1 | 518.3 | 518.3 | 519.9 | 518.0 | 517.8 | 518.5 | 514.7 | 516.5 |

TABLE 3 - PIEZOMETER DATA FROM AUGUST 9, 1990 TO AUGUST 18, 1995
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| | | | POREWATER ELEVATION, FT-NGVD | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | STAGE | POOL EL | PZ-1 | PZ-2 | PZ-3 | PZ-4 | PZ-5 | PZ-6 | PZ-7 | PZ-8 | PZ-9 | PZ-10 | PZ-11 | PZ-12 | PZ-13 | PZ-14 |
| 15-Mar-94 | 14.4 | 529.4 | 537.0 | DRY | 513.4 | 515.9 | 541.0 | 560.1 | 517.9 | 517.8 | 519.6 | 517.9 | 517.4 | 518.1 | 514.7 | 516.4 |
| 16-Mar-94 | 16.0 | 531.0 | 538.4 | DRY | 513.7 | 516.2 | 541.1 | 560.2 | 518.3 | 518.2 | 520.1 | 518.3 | 517.8 | 518.4 | 514.8 | 516.8 |
| 17-Mar-94 | 13.9 | 528.9 | 537.3 | DRY | 513.5 | 515.9 | 541.0 | 560.1 | 517.9 | 517.7 | 519.7 | 517.8 | 517.2 | 517.9 | 514.8 | 516.4 |
| 18-Mar-94 | 12.4 | 527.4 | 535.1 | DRY | 513.3 | 515.6 | 540.9 | 560.0 | 517.5 | 517.3 | 519.3 | 517.4 | 516.8 | 517.4 | 514.7 | 516.1 |
| 19-Mar-94 | 12.3 | 527.3 | 532.8 | DRY | 513.1 | 515.5 | 540.8 | 560.0 | 517.3 | 517.1 | 519.1 | 517.2 | 516.6 | 517.2 | 514.7 | 515.9 |
| 20-Mar-94 | 12.0 | 527.0 | DRY | DRY | 513.1 | 515.3 | 540.8 | 559.9 | 517.1 | 516.9 | 518.8 | 517.0 | 516.4 | 517.0 | 514.6 | 515.8 |
| 21-Mar-94 | 12.0 | 527.0 | DRY | DRY | 513.1 | 515.3 | 540.7 | 559.9 | 517.0 | 516.8 | 518.8 | 516.9 | 516.4 | 516.9 | 514.6 | 515.7 |
| 22-Mar-94 | 12.0 | 527.0 | DRY | DRY | 513.8 | 516.0 | 541.2 | 560.5 | 517.8 | 517.4 | 519.5 | 517.7 | 517.1 | 517.6 | 514.8 | 516.6 |
| 23-Mar-94 | 13.0 | 528.0 | DRY | DRY | 513.6 | 515.9 | 541.1 | 560.2 | 517.9 | 517.6 | 519.7 | 517.9 | 517.2 | 517.7 | 514.9 | 516.5 |
| 24-Mar-94 | 13.8 | 528.8 | DRY | DRY | 513.9 | 516.2 | 541.1 | 560.3 | 518.1 | 517.8 | 520.0 | 518.0 | 517.4 | 518.0 | 514.9 | 516.7 |
| 03-May-94 | 11.8 | 526.8 | DRY | DRY | 512.9 | 515.0 | 540.3 | 558.9 | 516.8 | 516.4 | 518.3 | 516.5 | 516.0 | 516.6 | 514.5 | 515.4 |
| 24-May-94 | 11.7 | 526.7 | DRY | DRY | 513.0 | 514.8 | 540.1 | 557.2 | 516.7 | 516.4 | 518.3 | 516.6 | 516.0 | 516.6 | 514.6 | 515.4 |
| 01-Jul-94 | 10.7 | 525.7 | DRY | DRY | 512.7 | 514.2 | 538.0 | 555.3 | 515.9 | 515.9 | 517.4 | 515.9 | 515.5 | 515.9 | 514.4 | 514.9 |
| 05-Aug-94 | 10.5 | 525.5 | DRY | DRY | 512.8 | 514.3 | 538.3 | 556.5 | 516.0 | 515.8 | 517.5 | 515.9 | 515.5 | 515.9 | 514.6 | 515.0 |
| 01-Sep-94 | 10.6 | 525.6 | DRY | DRY | 512.9 | 514.4 | 538.7 | 556.0 | 516.2 | 515.9 | 518.3 | 516.0 | 515.6 | 516.0 | 514.6 | 515.1 |
| 05-Oct-94 | 10.1 | 525.1 | DRY | DRY | 513.1 | 514.7 | 539.3 | 557.0 | 516.5 | 516.3 | 518.5 | 516.4 | 515.9 | 516.4 | 514.6 | 515.4 |
| 07-Nov-94 | 10.7 | 525.7 | DRY | DRY | 512.8 | 514.4 | 538.1 | 556.2 | 515.9 | 515.7 | 517.4 | 515.8 | 515.5 | 515.9 | 514.4 | 514.9 |
| 30-Nov-94 | 11.7 | 526.7 | 533.9 | DRY | 513.7 | 515.6 | 540.2 | 560.0 | 517.2 | 517.0 | 518.9 | 517.1 | 516.6 | 517.1 | 514.8 | 516.0 |
| 22-Dec-94 | 11.4 | 526.4 | DRY | DRY | 511.9 | 515.2 | 539.7 | 559.2 | 516.8 | 516.6 | 519.1 | 516.7 | 516.3 | 516.8 | 514.6 | 515.6 |
| 01-Feb-95 | 11.6 | 526.6 | DRY | DRY | 513.2 | 515.0 | 540.2 | 559.6 | 516.9 | 516.7 | 519.0 | 516.8 | 516.3 | 516.8 | 514.6 | 515.6 |
| 08-Mar-95 | 11.8 | 526.8 | DRY | DRY | 513.4 | 515.4 | 540.7 | 560.0 | 516.9 | 516.7 | 518.7 | 516.8 | 516.4 | 516.9 | 514.6 | 515.6 |
| 07-Apr-95 | 11.3 | 526.3 | DRY | DRY | 513.2 | 515.0 | 540.4 | 558.0 | 516.7 | 516.4 | 518.6 | 516.6 | 516.1 | 516.6 | 514.5 | 515.4 |
| 04-May-95 | 11.2 | 526.2 | DRY | DRY | 513.1 | 513.4 | 539.6 | 556.7 | 516.5 | 516.3 | 518.4 | 516.4 | 516.0 | 516.5 | 514.5 | 515.4 |
| 08-Jun-95 | 10.8 | 525.8 | DRY | DRY | 512.9 | 514.4 | 538.2 | 555.5 | 518.1 | 515.9 | 517.4 | 516.0 | 515.6 | 516.1 | 514.4 | 515.1 |
| 20-Jul-95 | 10.4 | 525.4 | DRY | DRY | 512.6 | 514.0 | 536.1 | 554.3 | 515.6 | 515.4 | 516.7 | 515.6 | 515.1 | 515.6 | 514.3 | 514.7 |
| 18-Aug-95 | 10.4 | 525.4 | DRY | DRY | 512.8 | 514.3 | 538.0 | 555.9 | 515.9 | 515.7 | 517.6 | 515.9 | 515.4 | 515.8 | 514.5 | 514.9 |

TABLE 4 - PIEZOMETER DATA USED TO CALCULATE AVERAGE WATER LEVELS FOR EACH PIEZOMETER
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

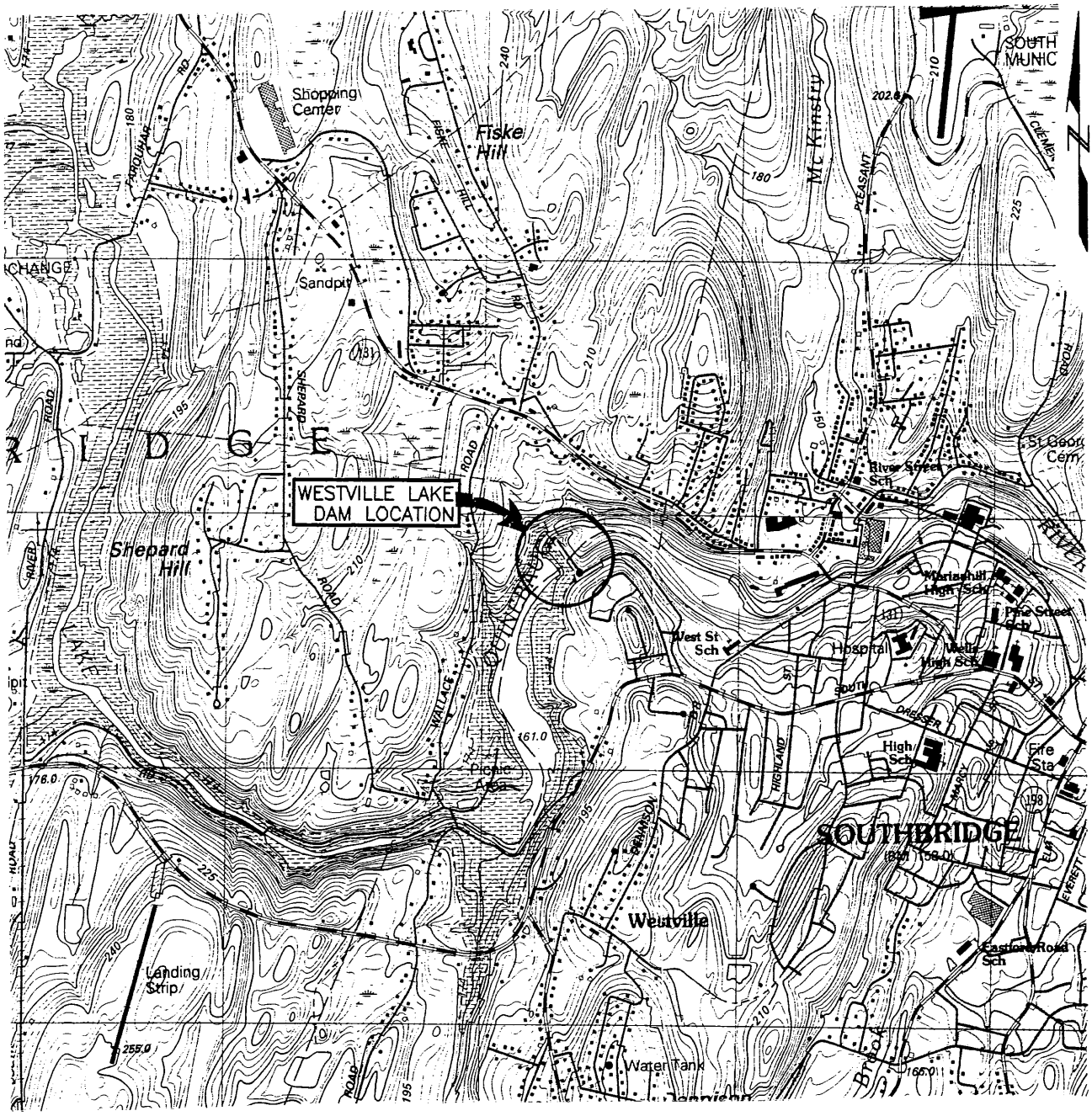
| | | | POREWATER ELEVATION FOR NORMAL POOL, FT-NGVD | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | STAGE | POOL EL | PZ-1 | PZ-2 | PZ-3 | PZ-4 | PZ-5 | PZ-6 | PZ-7 | PZ-8 | PZ-9 | PZ-10 | PZ-11 | PZ-12 | PZ-13 | PZ-14 |
| 17-Aug-90 | 10.9 | 525.9 | DRY | DRY | 512.5 | 514.1 | 539.0 | 557.2 | 516.0 | 515.8 | 517.6 | 516.0 | 515.4 | 515.9 | 514.6 | 515.1 |
| 18-Sep-90 | 10.2 | 525.2 | DRY | DRY | 512.1 | 513.6 | 537.4 | 555.6 | 515.4 | 515.1 | 516.9 | 515.3 | 514.8 | 515.3 | 514.3 | 514.5 |
| 26-Oct-90 | 16.0 | 531.0 | DRY | DRY | 513.4 | 515.6 | 540.2 | 559.7 | 517.9 | 517.9 | 519.8 | 518.0 | 517.3 | 518.0 | 514.8 | 516.5 |
| 26-Nov-90 | 11.0 | 526.0 | DRY | DRY | 512.4 | 514.3 | 539.2 | 557.5 | 515.9 | 515.7 | 517.7 | 515.9 | 515.4 | 515.9 | 514.5 | 515.0 |
| 26-Dec-90 | 11.6 | 526.6 | DRY | DRY | 512.9 | 515.0 | 540.1 | 559.9 | 516.8 | 516.5 | 518.6 | 516.7 | 516.5 | 516.7 | 514.3 | 515.6 |
| 04-Feb-91 | 11.4 | 526.4 | DRY | DRY | 512.6 | 514.7 | 540.1 | 557.7 | 516.5 | 516.3 | 518.0 | 516.3 | 515.8 | 516.4 | 514.5 | 515.3 |
| 05-Mar-91 | 14.5 | 529.5 | DRY | DRY | 513.9 | 516.1 | 540.9 | 557.0 | 518.0 | 517.9 | 519.8 | 518.0 | 517.5 | 518.0 | 514.9 | 516.7 |
| 18-Apr-91 | 10.8 | 525.8 | DRY | DRY | 510.6 | 514.4 | 539.9 | 555.2 | 516.2 | 515.9 | 517.8 | 516.0 | 516.4 | 516.1 | 514.5 | 515.1 |
| 21-May-91 | 11.2 | 526.2 | DRY | DRY | 512.5 | 514.4 | 539.6 | 557.1 | 516.3 | 516.1 | 518.1 | 516.2 | 515.8 | 516.3 | 514.5 | 515.1 |
| 26-Jun-91 | 10.1 | 525.1 | DRY | DRY | 512.1 | 513.4 | 538.0 | 555.6 | 515.4 | 515.4 | 517.0 | 515.5 | 515.1 | 515.6 | 514.4 | 514.7 |
| 24-Jul-91 | 9.1 | 524.1 | DRY | DRY | 511.9 | 513.3 | 536.3 | 554.7 | 515.0 | 514.9 | 515.9 | 514.9 | 514.5 | 514.9 | 514.3 | 514.2 |
| 30-Aug-91 | 10.6 | 525.6 | DRY | DRY | 512.4 | 514.1 | 539.2 | 557.3 | 516.0 | 515.8 | 518.1 | 516.1 | 515.4 | 515.9 | 514.5 | 515.1 |
| 01-Oct-91 | 11.5 | 526.5 | DRY | DRY | 512.7 | 514.7 | 539.9 | 559.1 | 516.6 | 516.3 | 518.6 | 516.5 | 515.9 | 516.5 | 514.7 | 515.4 |
| 04-Nov-91 | 11.1 | 526.1 | DRY | DRY | 512.4 | 514.2 | 539.4 | 556.5 | 516.1 | 515.9 | 517.9 | 516.0 | 515.6 | 516.1 | 514.5 | 515.1 |
| 07-Jan-92 | 11.2 | 526.2 | DRY | DRY | 512.6 | 514.6 | 540.0 | 558.2 | 516.3 | 516.0 | 517.9 | 516.2 | 515.7 | 516.2 | 514.4 | 515.2 |
| 20-Feb-92 | 11.4 | 526.4 | DRY | DRY | 512.6 | 514.5 | 540.1 | 559.7 | 516.2 | 516.1 | 517.9 | 516.1 | 515.7 | 516.3 | 514.4 | 515.2 |
| 12-Mar-92 | 17.0 | 532.0 | DRY | DRY | 513.6 | 515.9 | 540.7 | 560.1 | 517.9 | 517.9 | 519.7 | 517.9 | 517.4 | 518.2 | 514.8 | 516.5 |
| 22-Jun-92 | 10.7 | 525.7 | DRY | DRY | 512.3 | 514.0 | 538.7 | 555.9 | 516.0 | 515.8 | 517.8 | 515.9 | 515.5 | 515.9 | 514.5 | 515.0 |
| 27-Jul-92 | 10.5 | 525.5 | DRY | DRY | 512.4 | 514.1 | 538.5 | 555.8 | 516.0 | 515.8 | 518.0 | 515.9 | 515.4 | 515.9 | 514.5 | 515.0 |
| 03-Sep-92 | 10.4 | 525.4 | DRY | DRY | 512.4 | 514.2 | 538.7 | 556.5 | 516.0 | 515.7 | 518.0 | 515.9 | 515.4 | 515.9 | 514.5 | 515.0 |
| 06-Nov-92 | 7.3 | 522.3 | DRY | DRY | 512.5 | 514.3 | 540.1 | 559.9 | 515.5 | 515.1 | 516.9 | 515.3 | 514.9 | 515.2 | 514.4 | 514.6 |
| 07-Jan-93 | 17.0 | 532.0 | DRY | DRY | 513.8 | 516.2 | 541.0 | 560.5 | DRY | 518.2 | 520.5 | 518.2 | 517.7 | 518.4 | 515.2 | 516.7 |
| 28-Apr-93 | 12.2 | 527.2 | 532.8 | DRY | 513.3 | 515.5 | 540.8 | 560.2 | 517.2 | 516.9 | 519.7 | 517.1 | 516.4 | 516.9 | 514.9 | 515.9 |
| 14-Jun-93 | 10.8 | 525.8 | DRY | DRY | 512.2 | 514.9 | 538.8 | 556.5 | 515.7 | 515.3 | 517.5 | 515.7 | 515.1 | 515.1 | 514.4 | 514.7 |
| 16-Jul-93 | 10.3 | 525.3 | DRY | DRY | 511.9 | 513.5 | 536.8 | 555.0 | 515.2 | 515.1 | 516.3 | 515.2 | 514.7 | 515.1 | 514.3 | 514.1 |
| 22-Sep-93 | 10.6 | 525.6 | DRY | DRY | 512.3 | 513.8 | 538.1 | 557.8 | 515.6 | 515.3 | 516.6 | 515.6 | 515.0 | 515.4 | 514.5 | 514.7 |
| 18-Oct-93 | 11.2 | 526.2 | DRY | DRY | 512.7 | 514.5 | 539.5 | 557.9 | 516.3 | 516.0 | 517.8 | 516.2 | 515.7 | 516.1 | 514.6 | 515.2 |
| 16-Nov-93 | 11.2 | 526.2 | DRY | DRY | 512.7 | 514.0 | 539.3 | 556.7 | 516.2 | 515.9 | 518.1 | 516.1 | 515.6 | 516.0 | 514.6 | 515.1 |
| 14-Dec-93 | 13.8 | 528.8 | DRY | DRY | 513.1 | 515.4 | 540.2 | 560.0 | 517.4 | 517.3 | 519.4 | 520.6 | 516.8 | 517.4 | 514.7 | 516.0 |
| 12-Mar-94 | 19.7 | 534.7 | 536.7 | DRY | 513.5 | 516.0 | 540.8 | 559.9 | 518.4 | 518.4 | 520.0 | 518.3 | 517.9 | 518.7 | 514.7 | 516.6 |
| 24-Mar-94 | 13.8 | 528.8 | DRY | DRY | 513.9 | 516.2 | 541.1 | 560.3 | 518.1 | 517.8 | 520.0 | 518.0 | 517.4 | 518.0 | 514.9 | 516.7 |
| 03-May-94 | 11.8 | 526.8 | DRY | DRY | 512.9 | 515.0 | 540.3 | 558.9 | 516.8 | 516.4 | 518.3 | 516.5 | 516.0 | 516.6 | 514.5 | 515.4 |
| 24-May-94 | 11.7 | 526.7 | DRY | DRY | 513.0 | 514.8 | 540.1 | 557.2 | 516.7 | 516.4 | 518.3 | 516.6 | 516.0 | 516.6 | 514.6 | 515.4 |
| 01-Jul-94 | 10.7 | 525.7 | DRY | DRY | 512.7 | 514.2 | 538.0 | 555.3 | 515.9 | 515.9 | 517.4 | 515.9 | 515.5 | 515.9 | 514.4 | 514.9 |
| 05-Aug-94 | 10.5 | 525.5 | DRY | DRY | 512.8 | 514.3 | 538.3 | 556.5 | 516.0 | 515.8 | 517.5 | 515.9 | 515.5 | 515.9 | 514.6 | 515.0 |
| 01-Sep-94 | 10.6 | 525.6 | DRY | DRY | 512.9 | 514.4 | 538.7 | 556.0 | 516.2 | 515.9 | 518.3 | 516.0 | 515.6 | 516.0 | 514.6 | 515.1 |
| 05-Oct-94 | 10.1 | 525.1 | DRY | DRY | 513.1 | 514.7 | 539.3 | 557.0 | 516.5 | 516.3 | 518.5 | 516.4 | 515.9 | 516.4 | 514.6 | 515.4 |
| 07-Nov-94 | 10.7 | 525.7 | DRY | DRY | 512.8 | 514.4 | 538.1 | 556.2 | 515.9 | 515.7 | 517.4 | 515.8 | 515.5 | 515.9 | 514.4 | 514.9 |
| 30-Nov-94 | 11.7 | 526.7 | 533.9 | DRY | 513.7 | 515.6 | 540.2 | 560.0 | 517.2 | 517.0 | 518.9 | 517.1 | 516.6 | 517.1 | 514.8 | 516.0 |
| 22-Dec-94 | 11.4 | 526.4 | DRY | DRY | 511.9 | 515.2 | 539.7 | 559.2 | 516.8 | 516.6 | 519.1 | 516.7 | 516.3 | 516.8 | 514.6 | 515.6 |
| 01-Feb-95 | 11.6 | 526.6 | DRY | DRY | 513.2 | 515.0 | 540.2 | 559.6 | 516.9 | 516.7 | 519.0 | 516.8 | 516.3 | 516.8 | 514.6 | 515.6 |

TABLE 4 - PIEZOMETER DATA USED TO CALCULATE AVERAGE WATER LEVELS FOR EACH PIEZOMETER
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| | | | POREWATER ELEVATION FOR NORMAL POOL, FT-NGVD | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DATE | STAGE | POOL EL | PZ-1 | PZ-2 | PZ-3 | PZ-4 | PZ-5 | PZ-6 | PZ-7 | PZ-8 | PZ-9 | PZ-10 | PZ-11 | PZ-12 | PZ-13 | PZ-14 |
| 08-Mar-95 | 11.8 | 526.8 | DRY | DRY | 513.4 | 515.4 | 540.7 | 560.0 | 516.9 | 516.7 | 518.7 | 516.8 | 516.4 | 516.9 | 514.6 | 515.6 |
| 07-Apr-95 | 11.3 | 526.3 | DRY | DRY | 513.2 | 515.0 | 540.4 | 558.0 | 516.7 | 516.4 | 518.6 | 516.6 | 516.1 | 516.6 | 514.5 | 515.4 |
| 04-May-95 | 11.2 | 526.2 | DRY | DRY | 513.1 | 513.4 | 539.6 | 556.7 | 516.5 | 516.3 | 518.4 | 516.4 | 516.0 | 516.5 | 514.5 | 515.4 |
| 08-Jun-95 | 10.8 | 525.8 | DRY | DRY | 512.9 | 514.4 | 538.2 | 555.5 | 518.1 | 515.9 | 517.4 | 516.0 | 515.6 | 516.1 | 514.4 | 515.1 |
| 20-Jul-95 | 10.4 | 525.4 | DRY | DRY | 512.6 | 514.0 | 536.1 | 554.3 | 515.6 | 515.4 | 516.7 | 515.6 | 515.1 | 515.6 | 514.3 | 514.7 |
| 18-Aug-95 | 10.4 | 525.4 | DRY | DRY | 512.8 | 514.3 | 538.0 | 555.9 | 515.9 | 515.7 | 517.6 | 515.9 | 515.4 | 515.8 | 514.5 | 514.9 |
| AVE. WATER LEVEL: | | 526.6 | DRY | DRY | 512.7 | 514.6 | 539.3 | 557.6 | 516.5 | 516.2 | 518.2 | 516.4 | 515.9 | 516.4 | 514.5 | 515.3 |

Table 5 - PREDICTED PIEZOMETER PORE WATER ELEVATIONS FOR POOL LEVEL AT SPILLWAY CREST (EL. 572)
Instrumentation Appendix to Periodic Inspection Report No. 5
Westville Lake Dam
Southbridge/Sturbridge, Massachusetts

| Piezometer | Projected Piezometer Elevation for Reservoir at El.572 |
|---|---|
| PZ-1 | 541.6 |
| PZ-2 | 535.8 |
| PZ-3 | 516.1 |
| PZ-4 | 519.7 |
| PZ-5 | 541.3 |
| PZ-6 | 560.4 |
| PZ-7 | 525.1 |
| PZ-8 | 527.0 |
| PZ-9 | 526.8 |
| PZ-10 | 525.8 |
| PZ-11 | 525.7 |
| PZ-12 | 527.7 |
| PZ-13 | 515.1 |
| PZ-14 | 520.8 |




0 1000 2000 4000 6000

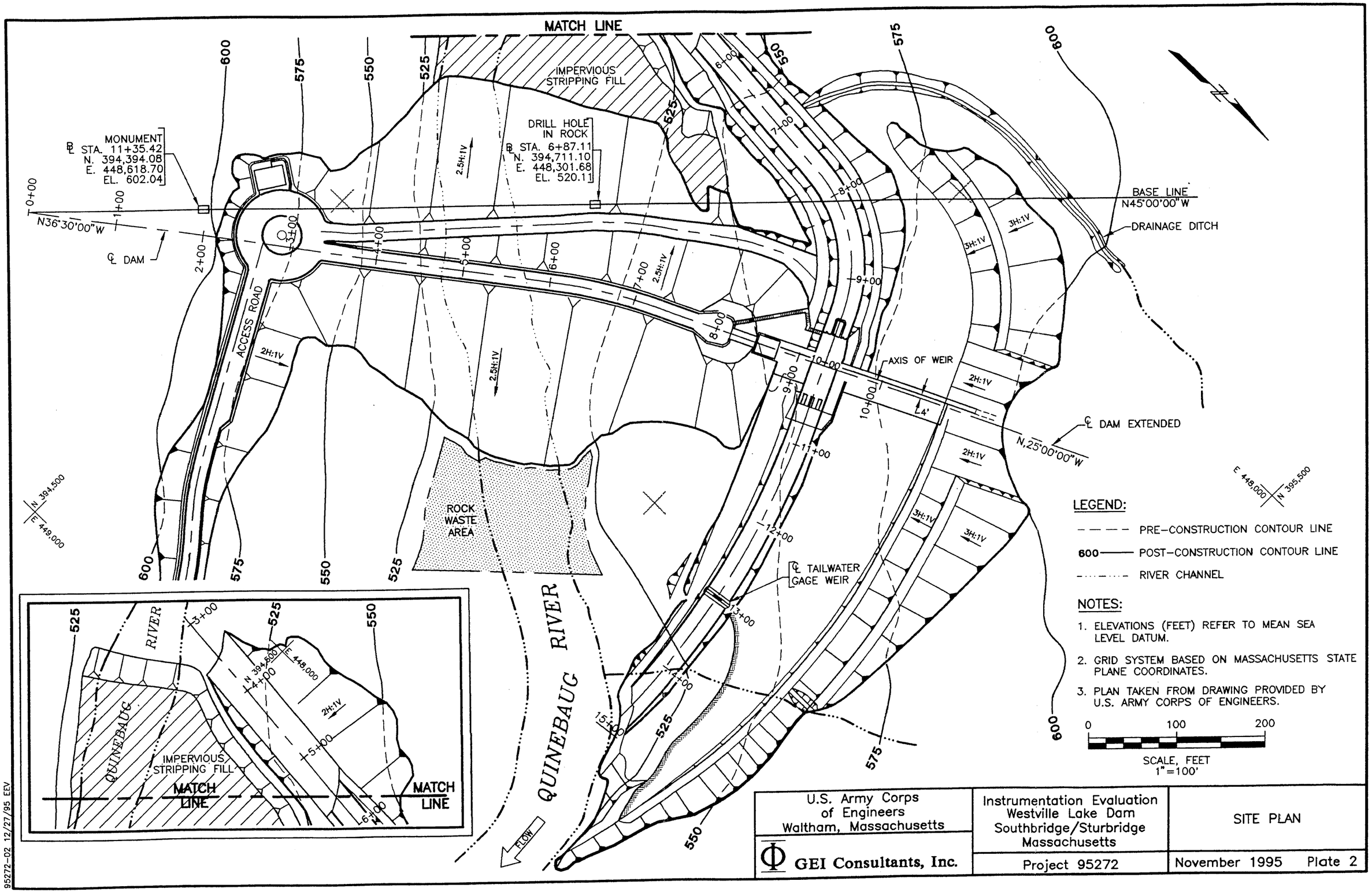
SCALE, FEET 1:25,000

Map is taken from U.S.G.S. Topographic 7.5 Minute Series
Southbridge, MA Quadrangle, 1982.
Datum is National Geodetic Vertical Datum (NGVD).
Contour Interval is 3 Meters.

MASSACHUSETTS
QUADRANGLE LOCATION

| | | |
|---|---|---|
| U.S. Army Corps of Engineers Waltham, Massachusetts | Instrumentation Evaluation Westville Lake Dam Southbridge/Sturbridge Massachusetts | SITE LOCATION PLAN |
| GEI Consultants, Inc. | Project 95272 | September 1995 Plate 1 |

95272-01 9/28/95 EEV




| | | |
|---|---|---|
| U.S. Army Corps of Engineers Waltham, Massachusetts | Instrumentation Evaluation Westville Lake Dam Southbridge/Sturbridge Massachusetts | SITE PLAN |
| GEI Consultants, Inc. | Project 95272 | November 1995 Plate 2 |

95272-02 12/27/95 EEV

MATCH LINE

IMPERVIOUS STRIPPING FILL

DRILL HOLE IN ROCK
℄ STA. 6+87.11
N. 394,711.10
E. 448,301.68
EL. 520.11

MONUMENT
℄ STA. 11+35.42
N. 394,394.08
E. 448,618.70
EL. 602.04

N36°30'00"W

℄ DAM

BASE LINE
N45°00'00"W

DRAINAGE DITCH

ACCESS ROAD

BL-3

BL-2

MON.1 MON.2 MON.3 MON.4 MON.5 MON.6

PZ-1 PZ-2 PZ-3 PZ-4 PZ-5 PZ-6 PZ-7 PZ-8 PZ-9 PZ-10 PZ-11 PZ-12 PZ-13 PZ-14

(SEE FIGS 6&13)

(SEE FIGS 7&14)

(SEE FIGS 8&15)

(SEE FIGS 9&16)

AXIS OF WEIR

℄ DAM EXTENDED
N25°00'00"W

℄ TAILWATER GAGE WEIR

ROCK WASTE AREA

QUINEBAUG RIVER

FLOW

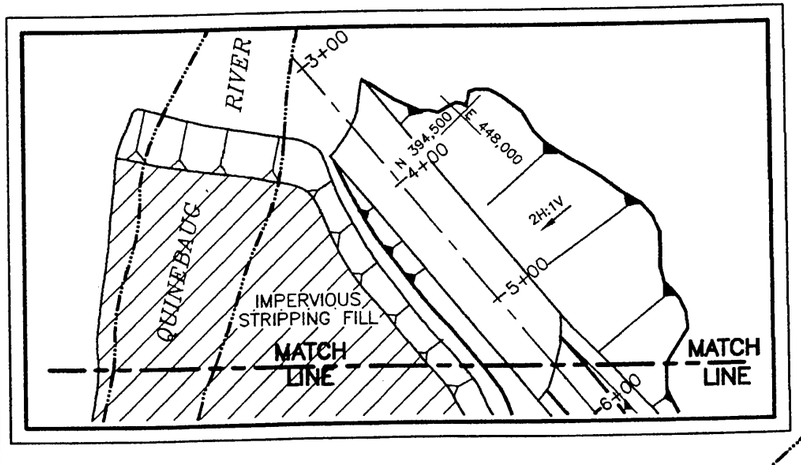
N 394,500
E 449,000

E 448,000
N 395,500

LEGEND:

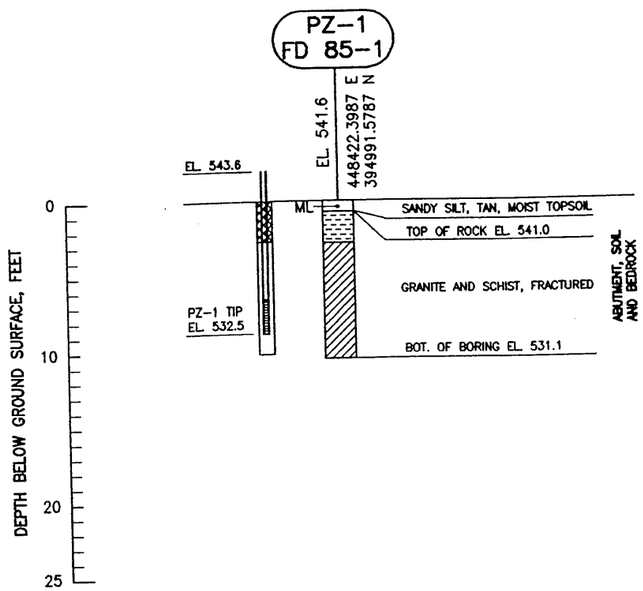
- MON.6 — CREST SURVEY MONUMENT
- A — CONTROL POINT FOR VERTICAL AND\OR HORIZONTAL CONTROL
- PZ-2 — PIEZOMETER LOCATION
- A A — LOCATION OF SUBSURFACE PROFILES

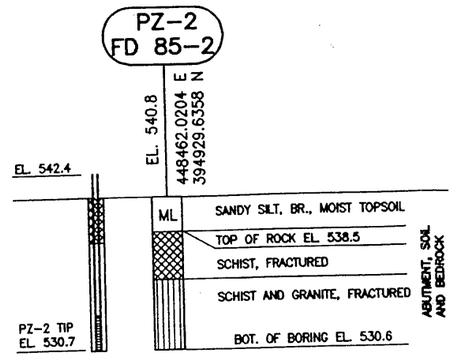
0 100 200
SCALE, FEET
1"=100'

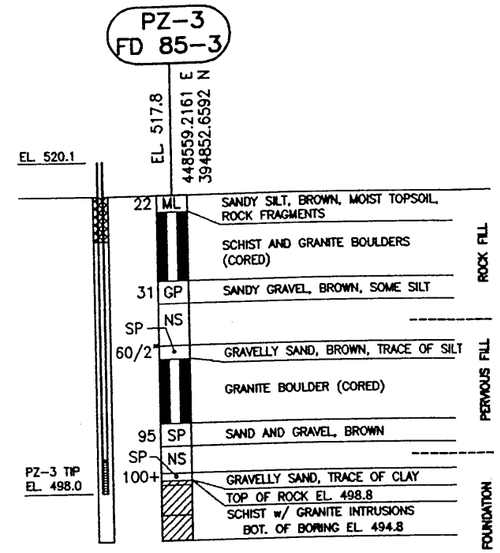


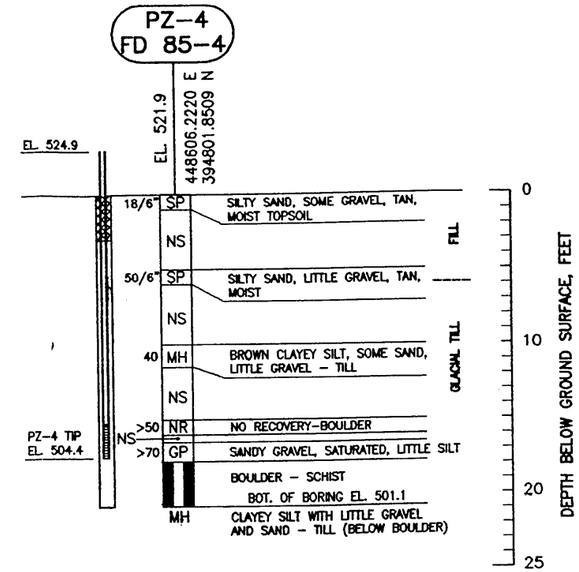

| U.S. Army Corps of Engineers Waltham, Massachusetts | Instrumentation Evaluation Westville Lake Dam Southbridge/Sturbridge Massachusetts | INSTRUMENTATION GENERAL PLAN |
|---|---|---|
| GEI Consultants, Inc. | Project 95272 | November 1995 Plate 3 |

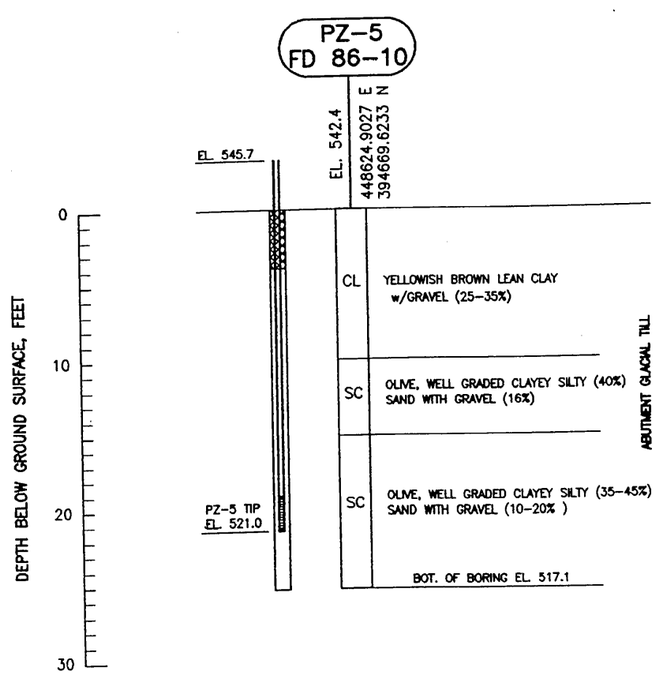
95272-03 12/27/95 EEV

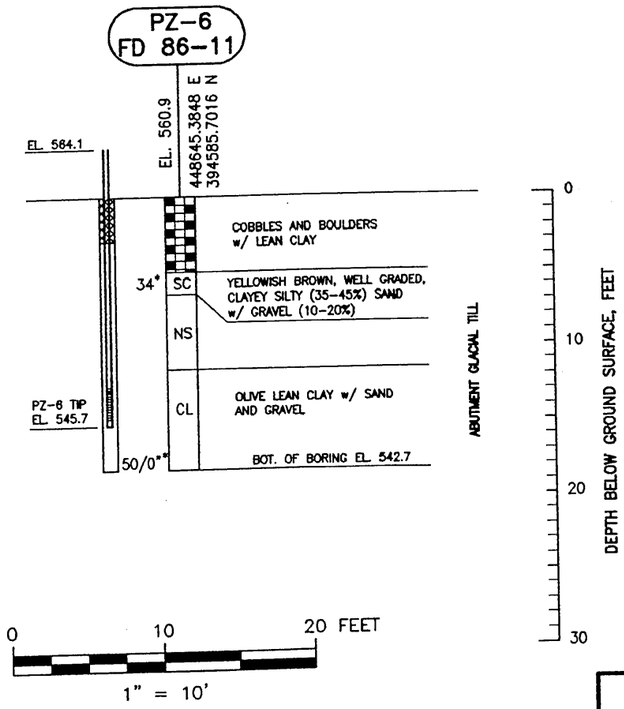


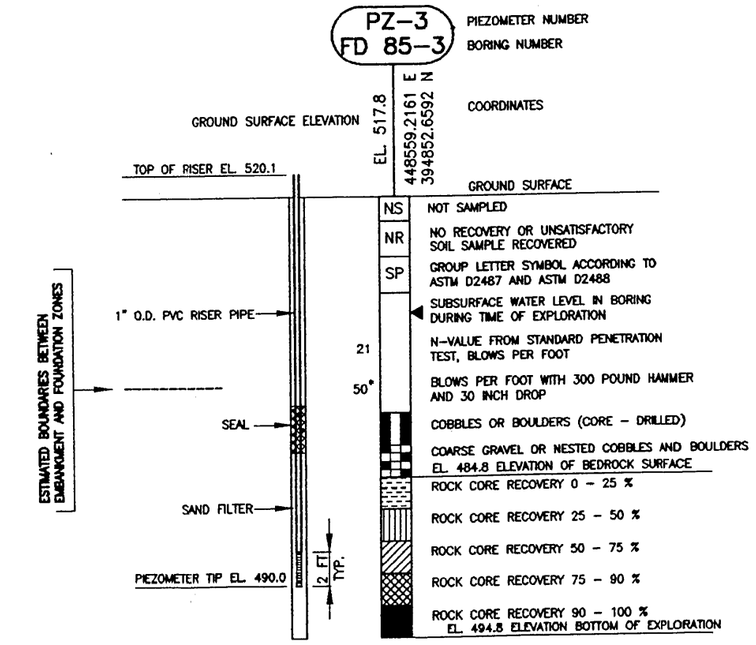




## LEGEND FOR GRAPHIC LOG

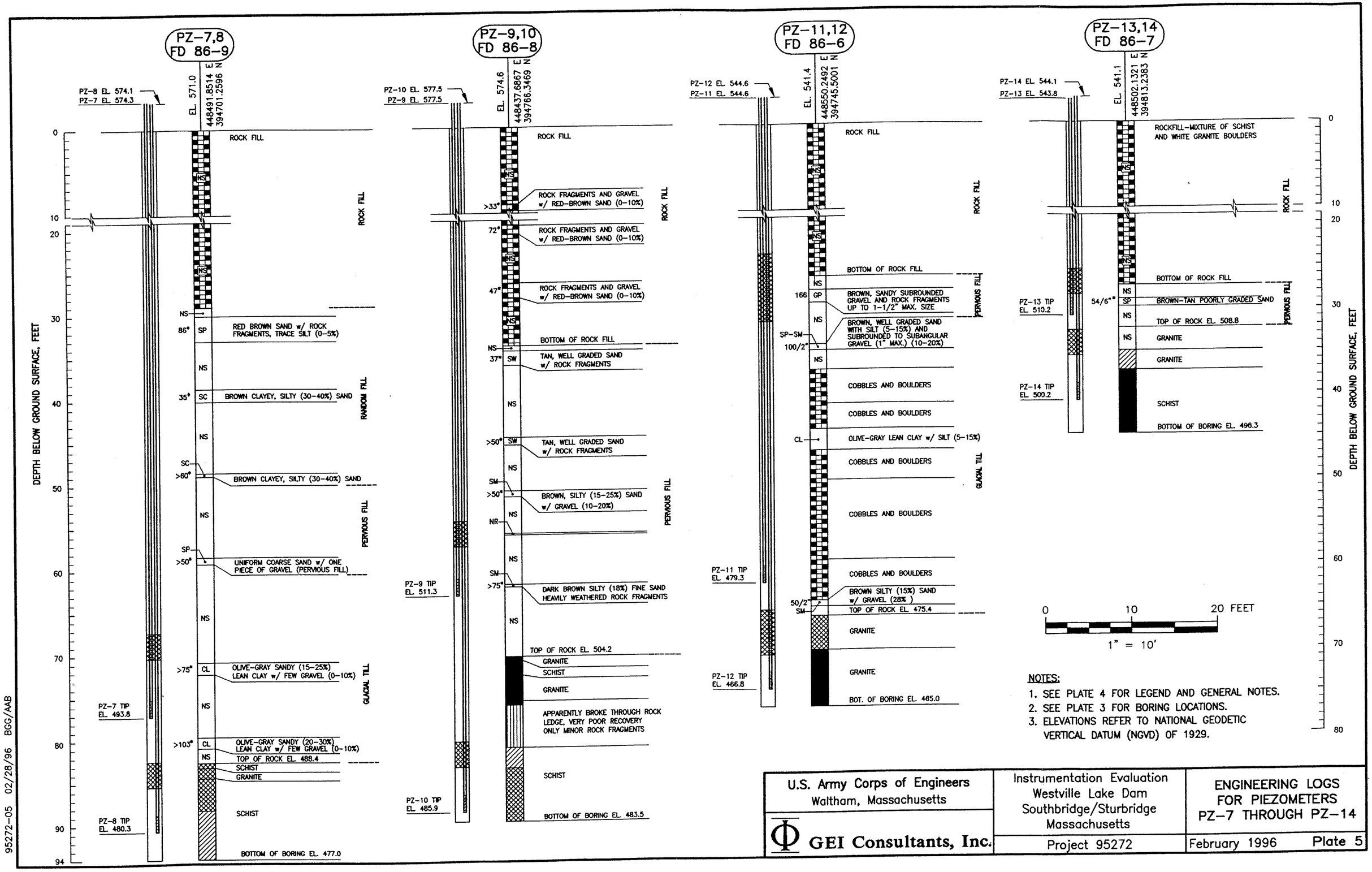



NOTES:

1. SEE PLATE 3 FOR BORING LOCATIONS.
2. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | ENGINEERING LOGS<br>FOR PIEZOMETERS<br>PZ-1 THROUGH PZ-6 |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 4 |

95272-04 02/28/96 BGG/AAB

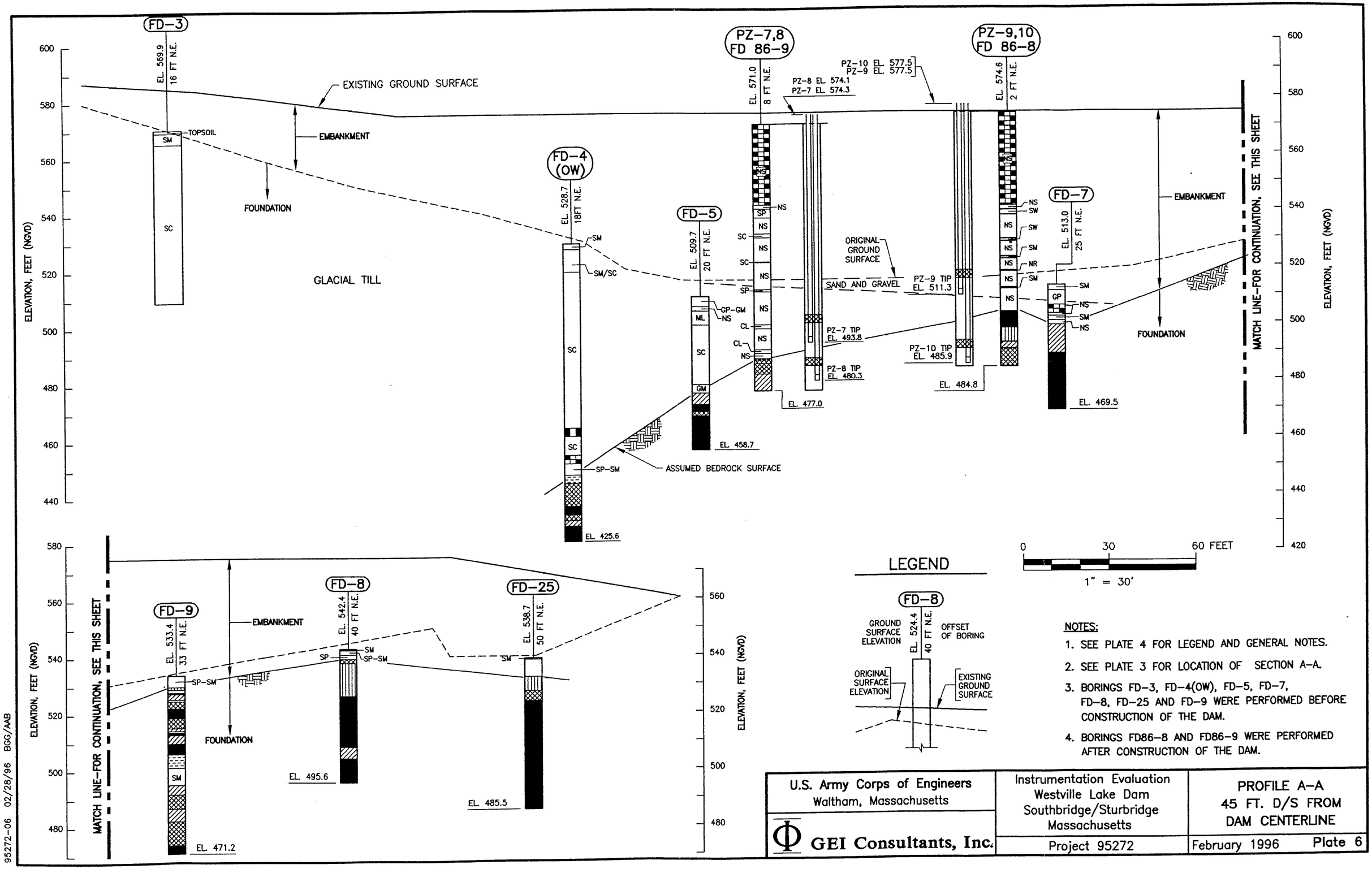



NOTES:

1. SEE PLATE 4 FOR LEGEND AND GENERAL NOTES.
2. SEE PLATE 3 FOR BORING LOCATIONS.
3. ELEVATIONS REFER TO NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1929.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | ENGINEERING LOGS<br>FOR PIEZOMETERS<br>PZ-7 THROUGH PZ-14 |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 5 |

95272-05 02/28/96 BGG/AAB

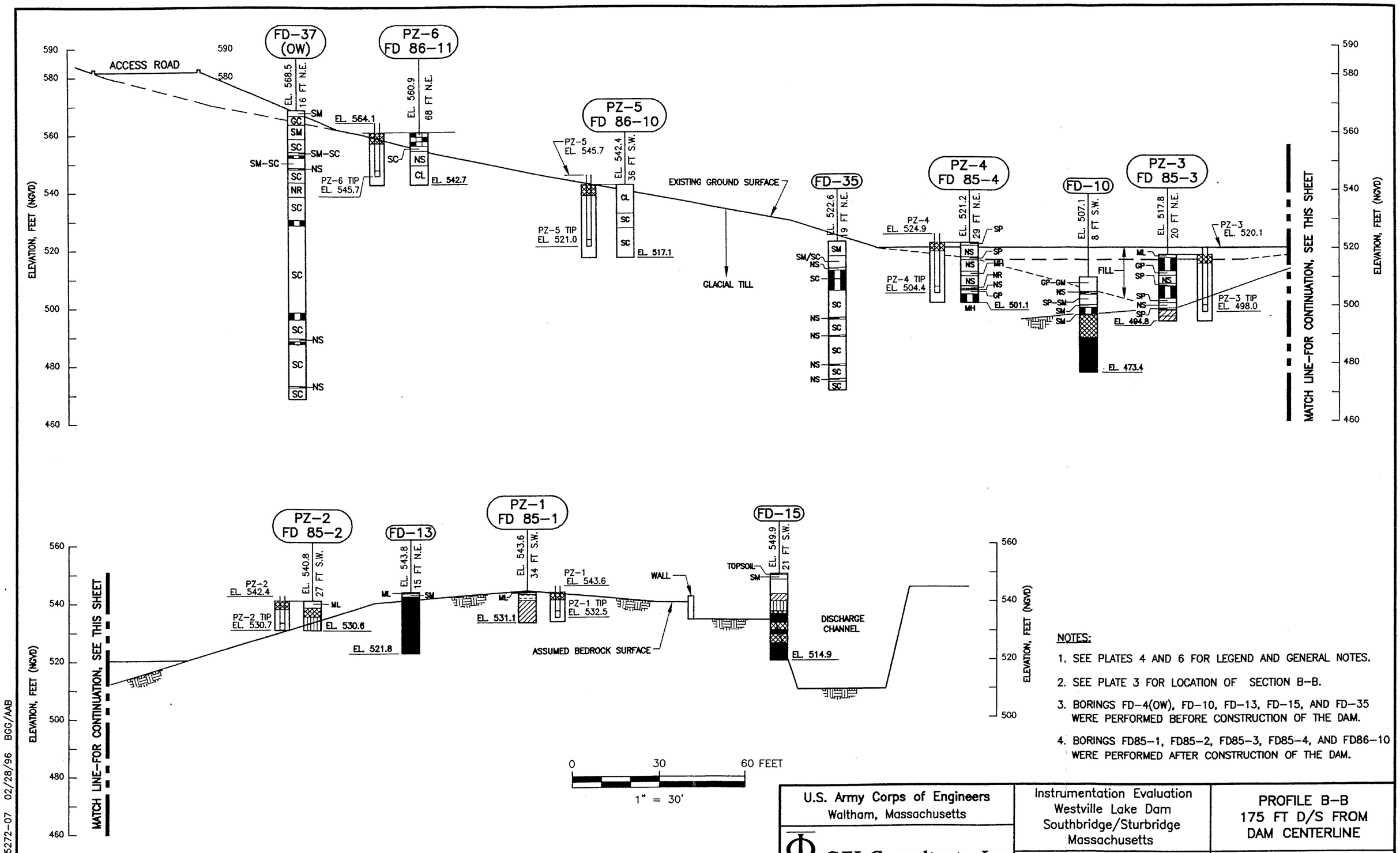



NOTES:

1. SEE PLATE 4 FOR LEGEND AND GENERAL NOTES.
2. SEE PLATE 3 FOR LOCATION OF SECTION A-A.
3. BORINGS FD-3, FD-4(OW), FD-5, FD-7, FD-8, FD-25 AND FD-9 WERE PERFORMED BEFORE CONSTRUCTION OF THE DAM.
4. BORINGS FD86-8 AND FD86-9 WERE PERFORMED AFTER CONSTRUCTION OF THE DAM.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | PROFILE A-A<br>45 FT. D/S FROM<br>DAM CENTERLINE |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 6 |

95272-06 02/28/96 BGG/AAB

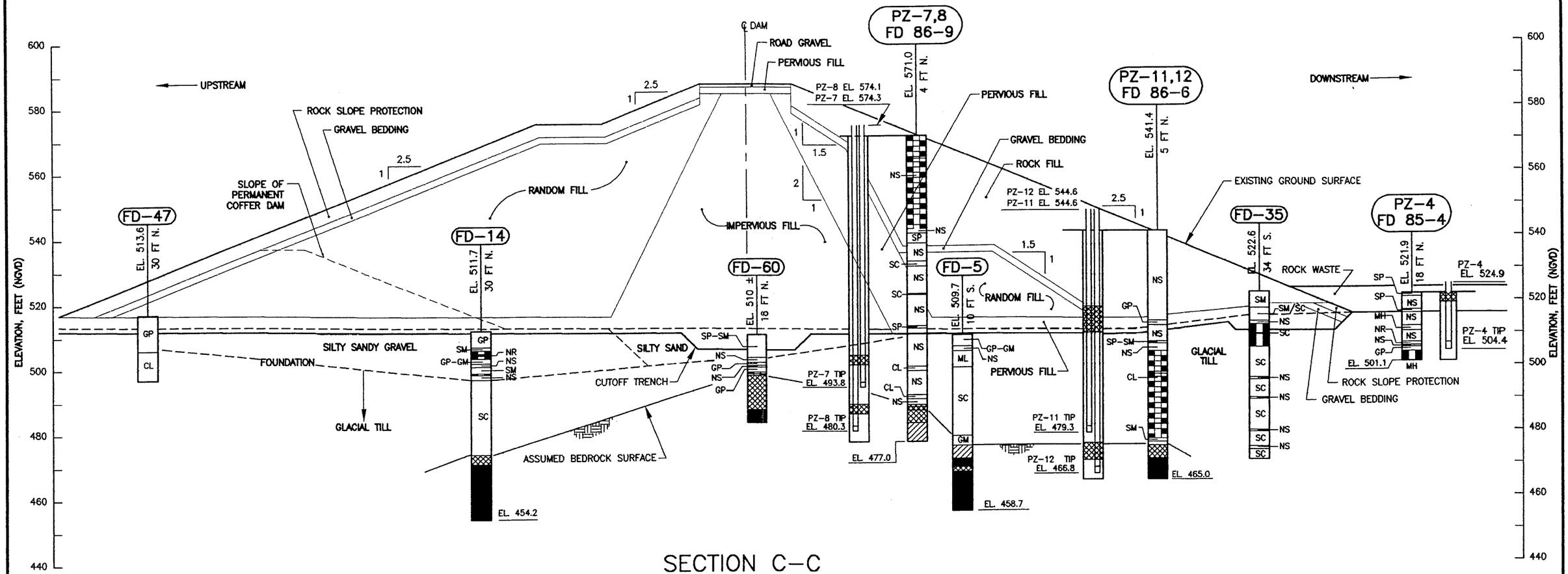



NOTES:

1. SEE PLATES 4 AND 6 FOR LEGEND AND GENERAL NOTES.
2. SEE PLATE 3 FOR LOCATION OF SECTION B–B.
3. BORINGS FD–4(OW), FD–10, FD–13, FD–15, AND FD–35 WERE PERFORMED BEFORE CONSTRUCTION OF THE DAM.
4. BORINGS FD85–1, FD85–2, FD85–3, FD85–4, AND FD86–10 WERE PERFORMED AFTER CONSTRUCTION OF THE DAM.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | PROFILE B–B<br>175 FT D/S FROM<br>DAM CENTERLINE |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 7 |

95272–07 02/28/96 BGG/AAB




## SECTION C–C

0 30 60 FEET

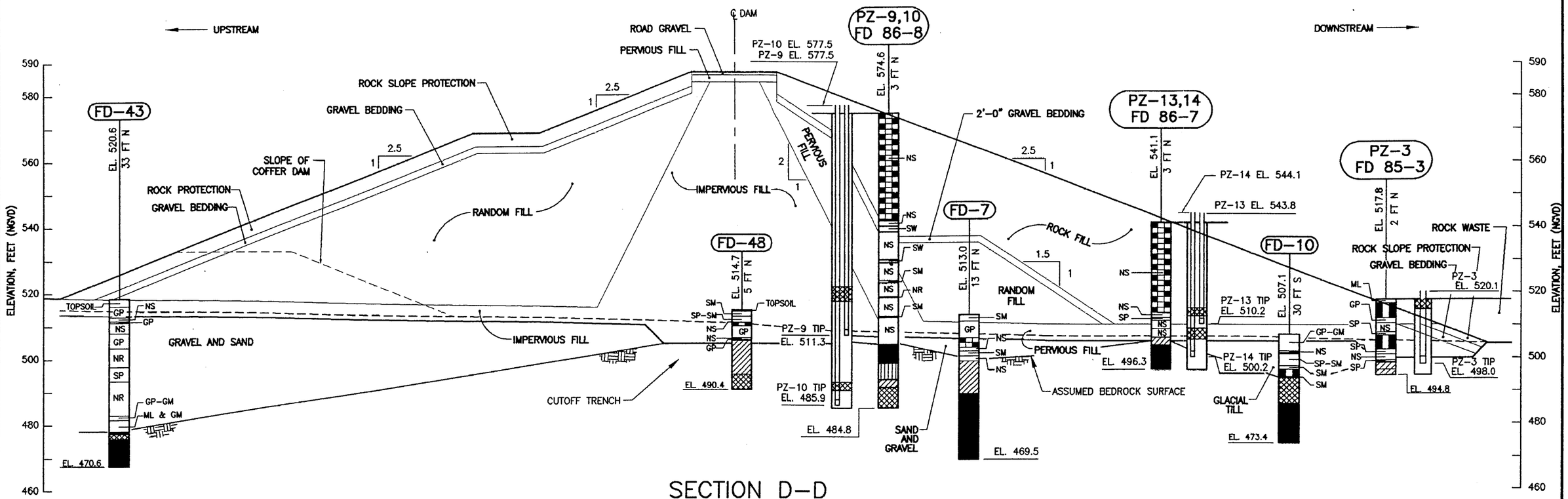
1" = 30'

NOTES:

1. SEE PLATE 4 AND 6 FOR LEGEND AND GENERAL NOTES.
2. SEE PLATE 3 FOR LOCATION OF SECTION C–C.
3. BORINGS FD–5, FD–14, FD–35, FD–47 AND FD–60 WERE PERFORMED PRIOR TO BUILDING THE DAM.
4. BORINGS FD 85–4, FD 86–6 AND FD 86–9 WERE PERFORMED AFTER THE DAM WAS BUILT.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | SECTION C–C<br>AT STATION 5+15 |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 8 |

95272–08 02/28/96 BGG/AAB




## SECTION D–D

0 30 60 FEET

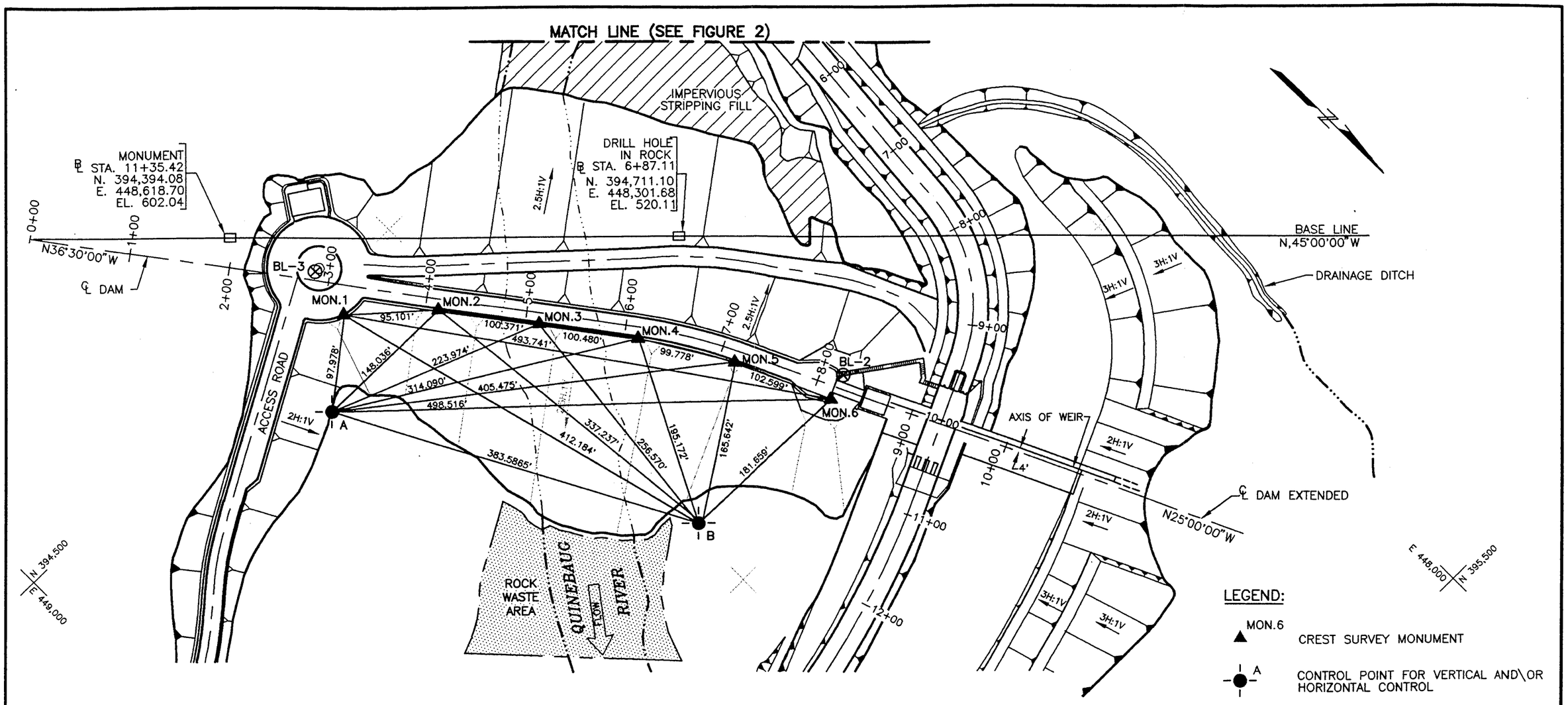
1" = 30'

NOTES:

1. SEE PLATES 4 AND 6 FOR LEGEND AND GENERAL NOTES.
2. SEE PLATE 3 FOR LOCATION OF SECTION D–D.
3. BORINGS FD–7, FD–10, FD–43, AND FD–48 WERE PERFORMED PRIOR TO BUILDING THE DAM.
4. BORINGS FD 85–3, FD 86–7 AND FD 86–8 WERE PERFORMED AFTER THE DAM WAS BUILT.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | SECTION D–D<br>AT STATION 6+00 |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 9 |

95272-09 02/28/96 BGG/AAB




LEGEND:

MON.6 ▲ CREST SURVEY MONUMENT

A CONTROL POINT FOR VERTICAL AND\OR HORIZONTAL CONTROL

NOTE:

DISTANCES SHOWN BETWEEN MONUMENTS ARE FOR THE JULY 1995 SURVEY.

0 100 200

SCALE, FEET
1" = 100'

## CREST MONUMENT COORDINATE DATA

| | SEPTEMBER 1988 | | | JULY 1995 | | |
|---|---|---|---|---|---|---|
| MON.# | NORTHING | EASTING | ELEV. | NORTHING | EASTING | ELEV. |
| MON.1 | 394528.9240 | 448592.5321 | 586.79 | 394528.9326 | 448592.5267 | 586.78 |
| MON.2 | 394592.6635 | 448521.9411 | 586.98 | 394592.6700 | 448521.9548 | 586.97 |
| MON.3 | 394673.5912 | 448462.5721 | 587.11 | 394673.6029 | 448462.5773 | 587.11 |
| MON.4 | 394754.5577 | 448403.0429 | 586.98 | 394754.5581 | 448403.0539 | 587.00 |
| MON.5 | 394839.9550 | 448351.5036 | 587.12 | 394839.9745 | 448351.5089 | 587.12 |
| MON.6 | 394933.7631 | 448309.9096 | 586.47 | 394933.7641 | 448309.9080 | 586.47 |
| BL-2 | 394925.2000 | 448284.0100 | 586.03 | 394925.2000 | 448284.0100 | 586.02 |
| BL-3 | 394477.8200 | 448582.3200 | 588.32 | 394477.8200 | 448582.3200 | 588.32 |

## CONTROL POINTS COORDINATE DATA

| CONTROL POINT | NORTHING | EASTING |
|---|---|---|
| A | 394588.9178 | 448669.9859 |
| B | 394928.6040 | 448491.4685 |

U.S. Army Corps of Engineers
Waltham, Massachusetts

GEI Consultants, Inc.

Instrumentation Evaluation
Westville Lake Dam
Southbridge/Sturbridge
Massachusetts

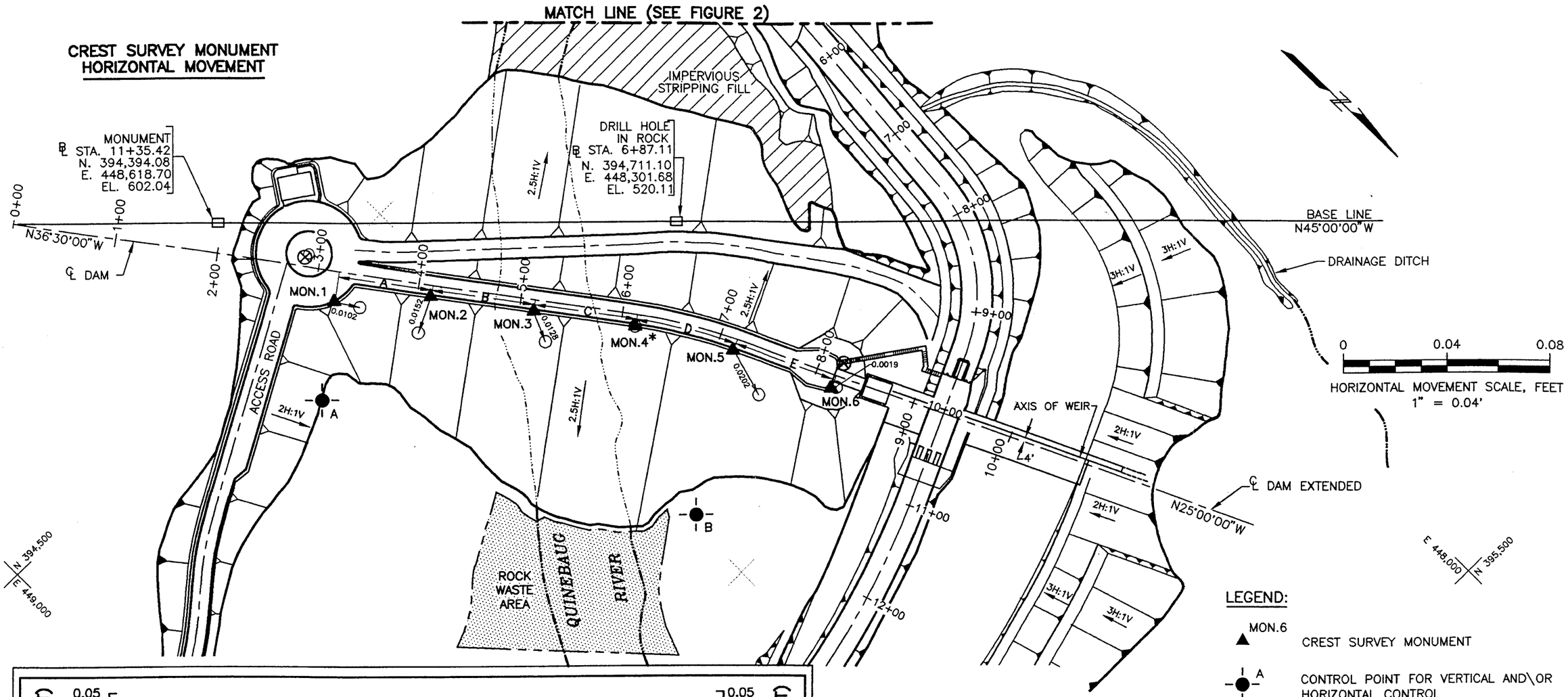
Project 95272

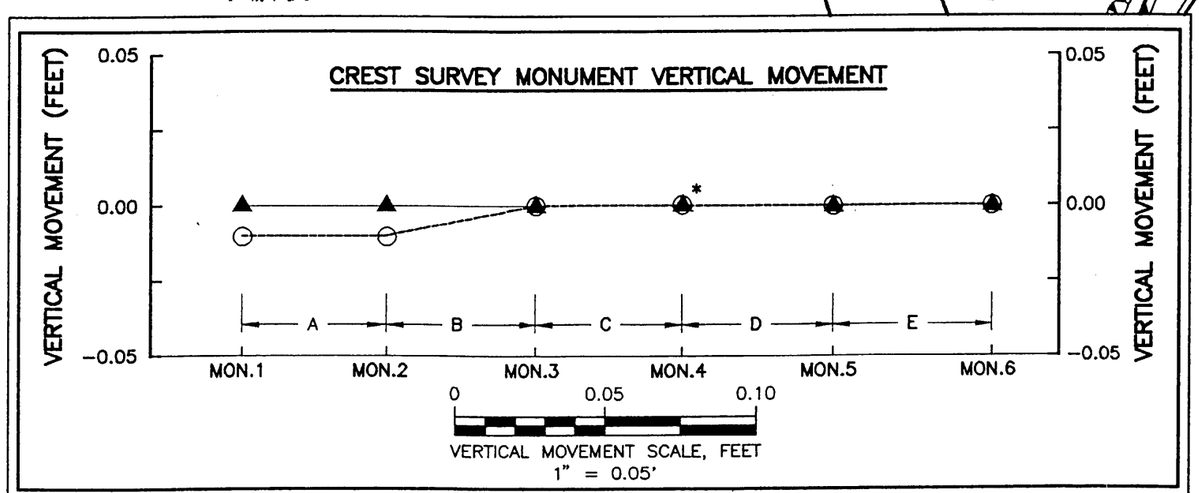
CREST MONUMENT SURVEY DATA

February 1996 Plate 10

95272-10 2/19/96 EEV/PTC

## CREST SURVEY MONUMENT HORIZONTAL MOVEMENT




**LEGEND:**

- MON.6 ▲ CREST SURVEY MONUMENT
- A CONTROL POINT FOR VERTICAL AND\OR HORIZONTAL CONTROL
- 0.0110 DIRECTION OF HORIZONTAL MOVEMENT SCALE: 1 INCH = 0.04 FEET
- * MON. 4 DAMAGED AND REPLACED BETWEEN 1988 AND 1995 SURVEYS

0 100 200
PLAN SCALE, FEET
1" = 100'

| LEGEND FOR ELEVATION | |
|---|---|
| SYMBOL | DESCRIPTION |
| ▲ | CREST SURVEY MONUMENT SEPTEMBER 1988 |
| ○ | CREST SURVEY MONUMENT JULY 1995 |

| | | |
|---|---|---|
| U.S. Army Corps of Engineers Waltham, Massachusetts | Instrumentation Evaluation Westville Lake Dam Southbridge/Sturbridge Massachusetts | HORIZONTAL AND VERTICAL MOVEMENT OF CREST MONUMENTS |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 11 |

95272-11 2/19/96 EEV/PTC

MATCH LINE

MAXIMUM POOL LEVEL = EL. 558.9

IMPERVIOUS STRIPPING FILL

MONUMENT
℄ STA. 11+35.42
N. 394,394.08
E. 448,618.70
EL. 602.04

DRILL HOLE IN ROCK
℄ STA. 6+87.11
N. 394,711.10
E. 448,301.68
EL. 520.11

BASE LINE
N45°00'00"W

N36°30'00"W

℄ DAM

DRAINAGE DITCH

ACCESS ROAD

BL-3

BL-2

PZ-6 (560.5)

PZ-5 (541.4)

PZ-7 (522.9)

PZ-11 (523.1)

PZ-9 (524.7)

PZ-13 (515.3)

PZ-3 (515.4)

PZ-4 (518.5)

PZ-2 (536.9)

PZ-1 (540.0)

ROCK WASTE AREA

AXIS OF WEIR

℄ DAM EXTENDED

N25°00'00"W

℄ TAILWATER GAGE WEIR

QUINEBAUG RIVER

FLOW

N 394,500
E 449,000

E 448,000
N 395,500

QUINEBAUG RIVER

IMPERVIOUS STRIPPING FILL

MATCH LINE

MATCH LINE

N 394,500
E 448,000

LEGEND:

PZ-2 PIEZOMETER LOCATION

(536.9) (MAXIMUM POREWATER ELEVATION)

550 GROUNDWATER ELEVATION CONTOUR

NOTE:

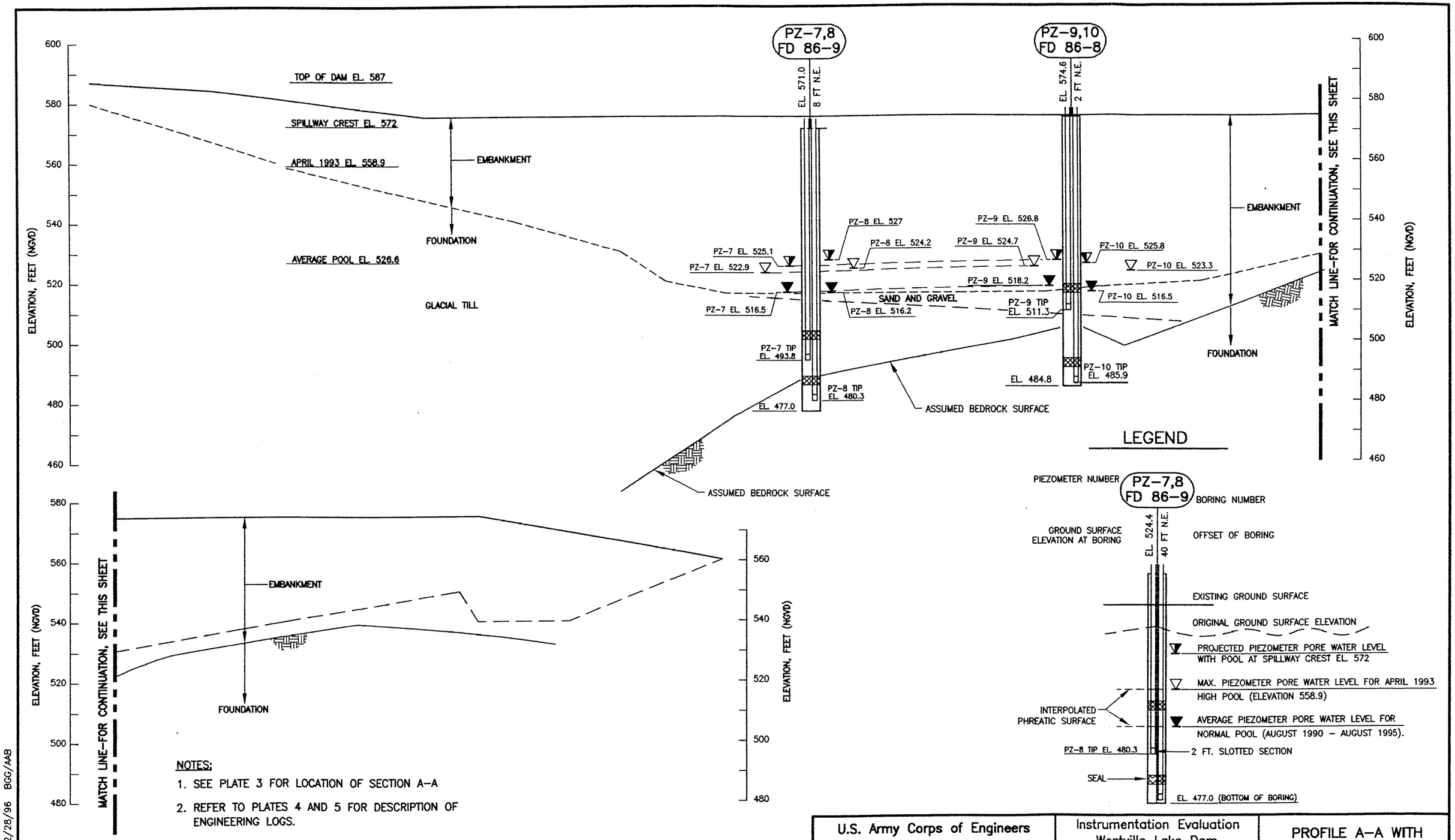
MAXIMUM POOL WAS EL. 558.9 FT NGVD WHICH OCCURRED ON APRIL 2, 1993.

0 100 200

SCALE, FEET
1" = 100'

| | | |
|---|---|---|
| U.S. Army Corps of Engineers Waltham, Massachusetts | Instrumentation Evaluation Westville Lake Dam Southbridge/Sturbridge Massachusetts | PHREATIC SURFACE PLAN OF MAXIMUM POREWATER LEVELS FOR APRIL 1993 HIGH POOL |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 12 |

95272-24 2/19/96 EEV/AJS/PTC




NOTES:

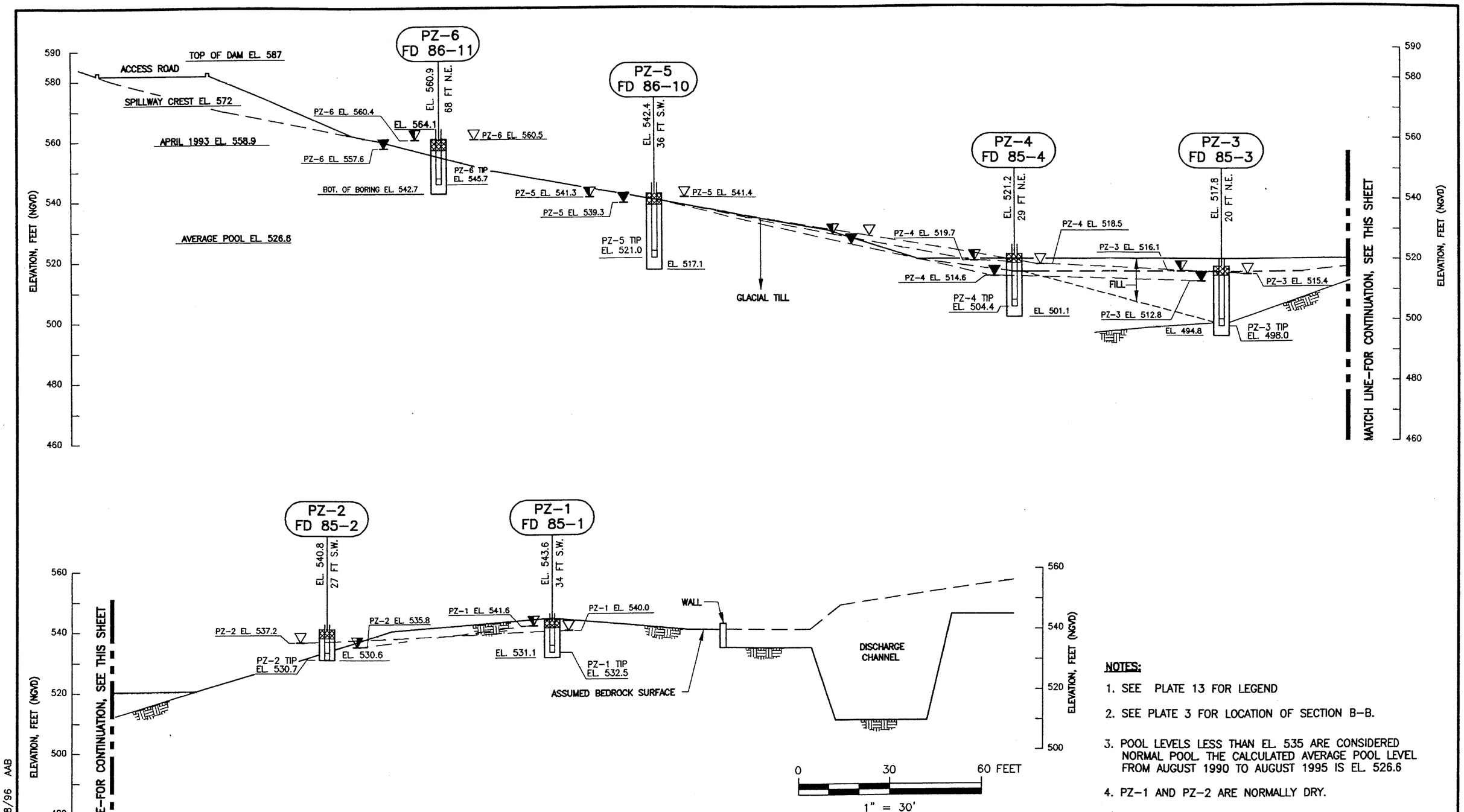
1. SEE PLATE 3 FOR LOCATION OF SECTION A–A
2. REFER TO PLATES 4 AND 5 FOR DESCRIPTION OF ENGINEERING LOGS.
3. POOL LEVELS LESS THAN EL. 535 ARE CONSIDERED NORMAL POOL. THE CALCULATED AVERAGE POOL LEVEL FROM AUGUST 1990 TO AUGUST 1995 IS EL. 526.6

0 30 60 FEET

1" = 30'

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | PROFILE A–A WITH PIEZOMETER PORE WATER LEVELS |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 13 |

95272-13 02/28/96 BGG/AAB

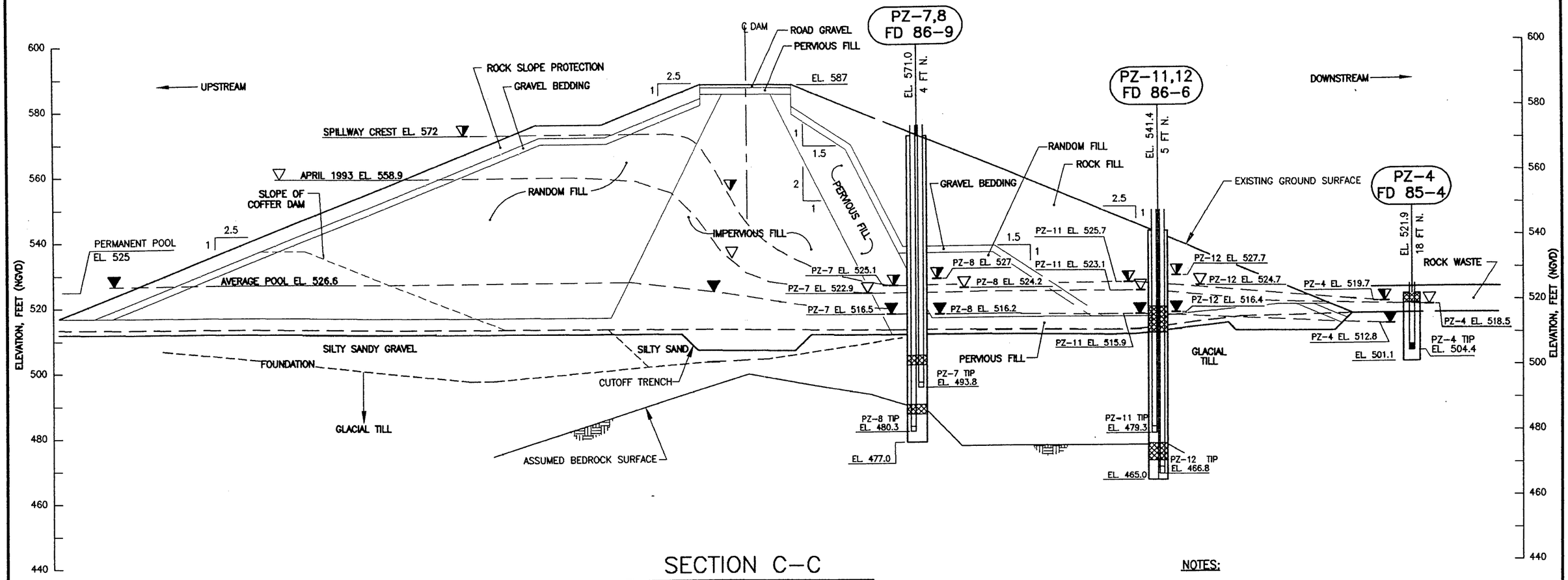



**NOTES:**

1. SEE PLATE 13 FOR LEGEND
2. SEE PLATE 3 FOR LOCATION OF SECTION B-B.
3. POOL LEVELS LESS THAN EL. 535 ARE CONSIDERED NORMAL POOL. THE CALCULATED AVERAGE POOL LEVEL FROM AUGUST 1990 TO AUGUST 1995 IS EL. 526.6
4. PZ-1 AND PZ-2 ARE NORMALLY DRY.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | PROFILE B-B WITH<br>PIEZOMETER PORE<br>WATER LEVELS |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 14 |

95272-14 02/28/96 AAB




## SECTION C–C

0 30 60 FEET

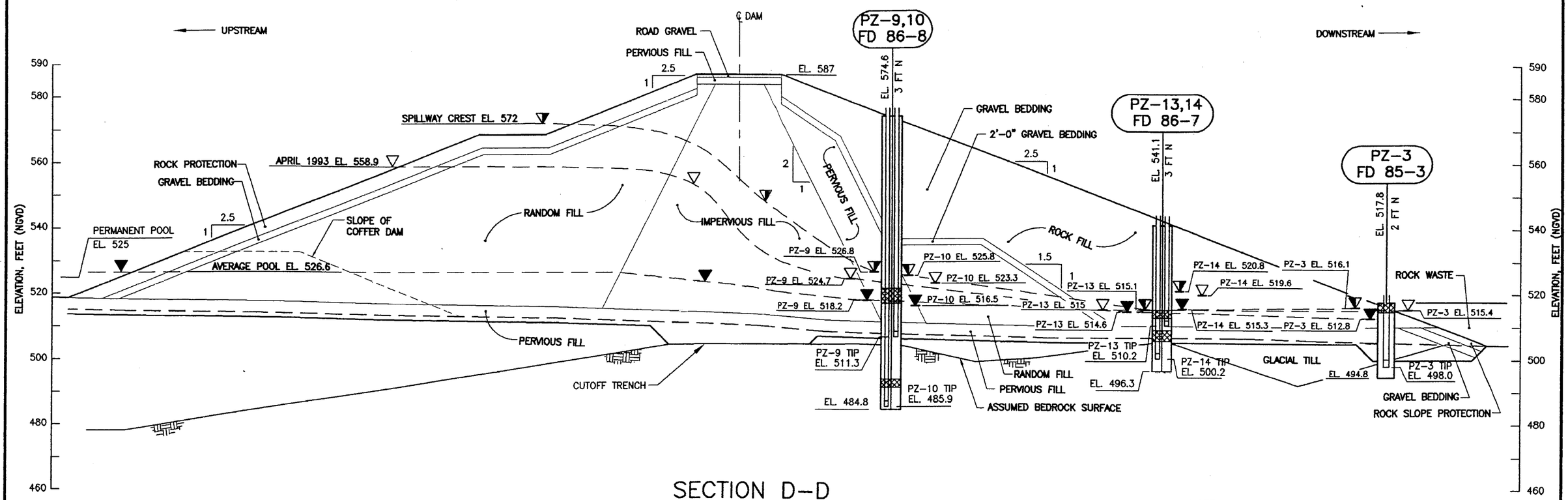
1" = 30'

NOTES:

1. SEE PLATE 13 FOR LEGEND.
2. SEE PLATE 3 FOR LOCATION OF SECTION C–C.
3. POOL LEVELS LESS THAN EL. 535 ARE CONSIDERED NORMAL POOL. THE CALCULATED AVERAGE POOL LEVEL FROM AUGUST 1990 TO AUGUST 1995 IS EL. 526.6
4. PHREATIC SURFACES SHOWN WERE ESTIMATED FROM DATA AT PIEZOMETERS SHOWN. ACTUAL WATER LEVELS BETWEEN PIEZOMETERS MAY HAVE VARIED FROM THAT SHOWN HERE.

| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | SECTION C–C WITH PIEZOMETER PORE WATER LEVELS |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 15 |

95272-15 02/28/96 BGG/AAB




## SECTION D–D

0 30 60 FEET

1" = 30'

NOTES:

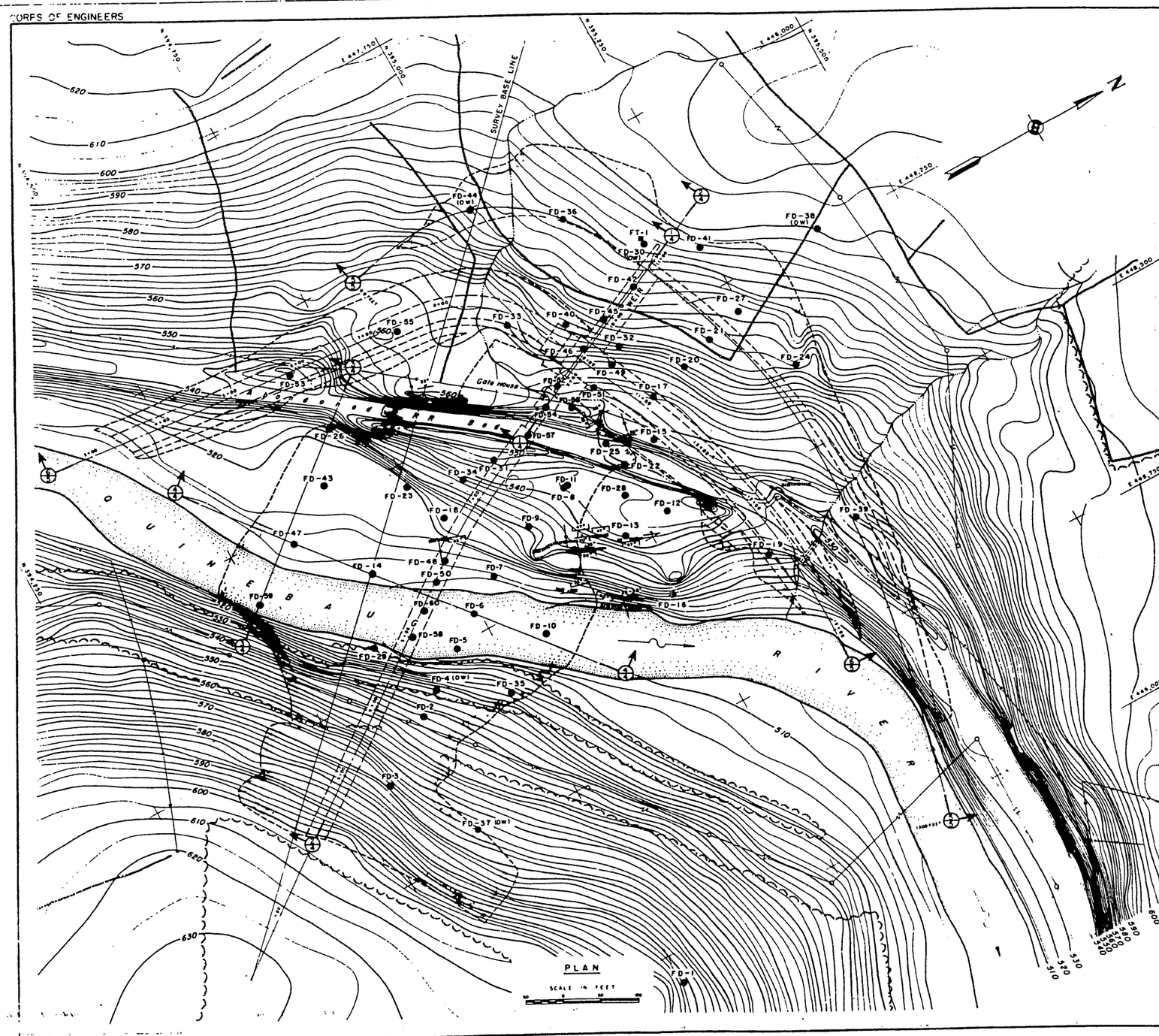
1. SEE PLATE 13 FOR LEGEND.
2. SEE PLATE 3 FOR LOCATION OF SECTION D–D.
3. POOL LEVELS LESS THAN EL. 535 ARE CONSIDERED NORMAL POOL. THE CALCULATED AVERAGE POOL LEVEL FROM AUGUST 1990 TO AUGUST 1995 IS EL. 526.6
4. PHREATIC SURFACES SHOWN WERE ESTIMATED FROM DATA AT PIEZOMETERS SHOWN. ACTUAL WATER LEVELS BETWEEN PIEZOMETERS MAY HAVE VARIED FROM THAT SHOWN HERE.

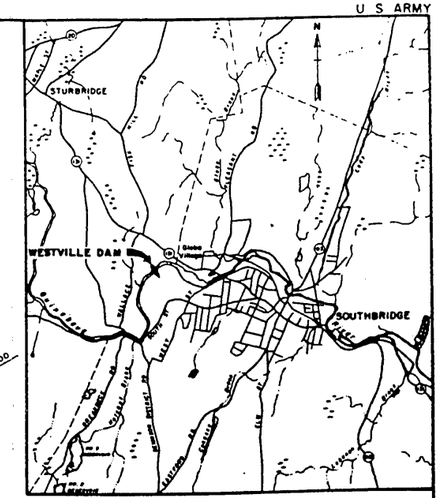
| | | |
|---|---|---|
| U.S. Army Corps of Engineers<br>Waltham, Massachusetts | Instrumentation Evaluation<br>Westville Lake Dam<br>Southbridge/Sturbridge<br>Massachusetts | SECTION D–D WITH PIEZOMETER PORE WATER LEVELS |
| GEI Consultants, Inc. | Project 95272 | February 1996 Plate 16 |

95272-16 02/28/96 AAB

CORPS OF ENGINEERS

U S ARMY




VICINITY MAP

SCALE IN MILES

## LEGEND FOR PLAN

- ● FD — Foundation Test Boring
- ■ FT — Foundation Test Pit
- (O W) — Observation Well Installed
- Bedrock Outcrop
- Strike and dip of foliation
- Strike and dip of joint planes
- Strike of vertical joint planes
- Geologic sections and log profile
- Section number / Sheet number

## NOTES

Elevations refer to Mean Sea Level Datum

Plan prepared from Plane Table Survey, Corps of Engineers,

Coordinates refer to Massachusetts Lambert Grid System

For Record of Foundation Explorations, see Sheets No. 6, 7, and 8

Record

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND

THAMES RIVER FLOOD CONTROL

WESTVILLE DAM

PLAN OF FOUNDATION EXPLORATIONS

QUINEBAUG RIVER, MASSACHUSETTS

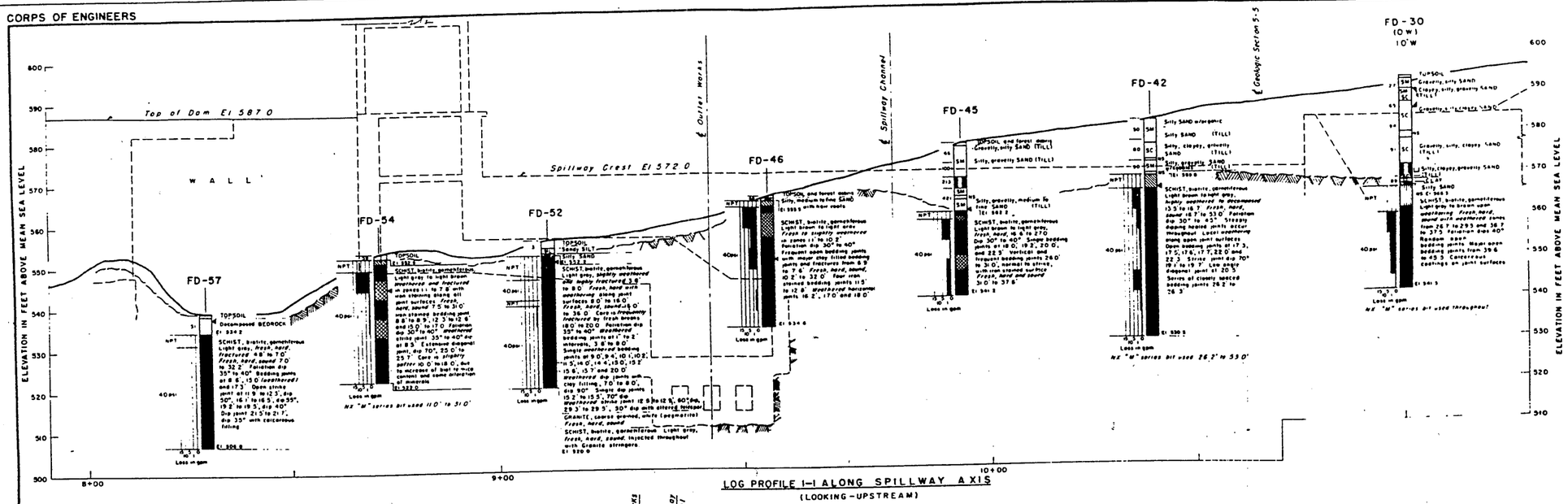
OCT 1959

TH-1-1642

PLATE 17

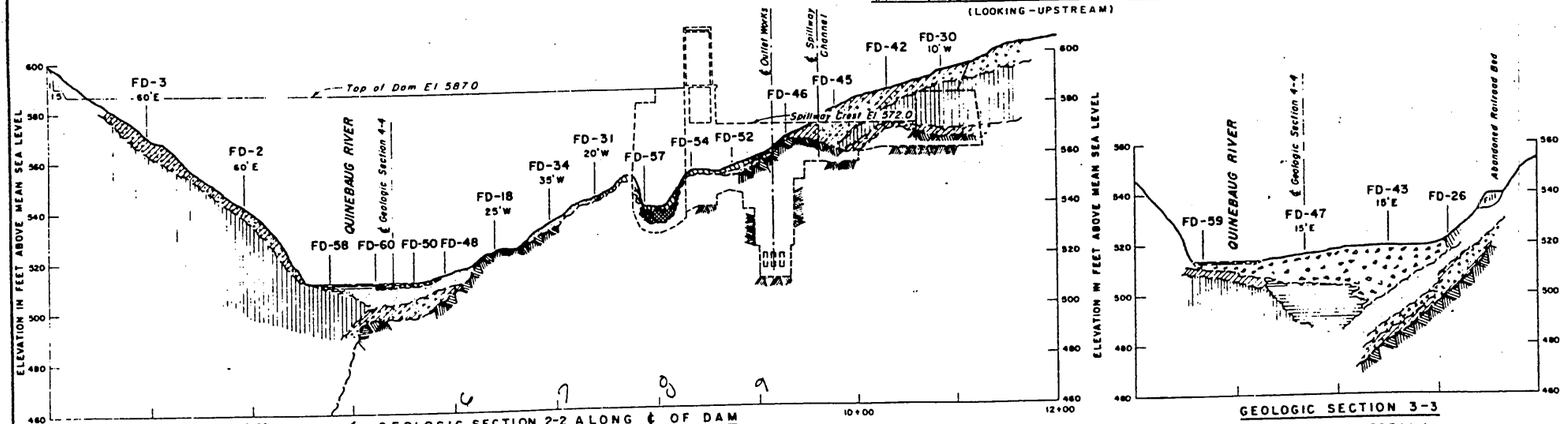
CORPS OF ENGINEERS

U. S. ARMY




LOG PROFILE I-I ALONG SPILLWAY AXIS

(LOOKING-UPSTREAM)



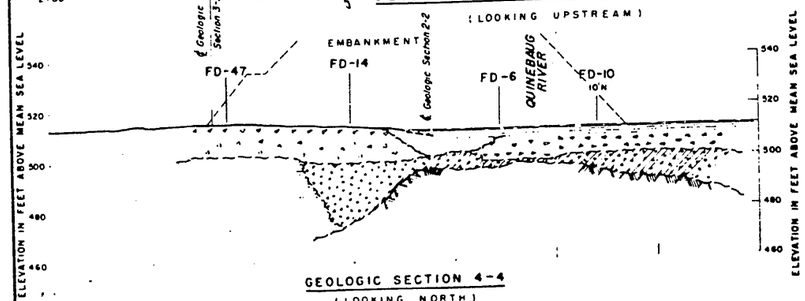

GEOLOGIC SECTION 2-2 ALONG ℄ OF DAM

(LOOKING UPSTREAM)




GEOLOGIC SECTION 3-3

(LOOKING UPSTREAM)




GEOLOGIC SECTION 4-4

(LOOKING NORTH)

## LEGEND FOR GEOLOGIC SECTION

- Varies from sandy GRAVEL to gravelly, silty SAND and silty SAND (TILL)
- Varies from clayey, gravelly SAND and gravelly, clayey SAND to clayey SAND and sandy CLAY (TILL)
- Sandy CLAY (TILL)
- Silty, sandy GRAVEL
- Silty SAND to silty, gravelly SAND
- Sandy SILT
- Decomposed ROCK (No apparent structure)
- Assumed Bedrock Surface
- Schist with Granitic Intrusions

## NOTES

For Location of Log Profile and Geologic Sections see Sheet No 3

For Record of Foundation Explorations see Sheets No. 6, 7, and 8

For Legend of Graphic Logs see Sheet No 6

Standard "NX" diamond bits used for core drilling of rock where not otherwise indicated.

This drawing is presented for general information and is to be considered only as a supplement to the records of exploration in other contract drawings. Geologic sections shown hereon are the Government interpretation of subsurface conditions believed to exist at and between borings. Variations between elevations, composition and structure of the individual formations as represented hereon and as actually encountered in the progress of the work are to be anticipated.

Record Drawing

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

THAMES RIVER FLOOD CONTROL

WESTVILLE DAM

LOG PROFILE I-I AND
GEOLOGIC SECTIONS 2-2, 3-3 AND 4-4

QUINEBAUG RIVER, MASSACHUSETTS

DATE OCT 1959

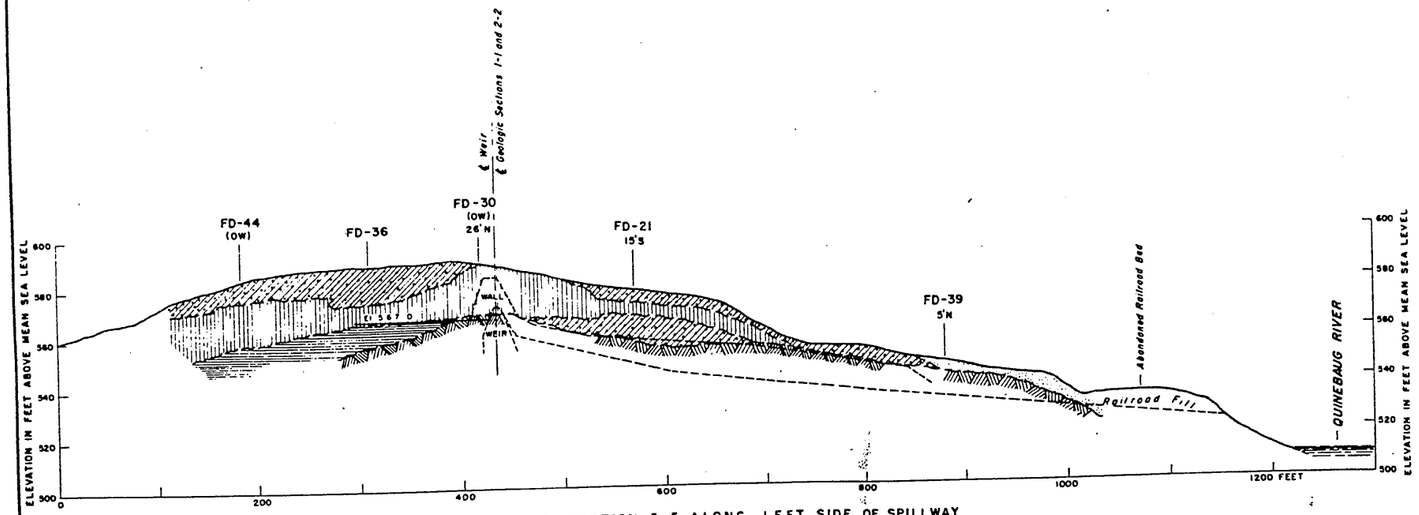
SCALE

DRAWING NUMBER TH-1-1643

SHEET 4

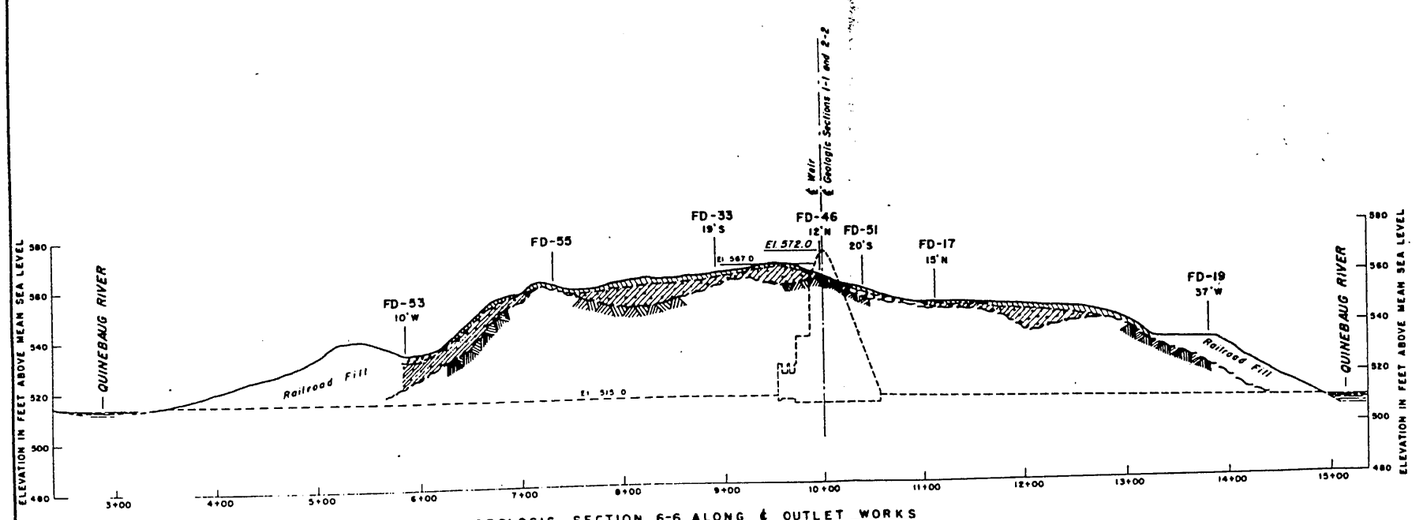
U. S. ARMY

CORPS OF ENGINEERS




GEOLOGIC SECTION 5-5 ALONG LEFT SIDE OF SPILLWAY

(LOOKING NORTH)




GEOLOGIC SECTION 6-6 ALONG ℄ OUTLET WORKS

(LOOKING NORTH)

## LEGEND FOR GEOLOGIC SECTION

- Varies from sandy GRAVEL to gravelly, silty SAND and silty SAND (TILL)
- Varies from clayey, gravelly SAND and gravelly, clayey SAND to clayey SAND and sandy CLAY (TILL)
- Sandy CLAY (TILL)
- Silty, sandy GRAVEL
- Silty SAND to silty, gravelly SAND
- Sandy SILT
- Decomposed ROCK. (No apparent structure)
- Assumed Bedrock Surface Schist with Granitic Intrusions

## NOTES

*For Location of Geologic Sections, see Sheet No. 3*

*For Record of Foundation Explorations, see Sheets No 6, 7 and 8*

*This drawing is presented for general information and is to be considered only as a supplement to the records of exploration in other contract drawings Geologic sections shown hereon are the Government interpretation of subsurface conditions believed to exist at and between borings Variations between elevations, composition and structure of the individual formations as represented hereon and as actually encountered in the progress of the work are to be anticipated.*

Record Drawing

| REVISIONS | DATE | DESCRIPTION | BY |
|---|---|---|---|

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS

DRAWN BY E.A.B. / H.L.W. — CHECKED BY D.C.B.

SUBMITTED: Chief, Geologic Section

RECOMMENDED: Chief, Foundation Branch

APPROVED: Chief, Engineering Division

THAMES RIVER FLOOD CONTROL

WESTVILLE DAM

GEOLOGIC SECTIONS 5-5 AND 6-6

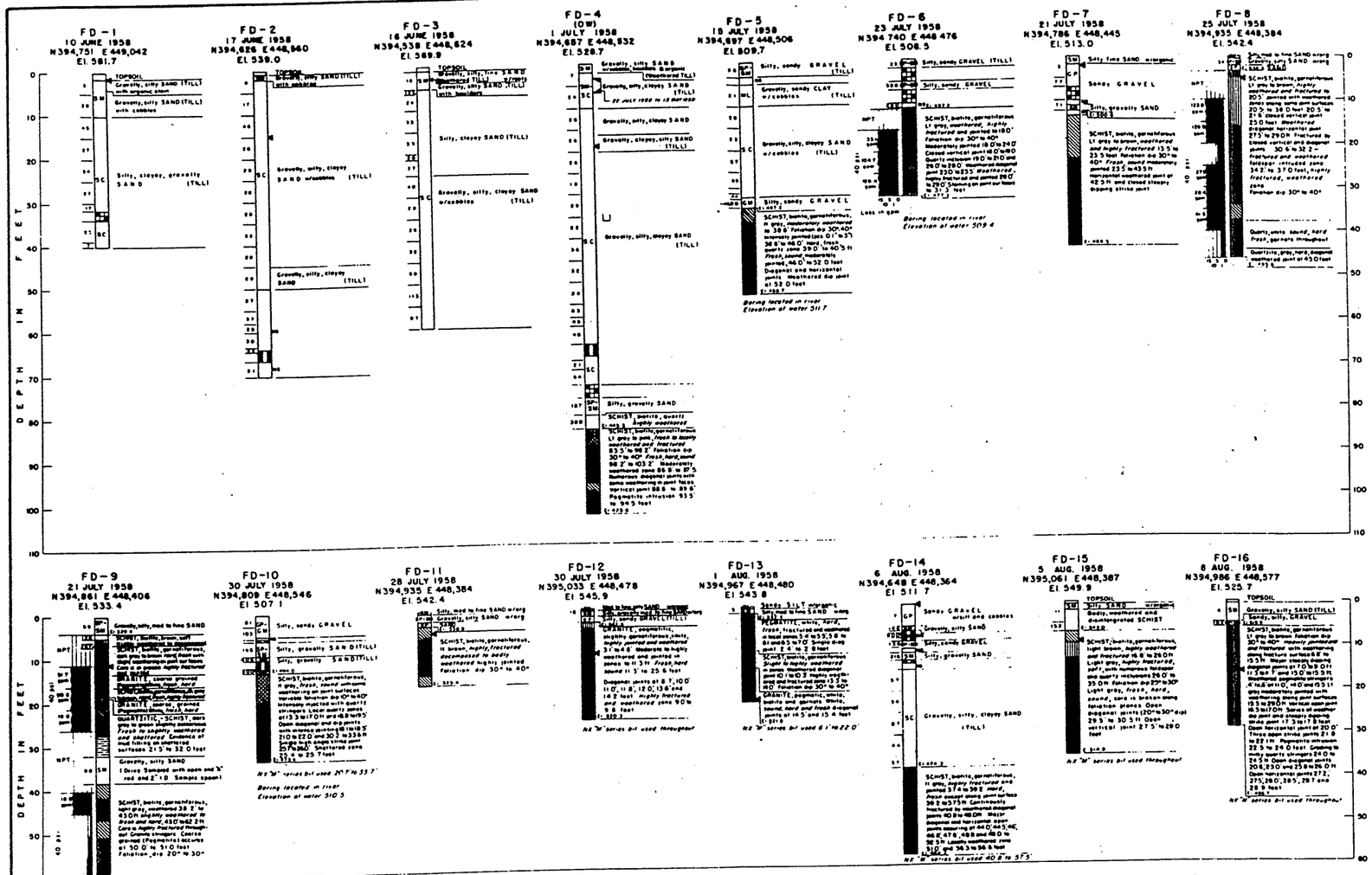
QUINEBAUG RIVER, MASSACHUSETTS

DATE OCT 1959

SCALE — NOT INDICATED

DRAWING NUMBER TH-1-1644

SHEET 5




## LEGEND FOR GRAPHIC LOGS

FD-9 (OW) 21 JULY 1958 N394,861 E448,384 El. 533.4 — Foundation Test Boring; Observation well installed; Date exploration completed; Location by coordinates; Elevation of ground surface during time of exploration

Maximum artesian head

Subsurface water level in boring at time of exploration.

Range of subsurface water . . . . during period of observation.

Artesian flow encountered

SP — Group letter symbol according to Unified Soil Classification System

NR — No Recovery or unsatisfactory soil samples recovered

U — Bottom of observation well.

NS — Not Sampled. Hole advanced by core-drilling, blasting and/or wash-boring due to operational difficulty

CD — Sampling in overburden by Core-drill method

24 — Blows per foot of penetration considered most representative usually within a 5 foot drive using a 300 or 350 pound hammer, with a free fall of about 18 inches on a 2½" I.D. or 3" O.D. and/or 2" I.D. or 2½" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.

Blow count not recorded or not considered representative.

Cobble or boulder (Core-drilled).

Cobbles or boulders, continuous or nested. (Core-drilled and/or blasted and chopped)

El. 845.5 — Elevation of bedrock surface.

Rock core recovery 0 – 25%
Rock core recovery 25 – 50%
Rock core recovery 50 – 75%
Rock core recovery 75 – 90%
Rock core recovery 90 – 100%

El. 914.5 — Elevation of bottom of exploration.

NPT — No Pressure Test Performed. Asterisk denotes that section could not be sealed for testing.

40 psi — Constantly maintained pressure for 1 to 5 minutes. Volume loss in gallons per minute under constant pressure, tested continuously in 5 foot sections. Scale expanded from 0 gpm to 1 gpm for clarification of low pressure losses.

Apparent excessive high losses of water during pressure testing are believed due to erratic behavior of water meters at very high rates of flow.

*Water levels recorded during subsurface explorations seldom correspond with the natural level of free ground water, except in extensive and thick deposits of sands and gravels which are sufficiently pervious to permit rapid stabilization of water levels in the exploratory hole. Absence of subsurface water level in the graphic log of any exploration is not necessarily to be construed that ground water will not be encountered in excavation at that location.*

*While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local minor variations characteristic of the overburden and rocks of this region are anticipated, and if encountered, such variations will not be considered as differing materially from represented conditions within the purview of Article 4 of the Contract.*

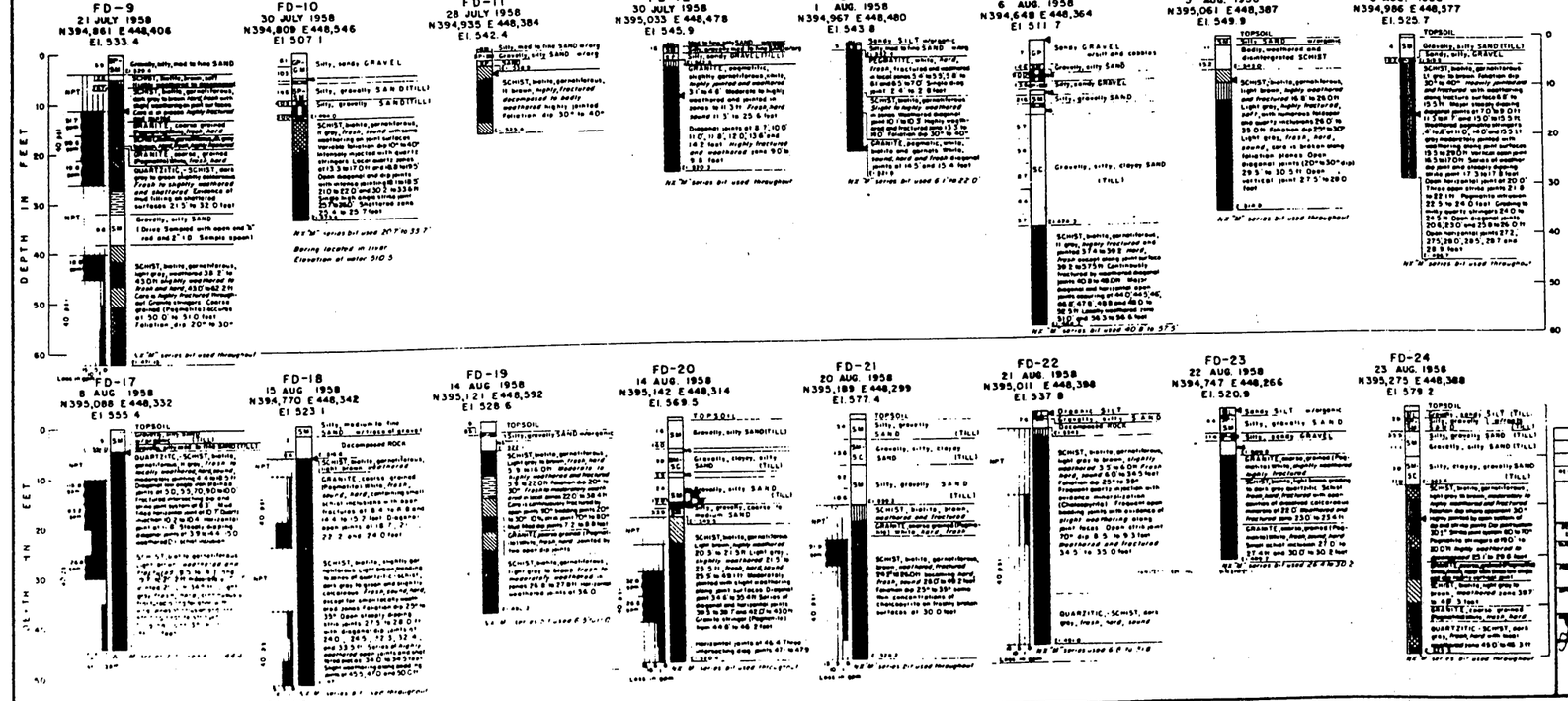
## NOTES

*Elevations refer to Mean Sea Level Datum*

*Coordinates refer to Massachusetts Lambert Grid System*

*For Location of Foundation Explorations, see Sheet No. 3*

*Standard NX diamond bits used for core drilling of rock where not otherwise indicated.*




Reproducible Copy

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

THAMES RIVER FLOOD CONTROL

**WESTVILLE DAM**

**RECORD OF FOUNDATION EXPLORATIONS NO. 1**

QUINEBAUG RIVER, MASSACHUSETTS

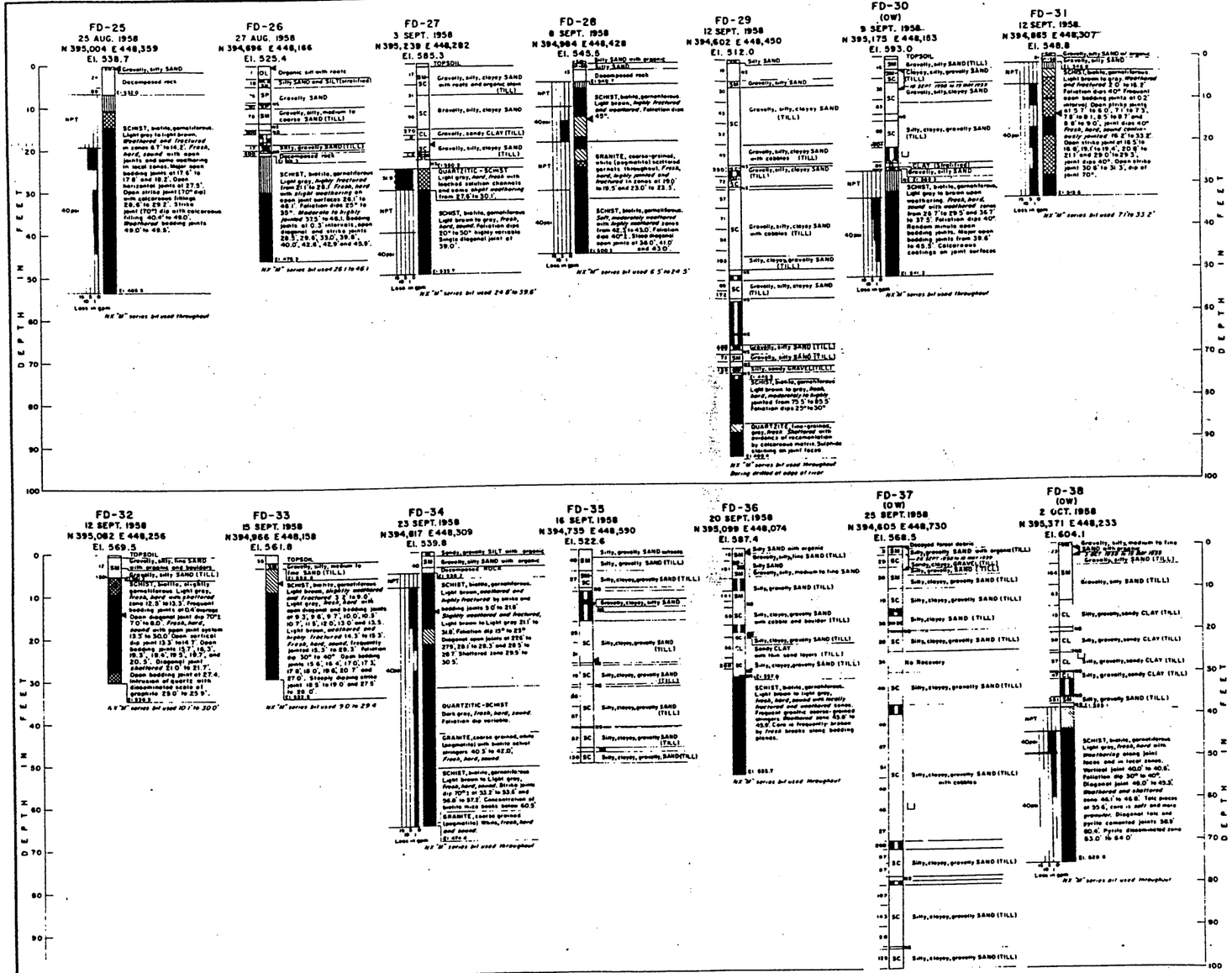
DATE OCT 1959

SCALE — SPEC. NO. CW-1165 - NO. D-6-00-27

TN-1-1848

SHEET 6

CORPS OF ENGINEERS




## LEGEND FOR GRAPHIC LOGS

FD-34 (OW) 23 SEPT. 1958 N 394,814 E 448,309 El. 539.8 — Foundation Test Boring

Observation well installed.

Date exploration completed.

Location by coordinates

Elevation of ground surface during time of exploration.

Maximum artesian head.

Subsurface water level in boring at time of exploration.

Range of subsurface water during period of observation.

Artesian flow encountered.

Group letter symbol according to Unified Soil Classification System.

No Recovery or unsatisfactory soil samples recovered.

Bottom of observation well.

Not Sampled. Hole advanced by core-drilling, blasting and/or wash-boring due to operational difficulty

Sampling in overburden by Core-drill Method

Blows per foot of penetration considered most representative usually within a 5 foot drive using a 300 or 350 pound hammer, with a free fall of about 18 inches on a 2½ I.D. or 3" O.D. and/or 2" I.D. or 2½" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.

Blow count not recorded or not considered representative.

Cobble or boulder (Core-drilled).

Cobbles or boulders, continuous or nested. (Core-drilled and/or blasted and chopped).

El. 528.5 Elevation of bedrock surface.

Rock core recovery 0 – 25%

Rock core recovery 25 – 50%

Rock core recovery 50 – 75%

Rock core recovery 75 – 90%

Rock core recovery 90 – 100%

El. 514.5 Elevation of bottom of exploration.

NPT — No Pressure Test Performed. Asterisk denotes that section could not be sealed for testing.

40 psi — Constantly maintained pressure for 1 to 5 minutes. Volume loss in gallons per minute under constant pressure, tested continuously in 5 foot sections. Scale expanded from 0 gpm to 1 gpm for clarification of low pressure losses.

Apparent excessive high losses of water during pressure testing are believed due to erratic behavior of water meters at very high rates of flow.

*Water levels recorded during subsurface explorations seldom correspond with the natural level of free ground water, except in extensive and thick deposits of sands and gravels which are sufficiently pervious to permit rapid stabilization of water levels in the exploratory hole. Absence of subsurface water level in the graphic log of any exploration is not necessarily to be construed that ground water will not be encountered in excavation at that location.*

*While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local minor variations characteristic of the overburden and rocks of this region are anticipated, and if encountered, such variations will not be considered as differing "materially" from represented conditions within the purview of Article 4 of the Contract.*

## NOTES

*Elevations refer to Mean Sea Level Datum*

*Coordinates refer to Massachusetts Lambert Grid System*

*For Location of Foundation Explorations, see Sheet 3.*

*Standard NX diamond bits used for core drilling of rock where not otherwise indicated.*

Record Drawing

| Symbols | DATE | DESCRIPTION | BY |
|---|---|---|---|

U. S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

THAMES RIVER FLOOD CONTROL

WESTVILLE DAM

RECORD OF FOUNDATION EXPLORATIONS NO 2

QUINEBAUG RIVER, MASSACHUSETTS

DATE OCT 1959

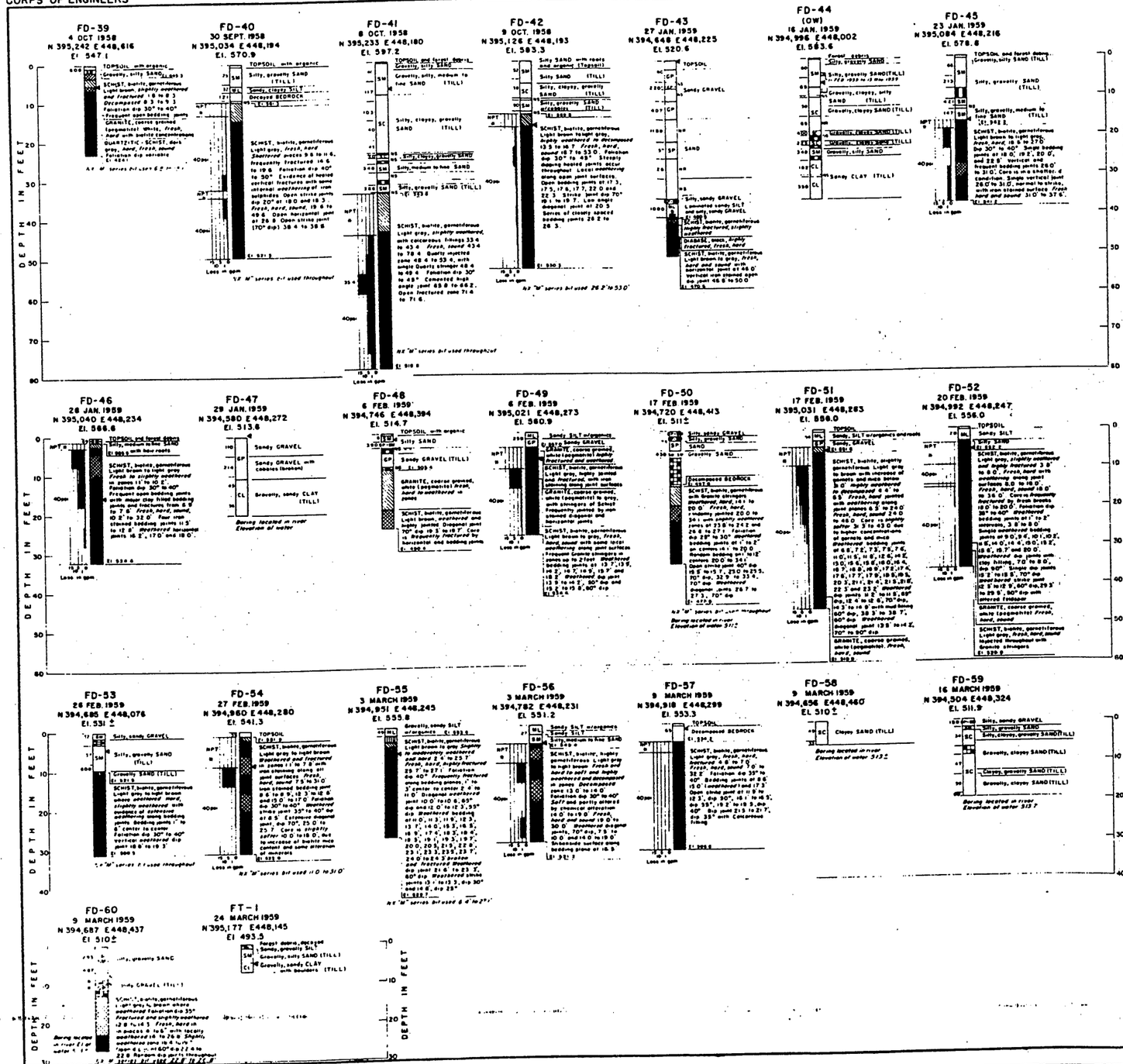
SCALE

DRAWING NUMBER TH-1-1646

SHEET 7

U. S. ARMY

CORPS OF ENGINEERS







## LEGEND FOR GRAPHIC LOGS

FD-41 — Foundation Test Boring
FT-1 — Foundation Test Trench
(OW) — Observation well installed
8 OCT. 1958 — Date exploration completed
N 395,233 E 448,180 — Location by coordinates
El 597.2 — Elevation of ground surface during time of exploration.
Maximum artesian head.
Subsurface water level in boring at time of exploration.
Range of subsurface water during period of observation
Artesian flow encountered.
SP — Group letter symbol according to Unified Soil Classification System
NR — No Recovery or unsatisfactory soil samples recovered.
LJ — Bottom of observation well.
NS — Not sampled Hole advanced by core-drilling, blasting and/or wash-boring due to operational difficulty.
CD — Cemping in overburden by Core-drill method.
24 — Blows per foot of penetration considered most representative usually within a 5 foot drive using a 300 or 350 pound hammer, with a free fall of about 18 inches on a 2½" I.D. or 3" O.D. and/or 2" I.D. or 2½" O.D. size sample spoon equipped with a beveled and sharpened drive shoe.
H — Blow count not recorded or not considered representative.
Cobble or boulder (Core-drilled).
Cobbles or boulders, continuous or nested (Core-drilled and/or blasted and chopped).
El 528.5 — Elevation of bedrock surface.
Rock core recovery 0 – 25%
Rock core recovery 25 – 50%
Rock core recovery 50 – 75%
Rock core recovery 75 – 90%
Rock core recovery 90 – 100%
El 514.5 — Elevation of bottom of exploration.

NPT — No Pressure Test Performed. Asterisk denotes that section could not be sealed for testing.

40 psi — Constantly maintained pressure for 1 to 5 minutes. Volume loss in gallons per minute under constant pressure, tested continuously in 5 foot sections. Scale expanded from 0 gpm to 1 gpm for clarification of low pressure losses.

Apparent excessive high losses of water during pressure testing are believed due to erratic behavior of water meters at very high rates of flow.

*Water levels recorded during subsurface explorations seldom correspond with the natural level of free ground water, except in extensive and thick deposits of sands and gravels which are sufficiently pervious to permit rapid stabilization of water levels in the exploratory hole. Absence of subsurface water level in the graphic log of any exploration is not necessarily to be construed that ground water will not be encountered in excavation at that location.*

*While the borings are representative of subsurface conditions at their respective locations and for their respective vertical reaches, local minor variations characteristic of the overburden and rocks of this region are anticipated, and if encountered, such variations will not be considered as differing materially from represented conditions within the purview of Article 4 of the Contract.*

## NOTES

*Elevations refer to Mean Sea Level Datum*

*Coordinates refer to Massachusetts Lambert Grid System*

*For Location of Foundation Explorations, see Sheet No 3*

*Standard NX diamond bits used for core drilling of rock where not otherwise indicated.*

Record Drawing
Contract No. DA 19-016 CIV ENG

| Revision | Date | Description | By |
|---|---|---|---|

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

THAMES RIVER FLOOD CONTROL

# WESTVILLE DAM

RECORD OF FOUNDATION EXPLORATIONS NO 3

QUINEBAUG RIVER, MASSACHUSETTS

DATE OCT 1959

SCALE

DRAWING NUMBER TH-1-1647

SHEET 1

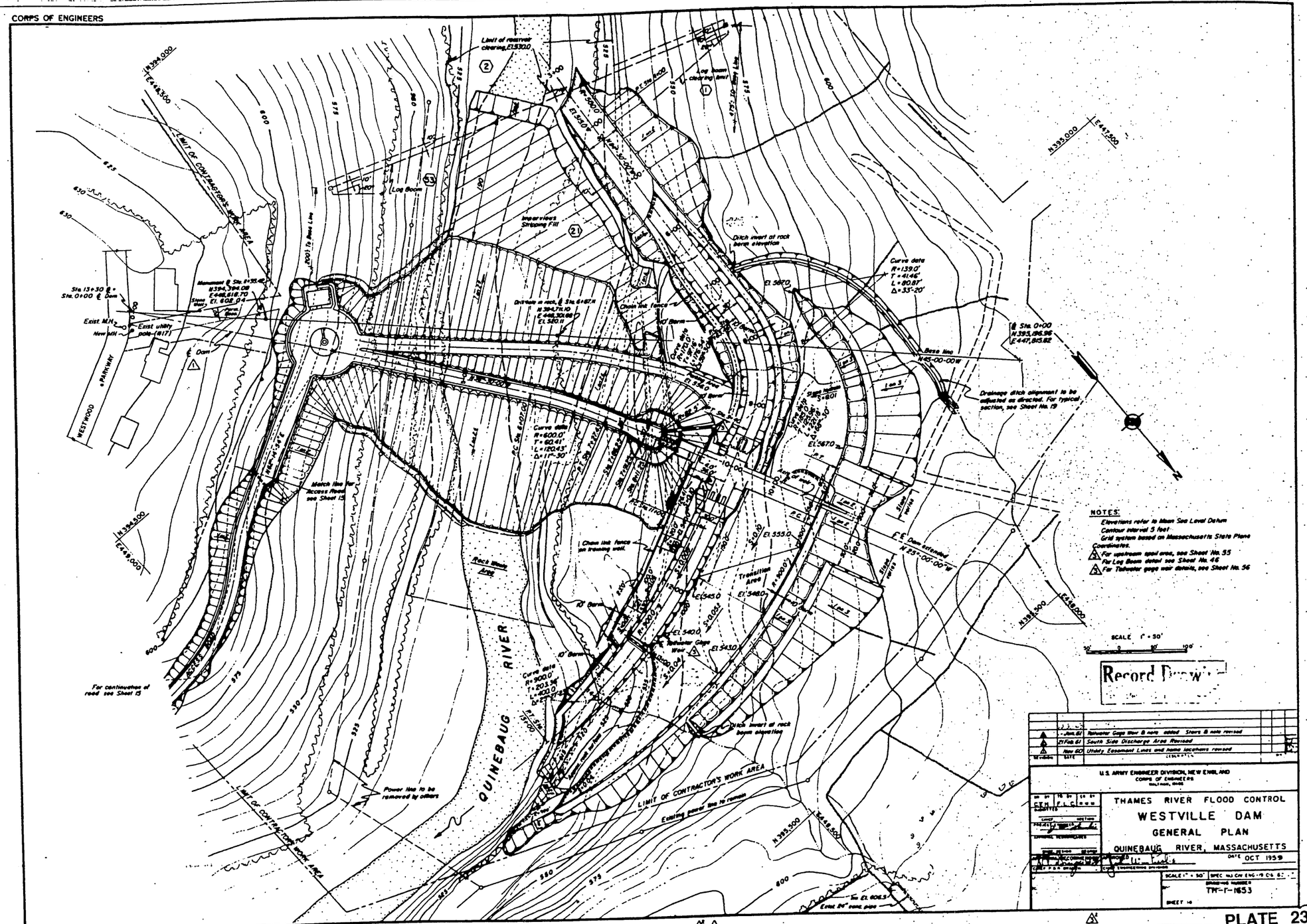

CORPS OF ENGINEERS
U. S. ARMY
QUINEBAUG RIVER
LIMIT OF CONTRACTOR'S WORK AREA
Limit of reservoir clearing, El. 530.0
Log Boom
Impervious Stripping Fill
Ditch invert at rock berm elevation
Curve data
R=139.0'
T=41.46'
L=80.87'
Δ=33°-20'
Base line
N45-00-00W
Drainage ditch alignment to be adjusted as directed. For typical section, see Sheet No. 19
Curve data
R=600.0'
T=60.41'
L=120.43'
Δ=11°-30'
Match line for Access Road see Sheet 15
Rock Waste Area
Chain link fence on training wall
Transition Area
Tailwater Gage Weir
Ditch invert at rock berm elevation
Existing power line to remain
Power line to be removed by others
For continuation of road see Sheet 15
Exist. M.H.
New MH
Exist utility pole (#17)
WESTWOOD PARKWAY
Sta. 13+30 ℄ = Sta. 0+00 ℄ Dam
℄ Dam
℄ Sta. 0+00
N395,196.96
E447,815.82
N394,000
E448,500
N395,000
E447,500
N394,500
E449,000
N395,500
E448,000
NOTES:
Elevations refer to Mean Sea Level Datum
Contour interval 5 feet
Grid system based on Massachusetts State Plane Coordinates.
For upstream spoil area, see Sheet No. 55
For Log Boom detail see Sheet No. 46
For Tailwater gage weir details, see Sheet No. 56
SCALE 1" = 50'
Record Drawing
Jan. 61 Tailwater Gage Weir & note added Stairs & note revised
21 Feb. 61 South Side Discharge Area Revised
Nov 60 Utility Easement Lines and home locations revised
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
THAMES RIVER FLOOD CONTROL
WESTVILLE DAM
GENERAL PLAN
QUINEBAUG RIVER, MASSACHUSETTS
DATE OCT 1959
TH-1-1653

PLATE 23

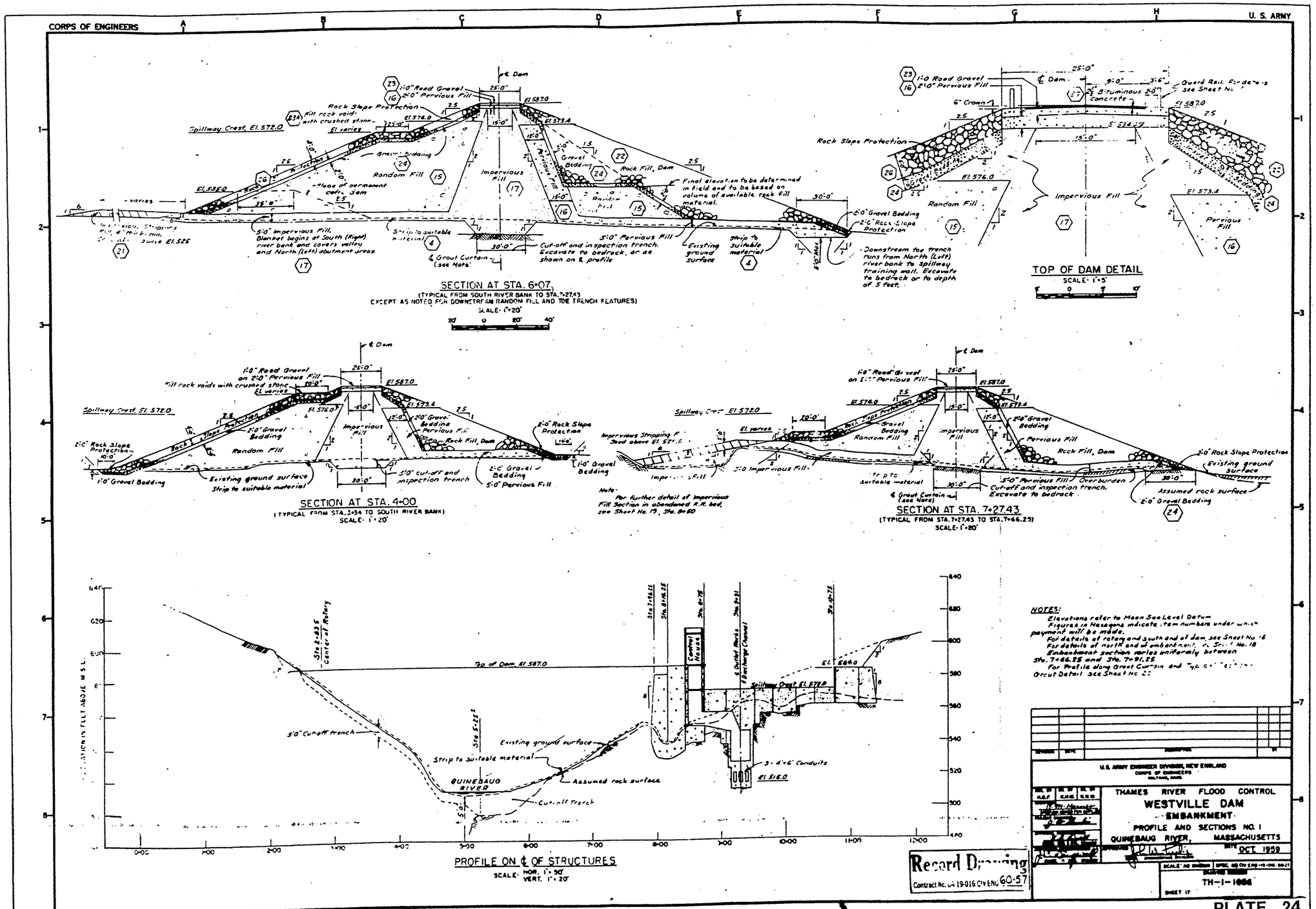
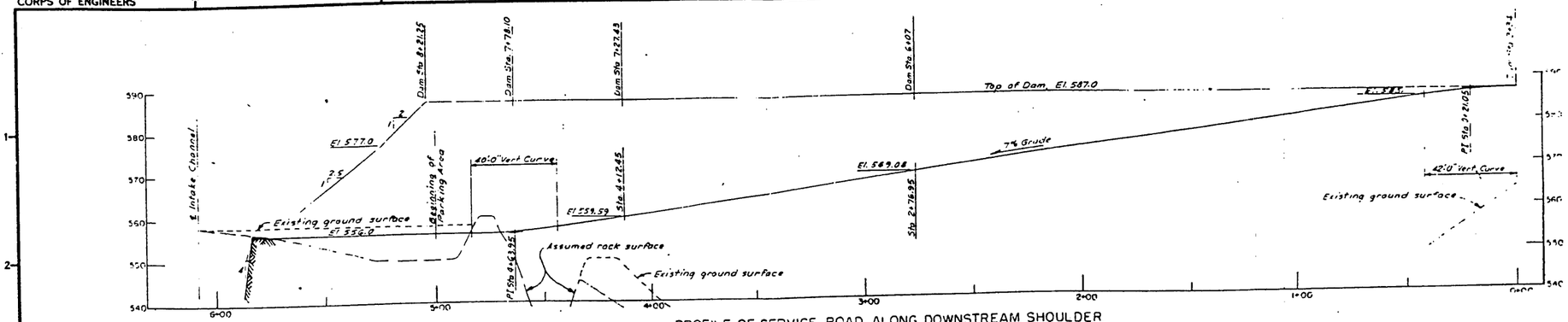

CORPS OF ENGINEERS
U. S. ARMY
SECTION AT STA. 6+07
(TYPICAL FROM SOUTH RIVER BANK TO STA. 7+27.43
EXCEPT AS NOTED FOR DOWNSTREAM RANDOM FILL AND TOE TRENCH FEATURES)
SCALE: 1"=20'
TOP OF DAM DETAIL
SCALE: 1"=5'
SECTION AT STA. 4+00
(TYPICAL FROM STA. 3+34 TO SOUTH RIVER BANK)
SCALE: 1"=20'
SECTION AT STA. 7+27.43
(TYPICAL FROM STA. 7+27.43 TO STA. 7+66.25)
SCALE: 1"=20'
PROFILE ON ℄ OF STRUCTURES
SCALE: HOR. 1"=50' VERT. 1"=20'
NOTES:
Elevations refer to Mean Sea Level Datum
Figures in Hexagons indicate item numbers under which payment will be made.
For details of rotary and south end of dam, see Sheet No. 16
For details of north end of embankment, see Sheet No. 18
Embankment section varies uniformly between Sta. 7+66.25 and Sta. 7+91.25
For Profile along Grout Curtain and Typical Section Grout Detail see Sheet No. 2
U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
THAMES RIVER FLOOD CONTROL
WESTVILLE DAM
EMBANKMENT
PROFILE AND SECTIONS NO. 1
QUINEBAUG RIVER, MASSACHUSETTS
OCT. 1959
TH-1-1086
SHEET 17
Record Drawing
Contract No. DA 19-016 CIV ENG 60-57

PLATE 24

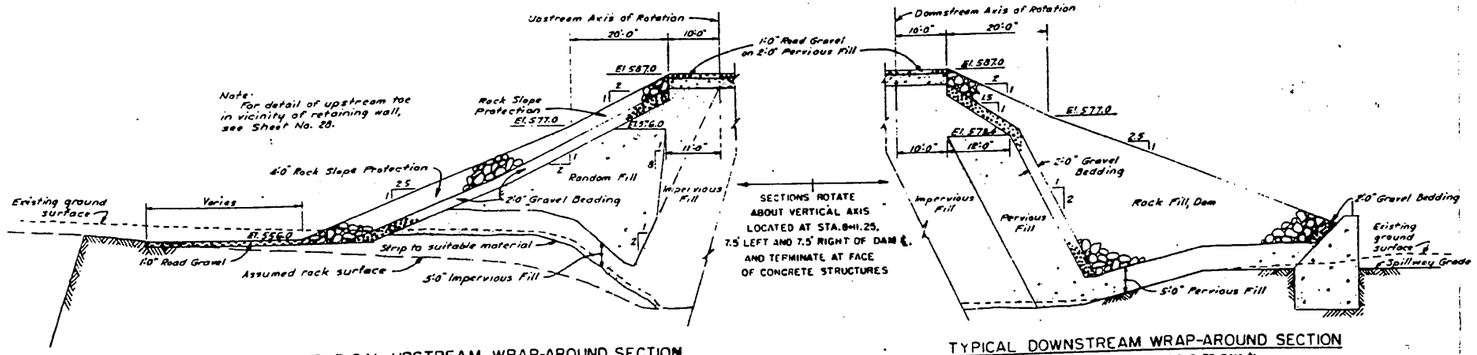
CORPS OF ENGINEERS

U. S. ARMY




PROFILE OF SERVICE ROAD ALONG DOWNSTREAM SHOULDER

SCALE: HOR. 1" = 20' VERT 1" = 10'




TYPICAL UPSTREAM WRAP-AROUND SECTION

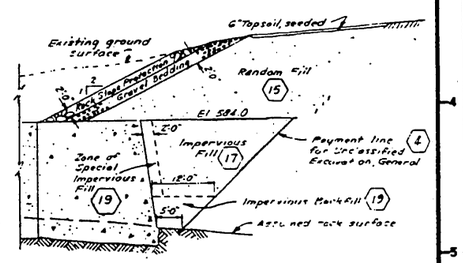
(SECTION TAKEN AT 45° ANGLE TO DAM ℄)

SCALE: 1" = 10'

TYPICAL DOWNSTREAM WRAP-AROUND SECTION

(SECTION TAKEN AT 45° ANGLE TO DAM ℄)

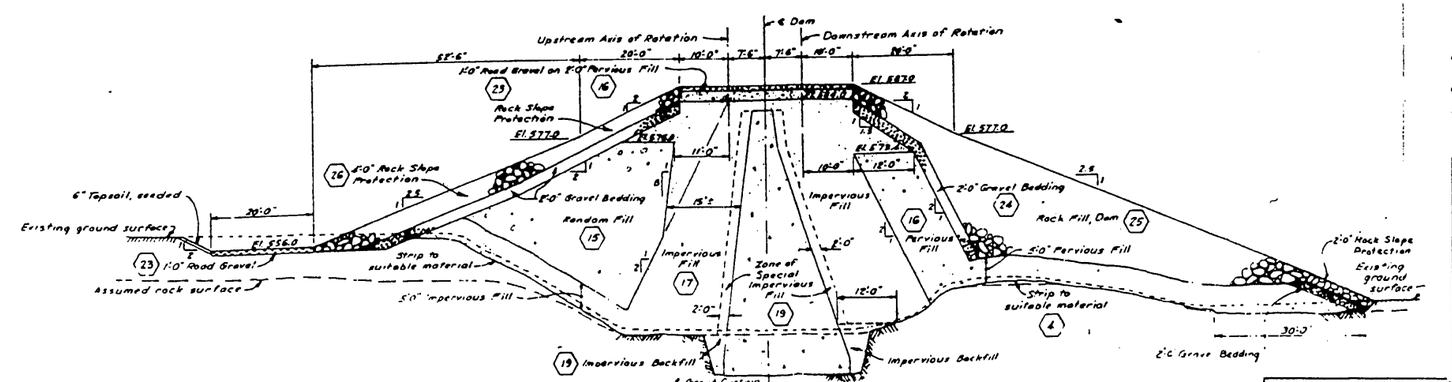
SCALE: 1" = 10'




NORTH ABUTMENT - BACKFILL SECTION

(SECTION ALONG STRUCTURE ℄ - LOOKING UPSTREAM)

SCALE: 1" = 10'




SECTION AT STATION 8+11.25

(TYPICAL FROM STA. 7+91.25 TO STA. 8+11.25)

SCALE: 1" = 10'

NOTES:

Elevations refer to Mean Sea Level Datum.

Figures in hexagons indicate item numbers under which payment will be made.

Embankment section varies uniformly between Sta. 7+66.25 and 7+93.25

For Typical Section - Grout Detail see Sheet No. 22

Record Drawing

Contract No. DA-1-[illegible]-60-57

| REVISION | DATE | DESCRIPTION | BY |
|---|---|---|---|

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

| DESIGNED | DRAWN | CHECKED | SUBMITTED |
|---|---|---|---|
| H.B.F. | K.A.B. | R.J.M. | |

THAMES RIVER FLOOD CONTROL

WESTVILLE DAM

EMBANKMENT

PROFILE AND SECTIONS NO. 2

QUINEBAUG RIVER, MASSACHUSETTS

DATE OCT. 1959

APPROVED [illegible]

SCALE: 1" = 10'

SPEC. NO. CIV ENG 19 DAC 27

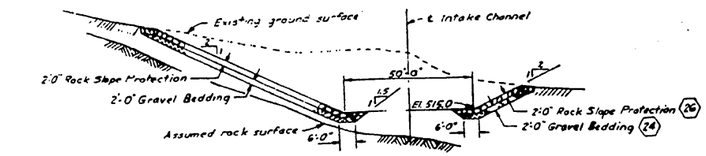
DRAWING NUMBER TH-1-1657

SHEET 10

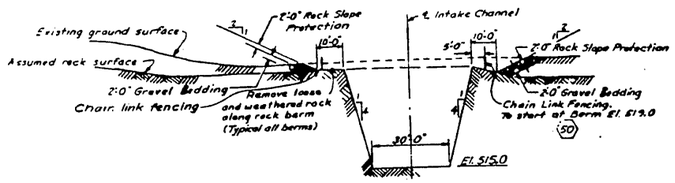
PLATE 25

CORPS OF ENGINEERS

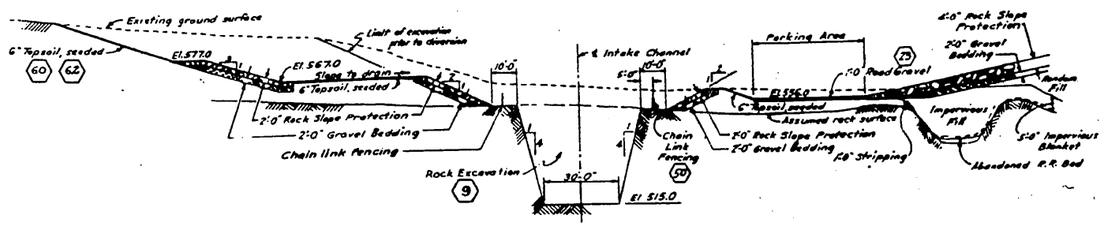
U. S. ARMY



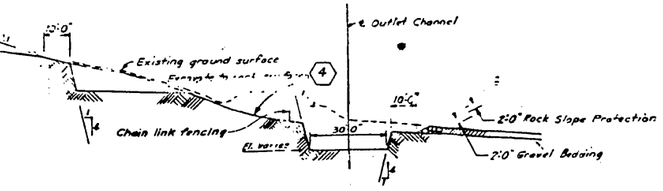

STATION 5+00
SCALE: 1"=20'



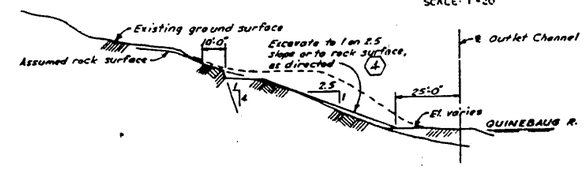

STATION 7+00
SCALE: 1"=20'



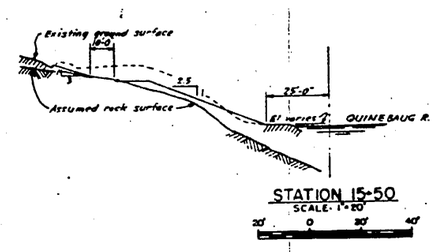

STATION 8+50
SCALE: 1"=20'




STATION 14+00
SCALE: 1"=20'

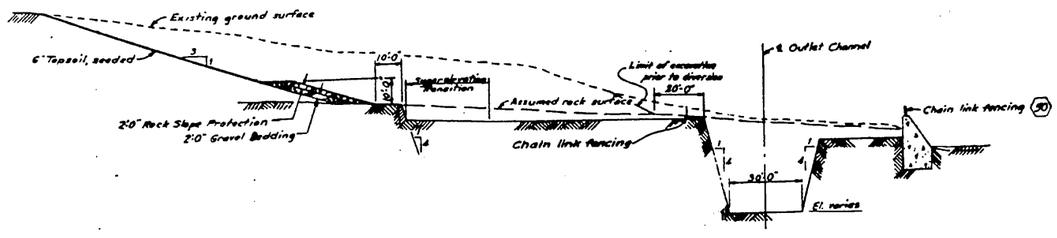



STATION 15+00
SCALE: 1"=20'

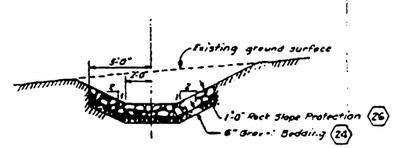



STATION 15+50
SCALE: 1"=20'

20' 0 20' 40'




STATION 11+00
SCALE: 1"=20'

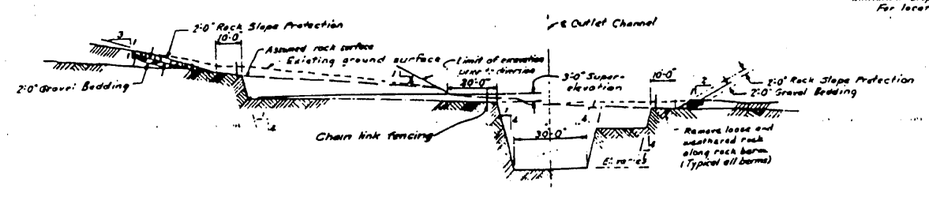



TYPICAL DRAINAGE DITCH SECTION
SCALE: 1"=4'

4 0 4 8'

Notes:
The alignment and slope of drainage ditch shall be as directed by the Contracting Officer. Minimum slope shall be 1.0%.
For location of drainage ditch, see Sheet No. 14.

NOTES:
Elevations refer to Mean Sea Level Datum.
Terminate chain link fencing 4' above channel invert.
For details of excavation in vicinity of concrete structures, see Sheet Nos. 20 thru 28 incl.
For Spillway and Outlet Works horizontal and vertical control, see General Plan, Sheet No. 14.




STATION 13+00
SCALE: 1"=20'

Record Drawing
Contract No. DA 19-117-ENG-3860-57

| REVISIONS | DATE | DESCRIPTION | BY |
|---|---|---|---|
| | 18-X-63 | Final Field Corrections | |

U.S. ARMY ENGINEER DIVISION, NEW ENGLAND
CORPS OF ENGINEERS
WALTHAM, MASS.

DES. BY G.E.M. | DR. BY E.H.W. | CK. BY R.W.M.

R. W. Mackey
Chief, Design Branch

APPROVED: [illegible]
Chief, Engineering Division

THAMES RIVER FLOOD CONTROL
WESTVILLE DAM
SPILLWAY AND OUTLET WORKS
CHANNEL SECTIONS
QUINEBAUG RIVER, MASSACHUSETTS

DATE OCT. 1959

SCALE: AS SHOWN | SPEC. NO. CIV ENG 19-ONE-60-27

DRAWING NUMBER
TH-1-1658

SHEET 19

PLATE 26

# APPENDIX A

Boring Logs

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site WESTVILLE LAKE DAM Page 1 of 1 Pages

Boring No. FD-85-1 Desig. PZ-1 Diam. (Casing) 4"

Co-ordinates: N STA 8+05 E OFF 29' D/S TOE

Elevation Top of Boring 540± M.S.L. Hammer Wt. — Boring Started 9/18/85

Total Overburden Drilled 0.6 Feet Hammer Drop —

Elevation Top of Rock 539.4± M.S.L. Casing Left 5' total 4" casing Boring Completed 9/19/85

Total Rock Drilled 9.9 Feet Subsurface Water Data _____ Page 5

Elevation Bottom of Boring 529.5± M.S.L. Obs. Well 2"

Total Depth of Boring 10.5 Feet Drilled By Jim Miller (CORPS)

Core Recovered 62 % No. Boxes 1 Mfg. Des. Drill truck mounted Failing 1500

Core Recovered 6.1 Ft. Diam. 4/2¾ in. Inspected By: Paul Fisher (ATL)

Soil Samples — in. Diam. — No. Classification By: Paul Fisher

Soil Samples — in. Diam. — No. Classification By: _____

| DEPTH 1" = 5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 0.6 | — | | | | Rotary Auger | sandy silt, tan, moist topsoil |
| 2.8 | RC-1 | 4" | | 23% | 4" Diamond Bit Turn shoe to 2.8' | granite & schist, fractured |
| 5.2 | RC-2 | 2¾" | | 75% | 2¾ ID x 3⅞ OD Core Barrel | |
| 8.2 | RC-3 | 2¾" | | 73% | | |
| 10.5 | RC-4 | 2¾" | | 70% | END OF EXPLORATION | |

GENERAL REMARKS: Elevations are approximate only and are estimated from the topographic map of the dam included in Section 3a.

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site WESTVILLE LAKE DAM — Page 1 of 1 Pages

Boring No. FD-85-2 Desig. PZ-2 Diam. (Casing) 4"

Co-ordinates: N STA 7+10 E OFF 23' D/S Toe

Elevation Top of Boring 530± M.S.L. Hammer Wt. — Boring Started 9/19/85

Total Overburden Drilled 2.3 Feet Hammer Drop — Boring Completed 9/23/85

Elevation Top of Rock 527.7± M.S.L. Casing Left 5' total 4" casing

Total Rock Drilled 7.9 Feet Subsurface Water Date — Page 5

Elevation Bottom of Boring 519.8± M.S.L. Obs. Well 2"

Total Depth of Boring 10.2 Feet Drilled By Jim Miller (CORPS)

Core Recovered 61 % No. Boxes 1 Mfg. Des. Drill truck mounted Failing 1500

Core Recovered 4.8 Ft. Diam. 2 3/4 / 1 3/4 in. Inspected By: Paul Fisher (ATL)

Soil Samples — In. Diam. — No. Classification By: Paul Fisher

Soil Samples — In. Diam. — No. Classification By:

| DEPTH | 1" = 5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|---|
| 2.3 | | | 4" | | | Rotary Auger | Sandy Silt, Br, Moist, TOPSOIL, rock fragments (ML) |
| 5.5 | | RC-1 | CORE 2 3/4 | | 88% | 2 3/4 ID Rock Core (See Note) | Schist, fractured |
| 10.2 | | RC-2 | 1 3/4 | | 43% | 1 3/4 ID Rock Core<br>END OF EXPLORATION | Schist + Granite, fractured |

GENERAL REMARKS: Lost diamond bit, 811C-127, and reaming shell, 812C-116, in hole at 5.5 ft.

Elevations are approximate only and are estimated from the topographic map of the dam included in Section 3a.

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site WESTVILLE LAKE DAM Page 1 of 1 Page:

Boring No. FD-85-3 Desig. PZ-3 Diam. (Casing) 4"

Co-ordinates: N STA 6+00 E OFF 10' D/S TOE

Elevation Top of Boring 520± M.S.L.
Total Overburden Drilled 19.0 Feet
Elevation Top of Rock 501.0± M.S.L.
Total Rock Drilled 4 Feet
Elevation Bottom of Boring 497± M.S.L.
Total Depth of Boring 23 Feet
Core Recovered 65 % No. Boxes 1
Core Recovered 2.6 Ft. Diam. 2 3/4 In.
Soil Samples 1 7/8 In. Diam. 1-5 No.
Soil Samples — In. Diam. — No.

Hammer Wt. 140 lb Boring Started 9/23/85
Hammer Drop 30"
Casing Left 5' total 4" casing Boring Completed 9/26/85
Subsurface Water Data Page 5
Obs. Well 2"
Drilled By Jim Miller (CORPS)
Mfg. Des. Drill truck mounted Failing 1500
Inspected By: Paul Fisher (ATL)
Classification By: Paul Fisher
Classification By:

| DEPTH 0 | DEPTH 1" = 5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|---|
| 1.1 | | SS-1 | 1 7/8 | REC 30% | 4 18 | Rotary Auger | Sandy silt, br, moist, topsoil, rock fragments (ML) |
| 5.7 | | RC-1 | 2 3/4 | | | 2 3/4 ID x 3 7/8 OD core barrel followed by 4" Drill Casing<br>@ 3.5 ft, lost water | Schist and granite Boulder (SPOIL) |
| 7.2 | | SS-2 | 1 7/8 | 30% | 8 16 15 | Continue with 3 7/8" Roller Bit<br>No Water Return | Sandy Gravel, Br, some silt (SPOIL) (GP) |
| 10.0 | | | | | | | |
| 10.8 | | SS-3 | 1 7/8 | 70% | 50 60/2" | | Gravelly sand, Br, trace silt (SPOIL) (SP) |
| 15.2 | | RC-2 | 2 3/4 | | | 2 3/4 Rock Core | Granite Boulder (SPOIL) |
| 16.7 | | SS-4 | 1 7/8 | 70% | 5 35 60 | Continue with 3 7/8" Roller Bit<br>Regained water Return @ 15.2 | Sand & Gravel, Br. (SP) |
| 18.5 | | | | | | | |
| 19.0 | | SS-5 | 1 7/8 | 70% | 100+ | | Gravelly sand, trace clay (SPOIL) (SP) |
| 19.3 | | RC-3 | 2 3/4 | 50% | | | |
| 21.3 | | RC-4 | 2 3/4 | 68% | | | Schist with Granite Intrusions |
| 23.0 | | RC-5 | 2 3/4 | 65% | | END OF EXPLORATIONS | |

GENERAL REMARKS:
piez set @ 20'

Elevations are approximate only and are estimated from the topographic map of the dam included in Section 3a.

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site WESTVILLE LAKE DAM — Page 1 of 1 Pages

Boring No. FD-85-4 — Desig. PZ-4 — Diam. (Casing) 4"

Co-ordinates: N STA 5+00 — E OFF 5' D/S TOE

Elevation Top of Boring 518± M.S.L.
Total Overburden Drilled 20.8 Feet
Elevation Top of Rock — M.S.L.
Total Rock Drilled — Feet
Elevation Bottom of Boring 497.2± M.S.L.
Total Depth of Boring 20.8 Feet
Core Recovered — % No. Boxes —
Core Recovered — Ft. — Diam. — In.
Soil Samples 1 1/2 In. Diam. 1-4 No.
Soil Samples — In. Diam. — No.

Hammer Wt. 140 lb — Boring Started 9/30/85
Hammer Drop 30" — Boring Completed 9/30/85
Casing Left 5' total 4" casing
Subsurface Water Data — Page 5
Obs. Well 2"
Drilled By Jim Miller (CORPS)
Mfg. Des. Drill truck mounted Failing 1500
Inspected By: Beddoe
Classification By: Beddoe
Classification By:

| DEPTH (0, 1" = 5') | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 1.0 | SS-1 | 1 1/2 | Rec 30% | 5 18 | Rotary Auger to 5.0' | silty sand, some gravel, tan, moist TOPSOIL (SP) |
| 5.0 | | | | | | |
| 6.0 | SS-2 | 1 1/2 | 75% | 30 50+ | Roller Bit (5 inch). followed by 6" dHven casing. | silty sand, little gravel, tan, moist (SP) |
| 10.0 | | | | | | |
| 11.5 | SS-3 | 1 1/2 | 70% | 11 15 25 | | Brown clayey silt, some sand, little gravel - TILL (MH) |
| 15.0 | | | | | 4" rotated casing | |
| 16.0 | | 1 1/2 | 0% | 33 50+ | | no recovery @ 15' due to boulder |
| 16.5 | | | | | 3 7/8" roller bit followed by 4" casing | |
| 17.8 | SS-4 | 1 1/2 | 30% | 4 20 50+ | | sandy gravel, saturated, little silt (GP) |
| 20.8 | RC-1 | 2 3/4 | 100% | — | encounter large boulders, core with the 2 3/4" ID 3 7/8" OD diamond bit<br>END OF EXPLORATIONS | boulder sample - schist |
| | RC-2* | 2 3/4 | 70% | — | breakthrough for sample @ 20.8' | clayey silt with little GRAVEL and SAND, TILL (MH) |

GENERAL REMARKS: Elevations are approximate only and are estimated from the topographic map of the dam included in Section 3a.
encounter boulders 17.8'
leave boulder horizon 20.8'
set piez @ 17.5' above large boulders in sandy gravel
* RC-2 consists of sample taken @ 20.8' below boulder

NED FORM 58 (Test) MAR 71

Boring No. FD-85-4

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site Westville Dam Page 1 of 1 Pages

Boring No. FD-A FD-86-10 Desig. _____ Diam. (Casing) 4"

Co-ordinates: N _____ E _____

Elevation Top of Boring _____ M.S.L.
Total Overburden Drilled 25.3 Feet
Elevation Top of Rock — M.S.L.
Total Rock Drilled — Feet
Elevation Bottom of Boring _____ M.S.L.
Total Depth of Boring 25.3 Feet
Core Recovered — % No. Boxes —
Core Recovered — Ft : _____ Diam. — In.
Soil Samples 3 In. Diam. 3 No.
Soil Samples _____ In. Diam. _____ No.

Hammer Wt. 300 Boring Started 10/20/86
Hammer Drop 30"
Casing Left 7' Boring Completed 10/20/86
Subsurface Water Data _____ Page _____
Obs. Well _____
Drilled By Mobile Dist. (F. Brown)
Mfg. Des. Drill Failing 314
Inspected By: E. McCollum
Classification By: E. McCollum
Classification By: _____

| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 5 | 1 | | | | 0-7': 5½" rockbit | Yellowish Br. Lean CLAY w/Gravel (25-35) (CL) |
| 10 | | | | | 7.0'-25.3' 4x5½ core barrel, | |
| 15 | 2 | | | | | Olive well-graded Clayey, Silty (40) SAND w/Gravel (16) (SC) |
| 20 | 3 | | | | | Olive well-graded Clayey, Silty (35-45) SAND w/Gravel (10-20) (SC) |
| 25 | | | | | | |

GENERAL REMARKS:

FORM 7.58 (Test)

Boring No. _____

PZ-6 —

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site Westville Dam. Page 1 of 1 Pages

Boring No. FD-B Desig. _____ Diam. (Casing) 4"
FD-86-11

Co-ordinates: N _____ E _____

Elevation Top of Boring _____ M.S.L.
Total Overburden Drilled 18.2 Feet
Elevation Top of Rock N/A M.S.L.
Total Rock Drilled N/A Feet
Elevation Bottom of Boring _____ M.S.L.
Total Depth of Boring 18.2 Feet
Core Recovered _____ % No. Boxes _____
Core Recovered _____ Ft : _____ Diam. _____ In.
Soil Samples 3" In. Diam. 1 No.
Soil Samples _____ In. Diam. _____ No.

Hammer Wt. 300 Boring Started 10/21/86
Hammer Drop 30
Casing Left 5 Boring Completed 10/21/86
Subsurface Water Data _____ Page _____
Obs. Well P-6
Drilled By Mobile Dist (F. Brown)
Mfg. Des. Drill Failing 314
Inspected By: E. McCollum
Classification By: E. McCollum
Classification By: _____

| DEPTH 1"=5 | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 0 | | | | | 0.0-5.0' 5 5/8" rock bit | Cobbles & Boulders w/Lean Clay |
| 5 | 1 | 3" | | | 5.0' to 6.5' 3" spoon Blows, 9/16/18 | Yellowish Br. Well-graded Clayey, Silty (35-45) SAND w/Gravel (10-20) (SC) (MS) |
| 10 | | | | | 6.5' to 18.2', 5 5/8" rk. bit. | |
| 15 | | | | | 18.2', 50 blows, NO PEN. | Olive Lean CLAY w/Sand & Gravel (CL) |
| 20 | | | | | B.O.H. d. 18.2' | |

GENERAL REMARKS:

NED FORM 7.58 (Test)

Boring No. _____

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

# FIELD LOG OF TEST BORING

Site Westville Dam Page 1 of 3 Pages

Boring No. ED-C Desig. _____ Diam. (Casing) 4"

Co-ordinates: N _____ E _____

Elevation Top of Boring 575.0 M.S.L.
Total Overburden Drilled 54.6 Feet
Elevation Top of Rock 492.4 M.S.L.
Total Rock Drilled 11.4 Feet
Elevation Bottom of Boring 481.0 M.S.L.
Total Depth of Boring 94 Feet
Core Recovered 75 % No. Boxes 1
Core Recovered 8.6 Ft: _____ Diam. HQ In.
Soil Samples 3" In. Diam. 6 No.
Soil Samples _____ In. Diam. _____ No.

Hammer Wt. 300 Boring Started 10/10/86
Hammer Drop 30"
Casing Left 35' Boring Completed 10/16/86
Subsurface Water Data _____ Page _____
Obs. Well _____
Drilled By Mobile Dist. (F. Brown)
Mfg. Des. Drill Failing 314
Inspected By: E. McCollum
Classification By: E. McCollum
Classification By: ~~E. M~~

| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 5, 10, 15, 20, 25 | | | | | 0-29'<br>6" ODEX air hammer<br>no samples taken. | Rockfill |

GENERAL REMARKS: Total overburden drilled does not include rockfill. Static water level not observed during drilling.

Site: Westville Dam

Boring No. ED-86-9



| DEPTH 1" = 5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 25 | | | | | d. 28.0' | (NS) |
| 30 | 1 | 3" | | | 30.0' to 33.0'<br>Blows: 34, 44, 42, 25, 30, 29. | Red Br. SAND w/Rock Frags (10-20) & tr. Silt (0-5) (SP) |
| 35 | | | | | | (NS) |
| 40 | 2 | 3" | | | 38.6' to 40.1'<br>Blows: 10, 16, 19 | Br. Clayey Silty (30-40) SAND (SC) |
| 45 | | | | | | (NS) |
| 50 | | | | | #3. 48.5' to 48.9'<br>Blows: 60+ | Br. Clayey Silty (30-40) SAND (SC) |
| 55 | | | | | | (NS) |
| 60 | 4 | 3" | | | #4. 58.4' to 59.2'<br>Blows: 14, 50+ | Uniform c. SAND (@ ½") w/1 piece Gravel (PERVIOUS FILL) (SP) |
| 65 | | | | | | (NS) |

Site: Westville Dam

Boring No. FD-86-9



| DEPTH (ft.) | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 70 | | | | | | (NS) |
| | 5 | 3" | | | 70.8' to 72.2'<br>Blows: 25,25,50+ | Olive Gr. Sandy (15-25) Lean CLAY w/f(c) Gravel (0-10) (CL) |
| 75 | | | | | | (NS) |
| 80 | 6 | 3" | | | 79.6' to 80.9'<br>Blows: 24,53,50+<br>d. 82.6 | Olive Gr. Sandy (20-30) Lean CLAY w/f(c) Gravel (0-10) (CL)<br>Top of Rock |
| 85 | 1 | HQ | | | Run 1: From: 82.6<br>To: 88.2<br>Run: 5.6<br>Rec: 4.6<br>U.L. 1.0<br>Tape depth: 88.2 | 82.6' to 83.2': Schist, lt. gray, hard, sli. to mod. weathered.<br>83.2' to 84.4': Granite, white, pegmatite.<br>84.4' to 92.2': Schist, lt. gray, hard, sli. to mod. weathered. Heavily weathered along jts. parallel to foliations, contains biotite, qtz. stringers and garnetiferous zones. |
| 90 | 2 | HQ | | | Run 2: From: 88.2<br>To: 94.0<br>Run: 5.8'<br>Rec: 4.0'<br>T.D. 92.2' 1.8' left in hole<br>d. 94.0 | |
| 95 | | | | | 84.1' to 84.4': vert. fracture, open, heavily stained.<br>84.6' to 86.6': Rock badly fractured, with clay filling, probable core loss in this zone. | B.O.H.<br>Core shows many breaks along foliations with mod. to heavy staining and weathering. Breaks on 0.1' to 0.4' centers. |

PZ-9/10

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# FIELD LOG OF TEST BORING

Site Westville Dam Page 1 of 3 Pages

Boring No. ED-D Desig. _____ Diam. (Casing) _____

Co-ordinates: N _____ E _____

Elevation Top of Boring 574.9 M.S.L.
Total Overburden Drilled 36.6 Feet
Elevation Top of Rock 504.5 M.S.L.
Total Rock Drilled 20.7 Feet
Elevation Bottom of Boring 483.8 M.S.L.
Total Depth of Boring 91.1 Feet
Core Recovered 69 % No. Boxes 2
Core Recovered _____ Ft: 14.3 Diam. HQ In.
Soil Samples 3" In. Diam. 8 No.
Soil Samples _____ In. Diam. ____ No.

Hammer Wt. 300 Boring Started 10/1/86
Hammer Drop 30"
Casing Left 45' Boring Completed 10/8/86
Subsurface Water Data _____ Page _____
Obs. Well _____
Drilled By Mobile Dist. (F. Brown)
Mfg. Des. Drill Failing 314
Inspected By: E. McCollum
Classification By: E. McCollum
Classification By: E. McCollum

| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| | | | | | 0.0' to 33.8' ODEX 6" hammer and 3" spoon | |
| 5 | | | | | | |
| 10 | 1 | 3" | | | 9.0-9.8' = 0.8' Blows: 25/33 bouncing refusal | Rock Frags. & GRAVEL w/Red. Br. Sand (0-10) (ROCK FILL) |
| | | | | | | (NS) |
| 15 | | | | | | |
| 20 | 2 | 3" | | | 19.4' to 20.7' = 1.4' Blows: 7/12/60 | Rock Frags. & GRAVEL w/Red. Br. Sand (0-10) (ROCK FILL) |
| | | | | | | (NS) |
| 25 | | | | | | |

GENERAL REMARKS:
Blows are listed for each 6" segment or fraction ~~thereof~~ thereof per drive

NED FORM 58 (Test)

Boring No. ED-86-8

PZ-9/10

| Site | Boring No. | Page 2 of 3 |
|---|---|---|
| Westville Dam | FD-86-8 (FD-D) | |

| DEPTH 1" = 5 | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 25 | | | | | | |
| | 3 | 3" | | | 26.4' to 28.2' = 1.8'<br>Blows: 20/26/31/29-<br>bouncing refusal | Rock Frags. & GRAVEL w/Red. Br. Sand (0-10) (ROCK FILL) |
| 30 | | | | | | (NS) |
| | | | | | el. 541.1 | Bottom of Rock Fill |
| 35 | 4 | 3" | | | 34.4' to 36.1' = 1.7'<br>Blows: 3/9/28 | Tan, well-graded SAND w/Rock Frags. (15-25) (SW) |
| 40 | | | | | | (NS) |
| 45 | 5 | 3" | | | 44.6' to 45.5' = 0.9'<br>Blows 25/50+ | Tan, well-graded SAND w/Rock Frags. (15-25) (SW) |
| | | | | | | (NS) |
| 50 | 6 | 3" | | | 50.9' to 51.6' = 0.7'<br>Blows: 34/50+ | Br. Silty (15-25) SAND w/Gravel (10-20) (SM) |
| | | | | | | (NS) |
| 55 | | | | | (#7) 55.9' to 56.1' = 0.2'<br>Blows: 75+ | (NR) |
| | | | | | | (NS) |
| 60 | | | | | (#8) 61.9' to 62.2' = 0.3'<br>Blows: 75+ | Dk. Br. Silty (18) f. SAND w/ heavily weathered rock frags (17) (SM) |
| 65 | | | | | | (NS) |

Site: Westville Dam

Boring No.: FD-86-8 (FD-D)



| DEPTH (ft) | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 70 | | | | | el. 504.5 T.O.R. | |
| 75 | 1 | HQ | | 91% | 70.4' to 76.1'<br>Run: 5.7'<br>Rec.: 5.2'<br>Hole blocked off at 67.6' | 70.4' to 70.9' - Granite: white, hard, mod. weathered.<br>70.9' to 72.6' - Schist: Lt. gray, sli. to mod. weathered, broken along foliations on 0.2' to 0.6' centers.<br>72.6' to 75.6' - Granite: white, peg. |
| 80 | 2 | HQ | | 36% | 76.1' to 81.1'<br>Run: 5.0'<br>Rec: 1.8'<br>Hole blocked off, no tape measurement. | |
| | 3 | HQ | | 62.5 | 81.1' to 83.5' C.D. 82.6'<br>Run: 2.4'<br>Rec: 1.5' | 75.6' to 81.1': Apparently broke through ledge rock. Very poor recovery. Only minor rock fragments. |
| 85 | 4 | HQ | | 76% | 83.5' to 91.1'<br>Run: 7.6'<br>Rec: 5.8'<br>C.D. 89.6 | 81.1' to 91.1' - Schist: lt. gray, quartz & biotite with zones containing varying amounts of garnet. Core broken along foliations on 0.3' to 0.5' centers. Breaks show mod. to heavy weathering. Rock is generally slightly weathered. |
| 90 | | | | | B.O.H | |
| 95 | | | | | 81.5' to 81.8': Intersecting joints; one @ 55°, one @ 70°. Both joints perpendicular to foliations or nearly so.<br>85.0 to 86.0 Core is badly broken. Breaks show mod. staining. Fractures appear to be randomly oriented. | |

PZ12/11

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# FIELD LOG OF TEST BORING

Site Westville Dam Page 1 of 3 Page

Boring No. FD 86-6 Desig. _____ Diam. (Casing) 4"

Co-ordinates: N _____ E _____

Elevation Top of Boring 543.0 M.S.L.
Total Overburden Drilled 40* Feet
Elevation Top of Rock 477.0 M.S.L.
Total Rock Drilled 10.4 Feet
Elevation Bottom of Boring 466.6 M.S.L.
Total Depth of Boring 76.4 Feet
Core Recovered 94.5 % No. Boxes 1
Core Recovered 10.4 Ft : _____ Diam. 3 7/8 In.
Soil Samples 1 1/2" In. Diam. 3 No.
Soil Samples 3 7/8" In. Diam. 1 No.

Hammer Wt. 140 Boring Started 9/16/86
Hammer Drop 30"
Casing Left 29' Boring Completed 9/24/86
Subsurface Water Data _____ Page _____
Obs. Well _____
Drilled By MOBILE DIST.
Mfg. Des. Drill FAILING 314 (CD-112)
Inspected By: Ernest R. McCollum
Classification By: McCollum
Classification By: McCollum

| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| | | | | | | 0-26' Rockfill |
| 5 | | | | | | |
| 10 | | | | | | |
| 15 | | | | | | (NS) |
| 20 | | | | | | |
| 25 | | | | | | |

GENERAL REMARKS: Used ODEX system to set 6" I.D. casing to 27.'
* Rockfill not included as over-burden.

NED FORM 58 (Test)

Boring No. FD-86-6

Site: Westville Dam

Boring No.: FD-86-6



| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 25 | | | | | Bottom of rock fill | |
| | 1 | 1½" | | | 27.6'-29.1'<br>S.P.T. - 31/73/93 | Br. Sandy, subrounded GRAVEL & rock frags. Gravel up to 1½" max. size (GP) |
| 30 | | | | | | (NS) |
| | 2 | 1½" | | | 34.0'-34.7'<br>S.P.T. - 50/100+ = 0.2' | Br. Well-graded SAND w/Silt (5-15) and subrounded to subangular Gravel (10-20) 1" max. (SP-SM) |
| 35 | | | | | | |
| | Run 1 | HQ | | | 37.0-41.0'<br>Run: 4'<br>Tape depth: 39.4' | COBBLES & BOULDERS |
| 40 | | | | | | |
| | Run 2 | HQ | | | 41.0'-50.0'<br>Run: 9.0'<br>Tape depth: 49.8' | |
| 45 | Jar 3 | | | | | Olive Gr. Lean CLAY w/Silt (5-15) (CL) |
| | | | | | | COBBLES & BOULDERS |
| 50 | | | | | | |
| | Run 3 | HQ | | | 50.0-59.4'<br>Run: 9.4'<br>Tape depth: 59.0' | COBBLES & BOULDERS |
| 55 | | | | | | |
| 60 | Run 4 | HQ | | | 59.4' to 64.8'<br>Run: 5.4'<br>Tape depth: 64.2'<br>Drive sample 4: 64.2' to 64.9'; S.P.T. - 83/50+-0.2' | |
| | Jar 4 | | | | | Br. Silty (15) SAND w/Gravel (28) (SM) |
| 65 | Top of Rock 66' | | | | 64.8' to 70.0'<br>Run: 5.2'<br>Recovered: 4.0' | Granite |

| Site | Boring No. | Page 3 of 3 |
|---|---|---|
| Westville Dam | FD-86-6 | |

| DEPTH (Ft.) | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| | Run 5 | HQ | | | Tape depth: 70.0' | |
| 70 | Run 6 | HQ | | | 70.0' to 77.0'<br>Run: 7.0'<br>Recovered: 6.4'<br>Tape depth: 76.4' | Granite; white, coarse grained, hard very hard, moderately weathered. Contains numerous garnets and some zones of qtz-biotite schist. |
| 75 | | | | | | |
| 80 | | | | | B.O.H.<br>Major Joints<br>1) 66.8'–67.0' @ 55°<br>2) 67.3'–67.6' @ 55°<br>3) 70.7'–71.0' @ 55°<br>4) 73.7–73.9 @ 55°<br>5) 74.3–74.5 @ 55°<br>6) 74.5–75.2; Shear zone, rock is fractured into less than 1" pieces, with no apparent orientation of fractures. | Foliations, when present, tend to be perpendicular to jointing. All joint surfaces heavily weathered. Entire section cored is horizontally fractured on generally 2"–4" centers and all fracture surfaces are stained brown and are ~~severly~~ weathered. |

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# FIELD LOG OF TEST BORING

Site Westville Dam Page 1 of 2 Pages

Boring No. FD-F Desig. _____ Diam. (Casing) 4"

Co-ordinates: N _____ E _____

Elevation Top of Boring 546.2 M.S.L.
Total Overburden Drilled 32.3 Feet
Elevation Top of Rock 513.9 M.S.L.
Total Rock Drilled 12.5 Feet
Elevation Bottom of Boring 501.4 M.S.L.
Total Depth of Boring 44.8 Feet
Core Recovered 92.9 % No. Boxes 1
Core Recovered 9.8 Ft : _____ Diam. 1.0 In.
Soil Samples 3" In. Diam. 1 No.
Soil Samples _____ In. Diam. _____ No.

Hammer Wt. 300 Boring Started _____
Hammer Drop 30"
Casing Left 27' Boring Completed _____
Subsurface Water Data _____ Page _____
Obs. Well _____
Drilled By Mobile Dist. (F. Brown)
Mfg. Des. Drill Failing 314
Inspected By: E. McCollum
Classification By: E. McCollum
Classification By: E. McCollum

| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 5, 10, 15, 20, 25 | | | | | 0-28.3 Drilled with ODEX hammer and 6" casing | 0-27.3' Rockfill; mixture of schist and white granite boulders. |

GENERAL REMARKS: Boring shown as FD-F on layout sheet. Samples and log labeled as boring no. FD-86-7.

| Site | Boring No. | Page 2 of 2 |
|---|---|---|
| Westville Dam | FD-86-7 (FD-F) | |

| DEPTH 1"=5' | CORE/SAMPLE NO. | SIZE | DEPTH RANGE | BLOWS PER FT. / CORE REC'VY | SAMPLING AND CORING OPERATIONS | CLASSIFICATION OF MATERIALS |
|---|---|---|---|---|---|---|
| 25 | | | | | Bottom of Rock fill | water level 27' (el. 5192) |
| | | | | | 27.3 to 32.3 5½" rock bit and 3" spoon | |
| | 1 | 3" | | | #1. 28.9' to 29.8' = 0.9' Blows 13/54 | Brtan poorly graded SAND (SP) |
| 30 | | | | | Top of Rock | |
| | | | | | 32.3' to 35' 5½ rock bit | 35.0'-37.3': Granite; white, hard, pegmatitic with numerous fractures on 0.2' to 0.3' centers. Fracture surfaces heavily stained and moderately weathered. |
| 35 | 1 | HQ | | 70% | 35.0' to 37.3' | |
| | 2 | HQ | | 100% | 37.3 to 40' | 37.3' to 40.0': Schist; lt. gray, hard, fresh to slightly weathered except along fractures which are parallel to foliations. |
| 40 | 3 | HQ | | 100% | 40' to 44.8' | |
| 45 | | | | | el. 501.4 BOH | |
| | | | | | 43.7' to 43.9' - jt, open, stained, perpendicular to foliations, jt. ~~plane~~ dip 55°. | Fractures are mod. to heavily weathered. Core is generally in pieces 0.2' which exhibit breaks along foliations. Zone from 39.0 to 40.0 severly fractured, had ~~total~~ loss of drilling fluid in this zone. Circ. not re-established. 40.0' to 44.8': Schist; lt. gray, hard, fresh to sli. weathered except along break parallel to foliations which are mod. to heavily weathered. Core in pieces 0.1' to 0.4' in length. |

# APPENDIX B

Falling Head Test Data

SITE: Westville Dam

BORING NUMBER: FD85-1

DATE: 09/26/85

PIEZOMETER NUMBER PZ-1

START TIME: 02:40:00

DATUM ELEVATION: 543.62

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 11.10

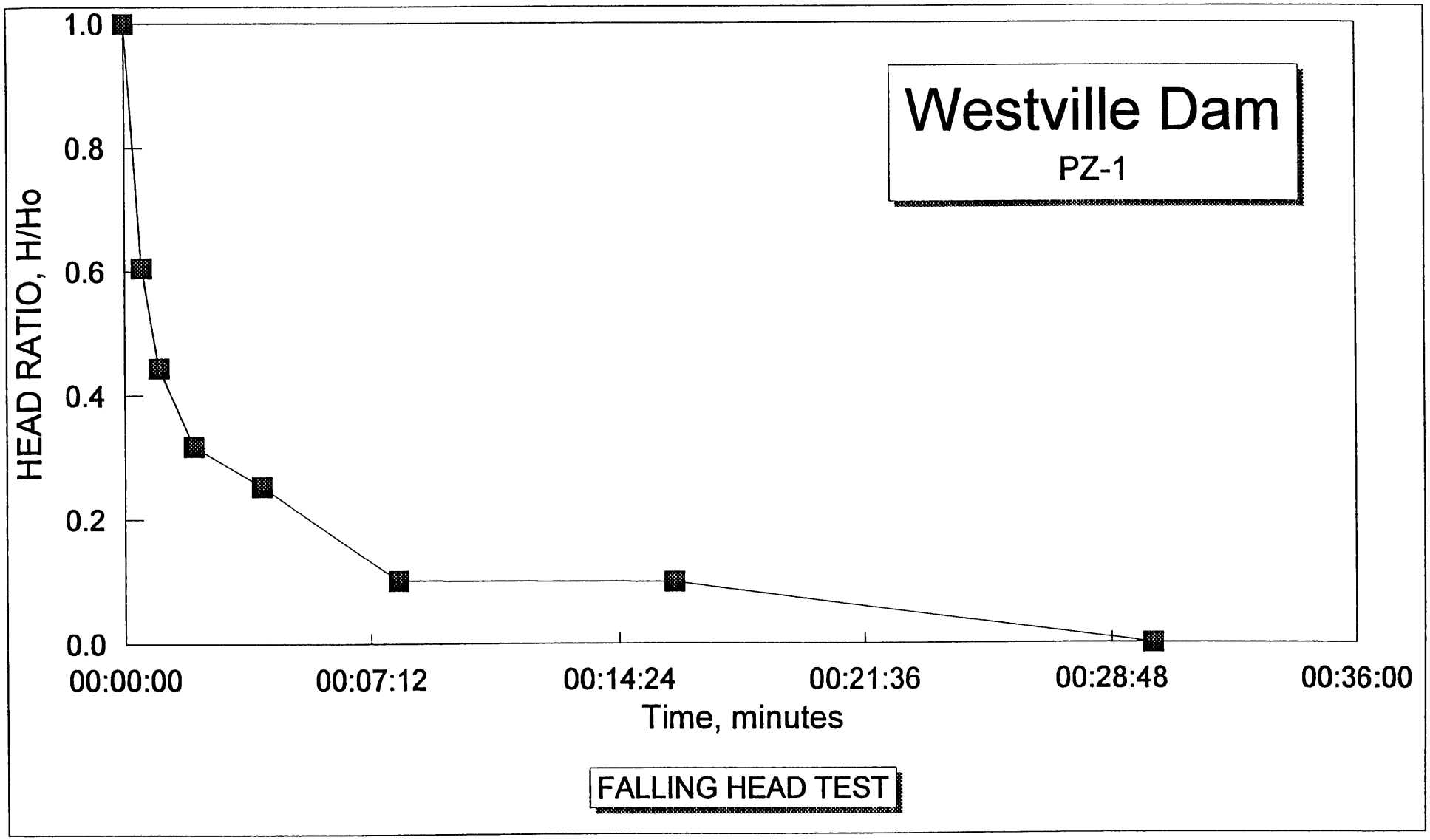
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 02:40:00 AM | 0.00 | 543.6 |
| 00:00:30 | 02:40:30 AM | 4.38 | 539.2 |
| 00:01:00 | 02:41:00 AM | 6.17 | 537.5 |
| 00:02:00 | 02:42:00 AM | 7.58 | 536.0 |
| 00:04:00 | 02:44:00 AM | 8.29 | 535.3 |
| 00:08:00 | 02:48:00 AM | 9.97 | 533.7 |
| 00:16:00 | 02:56:00 AM | 10.00 | 533.6 |
| 00:30:00 | 03:10:00 AM | 11.10 | 532.5 |

DATE REVISED: 09/14/95

INSPECTOR: FISHER

REMARKS:

09/14/95




WVPZ01FH.WK4

09/27/95

SITE: Westville Dam

BORING NUMBER: FD85-2

DATE: 09/26/85

PIEZOMETER NUMBER PZ-2

START TIME: 02:40:00

DATUM ELEVATION: 542.40

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 11.70

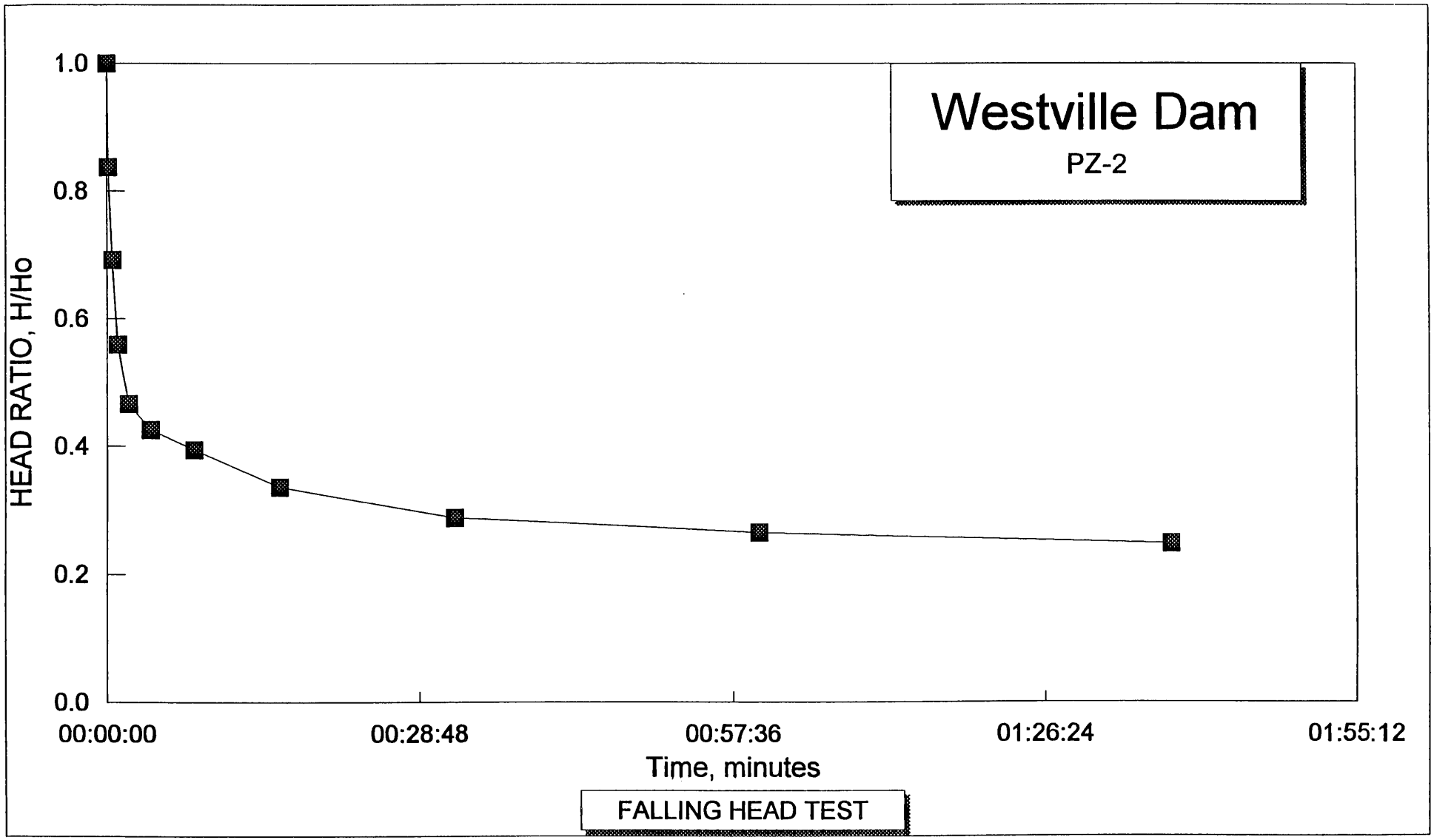
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 02:40:00 AM | 0.00 | 542.4 |
| 00:00:10 | 02:40:10 AM | 1.90 | 540.5 |
| 00:00:30 | 02:40:30 AM | 3.60 | 538.8 |
| 00:01:00 | 02:41:00 AM | 5.15 | 537.3 |
| 00:02:00 | 02:42:00 AM | 6.25 | 536.2 |
| 00:04:00 | 02:44:00 AM | 6.72 | 535.7 |
| 00:08:00 | 02:48:00 AM | 7.09 | 535.3 |
| 00:16:00 | 02:56:00 AM | 7.77 | 534.6 |
| 00:32:00 | 03:12:00 AM | 8.33 | 534.1 |
| 01:00:00 | 03:40:00 AM | 8.60 | 533.8 |
| 01:38:00 | 04:18:00 AM | 8.80 | 533.6 |

DATE REVISED: 09/27/95

INSPECTOR: FISHER

REMARKS:

09/27/95




WVPZ02FH.WK4

SITE: Westville Dam

BORING NUMBER: FD85-3

DATE: 10/01/85

PIEZOMETER NUMBER PZ-3

START TIME: 08:05:00

DATUM ELEVATION: 520.08

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 7.03

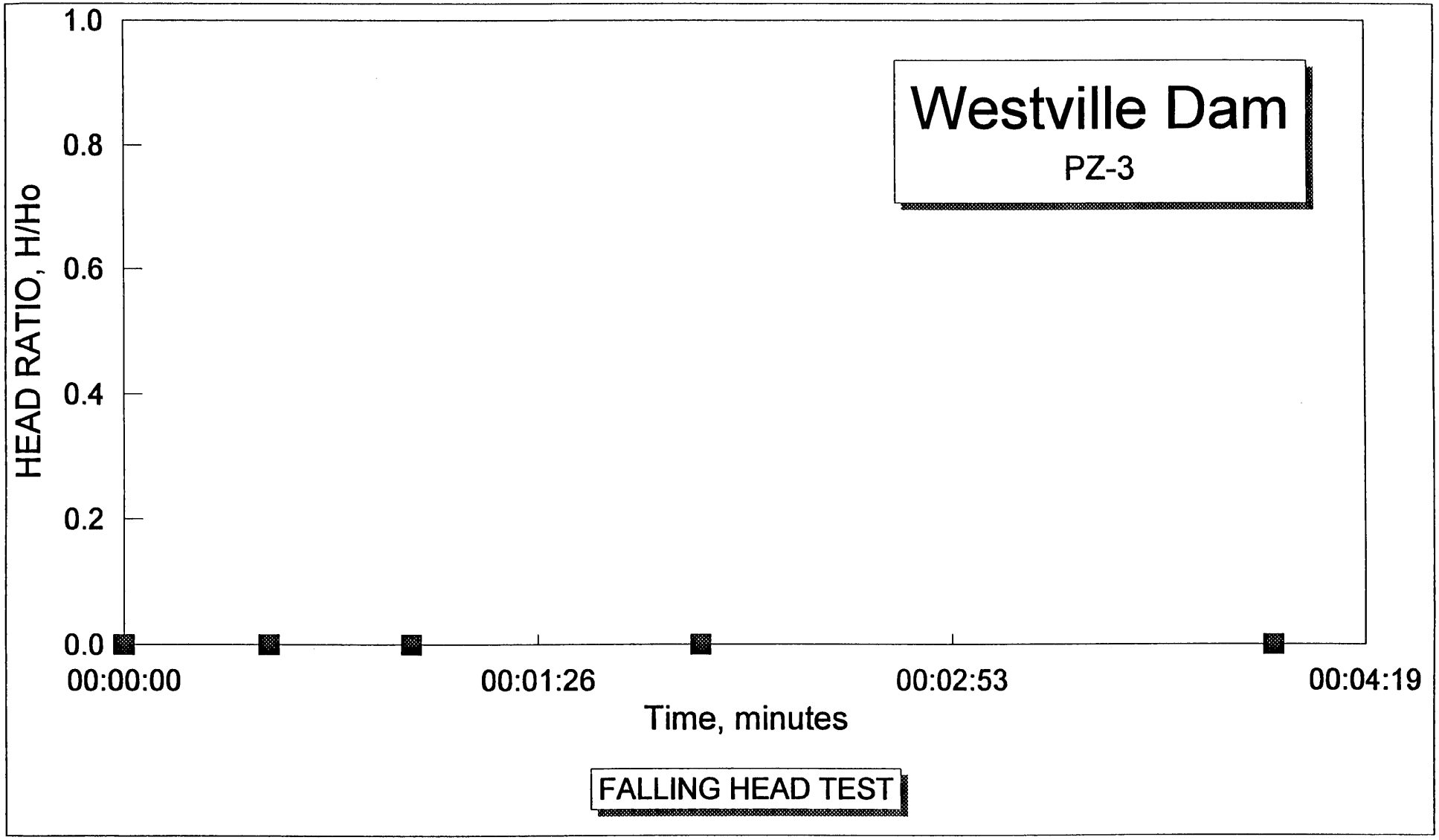
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 08:05:00 AM | 7.03 | 513.1 |
| 00:00:30 | 08:05:30 AM | 7.03 | 513.1 |
| 00:01:00 | 08:06:00 AM | 7.03 | 513.1 |
| 00:02:00 | 08:07:00 AM | 7.03 | 513.1 |
| 00:04:00 | 08:09:00 AM | 7.03 | 513.1 |

DATE REVISED: 09/14/95

INSPECTOR: BEDDOE

REMARKS: Piez test performed correctly, piez tested twice. Rapid decay of water level observed at start of tests.

09/14/95




WVPZ03FH.WK4

09/14/95

SITE: Westville Dam

BORING NUMBER: FD85-4

DATE: 10/01/85

PIEZOMETER NUMBER PZ-4

START TIME: 08:00:00

DATUM ELEVATION: 524.85

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 10.05

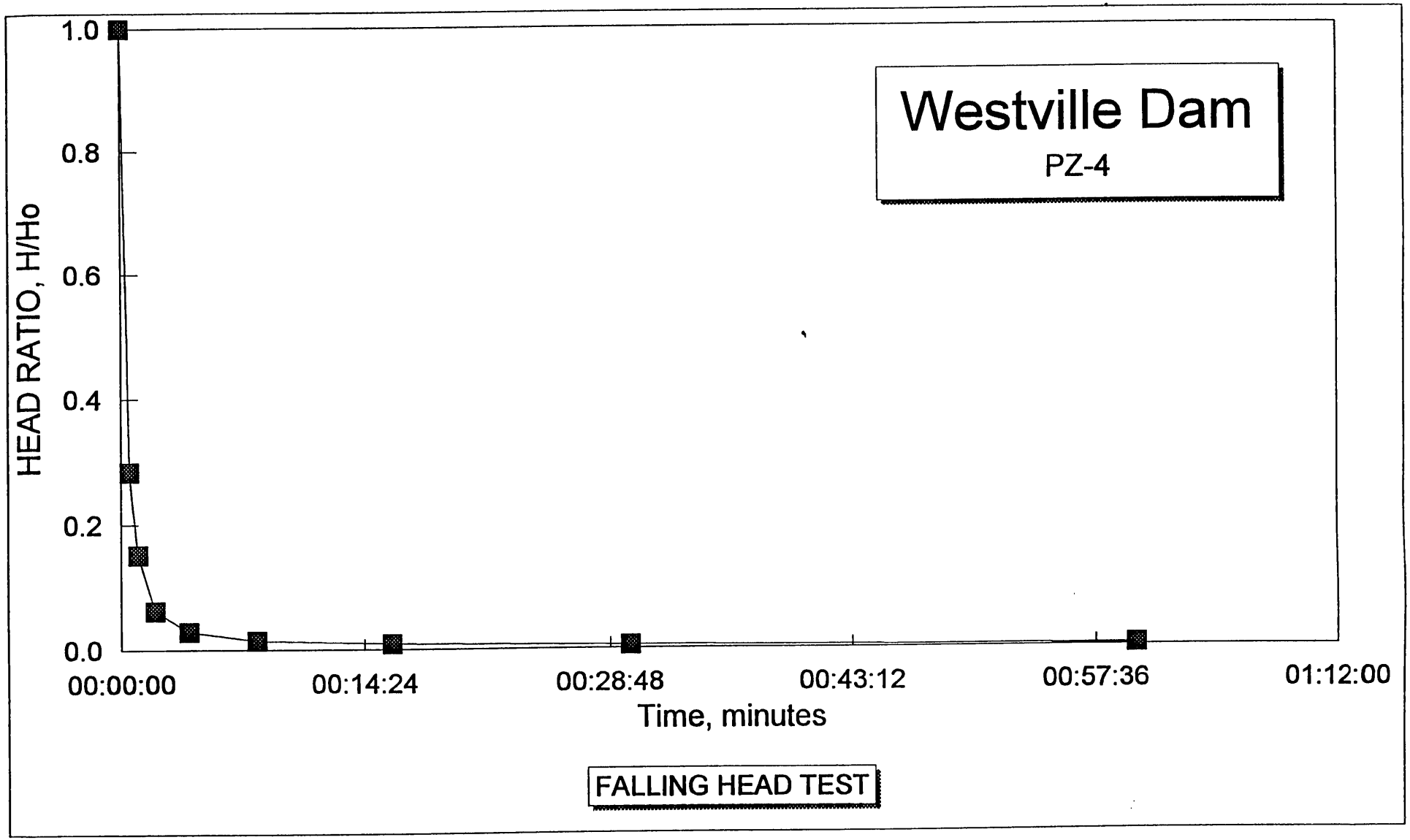
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 08:00:00 AM | 0.00 | 524.9 |
| 00:00:30 | 08:00:30 AM | 7.21 | 517.6 |
| 00:01:00 | 08:01:00 AM | 8.53 | 516.3 |
| 00:02:00 | 08:02:00 AM | 9.43 | 515.4 |
| 00:04:00 | 08:04:00 AM | 9.76 | 515.1 |
| 00:08:00 | 08:08:00 AM | 9.91 | 514.9 |
| 00:16:00 | 08:16:00 AM | 9.96 | 514.9 |
| 00:30:00 | 08:30:00 AM | 10.00 | 514.9 |
| 01:00:00 | 09:00:00 AM | 10.02 | 514.8 |

DATE REVISED: 09/14/95

INSPECTOR: BEDDOE

REMARKS: Total length of piez 20.58'

09/14/95




WVPZ04FH.WK4

SITE: Westville Dam

BORING NUMBER: FD86-10

DATE: 10/20/86

PIEZOMETER NUMBER PZ-5

START TIME: 14:12:00

DATUM ELEVATION: 545.68

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 5.30

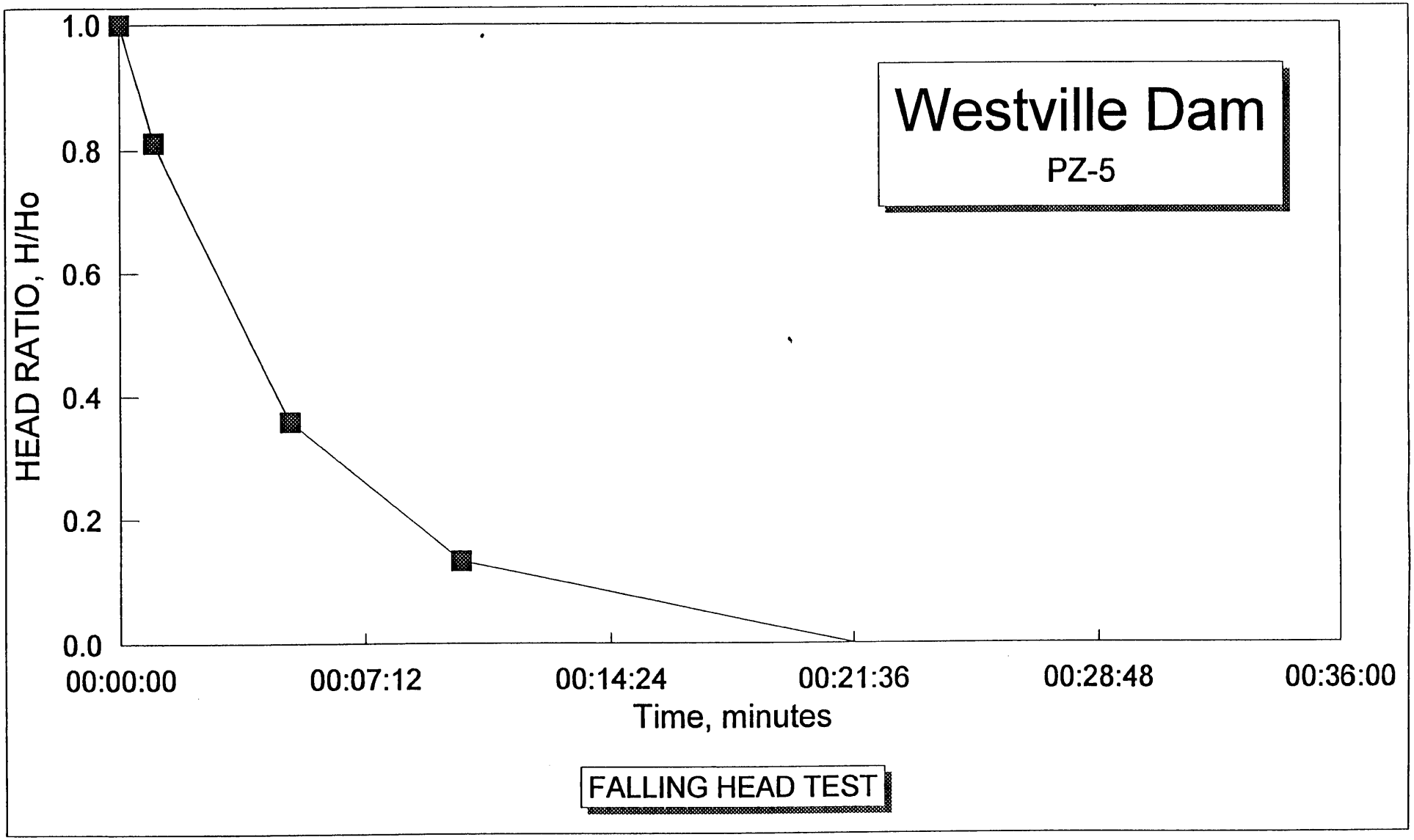
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 02:12:00 PM | 0.00 | 545.7 |
| 00:01:00 | 02:13:00 PM | 1.00 | 544.7 |
| 00:05:00 | 02:17:00 PM | 3.40 | 542.3 |
| 00:10:00 | 02:22:00 PM | 4.60 | 541.1 |
| 00:30:00 | 02:42:00 PM | 5.80 | 539.9 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS: No survey elevattiion on layout stake

09/14/95




WVPZ05FH.WK4

SITE: Westville Dam

BORING NUMBER: FD66-11

DATE: 10/26/86

PIEZOMETER NUMBER PZ-6

START TIME: 12:57:00

DATUM ELEVATION: 564.10

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 5.00

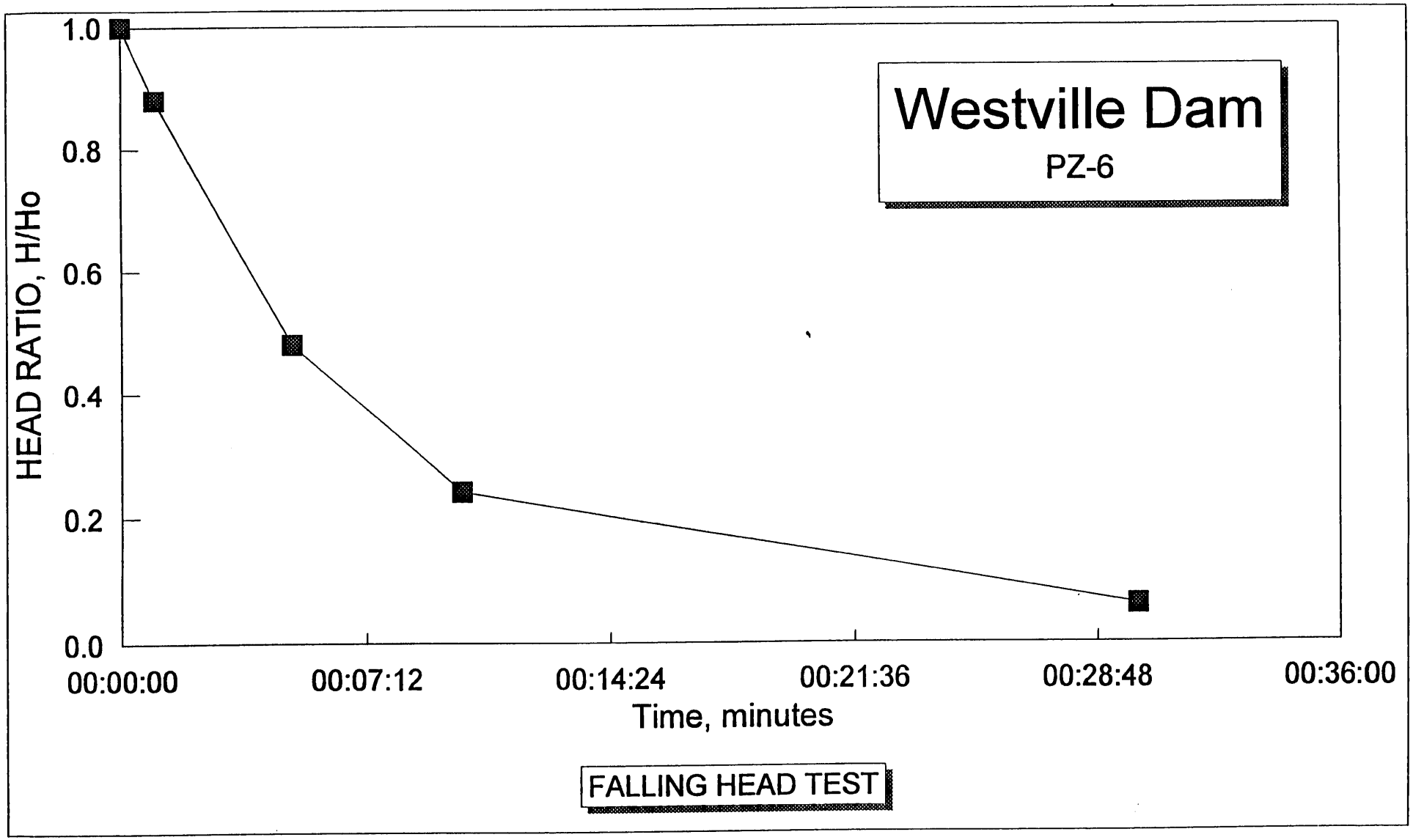
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 12:57:00 PM | 0.00 | 564.1 |
| 00:01:00 | 12:58:00 PM | 0.60 | 563.5 |
| 00:05:00 | 01:02:00 PM | 2.60 | 561.5 |
| 00:10:00 | 01:07:00 PM | 3.80 | 560.3 |
| 00:30:00 | 01:27:00 PM | 4.70 | 559.4 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS:

09/14/95




WVPZ06FH.WK4

SITE: Westville Dam

BORING NUMBER: FD86-9

DATE: 10/20/86

PIEZOMETER NUMBER PZ-7

START TIME: 10:45:00

DATUM ELEVATION: 574.25

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 60.80

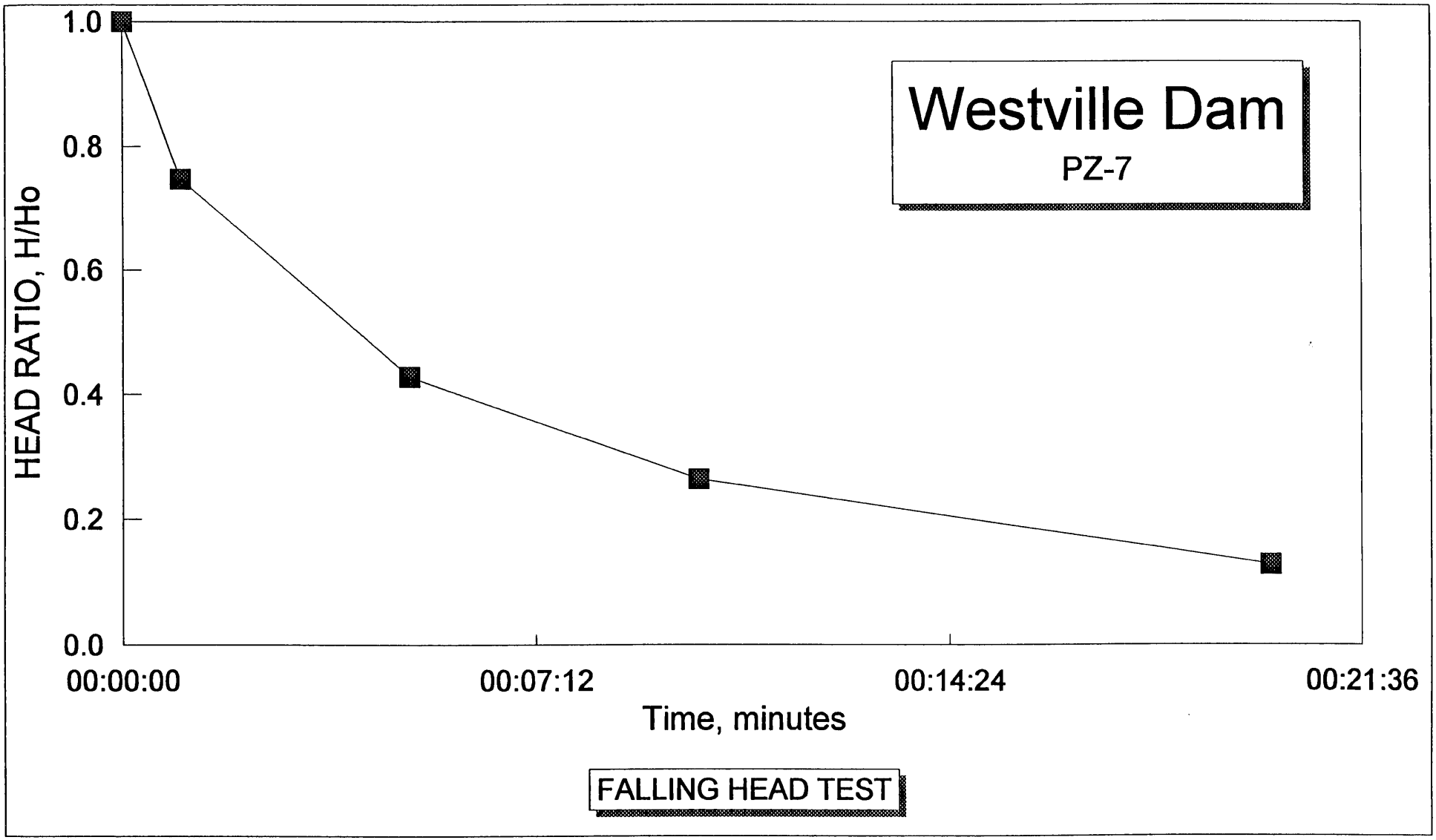
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 10:45:00 AM | 0.00 | 574.3 |
| 00:01:00 | 10:46:00 AM | 15.40 | 558.9 |
| 00:05:00 | 10:50:00 AM | 34.80 | 539.5 |
| 00:10:00 | 10:55:00 AM | 44.70 | 529.6 |
| 00:20:00 | 11:05:00 AM | 53.00 | 521.3 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS:

09/14/95




WVPZ07FH.WK4

09/14/95

SITE: Westville Dam

BORING NUMBER: FD86-9

DATE: 10/20/86

PIEZOMETER NUMBER PZ-8

START TIME: 11:59:00

DATUM ELEVATION: 574.14

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 60.80

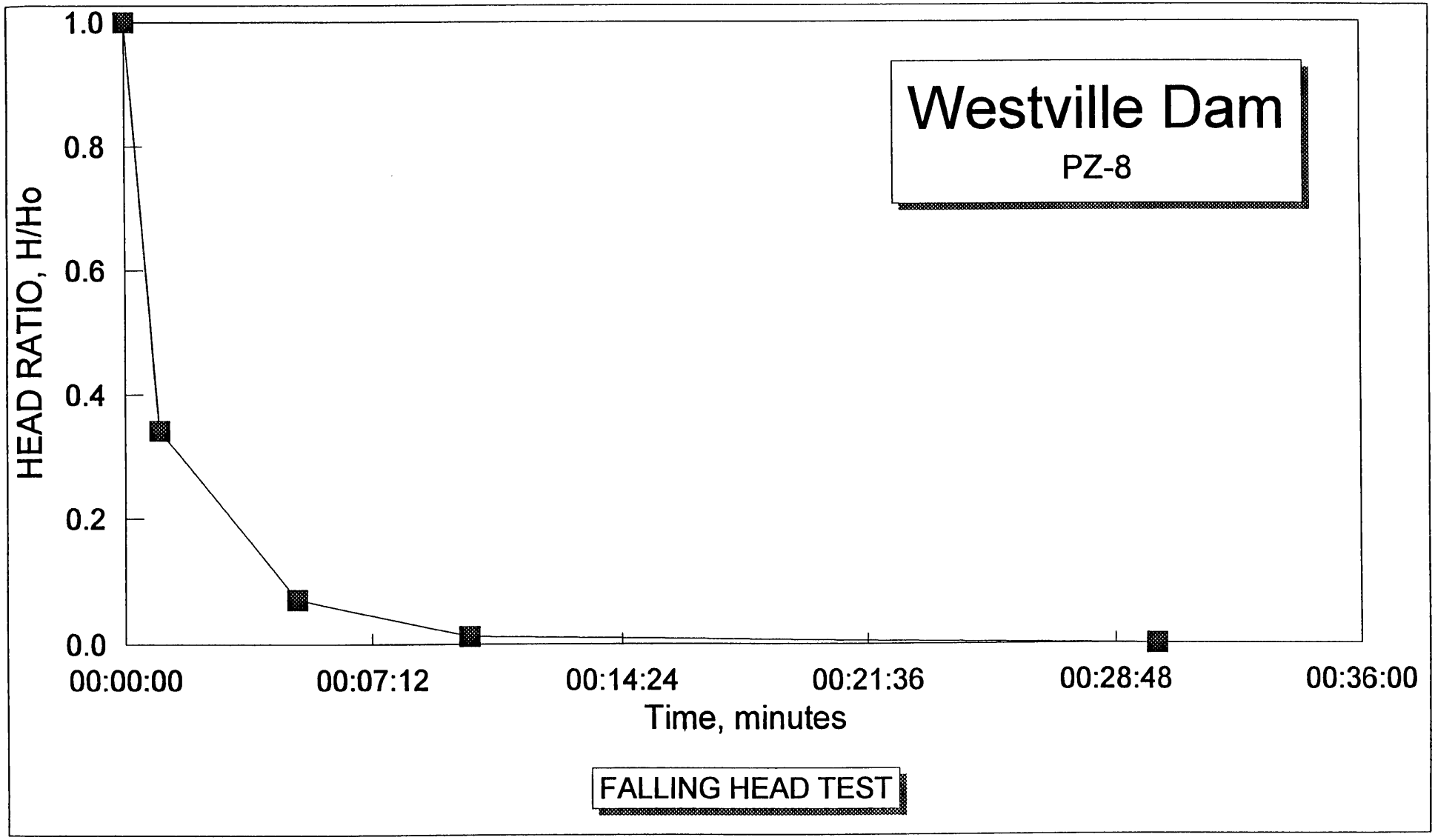
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 11:59:00 AM | 0.00 | 574.1 |
| 00:01:00 | 12:00:00 PM | 40.00 | 534.1 |
| 00:05:00 | 12:04:00 PM | 56.50 | 517.6 |
| 00:10:00 | 12:09:00 PM | 60.10 | 514.0 |
| 00:30:00 | 12:29:00 PM | 60.80 | 513.3 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS:

09/14/95




WVPZ08FH.WK4

09/14/95

SITE: Westville Dam

BORING NUMBER: FD86-8

DATE: 10/10/86

PIEZOMETER NUMBER PZ-9

START TIME: 00:00:00

DATUM ELEVATION: 577.49

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 61.60

| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 12:00:00 AM | NA | NA |
| 00:00:15 | 12:00:15 AM | NA | NA |
| 00:00:30 | 12:00:30 AM | NA | NA |
| 00:01:00 | 12:01:00 AM | NA | NA |
| 00:02:00 | 12:02:00 AM | NA | NA |
| 00:04:00 | 12:04:00 AM | NA | NA |
| 00:08:00 | 12:08:00 AM | NA | NA |
| 00:16:00 | 12:16:00 AM | NA | NA |
| 00:30:00 | 12:30:00 AM | NA | NA |
| 01:00:00 | 01:00:00 AM | NA | NA |
| 02:00:00 | 02:00:00 AM | NA | NA |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS: Water level at 61.6 prior to starting test. After adding water, could not fill riser pipe; water level was below tip of piez.

09/14/95

SITE: Westville Dam

BORING NUMBER: FD86-8

DATE: 10/10/86

PIEZOMETER NUMBER PZ-10

START TIME: 10:08:00

DATUM ELEVATION: 577.50

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 64.00

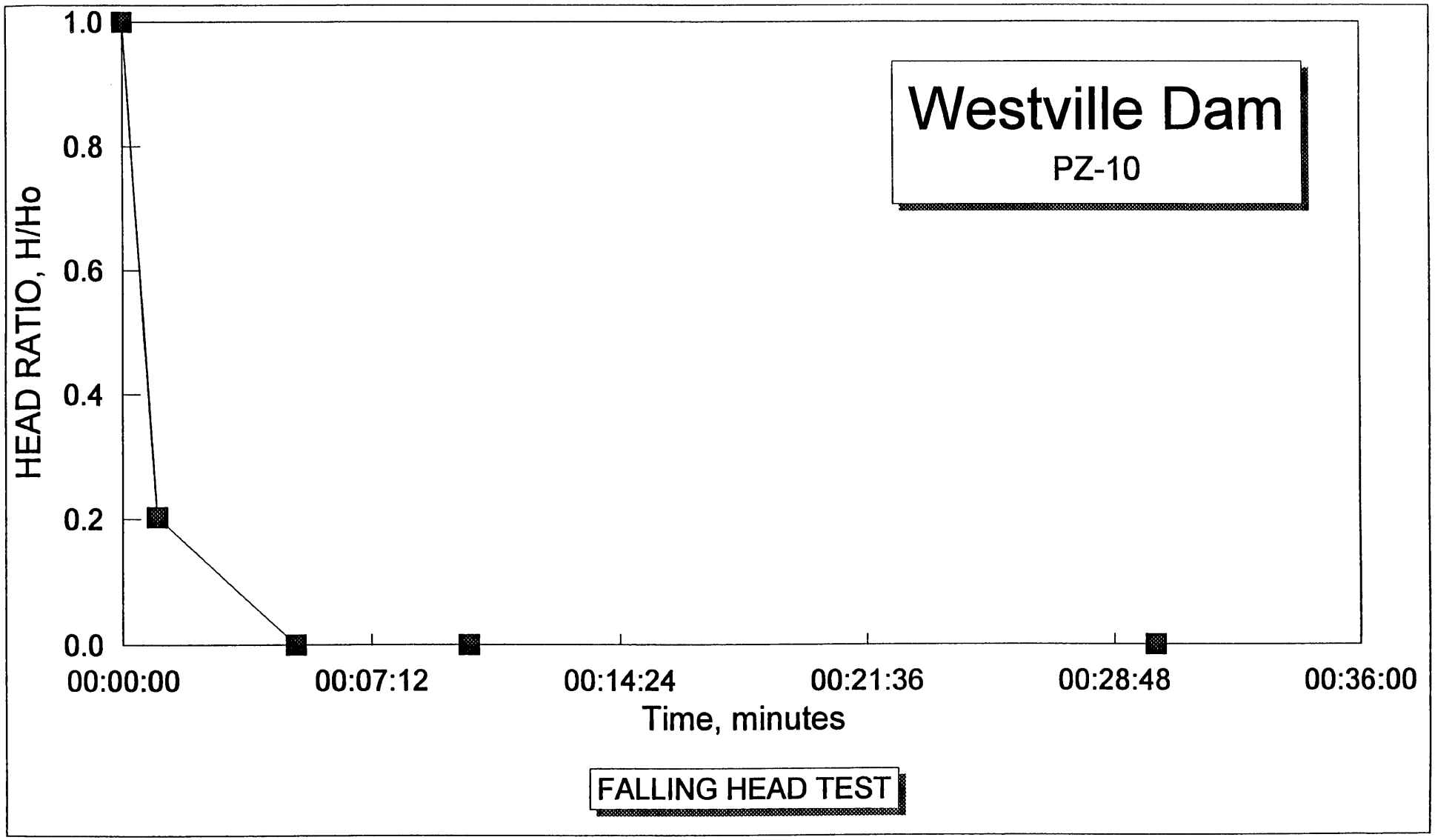
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 10:08:00 AM | 0.00 | 577.5 |
| 00:01:00 | 10:09:00 AM | 51.00 | 526.5 |
| 00:05:00 | 10:13:00 AM | 64.00 | 513.5 |
| 00:10:00 | 10:18:00 AM | 64.00 | 513.5 |
| 00:30:00 | 10:38:00 AM | 64.00 | 513.5 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS:

09/14/95




WVPZ10FH.WK4

SITE: Westville Dam

BORING NUMBER: FD86-6

DATE: 09/25/86

PIEZOMETER NUMBER PZ-11

START TIME: 12:29:00

DATUM ELEVATION: 544.59

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 31.60

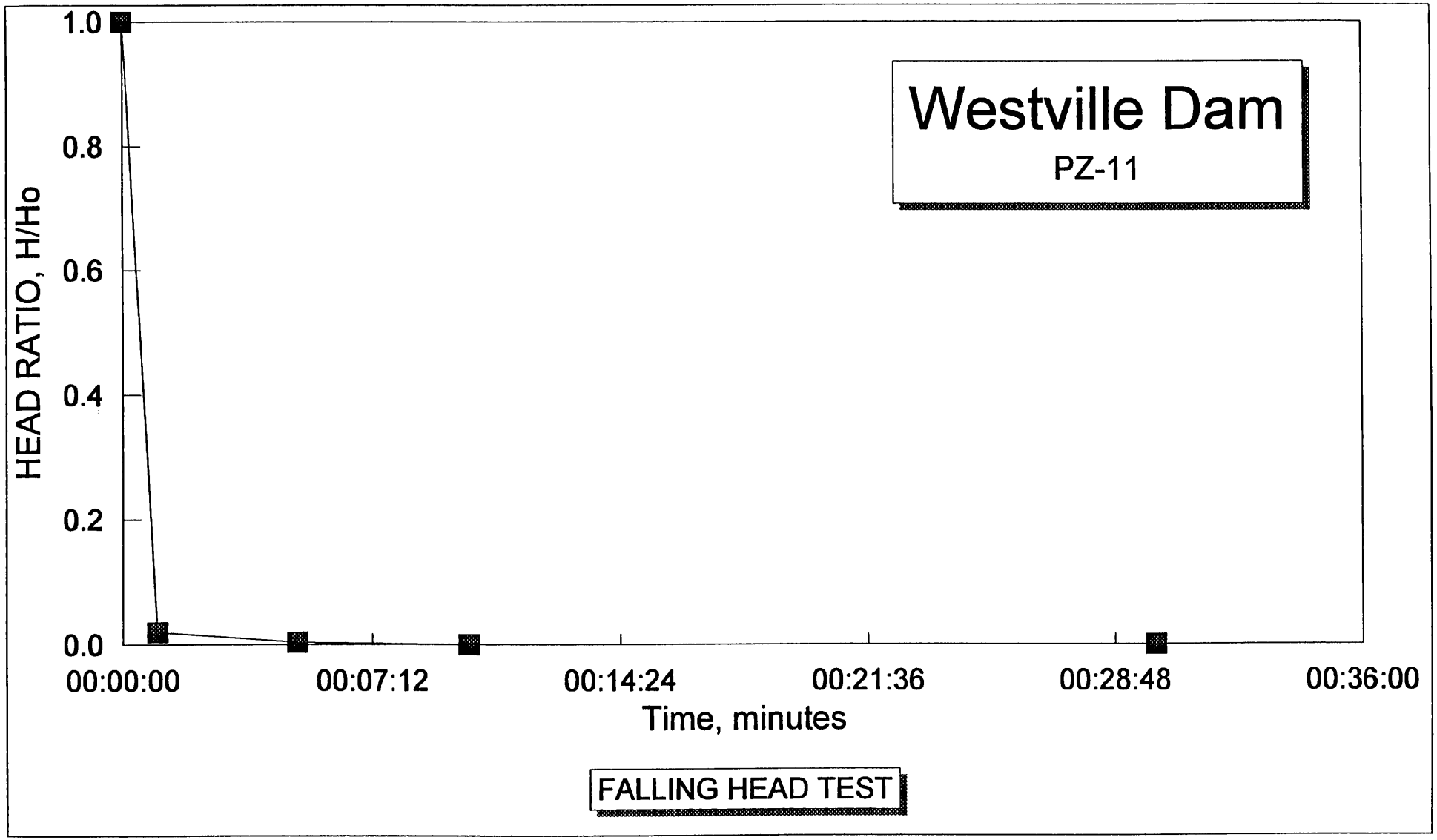
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 12:29:00 PM | 0.00 | 544.6 |
| 00:01:00 | 12:30:00 PM | 31.00 | 513.6 |
| 00:05:00 | 12:34:00 PM | 31.50 | 513.1 |
| 00:10:00 | 12:39:00 PM | 31.60 | 513.0 |
| 00:30:00 | 12:59:00 PM | 31.60 | 513.0 |

DATE REVISED: 09/14/95

INSPECTOR: FISHER

REMARKS:

09/14/95




WVPZ11FH.WK4

09/14/95

SITE: Westville Dam

BORING NUMBER: FD86-6

DATE: 09/25/86

PIEZOMETER NUMBER PZ-12

START TIME: 12:15:00

DATUM ELEVATION: 544.60

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 31.40

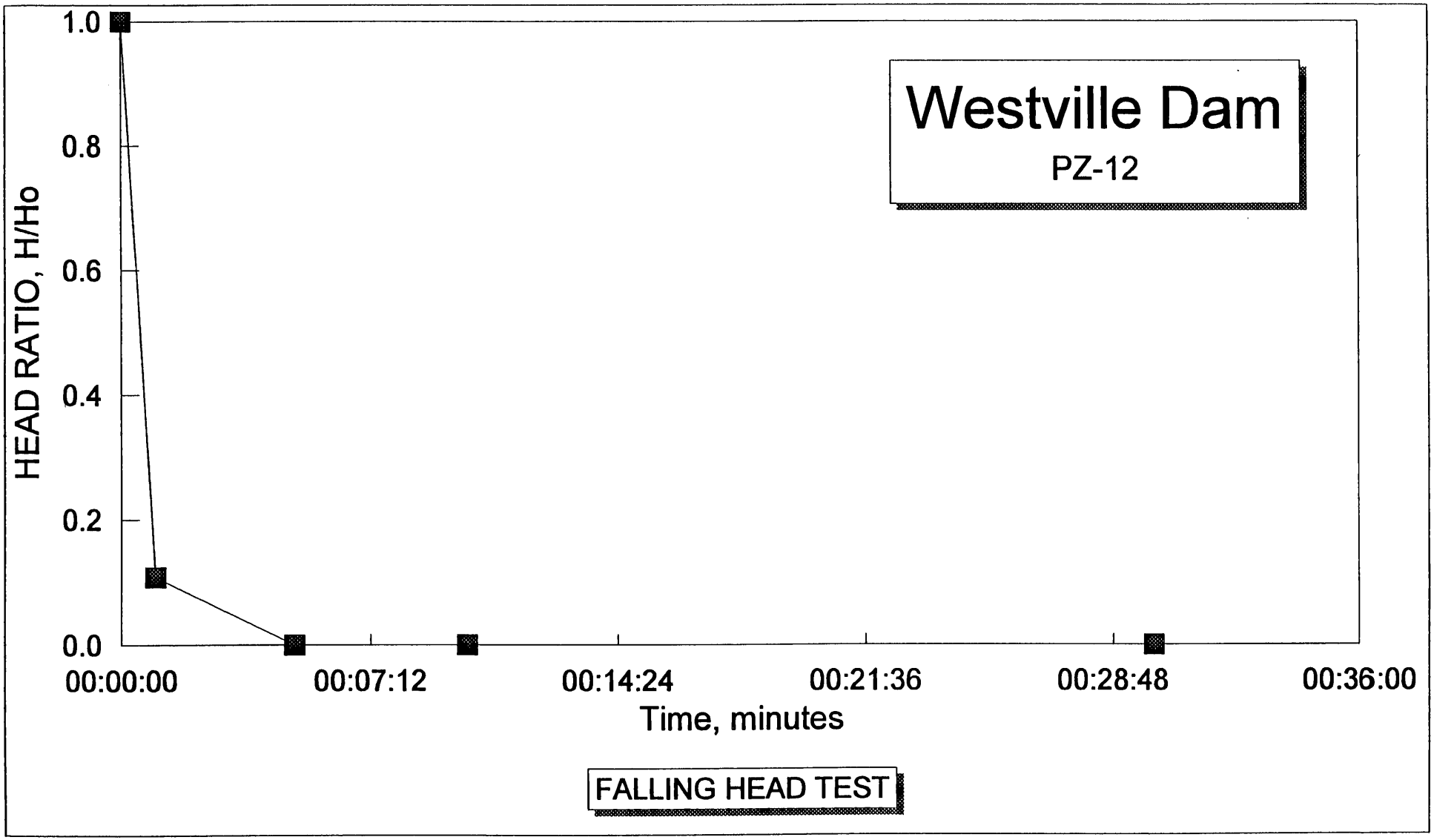
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 12:15:00 PM | 0.00 | 544.6 |
| 00:01:00 | 12:16:00 PM | 28.00 | 516.6 |
| 00:05:00 | 12:20:00 PM | 31.40 | 513.2 |
| 00:10:00 | 12:25:00 PM | 31.40 | 513.2 |
| 00:30:00 | 12:45:00 PM | 31.40 | 513.2 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS:

09/14/95




WVPZ12FH.WK4

SITE: Westville Dam

BORING NUMBER: FD86-7

DATE: 10/03/86

PIEZOMETER NUMBER PZ-13

START TIME:

DATUM ELEVATION: 543.83

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 29.40

| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 12:00:00 AM | NA | NA |
| 00:00:15 | 12:00:15 AM | NA | NA |
| 00:00:30 | 12:00:30 AM | NA | NA |
| 00:01:00 | 12:01:00 AM | NA | NA |
| 00:02:00 | 12:02:00 AM | NA | NA |
| 00:04:00 | 12:04:00 AM | NA | NA |
| 00:08:00 | 12:08:00 AM | NA | NA |
| 00:16:00 | 12:16:00 AM | NA | NA |
| 00:30:00 | 12:30:00 AM | NA | NA |
| 01:00:00 | 01:00:00 AM | NA | NA |
| 02:00:00 | 02:00:00 AM | NA | NA |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS: Was not able to fill riser pipe. Tried pouring water out of 5 gallon bucket through a funnel. After using several buckets of water no change in water level could be detected.

SITE: Westville Dam

BORING NUMBER: FD86-7

DATE: 10/03/86

PIEZOMETER NUMBER PZ-14

START TIME: 12:15:00

DATUM ELEVATION: 544.06

POOL ELE.: NA

INTIAL WATER DEPTH FROM TOP OF RISER 31.10

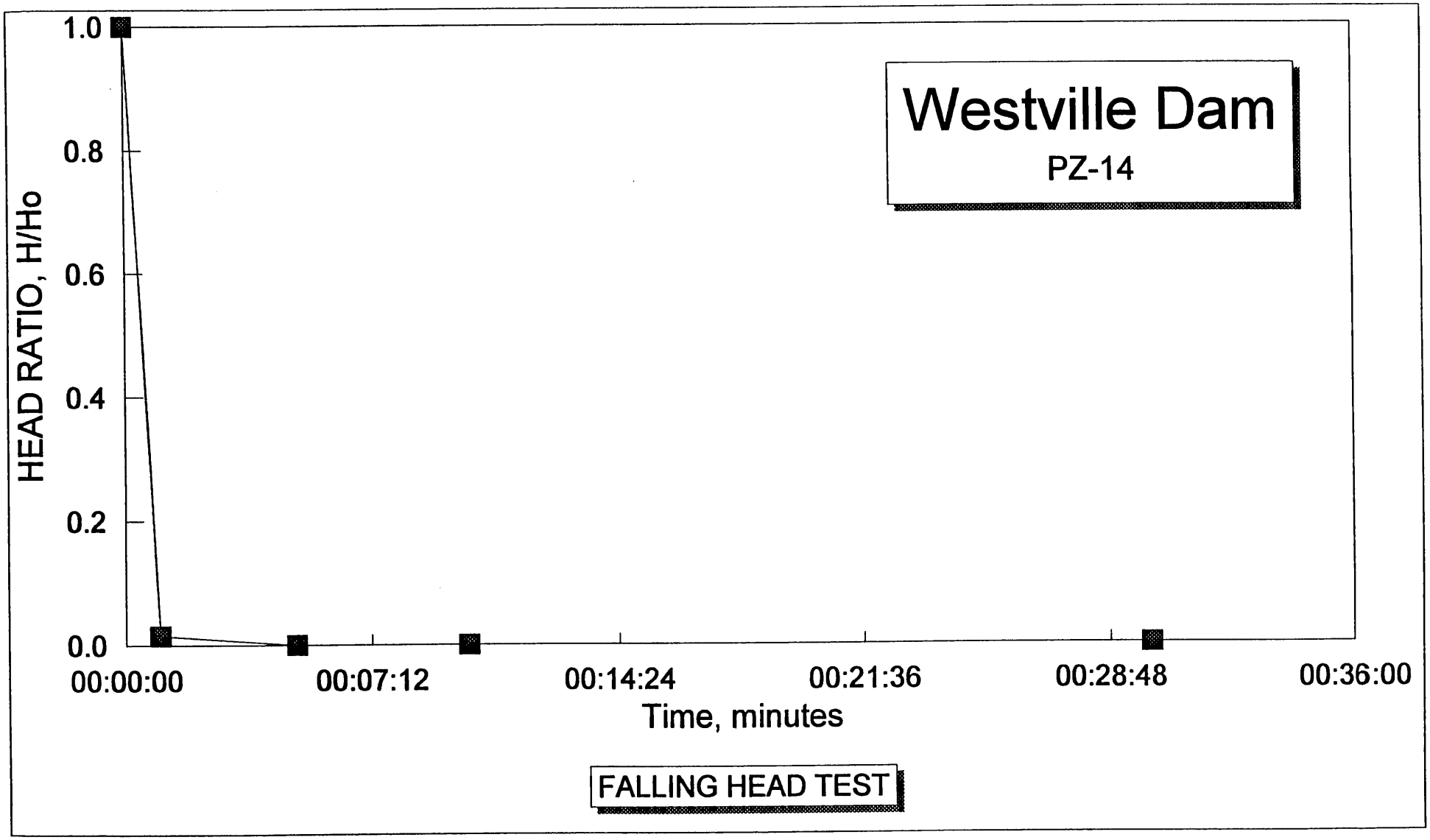
| LAPSE TIME | CLOCK TIME | DEPTH | ELEVATION |
|---|---|---|---|
| 00:00:00 | 12:15:00 PM | 0.00 | 544.1 |
| 00:01:00 | 12:16:00 PM | 30.65 | 513.4 |
| 00:05:00 | 12:20:00 PM | 31.10 | 513.0 |
| 00:10:00 | 12:25:00 PM | 31.10 | 513.0 |
| 00:30:00 | 12:45:00 PM | 31.10 | 513.0 |

DATE REVISED: 09/14/95

INSPECTOR: E. R. McCollum

REMARKS:

09/14/95




WVPZ14FH.WK4

# APPENDIX C

Reading Schedule for Piezometers

Source: Department of the Army, New England Division, Corps of Engineers

# READING SCHEDULE FOR PIEZOMETERS

1. General. Piezometers are utilized to measure groundwater levels and pore pressures both in the foundation and embankments of earth and rockfill dams. Experience has shown that installation of piezometers in earth fills and their foundation provides significant data indicating the magnitude and distribution of pore pressures and their variations with time and also patterns of seepage, zones of potential piping, and the effectiveness of underseepage control measures.

2. Piezometer Readings. At the present time, files are maintained for dams which have operating piezometers and most of the data is put on the computer. Data is transmitted to GED in writing by the project manager. Piezometer data should be reduced in the field and each reading compared with previous data; thus, if a piezometer has an unusual reading, the reading can be checked immediately. Pool elevations, tailwater elevations, measuring weir discharge quantities, and rainfall data should be recorded simultaneously with piezometer readings.

a. Reading Schedule.

(1) Routine. During periods when the reservoir is below the 20.0 foot stage (elevation 535.0 ft-NGVD) readings of all piezometers should be made by the project manager at least once a month. When access to instruments is made hazardous by snow or ice, the readings may be deferred until safe access is possible.

(2) High Pool. During periods when the reservoir level is at or above the 20 foot stage, including rising and falling pools, readings should be made on a daily basis. On a falling pool, the piezometers should continue to be read on a daily basis for at least five days after the pool has returned to its normal elevation. Pool elevations and all the other information requested in paragraph 2 should be recorded simultaneously with piezometer readings.

b. Data Collection.

(1) Location Maps. A general plan of the project showing the location of the active piezometers and the corresponding identification number for each piezometer is provided to eliminate identification and data recording inaccuracies.

(2) Data Collection Tables. A table listing the piezometer identification number, stationing and offset, as well as piezometer top and tip elevations is also provided for recording and submitting piezometer readings.

(3) Destination. All data should be sent to the following address:

U. S. Army Corps of Engineers
New England Division
ATTN: CENED-ED-GD
424 Trapelo Road
Waltham, MA 02254-9149 RE: Piezometers

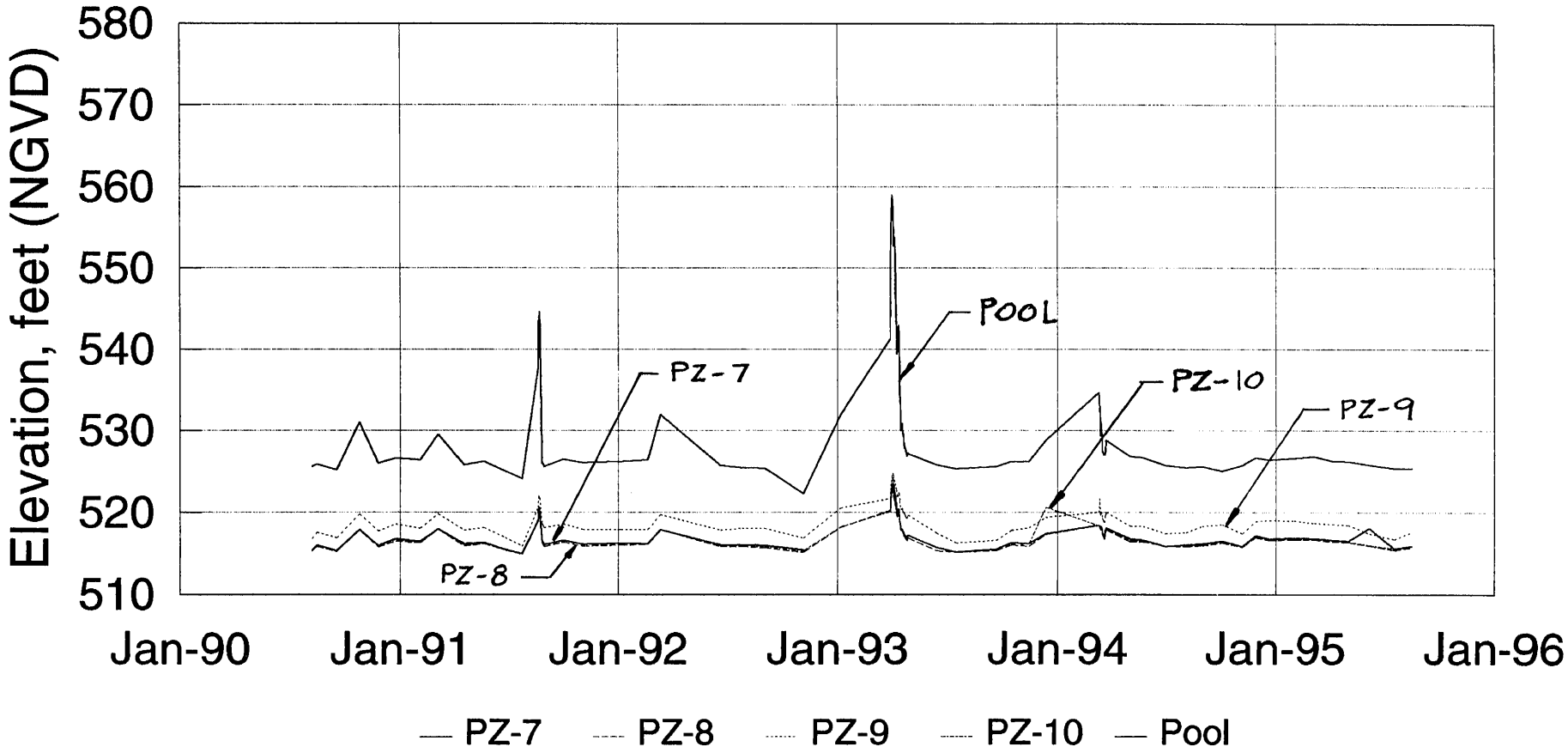
(4) Special Conditions. If unusual changes in readings develop or if piezometers become inoperable, Geotechnical Engineering Division should be contacted.

# APPENDIX D

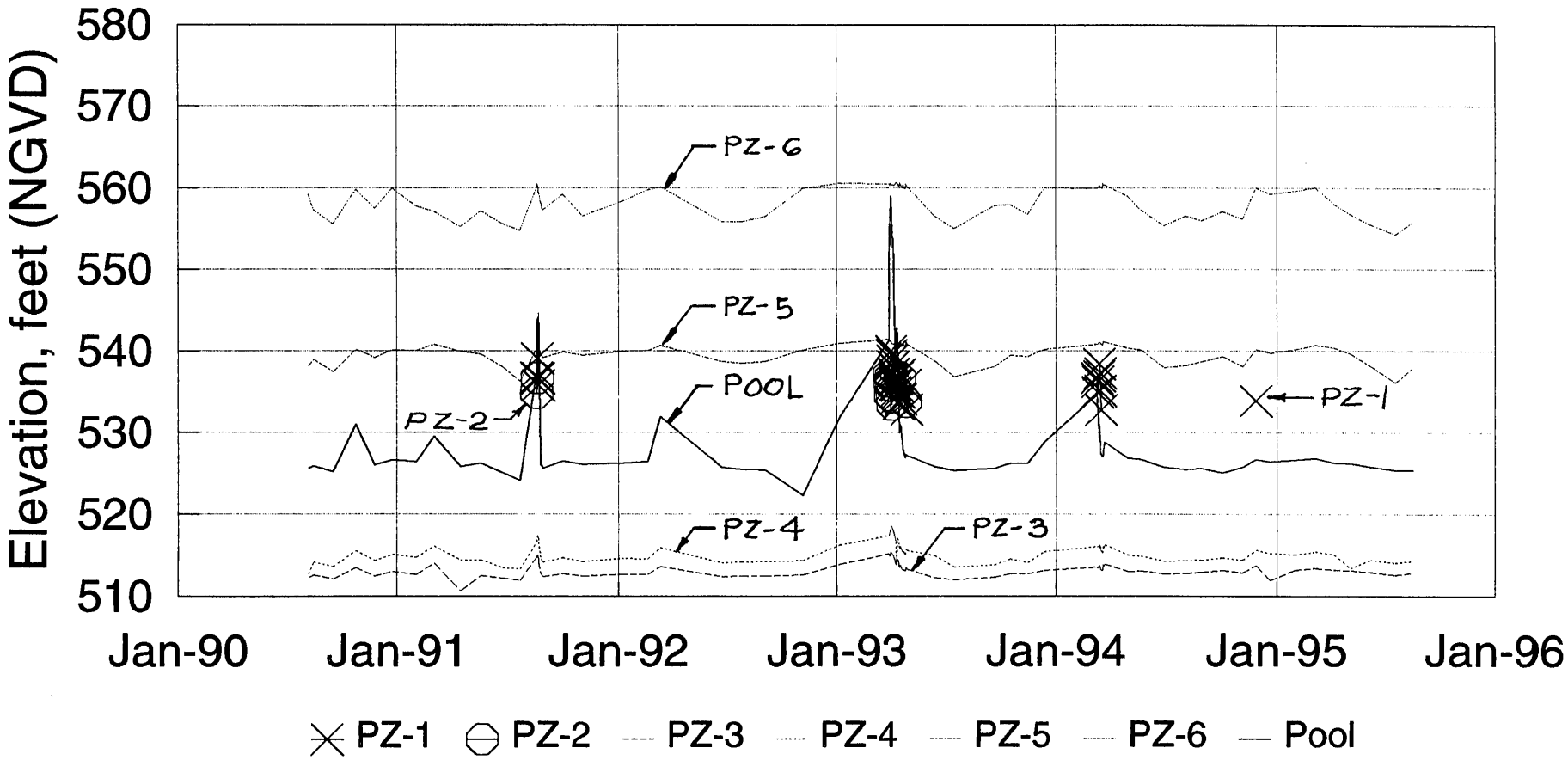
Piezometer Data, Time History Plots

Piezometer Time History, Profile A-A (PZ-7, 8, 9, and 10)
Piezometer Time History, Profile B-B (PZ-1, 2, 3, 4, 5, and 6)
Piezometer Time History, Section C-C at Station 5+15 (PZ-7, 8, 11, 12, and 4)
Piezometer Time History Plots, Section D-D at Station 6+00 (PZ-9, 10, 13, 14, and 3)

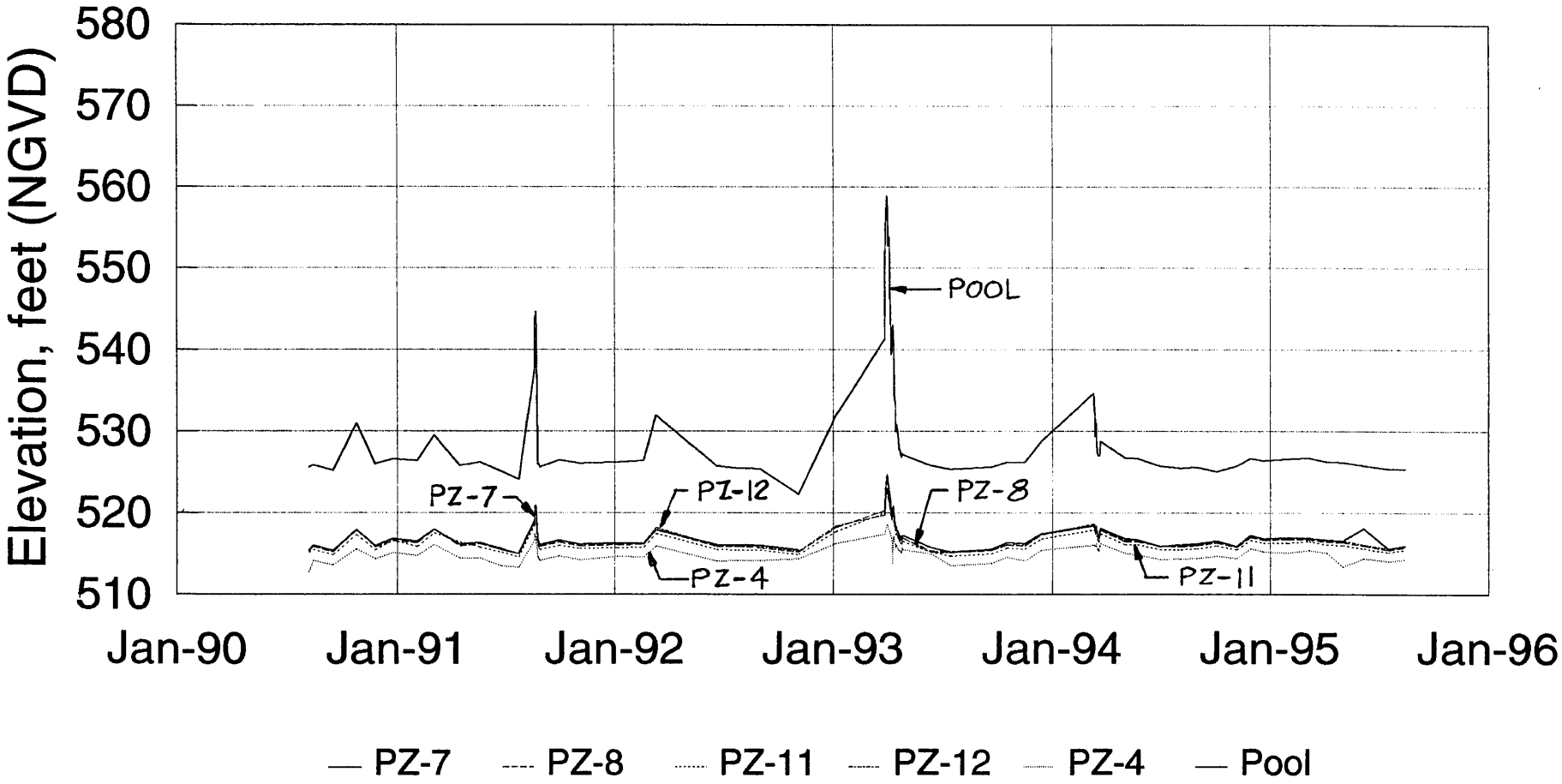
# Piezometer Time History, Profile A-A
# Piezometers PZ-7,8,9,&10



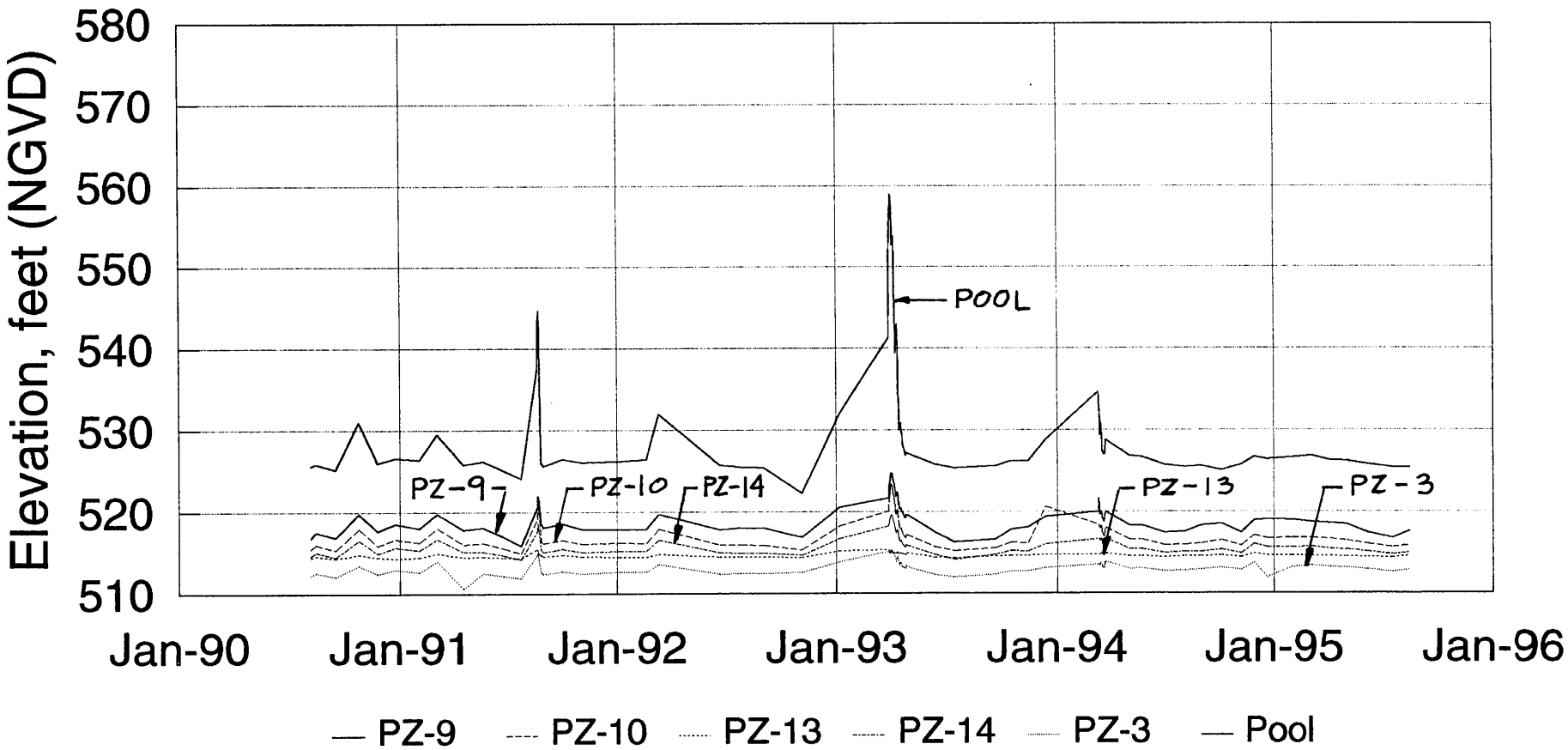
# Piezometer Time History, Profile B-B
# Piezometers PZ-1,2,3,4,5,&6



# Piezometer Time History, Section C-C, Station 5+15
## Piezometers PZ-7,8,11,12,&4



# Piezometer Time History, Section D-D, Station 6+00
## Piezometers PZ-9,10,13,14,&3



# APPENDIX E

Piezometer Data, April 1993 Event Plots

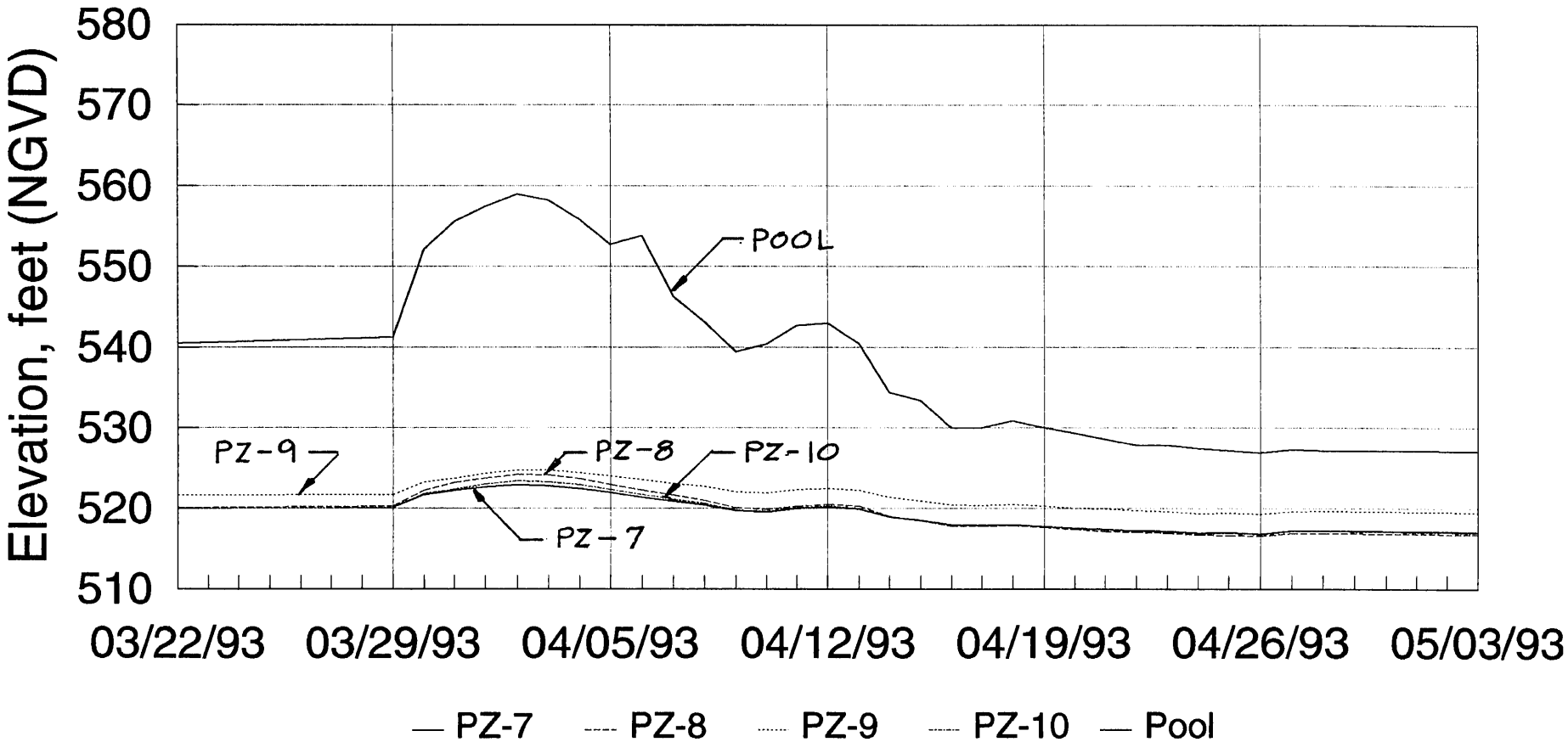
Piezometer Time History, Profile A-A, April 1993 Event (PZ-7, 8, 9, and 10)

Piezometer Time History, Profile B-B, April 1993 Event (PZ-1, 2, 3, 4, 5, and 6)

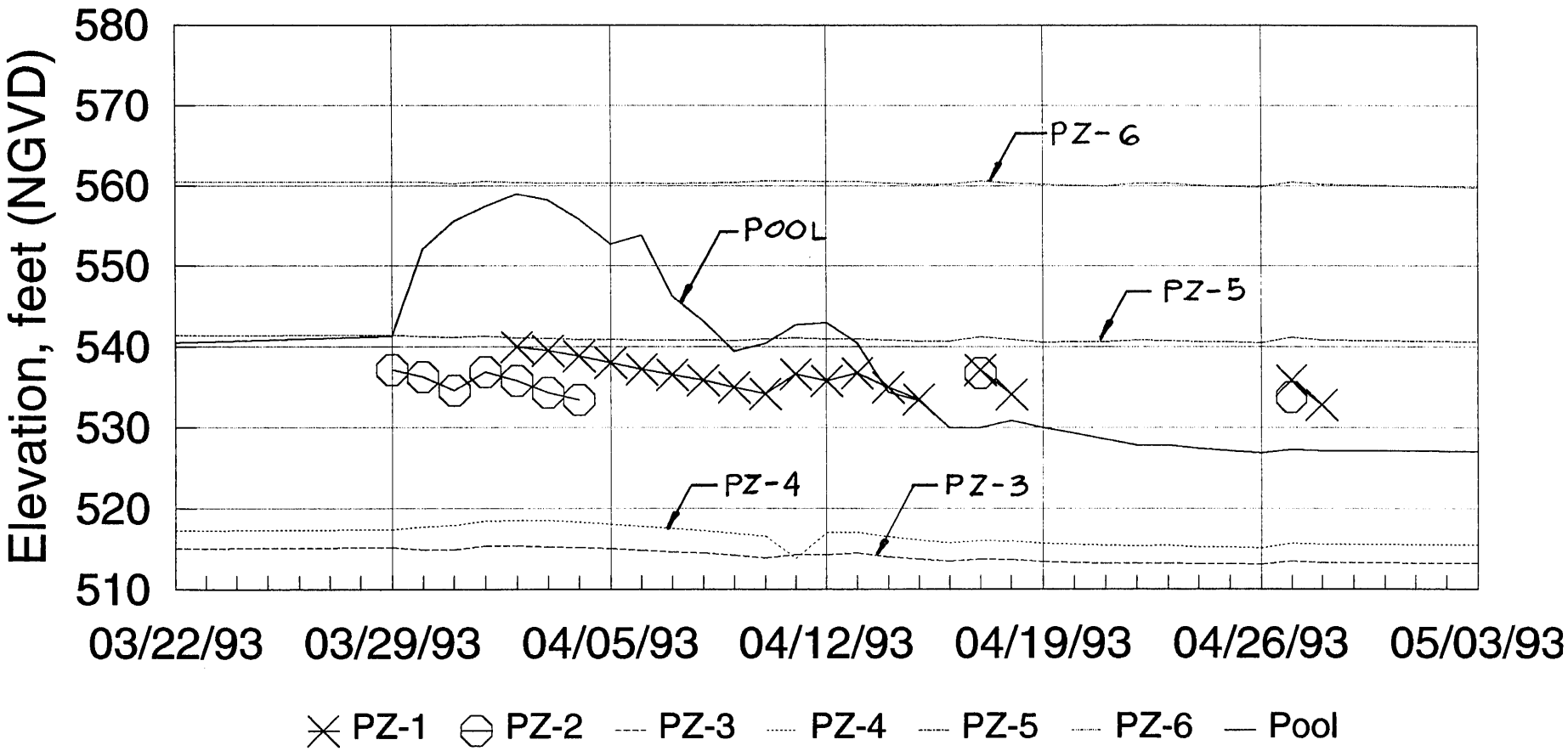
Piezometer Time History, Section C-C at Station 5+15, April 1993 Event (PZ-7, 8, 11, 12, and 4)

Piezometer Time History, Section D-D at Station 6+00, April 1993 Event (PZ-9, 10, 13, 14, and 3)

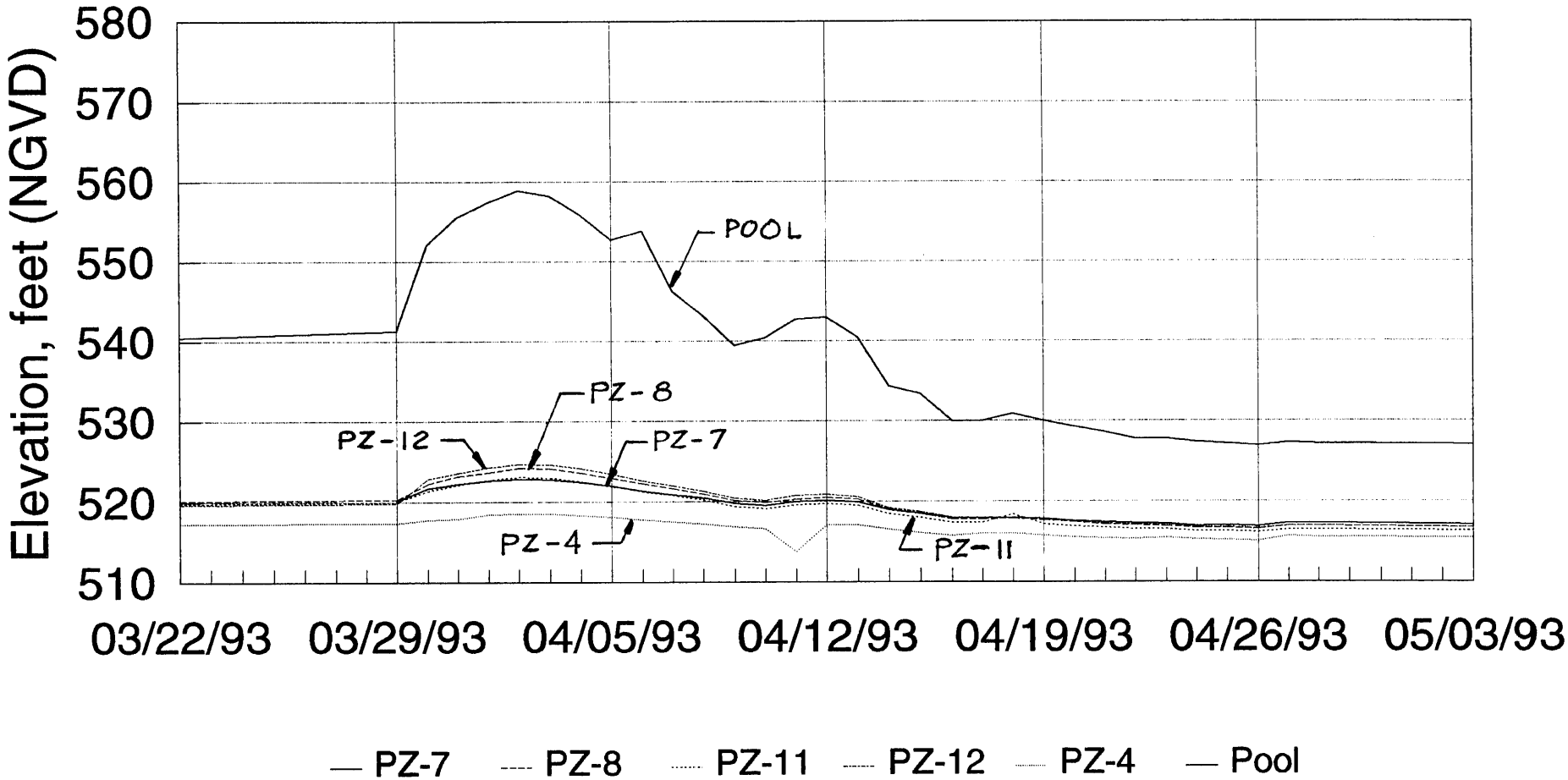
# April 1993 Event Piezometer Time History, Profile A-A
## Piezometers PZ-7,8,9,&10



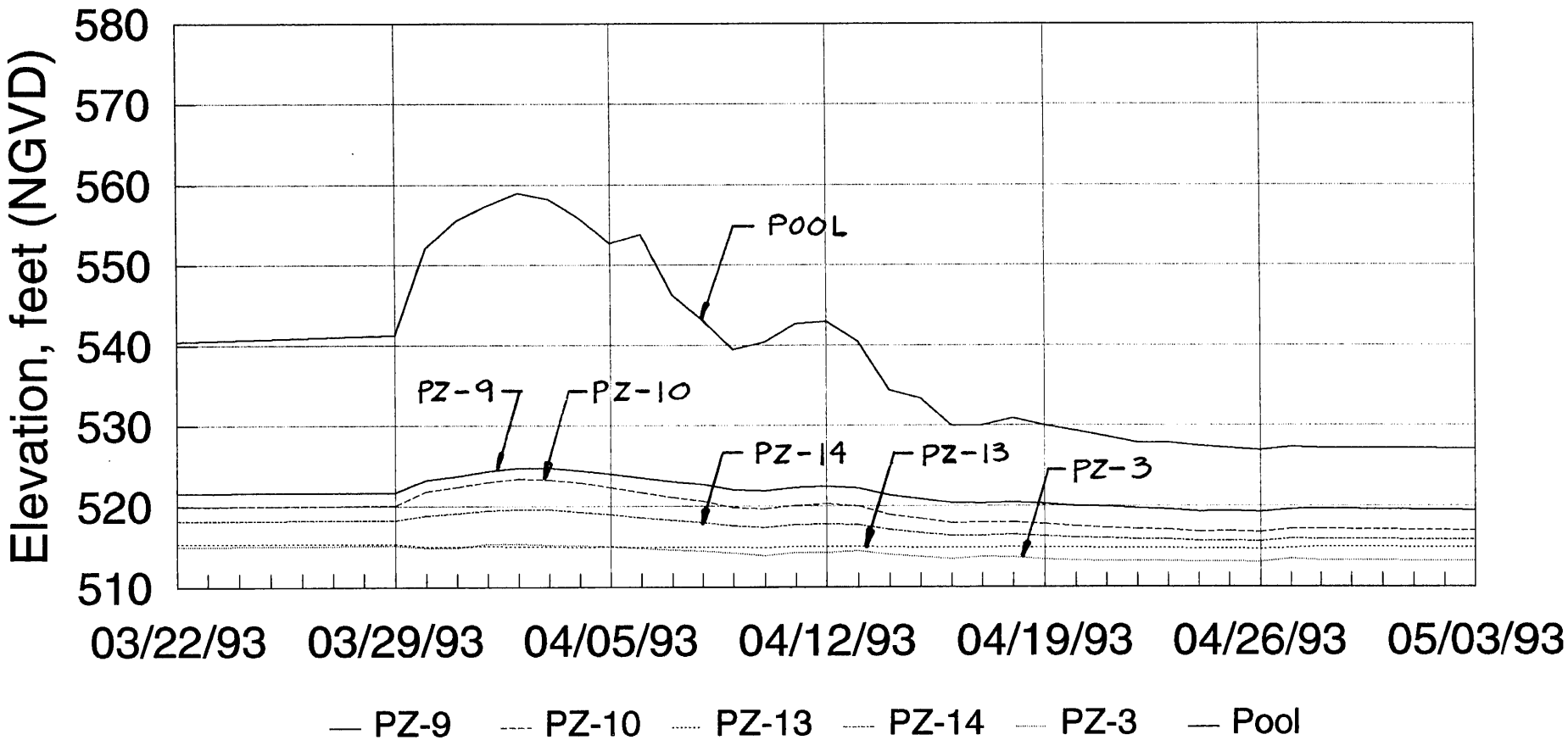
# April 1993 Event Piezometer Time History, Profile B-B
# Piezometers PZ-1,2,3,4,5,&6



# April 1993 Event Piezometer Time History, Section C-C
## Station 5+15, Piezometers PZ-7,8,11,12,&4



# April 1993 Event Piezometer Time History, Section D-D
## Station 6+00, Piezometers PZ-9,10,13,14,&3

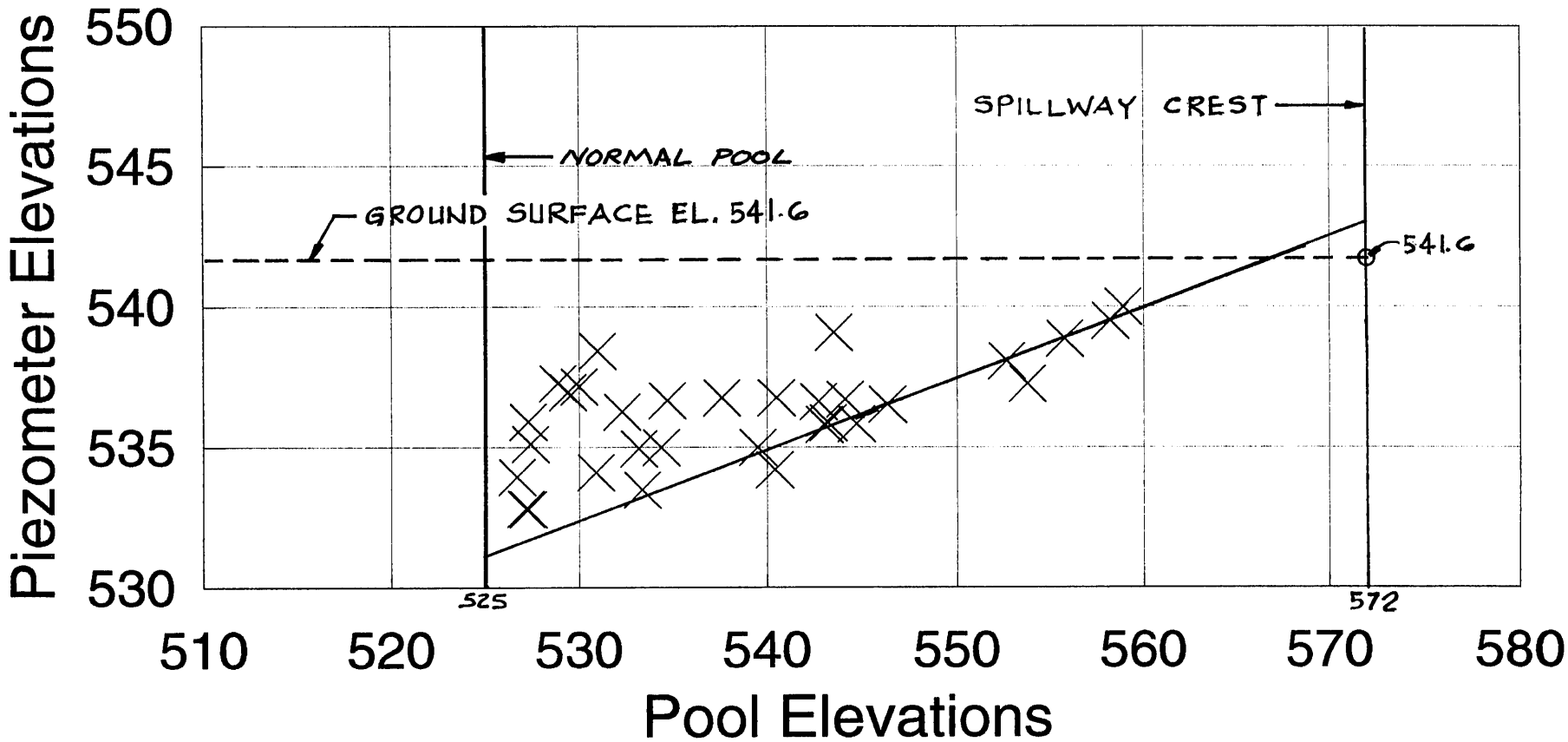


# APPENDIX F

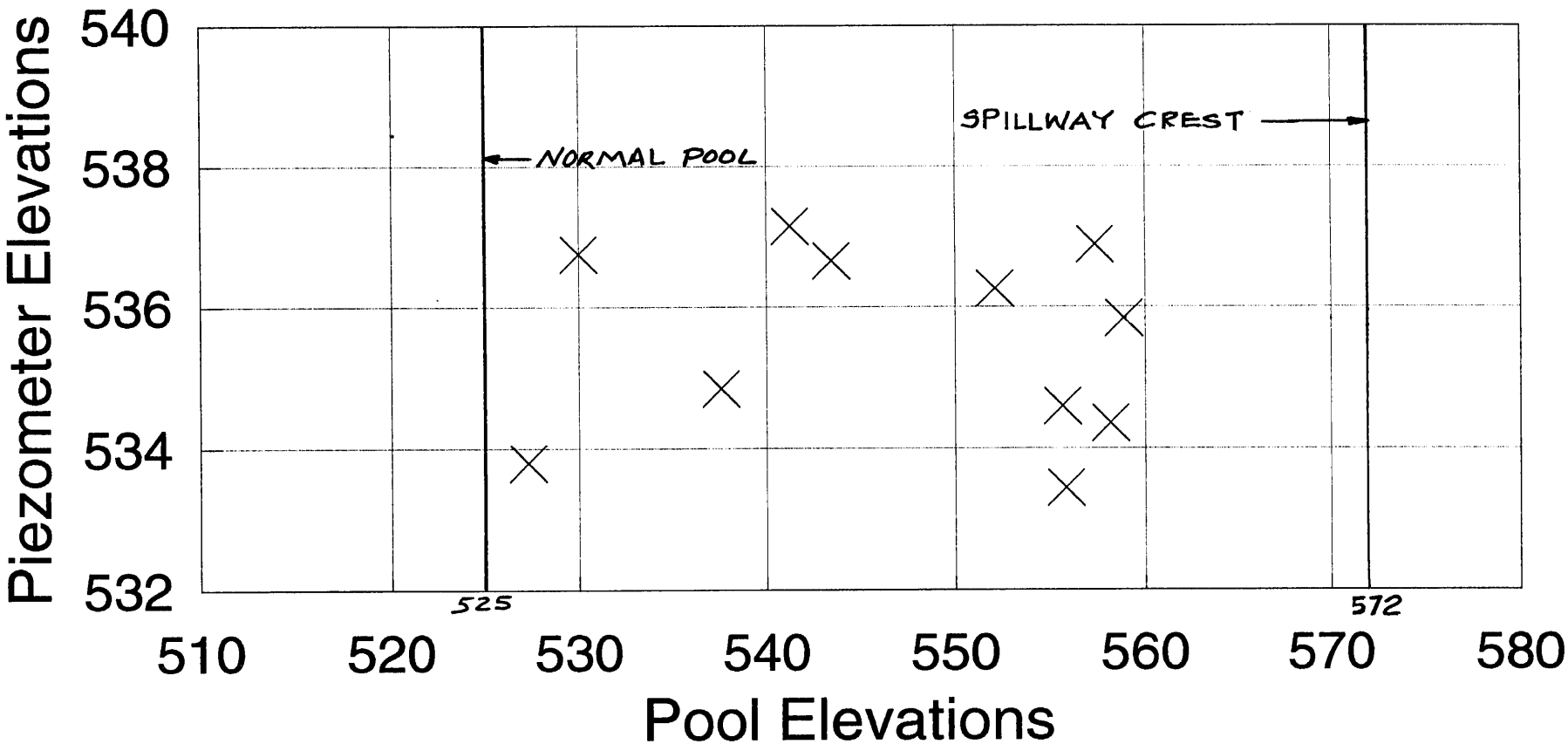
Piezometer Elevations vs. Pool Elevations Plots

Piezometer Elevations vs. Pool Elevations, PZ-1
Piezometer Elevations vs. Pool Elevations, PZ-2
Piezometer Elevations vs. Pool Elevations, PZ-3
Piezometer Elevations vs. Pool Elevations, PZ-4
Piezometer Elevations vs. Pool Elevations, PZ-5
Piezometer Elevations vs. Pool Elevations, PZ-6
Piezometer Elevations vs. Pool Elevations, PZ-7
Piezometer Elevations vs. Pool Elevations, PZ-8
Piezometer Elevations vs. Pool Elevations, PZ-9
Piezometer Elevations vs. Pool Elevations, PZ-10
Piezometer Elevations vs. Pool Elevations, PZ-11
Piezometer Elevations vs. Pool Elevations, PZ-12
Piezometer Elevations vs. Pool Elevations, PZ-13
Piezometer Elevations vs. Pool Elevations, PZ-14

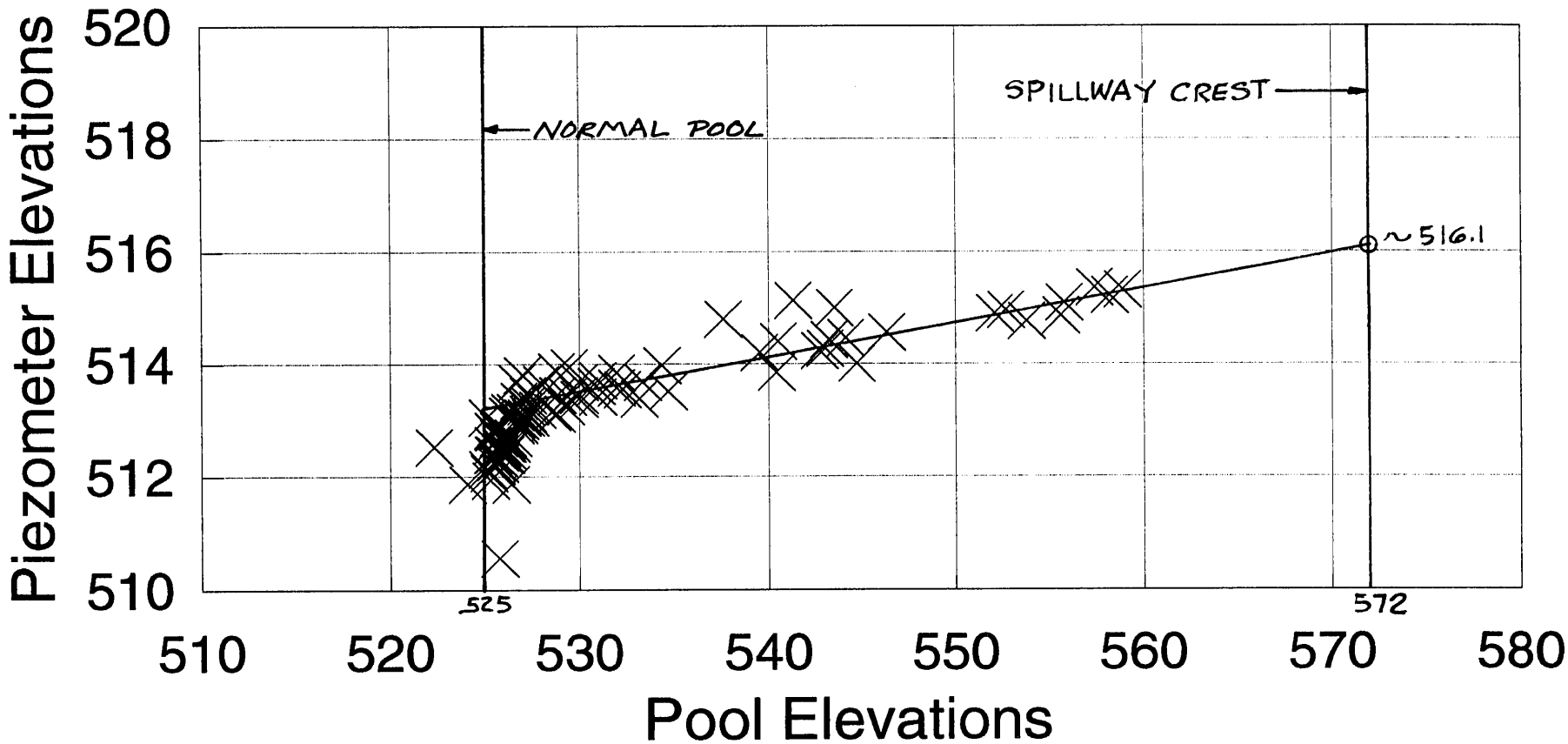
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-1



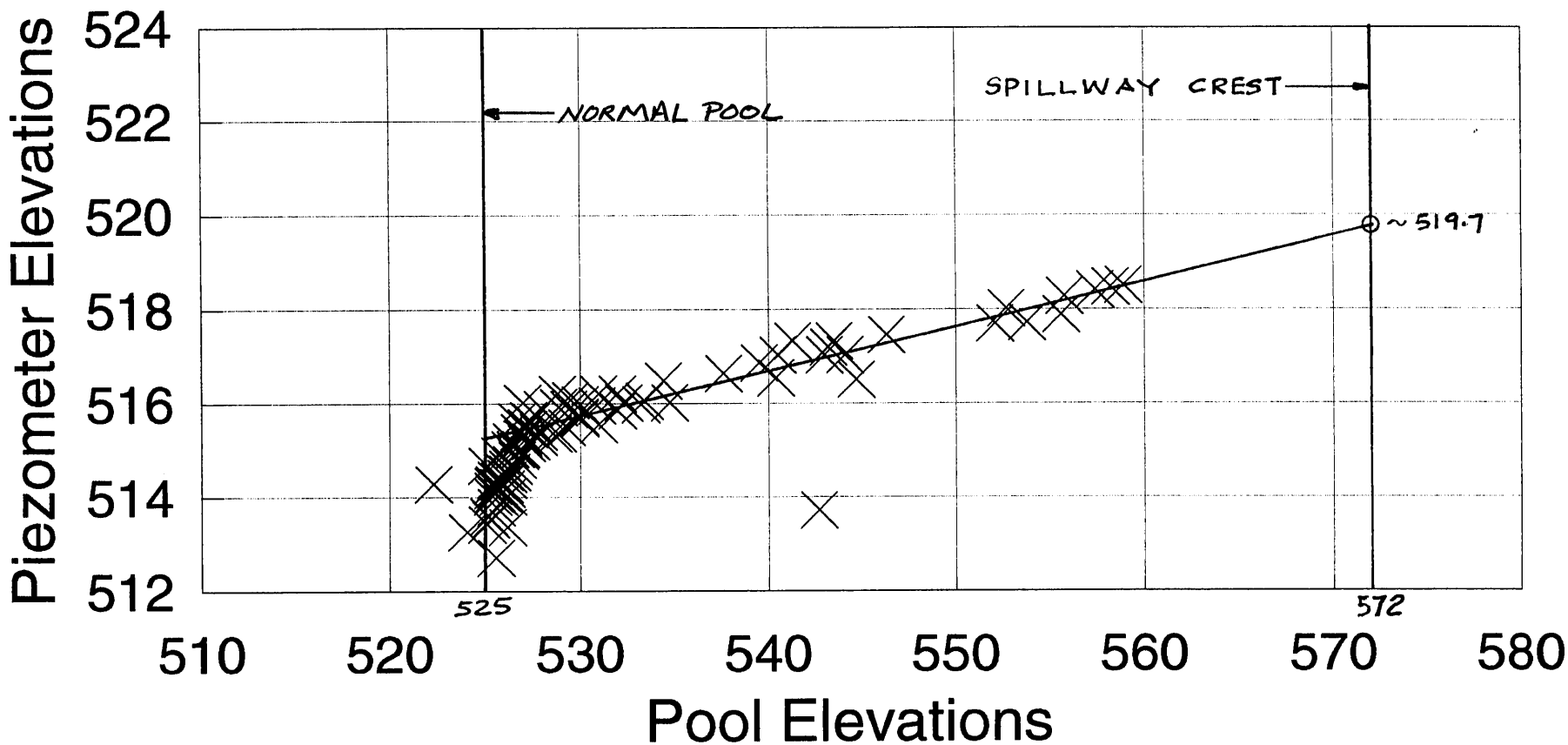
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-2



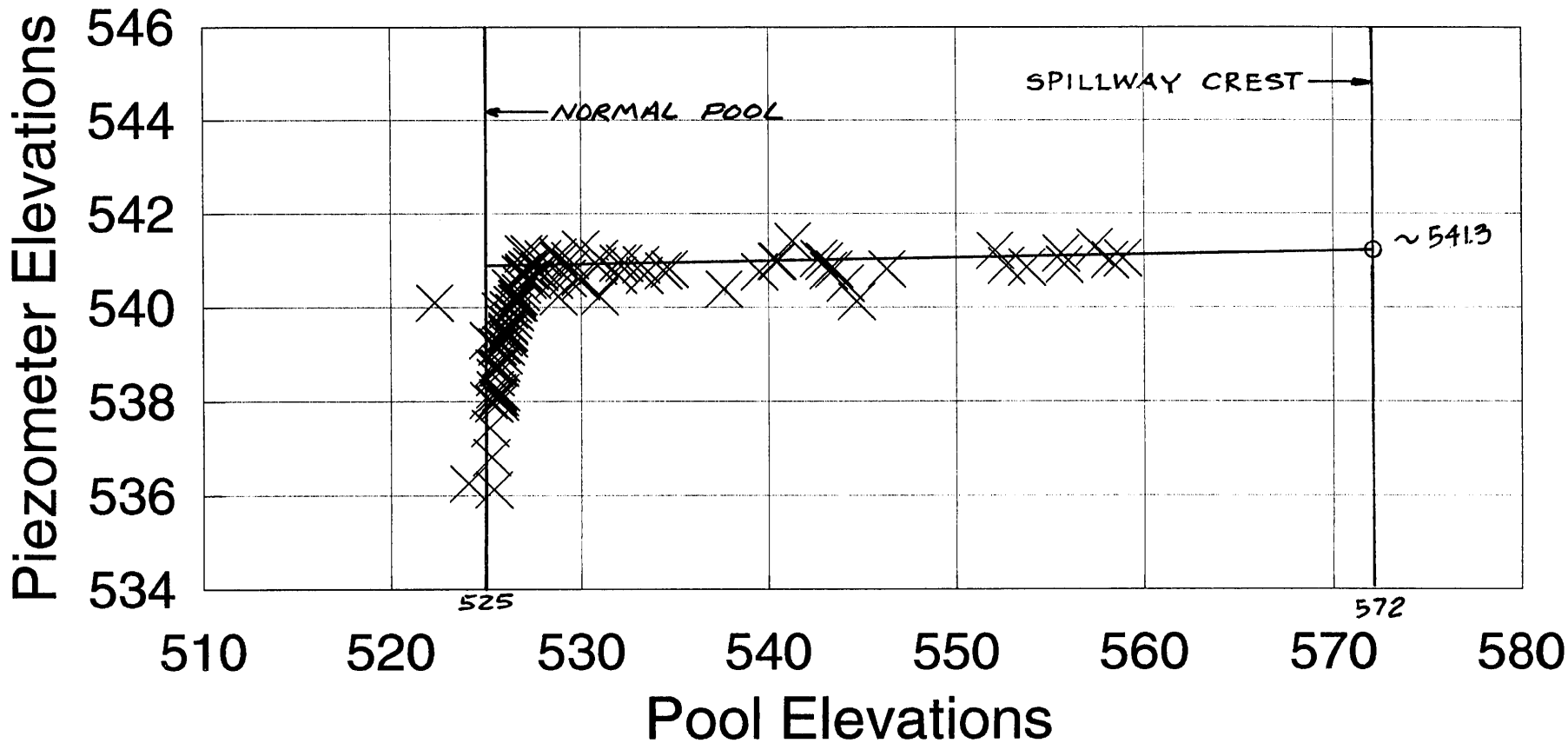
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-3



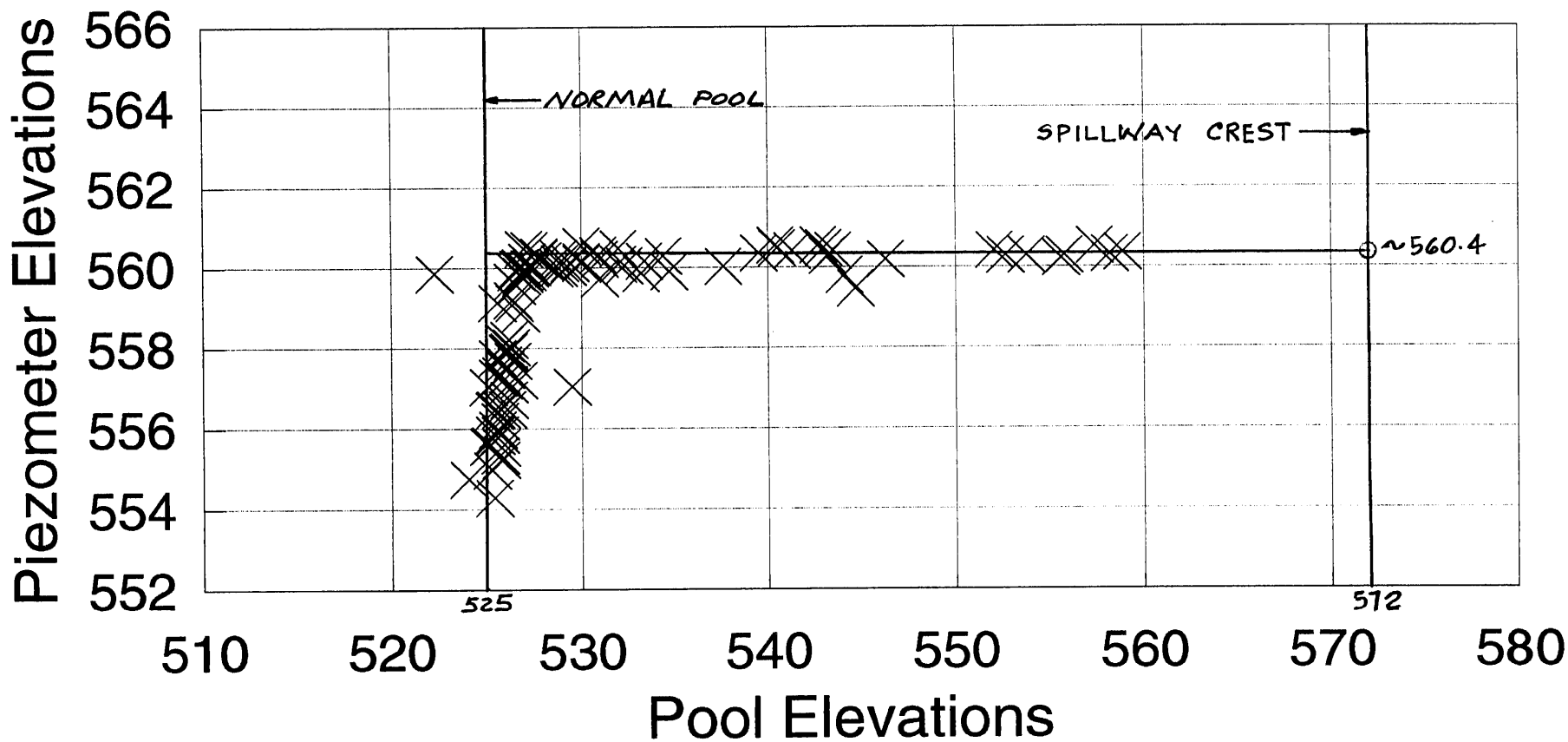
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-4



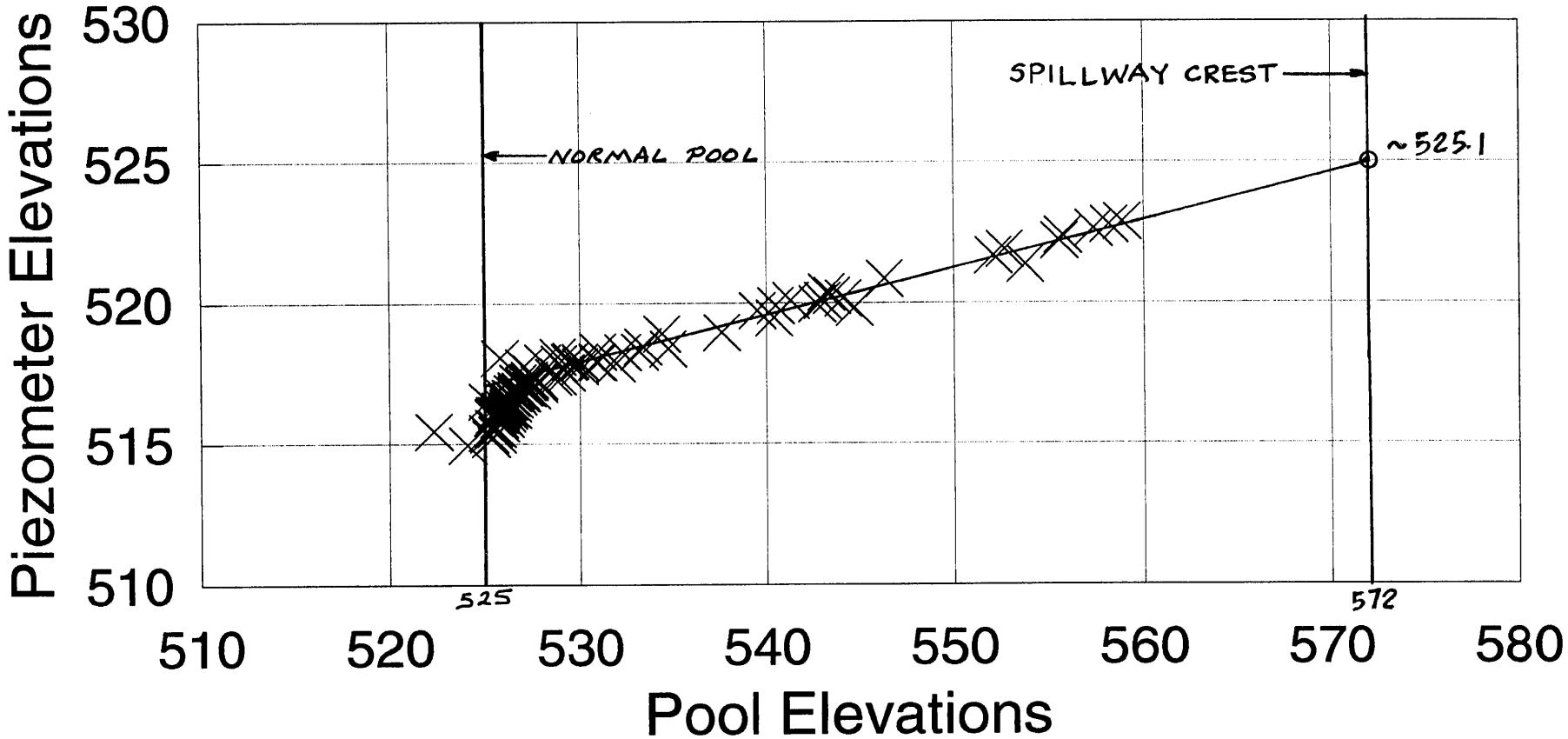
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-5



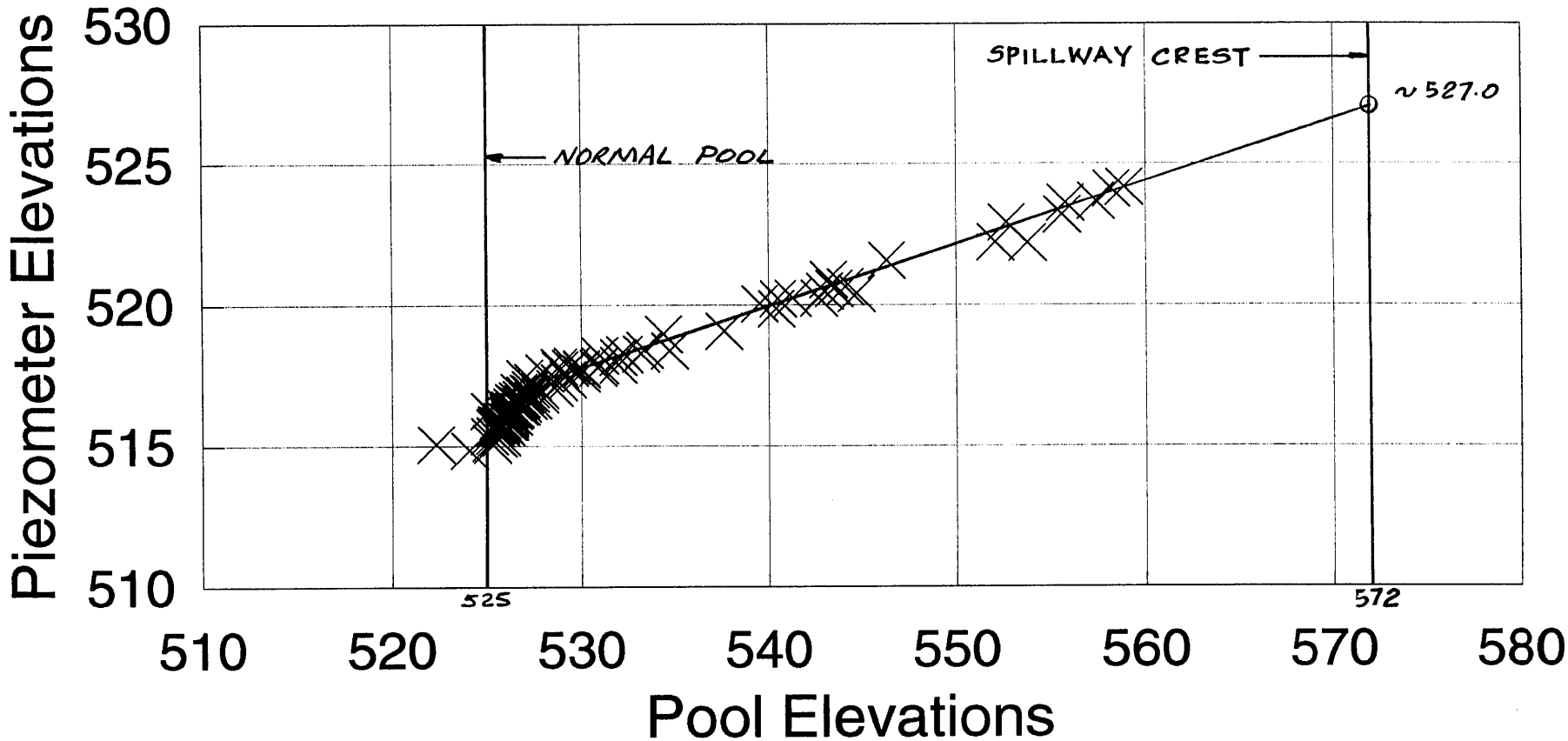
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-6



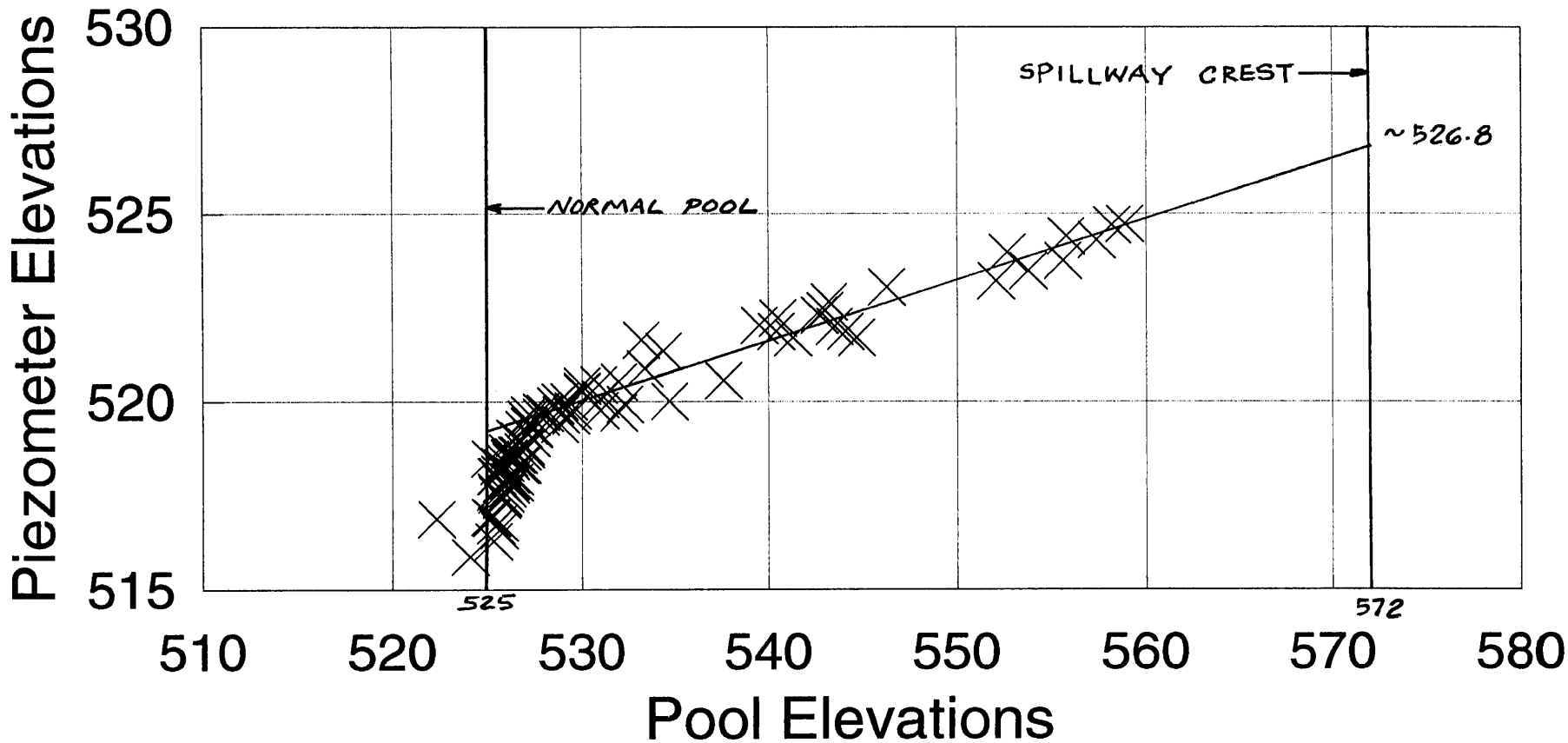
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-7



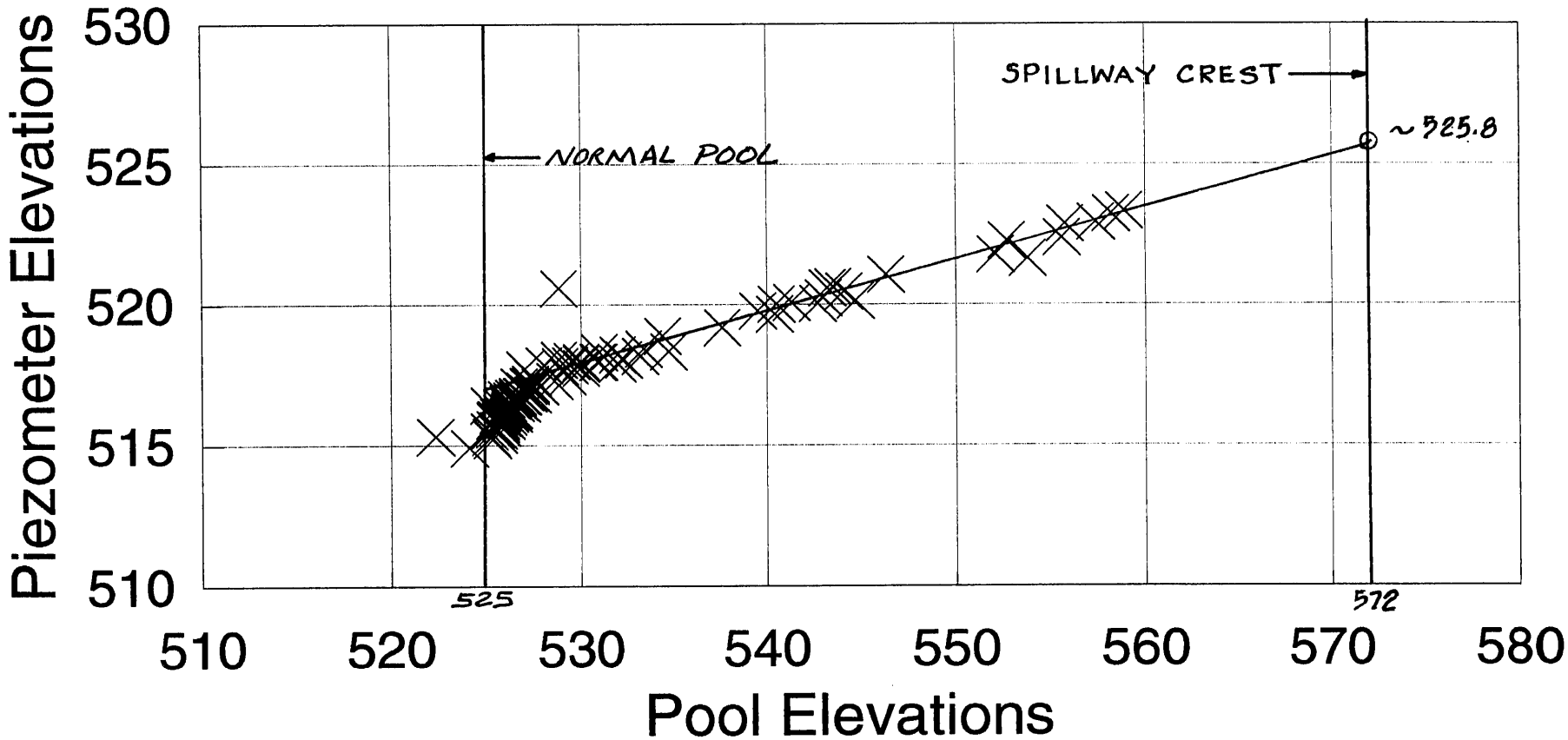
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-8



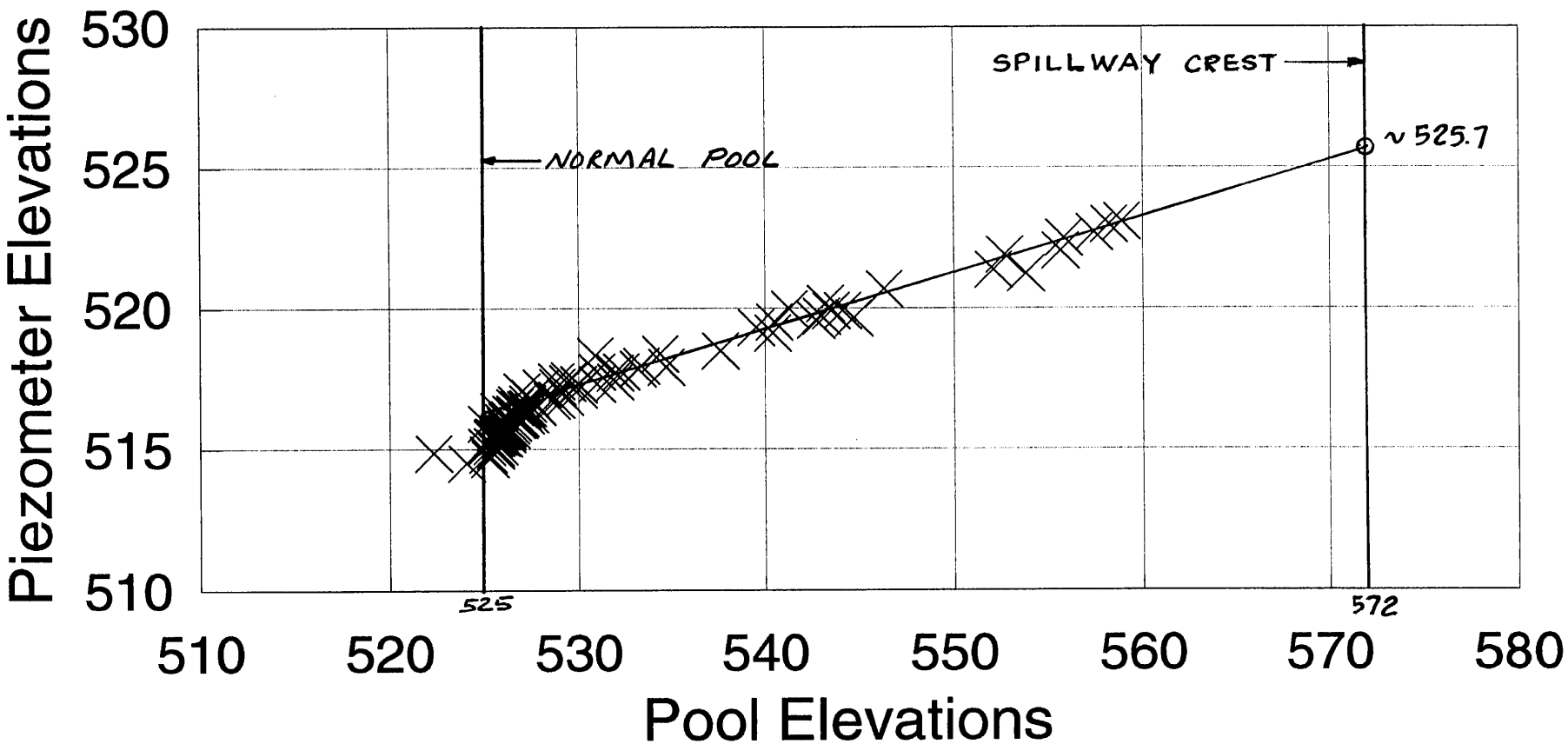
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-9



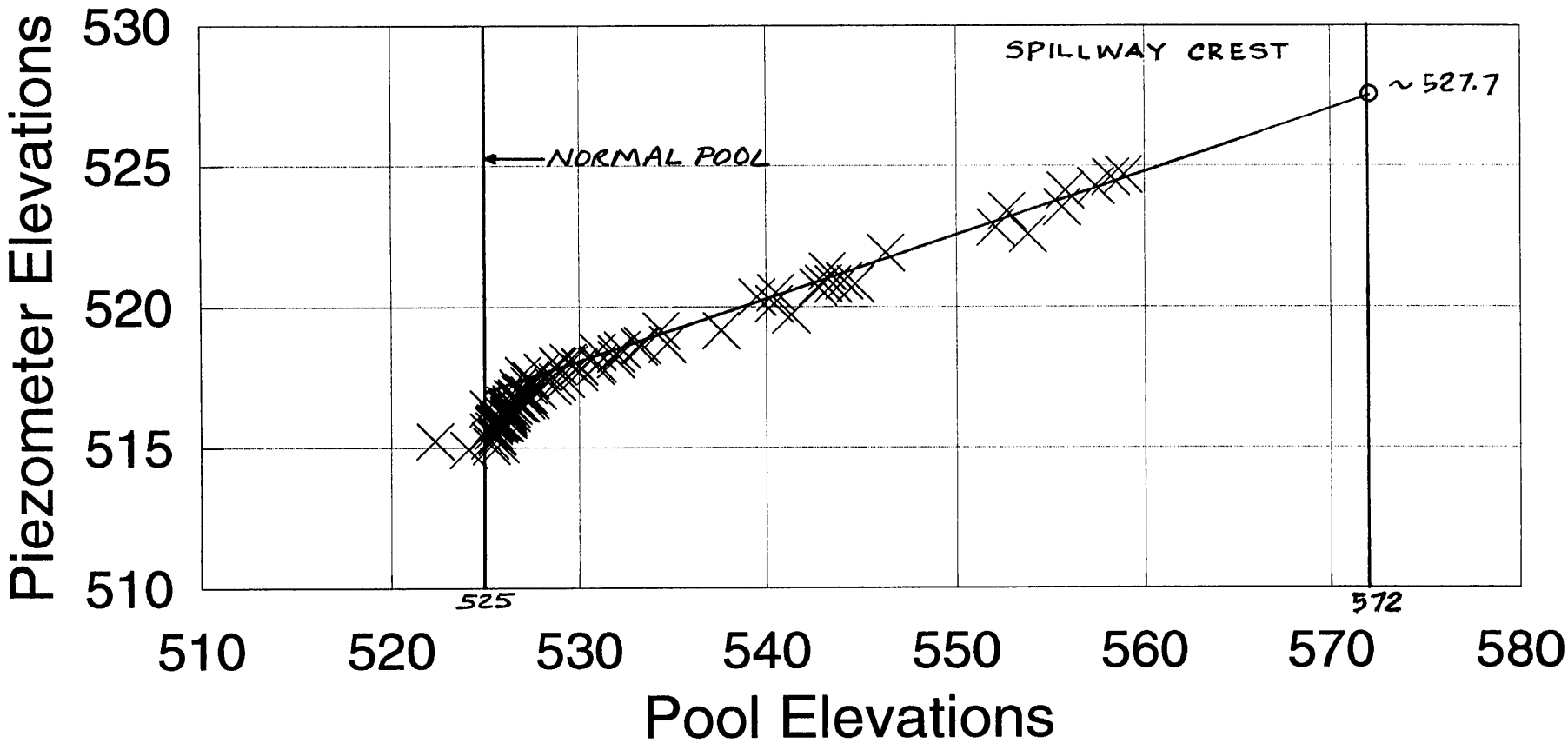
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-10



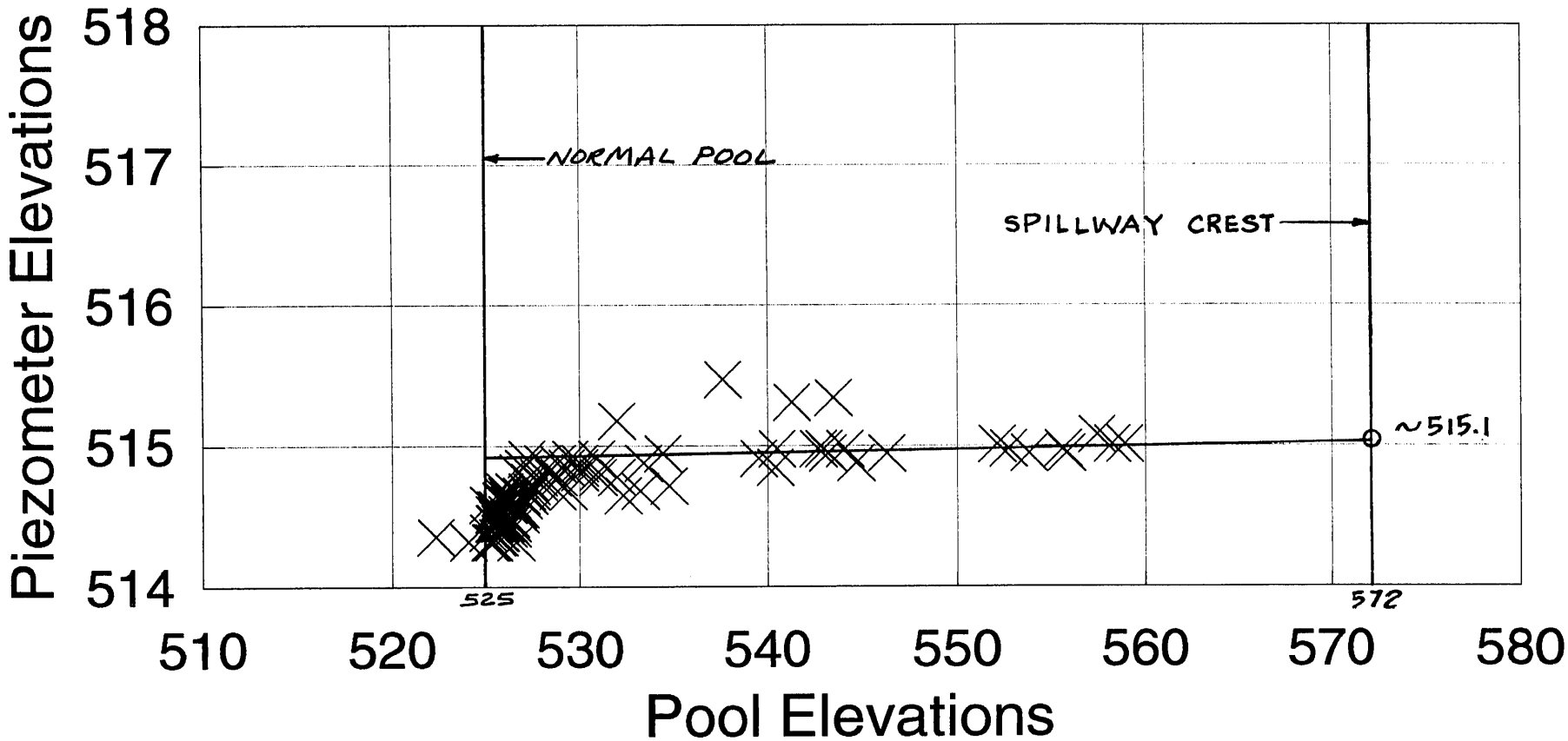
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-11



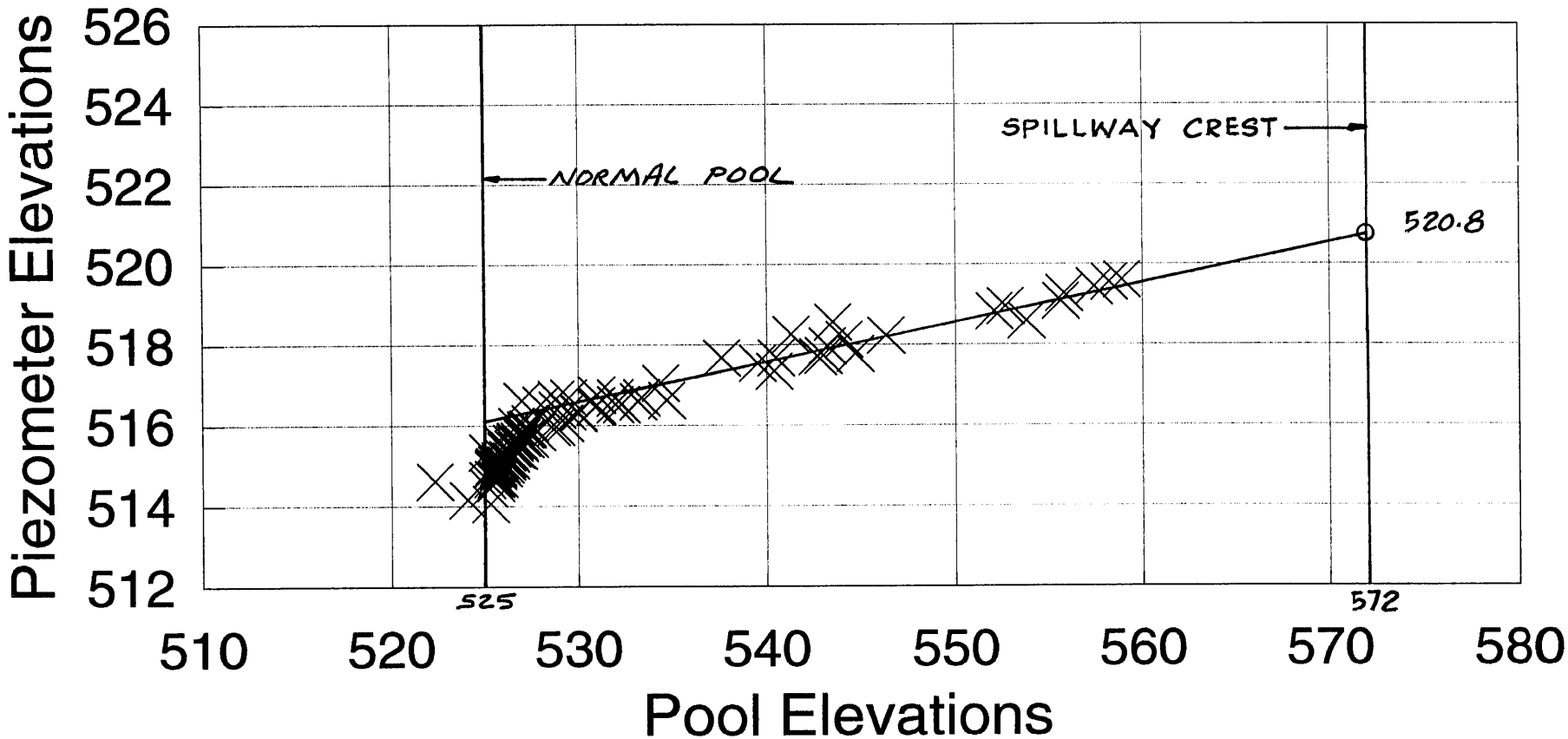
# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-12



# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-13



# Piezometer Elevations vs. Pool Elevations
# Piezometer PZ-14



# APPENDIX G

Standards and Procedures for Settlement Surveys

Standard 1

The following standards and procedures are employed for Crest Monument Surveys at Westville Lake Dam.

## STANDARDS FOR SETTLEMENT SURVEYS

1. Control points are stamped brass disks preferably set in a ledge area. Where no ledge is available, they are set in concrete bounds placed flush with the ground.

2. Control points are set in areas such that the maximum possible number of crest monuments on the dam are visible.

3. Control points are tied into four reference points by distance. This provides a check each time they are occupied for settlement surveys or allow them to be replace if found to be destroyed.

4. Distances are read and recorded between settlement bounds. Both distance and angle are read and recorded from the control points that are being occupied to locate each settlement bound on the dam.

5. In locating each settlement bound, a control point will be occupied setting 0-00'-00" (referenced line of site) on a second control point, reading and recording both interior and exterior angle closure, along with distances through each settlement bound located on the dam. Each settlement bound is located from a minimum of two control points. These locations are third order, class II survey with relative accuracies of not less than 1 part in 5,000.

6. Levels are run from control points through each settlement bound on the dam with a return run back into the control points to check the elevation closure on the run. Closure tolerance should be no greater than 0.05'. These levels are third order, class I survey with relative accuracies not less than 1 part in 10,000.

7. Crest monument surveys are performed using Topcon EDM Total Stations and recording both horizontal angles and horizontal distances.

## PROCEDURE FOLLOWED FOR SETTLEMENT SURVEYS

The horizontal and vertical monitoring plan for settlement bound movement points employed a combination of triangulation and trilateration angle and distance techniques to survey the control network. Control points, in the form of stamped brass disks, were placed on the dam structure in a location that is clearly

visible from the control points. Horizontal coordinates of the control points are based on the State Plane Coordinate System. Elevations of the control points are bawd on the National Geodetic Vertical Datum (NGVD). Control points are occupied utilizing an EDM Total Station; observed distances and angles (interior and exterior angles), between control points and settlement bound establishing permanent bench marks. Standard leveling techniques are followed. Levels are double run and the means of the front and back runs were computed and recorded.

## DATA ADJUSTMENT

A combination of triangulation and trilateration surveying techniques are applied. Each crest monument is located from two control points and two sets of coordinates are calculated using adjusted field angles and compliments and EDM distances. The two sets of coordinates are averaged to give a net result. The averaged coordinates are then established on each settlement bound for use in determining shifts in the dam surface structure over a period of years by comparing repetitive surveys.

NEW ENGLAND DIVISION, Corps of Engineers
WESTVILLE DAM

Date _____

Time of Reading _____
Pool Stage (ft) _____
Tailwater (ft-NGVD) _____
Discharge _____

Invert Elevation 515.0 feet N.G.V.D.

| | Piezometer | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | PZ-1 | PZ-2 | PZ-3 | PZ-4 | PZ-5 | PZ-6 | PZ-7 |
| North Coordinate | 394991.5787 | 394929.6358 | 394852.6592 | 394801.8509 | 394669.6233 | 394585.7016 | 394701.2596 |
| East Coordinate | 448422.3987 | 448462.0204 | 448559.2161 | 448606.2220 | 448624.9027 | 448645.3848 | 448491.8514 |
| Estimated Centerline Station | 8+05 | 7+10 | 6+00 | 5+00 | 4+00 | 3.00 | 5+15 |
| Estimated Offset | 150' D/S | 185' D/S | 220' D/S | 200' D/S | 160' D/S | 120' D/S | 45' D/S |
| Boring Number | FD 85-1 | FD 85-2 | FD 85-3 | FD 85-4 | FD 86-10 | FD 86-11 | FD 86-9 |
| Top of Casing Elevation (ft) | 543.66 | 542.36 | 520.25 | 525.01 | 545.59 | 564.10 | 574.06 |
| Top of Riser Elevation (ft) | 543.62 | 542.40 | 520.08 | 524.85 | 545.68 | 564.10 | 574.25 |
| Length of Piezometer (ft) | 11.1 | 11.7 | 22.3 | 20.6 | 24.6 | 18.4 | 80.3 |
| Elevation of Tip (ft) | 532.5 | 530.7 | 498.0 | 504.4 | 521.0 | 545.7 | 493.8 |
| Depth to Water Surface (See Note 1) | | | | | | | |

| | Piezometer | | | | | | |
|---|---|---|---|---|---|---|---|
| Description | PZ-8 | PZ-9 | PZ-10 | PZ-11 | PZ-12 | PZ-13 | PZ-14 |
| North Coordinate | 394701.2596 | 394766.3469 | 394766.3469 | 394745.5001 | 394745.5001 | 394813.2383 | 394813.2383 |
| East Coordinate | 448491.8514 | 448437.6867 | 448437.6867 | 448550.2492 | 448550.2492 | 448502.1321 | 448502.1321 |
| Estimated Centerline Station | 5+15 | 6+00 | 6+00 | 5+15 | 5+15 | 6+00 | 6+00 |
| Estimated Offset | 45' D/S | 45' D/S | 45' D/S | 125' D/S | 125' D/S | 125' D/S | 125' D/S |
| Boring Number | FD 86-9 | FD 86-8 | FD 86-8 | FD 86-6 | FD 86-6 | FD 86-7 | FD 86-7 |
| Top of Casing Elevation (ft) | 574.06 | 577.47 | 577.47 | 544.60 | 544.60 | 543.84 | 543.84 |
| Top of Riser Elevation (ft) | 574.14 | 577.49 | 577.50 | 544.59 | 544.60 | 543.83 | 544.06 |
| Length of Piezometer (ft) | 93.7 | 66.2 | 91.6 | 65.3 | 77.8 | 33.6 | 43.6 |
| Elevation of Tip (ft) | 480.3 | 511.3 | 485.9 | 479.3 | 466.8 | 510.2 | 500.2 |
| Depth to Water Surface (See Note 1) | | | | | | | |

NOTES:

r Surface shall be measured in **Meters**
e taken from top of plastic pipe.
rm was last revised on **09/07/95**

Prepared by _SMB_ Checked by _____

Readings Taken By _____

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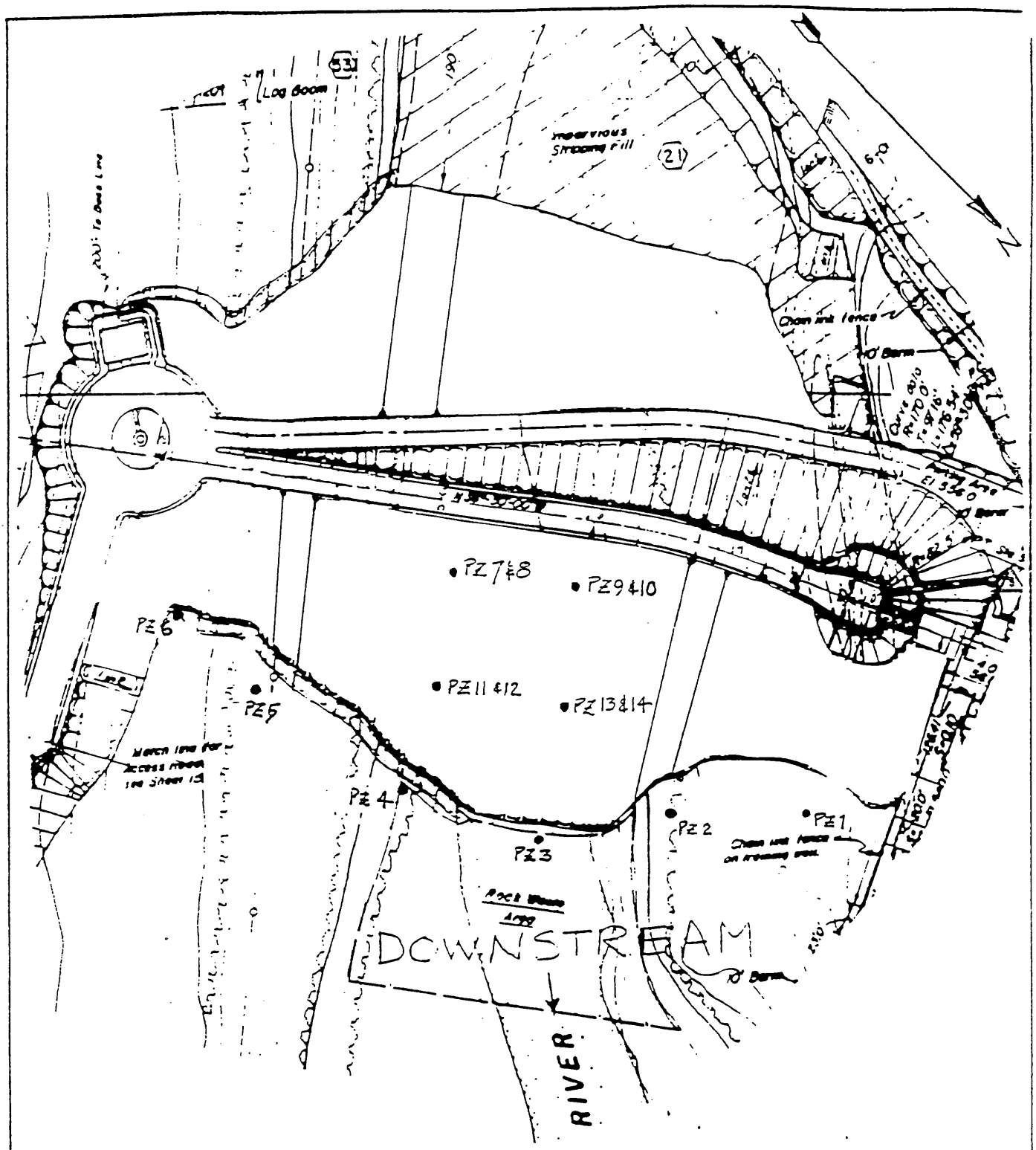


SCALE 1" = 100'

| LEGEND | |
|---|---|
| SYMBOL | DESCRIPTION |
| • PZ-5 | PIEZOMETER LOCATION NO. 5 |

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

THAMES RIVER FLOOD CONTROL

WESTVILLE DAM

PIEZOMETER LOCATION PLAN

QUINEBAUG RIVER, MASSACHUSETTS

DES. BY

DR BY

CK. BY

GEOTECH. ENG. BR.

SCALE: AS SHOWN

SK. NO.

DATE