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INSTRUMENTATION APPENDIX TO PERIODIC INSPECTION REPORT NO. 5 FRANKLIN FALLS DAM, NEW HAMPSHIRE

by

Haley & Aldrich, Inc.
Cambridge, Massachusetts

for

Department of the Army
New England Division

File No. 11163-004
January 1995

HALEY & ALDRICH INC.

Geotechnical Engineers &
Environmental Consultants

31 January 1995
File No. 11163-004

Department of the Army
New England Division, Corps of Engineers
424 Trapelo Road
Waltham, Massachusetts 02254-9149

Attention: Mr. Richard Reardon
Director of Engineering

Subject: Instrumentation Appendix to Periodic Inspection Report No. 5
Franklin Falls Dam
Franklin, New Hampshire

Gentlemen:

We are pleased to submit herewith our report entitled "Instrumentation Appendix to Periodic Inspection Report No. 5, Franlin Falls Dam, New Hampshire", prepared in accordance with our Contract No. DACW33-93 -D-005 dated 3 August 1994.

This report is a compilation of the results of the instrumentation analysis for the Franklin Falls Dam conducted as part of Periodic Inspection Report No. 5. This report has been prepared in consideration of verbal and written comments on the draft report prepared by Haley and Aldrich.

It has been a pleasure working with the New England Division, Corps of Engineers on this project. Please do not hesitate to contact us if you have any questions on this report.

Sincerely yours,
HALEY & ALDRICH, INC.

Douglas G. Gifford
Vice President

cc: Ms. Laura Fraser, New England Division, Corps of Engineers.

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INSTRUMENTATION APPENDIX

TO PERIODIC INSPECTION REPORT NO. 5

FRANKLIN FALLS DAM, NEW HAMPSHIRE

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1. PROJECT PERFORMANCE

The dam performance is rated as good based on the visual observations and the analysis of the instrumentation data compiled to date. Crest monument data indicates that very little vertical movement has taken place (0.05 ft.). It also indicates minimal horizontal movement (0.06 ft.).

The instrumentation evaluation is based on the piezometer readings from September 1989 to December 1993.

2. GENERAL PROJECT DESCRIPTION

a. History

(1) General. The Franklin Falls Dam and Reservoir is part of a coordinated system of reservoirs for flood control on the Pemigewasset River Watershed of the Merrimack River Basin in the state of New Hampshire. This project is a unit of the comprehensive plan which was authorized by the Flood Control Act approved June 22, 1936 (Public Law 738-74th Congress), modified by the Flood Control Act approved June 28, 1938 (Public Law 761-75th Congress).

All elevations in this report are in feet and are referenced to the National Geodetic Vertical Datum of 1929 (NGVD).

The Franklin Falls Dam and Reservoir is located on the Pemigewasset River, the main tributary of the Merrimack River, about 2.5 miles upstream from the city of Franklin in Merrimack County, New Hampshire. The general site locus is shown on Figure 1. The drainage area controlled by the dam is 1,000 square miles and affects the counties of Grafton, Merrimack and Belknap in New Hampshire. Construction of the project started in November 1939 and was completed in October 1943.

The dam is rolled earth fill, with a protective rock shell, rising 140 ft. above the river bed with the crest at El. 416. Typical as built profiles and cross sections are shown on Figures 2 and 3. The spillway consists of an excavated channel along the westerly abutment of the dam and a concrete ogee weir with a crest length of 550 ft. at El. 389. Outlet works are on the westerly bank and consist of an intake channel and two 22 ft. horseshoe-shaped conduits, each controlled by four Broome gates

operated through a control tower from the gatehouse above. Normal "run of the river" operation keeps the river elevation through the intake near El. 305 to El. 309. The outlet works also have a stilling basin and an outlet channel. The reservoir is operated for flood control and has a total storage capacity of 154,000 acre-feet.

b. Geology and Foundations

(1) General. The Pemigewasset River follows the course of a wide pre-glacial bedrock valley which has been very deeply filled by glacial deposits of gravel and sand. The river has eroded an inner valley in these deposits which is generally flanked by sand or gravel terraces and is underlain by a considerable depth of similar material. Occasional short reaches exist where the river bed encounters the bedrock of one or the other of the preglacial valley walls. These reaches are characterized by rapids or low falls and are complimented by a short upstream stretch of narrow flood plain and meandering river. Except in these flood plain reaches, the river is actively incising its channel and the valley floor is correspondingly narrow and sloping.

About 45 years after construction of the dam, test borings were completed along the upstream and downstream slopes to permit the installation of piezometers and observation wells. The locations of the piezometers are shown on Figure 4 with the corresponding boring logs presented on Figure 5. The engineering and piezometer logs are presented in Figures 6 and 7. When plotted against the typical embankment cross sections, the boring data provides confirmation of the general site geology as discussed below. Refer to Figures 8 through 11 for typical embankment cross sections and profiles.

(2) Site Geology.

(a) Dam Site. At the Franklin Falls dam site, the Pemigewasset Valley has a flat-bottomed U-shaped cross section lying primarily in glacial deposits within the much larger preglacial bedrock valley. The river, meandering across a 1,000 ft. flood plain, has cut numerous steep slopes into the overburden of the east wall and in a few places on the west wall of the valley. A bedrock spur of the preglacial valley wall has been partially exposed on this west wall. The bedrock is a solid, unweathered variation of micaceous gneiss and granular mica schist with numerous but minor veins of coarse granite. The preglacial bedrock surface, now buried by glacial deposits, was little modified by glacial erosion. A marked irregularity of the present bedrock-overburden contact reflects the considerable bedrock dissection existing in the old valley walls. Although very irregular, this contact is clean and sharp, with only occasional small shallow pockets of weathered and broken rock.

The overburden varies both laterally and vertically, from silty very fine sand to gravelly coarse sand as shown in the logs on Figures 6 and 7. Clay and clayey silt are generally absent. However, a strata of clayey sand (SC) was encountered in test boring FD-85-9. There is no natural top blanket of silt.

(b) Spillway. The spillway is located on the right abutment as shown on Figure 4. The right abutment is an overburden slope averaging approximately 4.5 ft horizontal to 1 ft vertical (4.5H:1V) that recedes above the dam site. The slope is eroded and strongly gulled below the spillway. The abutment is underlain by a bedrock nose which is exposed at the foot of the abutment along the centerline of the dam and is buried along the slope. This bedrock nose drops away both upstream and downstream from the spillway location and it is notched by several buried rock ravines. The bedrock formations are as described above and are believed to be structurally safe.

c. Dam and Appurtenant Structures Description. The dam embankment is a rolled earth fill with heavy rock shells constructed across the Pemigewasset River with a crest length of 1,740 ft. and a maximum height of 140 ft. The crest of the dam (crest El. 416) is 35 ft. wide, and the embankment slopes vary between 2H:1V to 3.5H:1V. The embankment contains an impervious central core section extending from bedrock on the right abutment to approximately a depth of 10 ft. through overburden into the left abutment. The core was included to reduce seepage through the dam. To provide additional seepage control, an impervious 3 ft. thick blanket was constructed upstream from the core section at El. 315 in the bottom of the valley and up the left abutment slope. The blanket is well connected with the core by means of fillets to reduce the quantity of seepage through the base foundation and left abutment during a flood pool.

A large portion of the upstream shell section is compacted pervious fill. A blanket of gravel of 1-ft. thickness, graded between 1/4 in. and 2 in., was placed between the compacted selected pervious fill and the rock-fill slope protection on the upstream slope, to serve as a transition to prevent the loss of fines during drawdown and wave action. The compacted pervious fill in the downstream section is underlain by a triangular section of selected pervious fill to insure complete drainage and stability in the downstream shell. A 4-ft. blanket of sand and gravel backing was placed under the rock-fill slope protection to serve as a transition.

The outlet works, which are located on the right bank, consist of an approach channel, two conduits controlled by gates, a control tower, a stilling basin and an outlet channel. These are further described below.

The 99 ft. wide approach channel to the gate tower is 840 ft. long and was excavated in rock. The channel, with a floor at El. 300.0, is contained by concrete walls that support the dam upstream

blanket. The east wall is 470 ft. long and its height is generally 35 ft. above the invert of the channel. The west wall is 85 feet long and varies in height from 37 ft. to 14 ft. above the invert of the channel.

The concrete conduits consist of eight 116.5 ft. long rectangular sections under the control tower and 32.0 ft. long transition sections leading to the 22.0 ft. wide by 10.0 ft. high horseshoe-shaped conduits about 393 ft. long discharging into a stilling basin. The invert of the conduits varies from El. 300.0 under the control tower to El. 299.0 at the stilling basin.

The stilling basin for the two flood control conduits is partitioned by a 299 ft. long wall. Each conduit barrel discharges into a single U-shaped concrete outlet with an invert at El. 299.0 at the conduit exit. The invert elevation of each outlet drops 26 feet to El. 273.0 over 125 feet and then remains constant for a 75-foot long section containing a series of concrete baffles. The flow then merges into a single U-shaped rock-bottom section 168 feet wide, approximately 100 feet long with an invert at El. 273.0. At the end of the stilling basin the flow discharges into the outlet discharge channel.

Below the stilling basin the invert of the outlet discharge slopes up from El. 273 to El. 280.0 over 140 feet. The outlet discharge channel is 168 feet wide at the invert and is excavated in rock with 1V on 2H side slopes. The junction of the outlet channel with the river is approximately 2400 feet from the end of the stilling basin.

The spillway is an uncontrolled fixed-crest weir with a crest length of 550 feet at El. 389.0. The weir is a gravity concrete ogee section founded on rock. The structure has a design discharge capacity of 1900 cubic feet per second. The spillway approach channel is curved in alignment and

flared, with the left side consisting of a concrete wall adjacent to the embankment and the right side a 1V on 2H sloped bank in overburden. This channel was excavated in rock and earth at invert El. 384.0 and is approximately 1,785 feet long. The spillway chute or discharge channel was cut in earth and rock sloping from approximately El. 363 to El. 280, where it discharges into the outlet discharge channel. The spillway discharge channel is approximately 900 feet long and 550 feet wide at the weir, and narrows to 450 feet wide where it joins the outlet discharge. The east spillway channel retaining wall is a 720 feet long gravity type design.

3. INSTRUMENTATION

Instrumentation to monitor embankment performance consists of nine crest survey monuments and thirteen piezometers. Seven locations (PZ - 7 through P-13) have two piezometers installed in the same borehole at different elevations. The lower of the two piezometers is labeled "A" and the higher "B". There are also three strong motion accelerographs installed in the structure. The instrumentation plan is shown in Figure 4.

a. Crest Monuments. Nine crest monuments and three control points (monuments B, C and D) were installed at the dam in 1974 as part of the New England Division Dam Safety Program. The nine crest monuments are located along the downstream edge of the embankment crest and are labeled 1 through 9. The crest survey monuments reportedly consist of a 10-foot length of 3-3/16-inch I.D. steel casing filled with concrete and capped with a brass disk. This description is based on visual inspection and information provided by the Corps of Engineers. The three control points, Mon B, C and D were drilled into ledge or placed and grouted deep into undisturbed soil, and are assumed to be fixed reference points. Monument B has since been abandoned. The initial survey was performed in October of 1974 to establish the elevations of the crest survey monuments. Subsequent surveys were performed in 1975, 1978, 1982, 1987 and 1991 by New England Division surveyors. The last survey was performed in December 1991. The September 1987 and December 1991 surveys were performed using electronic distance meter (EDM) instruments.

b. Piezometers. A total of thirteen piezometers were installed at Franklin Falls Dam. Seven of the piezometers, PZ-7 through PZ-13, have two piezometers in the same borehole but at different elevations with the lower piezometer labeled "A" and the upper "B". The piezometers at Franklin Falls Dam were installed by Mobile District drill crews. Units PZ-1 through PZ-6 were installed

from May to October 1985 while PZ-7 was installed in August 1987 and PZ-8 through PZ-13 were installed from July to August 1991. The piezometers are Casagrande type and are currently read manually using an M-Scope water level indicator. A summary of piezometer locations (station and offset), elevations and a description of the material type at the tip are included on Table I.

c. Strong Motion Accelerographs. Three strong motion accelerographs were installed at Franklin Falls Dam in 1977 to monitor shock wave attenuation through the embankment and foundation during an earthquake. Three Kinemetrics SMA-1 accelerographs were installed in reinforced concrete shelters. SMA-1 A is located on the right abutment west of the spillway, SMA-1 B is on the downstream crest of the embankment (approximate station 17+00), and SMA-1 C is about 420 feet downstream from the toe of the embankment. The SMA-1 accelerographs are compact, portable, self-contained units with an accelerometer for measuring and recording motions in three orthogonal directions. The units are activated automatically by an omni-directional trigger sensitive to vertical accelerations of 0.01g or greater.

4. DATA COLLECTION, INTERPRETATION, AND EVALUATION.

a. Crest Monuments.

(1) Data Collection. The results of the crest monument surveys are shown on Figure 12. Dimensions between control points and crest monuments for the survey performed in October 1991 along with the coordinates and elevations of the control points are also shown on Figure 12. Computed horizontal and vertical movements of each monument are plotted on Figure 13.

(2) Interpretation and Evaluation. Two surveys were performed using an electronic distance meter (EDM) with Third Order, Class II accuracy (1:5000) for horizontal measurements and Third Order, Class I accuracy (1:10,000) for vertical measurements according to the standards and procedures presented in Appendix A.

The surveys indicate that the total rise or settlement of all monuments was limited to, or less than 0.05 feet over the four-year period. This range of movement is within the range of third order accuracy so it is possible that no rise or settlement occurred at all. However, minor settlement of the embankments or settlement of the monument itself within the embankment could have occurred. This small amount of settlement or rise is considered negligible.

The computed horizontal movements are less than 0.06 feet between 1987 and 1991. There was no physical evidence of movement at any monument such as slumps, scarps, cracks or depressions which would indicate movement of any magnitude in the embankment. Also the condition of each monument was judged to be satisfactory; no physical damage or displacement was observed.

The lack of any manifestation of movement of the embankment leads to the conclusion that no significant movement of the dam is occurring at this time. From the data which has been acquired to date, it is concluded that there has been insignificant vertical movement of the embankment and apparent movements are probably due to limitations and accuracy of measurement.

b. Piezometers.

(1) Data Collection.

(a) Reading Schedule. Piezometer monitoring at Franklin Falls Dam is performed manually. The minimum piezometer reading schedule presently in effect is as follows:

- Routine. During periods when the reservoir level is below El. 315, a reading of all piezometers and the pool elevation should be made at least once a month. When access to piezometers is made hazardous by snow or ice, the readings may be deferred until safe passage is possible.

- High Pool. During periods when the reservoir level is above El. 315, readings of all piezometers and pool elevation should be made on a daily basis. On a falling pool, the piezometers should continue to be read on a daily basis for five days after the pool has returned to its normal elevation.

- Special Conditions. If unusual changes in readings develop or if piezometers become inoperable, the Geotechnical Engineering Branch should be notified.

Readings obtained from the piezometers are presented in Table II. Pertinent information includes the date of reading, pool stage and elevation, and piezometer water elevations.

(2) Interpretation and Evaluation.

(a) Presentation of Data. Numerous plots have been developed to present the piezometric data. All the plots were developed using "Quattro Pro for Windows" Version 5.0 computer software. The piezometer plots fall into three categories: time-history, event and "x-y" plots.

Time-history plots were developed for years 1991-1993 and are presented on Figures 14 through 22. Event plots were produced for the rising pool of April 1993 and are shown on Figures 23 through 31. An x-y plot of piezometer water level elevation vs. pool elevation was developed for each piezometer and is shown on Figures 32 through 51. These plots incorporate piezometric data from September 1, 1989 through December 29, 1993. Also plotted is a projection of the piezometer level corresponding to a pool elevation at the spillway crest. This projection was calculated by linearly regressing the piezometer data provided and plotting the best fit line.

In general, the time history plots, including the April 1993 event, indicate very little change in piezometric water levels both with time and from upstream to downstream locations. This behavior indicates free draining deposits beneath the dam. During the summer of 1991 and 1992, lowered piezometric levels were recorded as shown in the time history plots. These lowered levels were associated with repairs to the discharge conduits beneath the embankment which required dewatering.

(b) Individual Piezometer Response. All pertinent information (station, offset, tip elevations, zone and material type at tip location) for each piezometer is listed on Table II. A falling head test was performed on all piezometers immediately after completion of installation. Records of the field tests are kept with the piezometer logs. The tests indicated that the piezometers were working as expected at that time, with the exception of PZ-9B.

The following paragraphs summarize the performance of each piezometer during the normal steady state operation and the response to the April 1993 flood event. Piezometer response, as used in the following paragraphs, is defined as follows:

Magnitude change	Fluctuation
o small / little	0 - 2 ft.
o moderate	2 - 5 ft.
o large	> 5 ft.

(1) PZ-1. PZ-1 is located on the rock fill terrace at Sta. 14+20 and is offset from the dam centerline downstream by 275 feet. The top of the riser pipe is at El. 319.7. The tip is located in the foundation of the dam at El. 269.7. The piezometer was installed in 1985 with a wick of filter sand which extends upward 9.6 feet from El. 254.7. The material influencing the piezometer is a well graded light brown sand with gravel and silt (SW).

The normal "average" water level for PZ-1 is about El. 305.1 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 15. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to

determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 24, the following performance was noted. The water level in PZ-1 rose from its El. 305.1 average level (about 1.1 ft) to El. 306.2 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-1 only changed slightly from El. 305.8 to 306.0. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-1 apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-1 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 32. Based on the linear projection, PZ-1 should rise to El. 312 when the pool rises to the spillway crest at El. 389.

(2) PZ-2. PZ-2 is located on the rock fill terrace at Sta. 15+90 and is offset from the dam centerline downstream by 275 feet. The top of the riser pipe is at El. 331.2. The tip is located in the foundation of the dam at El. 252.2. The piezometer was installed in 1985 with a wick of filter sand which extends upward 39.2 feet from El. 251 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brownish grey, silty sand with gravel (SP-SM).

The normal "average" water level for PZ-2 is about El. 305.1 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 15. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 24, the following performance was noted. The water level in PZ-2 rose from its average level (about 1.1 ft) to El. 306.2 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-2 only changed slightly from El. 305.7 to 306. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-2 apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-2 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 33. Based on the linear projection, PZ-2 should rise to El. 311.1 when the pool rises to the spillway crest at El. 389.

(3) PZ-3. PZ-3 is located on the rock fill terrace at Sta. 18+00 and is offset from the dam centerline downstream by 275 feet. The top of the riser pipe is at El. 330.0. The tip is located in the foundation of the dam at El. 233.7. The piezometer tip was installed in 1985 with a

wick of filter sand which extends upward 28.6 feet from El. 232.05 to a bentonite seal. The material influencing the piezometer tip is a light brown silty sand (SM).

The normal "average" water level for PZ-3 is about El. 304.9 as noted in Table II for pool levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 15. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 24, the following performance was noted. The water level in PZ-3 rose from its average level (about 1.7 ft) to El. 306.6 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-3 only changed slightly from El. 305.6 to 305.9. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-3 apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-3 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 34. Based on the linear projection, PZ-3 should rise to El. 312.3 when the pool rises to the spillway crest at El. 389.

(4) PZ-4. PZ-4 is located on the rock fill terrace at Sta. 19+50 and is offset from the dam centerline downstream by 275 feet. The top of the riser pipe is at El. 330.1. The tip is located in the foundation of the dam at El. 223.4. The piezometer was installed in 1985. The hole collapsed before the filter sand could be placed. A bentonite seal was constructed from El 292.1 to El 296.2. The material influencing the piezometer tip is cobbles and boulders.

The normal "average" water level for PZ-4 is about El. 304.7 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 16. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 25, the following performance was noted. The water level in PZ-4 rose from its average level about 2.8 ft to El. 307.5 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-4 only changed slightly from El. 305.2 to 305.7. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-4 apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-4 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 35. Based on the linear projection, PZ-4 should rise to El. 312.2 when the pool rises to the spillway crest at El. 389.

(5) PZ-5. PZ-5 is located on the rock fill terrace at Sta. 22+60 and is offset from the dam centerline downstream by 275 feet. The top of the riser pipe is at El. 330.7. The tip is located in the foundation of the dam at El. 230.7. The piezometer was installed in 1985 with a wick of filter sand which extends upward 58 feet from El. 229.7 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, grey, medium to fine silty sand (SM).

The normal "average" water level for PZ-5 is about El. 304.5 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 16. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 25, the following performance was noted. The water level in PZ-5 rose from its average level (about 3.4 ft) to El. 307.9 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-5 actually decreased slightly from El. 306.4 to 305.3. This change is small and may be the result of the decreasing pool elevation from 13 April through 17 April. The peak measurement at PZ-5 apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days.

The measured water levels in PZ-5 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 36. Based on the linear projection, PZ-5 should rise to El. 309.3 when the pool rises to the spillway crest at El. 389.

(6) PZ-6. PZ-6 is located on the downstream slope of the dam at Sta. 17+85 and is offset from the dam centerline by 25 feet. The top of the riser pipe is at El. 419.8. The tip is located in the foundation of the dam at El. 223.8. The piezometer was installed in 1985 with a wick of filter sand which extends upward 58.3 feet from El. 218.5 to a bentonite seal. The material influencing the piezometer tip is a well graded, brown gravel with sand and cobbles (GW).

The normal "average" water level for PZ-6 is about El. 305.2 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 14. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 29, the following performance was noted. The water level in PZ-6 rose from its average level (about 3 ft) to El. 308.2 compared to a high pool increase of 23 ft to El. 330. Between 16 and 18 April (no data was available for 17 April), when the pool level varied between El. 319 and 330, PZ-6 rose from El. 307.2 to 308.2. Thus the peak measurement at PZ-6 apparently occurred on 18 April, and the instrument response time lag is about 1 day or less.

The measured water levels in PZ-6 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 37. Based on the linear projection, PZ-6 should rise to El. 320.4 when the pool rises to the spillway crest at El. 389.

(7) PZ-7A. PZ-7A is located on the downstream slope of the dam at Sta. 18+10 and is offset from the dam centerline by 150 feet. The top of the riser pipe is at El. 370.2. The tip is located in the foundation of the dam at El. 218.0. The piezometer was installed in 1987 with a wick of filter sand which extends upward 16.3 feet from El. 208.7 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brown and grey, silty sand (SP-SM).

The normal "average" water level for PZ-7A is about El. 305.1 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 20. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 29, the following performance was noted. The water level in PZ-7A rose from its average level (about 1.9 ft) to El. 307 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-7A only changed slightly from El. 306.4 to 306.5. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-7A apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the

piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-7A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 38. Based on the linear projection, PZ-7A should rise to El. 313.5 when the pool rises to the spillway crest at El. 389.

(8) PZ-7B. PZ-7B is located on the downstream slope of the dam at Sta. 18+10 and is offset from the dam centerline by 150 feet. The top of the riser pipe is at El. 370.5. The tip is located in the horizontal blanket drain at El. 284.5. The piezometer was installed in 1987 with a wick of filter sand which extends upward 114.8 feet from El. 233.7 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brownish grey, gravel with sand (GP).

The normal "average" water level for PZ-7B is about El. 305.1 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 20. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 29, the following performance was noted. The water level in PZ-7B rose from its average level (about 1.1 ft) to El. 306.2 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-7B only changed slightly from El. 305.7 to 306.1. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-7B apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-7B appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 39. Based on the linear projection, PZ-7B should rise to El. 311.2 when the pool rises to the spillway crest at El. 389.

(9) PZ-8A. PZ-8A is located on the upstream slope of the dam at Sta. 18+00 and is offset from the dam centerline by 195 feet. The top of the riser pipe is at El. 360.4. The tip is located in the foundation of the dam at El. 268.8. The piezometer was installed in 1991 with a wick of filter sand which extends upward 15 feet from El. 266.8 to a bentonite seal. The material influencing the piezometer tip is a well graded, orange gravel with sand and large cobbles (GW).

The normal "average" water level for PZ-8A is about El. 305.6 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 21. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest changes in piezometric level that make it difficult to determine a response time for the unit. However, for major fluctuations in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 30, the following performance was noted. The water level in PZ-8A rose from its average level (about 5.5 ft) to El. 311.1 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, when the pool rose from El. 316 to 330, PZ-8A rose

from El. 308.4 and peaked at El. 311.1. This 2.7 ft. rise constitutes a moderate change in piezometric level. With the peak measurement at PZ-8A apparently occurring on 18 April, the value of the instrument response time lag is approximately 1 day or less.

The measured water levels in PZ-8A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 40. Based on the linear projection, PZ-8A should rise to El. 328.1 when the pool rises to the spillway crest at El. 389.

(10) PZ-8B. PZ-8B is located on the upstream slope of the dam at Sta. 18+00 and is offset from the dam centerline by 195 feet. The top of the riser pipe is at El. 360.7 . The tip is located in the compacted pervious fill zone of the embankment at El. 301.8. The piezometer was installed in 1991 with a wick of filter sand which extends upward 11 feet from El. 296.8 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, orange, medium to fine silty sand (SP-SM).

The normal "average" water level for PZ-8B is about El. 306.2 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 21. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 30, the following performance was noted. The water level in PZ-8B rose from its average level (about 3 ft) to El. 309.2 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from

El. 316 to 330, PZ-8B did not change at all and remained at El. 308.5. The peak measurement at PZ-8B apparently occurred the next day on 19 April, and thus the value of the instrument response time lag might be about 2 days.

The measured water levels in PZ-8B appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 41. Based on the linear projection, PZ-8B should rise to El. 321.5 when the pool rises to the spillway crest at El. 389.

(11) PZ-9A. PZ-9A is located on the upstream slope of the dam at Sta. 18+00 and is offset from the dam centerline by 95 feet. The top of the riser pipe is at El. 392.0. The tip is located in the foundation of the dam at El. 269.3. The piezometer was installed in 1991 with a wick of filter sand which extends upward 22 feet from El. 268.3 to a bentonite seal. The material influencing the piezometer tip is a well graded, orange brown, medium sand with gravel and silt (SW-SM).

The normal "average" water level for PZ-9A is about El. 306.9 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 22. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 31, the following performance was noted. The water level in PZ-9A rose from its average level (about 3 ft) to El. 309.9 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, when the pool rose from El. 316

to 330, PZ-9A rose from El. 307.8 and peaked at 309.9. This change is small and certainly could be affected by accuracy of measurement. With the peak measurement at PZ-9A apparently occurring on 18 April, the value of the instrument response time lag is 1 day or less.

The measured water levels in PZ-9A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 42. Based on the linear projection, PZ-9A should rise to El. 324 when the pool rises to the spillway crest at El. 389.

(12) PZ-9B. PZ-9B is located on the upstream slope of the dam at Sta. 18+00 and is offset from the dam centerline by 95 feet. The top of the riser pipe is at El. 392.3. The tip is located in the compacted pervious fill zone of the embankment at El. 315.3. The piezometer was installed in 1991 with a wick of filter sand which extends upward 16 feet from El. 314.3 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, orange brown, medium to course sand with gravel and silt (SP-SM).

The normal "average" water level for PZ-9B is about El. 335.1 as noted in Table II for normal river levels ranging from El. 305 to 309. PZ-9B had little to no response to fluctuations in the pool elevation as shown in Fig. 22. In fact, during a portion of the high pool event in April 1993 as shown in Fig. 31, there was little change in PZ-9B readings for more than 18 days after a 13.5 foot, single day increase in pool elevation had occurred. The water level in PZ-9B changed only 0.7 ft. throughout the entire high pool event in April 1993.

During installation, falling head field test records showed that the water level dropped only 0.5 ft. in 10 minutes. Tests on other piezometers installed in similar embankment materials produced significantly larger drops in water levels. Based on the lack of response to falling head tests and to

fluctuations in pool water level, either (1) the piezometer tip is plugged or (2) the compacted pervious fill surrounding the tip and 16 foot wick actually behaves as low permeability, "impervious" fill. Piezometer 11B, which was installed at a similar elevation in the cross section, behaves in the same manner as PZ-9B. Since other piezometers installed in 1991 including PZ 9A and 11A, function properly, the installation techniques used by the drillers were probably similar. Thus, a plugged piezometer is unlikely. Therefore, at least the lower portion of the upstream pervious fill may act as an extension of the impervious core and upstream blanket. Water trapped by the blanket and core might be producing a perched water table indicated by the higher piezometer readings of 9B and 11B.

The response of PZ-9B to changes in the pool elevation is nearly linear as shown in Figure 43. However, since the instrument response time lag is so large, this regression does not serve a useful purpose.

(13) PZ-10A. PZ-10A is located on the upstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 195 feet. The top of the riser pipe is at El. 360.3. The tip is located in the foundation of the dam at El. 266.4. The piezometer was installed in 1991 with a wick of filter sand which extends upward 7 feet from El. 263.4 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brown sand with silt (SP-SM).

The normal "average" water level for PZ-10A is about El. 305.9 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 17. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the

piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 26, the following performance was noted. The water level in PZ-10A rose from its average level about 6.4 ft to El. 312.3 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, which was the largest daily fluctuation in the April 1993 event, the pool rose from El. 316 to 330 and PZ-10A responded moderately, rising from El. 309.2 to peak at El. 312.3. Thus the value of the instrument response time lag is about 1 day or less.

The measured water levels in PZ-10A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 44. Based on the linear projection, PZ-10A should rise to El. 330.7 when the pool rises to the spillway crest at El. 389.

(14) PZ-10B. PZ-10B is located on the upstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 195 feet. The top of the riser pipe is at El. 360.2. The tip is located in the compacted pervious fill zone of the dam embankment at El. 307.4, which is slightly above the normal pool elevation. The piezometer was installed in 1991 with a wick of filter sand which extends upward 4.5 feet from El. 306.4 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brown, medium sand with silt (SP-SM).

The normal "average" water level for PZ-10B was not determined for normal river levels ranging from El. 305 to 309. The piezometer was dry when the pool was at normal levels. Therefore, piezometer levels were only obtained during part of the April 1993 event, from 13 April 1993 to 23 April 1993 as shown on Figures 17 and 26. Because of the short duration over which the piezometric levels were recorded, limited information may be obtained from PZ-10B.

Between 17 and 18 April, when the pool rose from El. 316 to 330, PZ-10B rose from El. 309 to 309.4. This change is small and certainly could be affected by accuracy of measurement. The peak measurement of El. 310.2 at PZ-10B apparently occurred the next day, on 19 April, suggesting that the value of the instrument response time lag might be about 2 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls between 1 and 2 days.

The measured water levels in PZ-10B appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 45. Based on the linear projection, PZ-10B should rise to El. 309.2 when the pool rises to the spillway crest at El. 389. However, this projected elevation is less than the peak elevation measured in April 1993, and thus the actual water level in PZ-10B when the pool is at the spillway crest would be higher than the projected value. This discrepancy may probably be attributed to the small amount of data on which the regression was performed.

(15) PZ-11A. PZ-11A is located on the upstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 95 feet. The top of the riser pipe is at El. 390.2. The tip is located in the foundation of the dam at El. 268.4. The piezometer was installed in 1991 with a wick of filter sand which extends upward 31 feet from El. 266.4 to a bentonite seal. The material influencing the piezometer tip is a light brown sandy silt (ML).

The normal "average" water level for PZ-11A is about El. 305.7 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 18. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the

flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 27, the following performance was noted. The water level in PZ-11A rose from its average level about 4.4 ft to El. 310.1 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, when the pool rose from El. 316 to 330, PZ-11A rose from El. 308 to 310.1. This 2.1 ft. rise constitutes a moderate change in piezometric level. Thus the peak measurement at PZ-11A apparently occurred on 18 April, and the value of the instrument response time lag is about 1 day or less.

The measured water levels in PZ-11A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 46. Based on the linear projection, PZ-11A should rise to El. 324.7 when the pool rises to the spillway crest at El. 389.

(16) PZ-11B. PZ-11B is located on the upstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 95 feet. The top of the riser pipe is at El. 390.3. The tip is located in the compacted pervious fill zone of the dam embankment at El. 316.4 just above the top surface impervious blanket at El. 313.0. The piezometer was installed in 1991 with a wick of filter sand which extends upward 15 feet from El. 313.4 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brown silty sand with trace gravel (SP-SM).

The normal "average" water level for PZ-11B is about El. 333.7 as noted in Table II for normal river levels ranging from El. 305 to 309. PZ-11B had little to no response to fluctuations in the pool elevation as shown in Figures 18 and 27. Based on the lack of response to changes in pool water level, it is likely that the "pervious fill" surrounding the tip and 1 ft. wick section actually behaves as

low permeability impervious fill. Refer to the discussion of PZ-9B where similar insensitive piezometric performance was encountered.

The response of PZ-11B to changes in the pool elevation is nearly linear as shown in Figure 47. However, since the piezometer tip is located just above the impervious blanket and may be measuring a perched water level, this regression does not serve a useful purpose.

(17) PZ-12A. PZ-12A is located on the downstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 20 feet. The top of the riser pipe is at El. 417.9. The tip is located in the foundation of the dam at El. 276.2. The piezometer was installed in 1991 with a wick of filter sand which extends upward 15 feet from El. 273.2 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brown sand with trace gravel (SP).

The normal "average" water level for PZ-12A is about El. 305.2 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 19. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 28, the following performance was noted. The water level in PZ-12A rose from its average level about 2.8 ft to El. 308 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, when the pool rose from El. 316 to 330, PZ-12A rose from El. 306.9 to El. 308. It appears then, that changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained

on 17 and 18 April. The peak measurement at PZ-12A apparently occurred on 18 April, and thus the value of the instrument response time lag is about 1 day or less.

The measured water levels in PZ-12A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 48. Based on the linear projection, PZ-12A should rise to El. 318.6 when the pool rises to the spillway crest at El. 389.

(18) PZ-12B. PZ-12B is located on the downstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 20 feet. The top of the riser pipe is at El. 418.1. The tip is located in the core of the dam at El. 305.2. The piezometer was installed in 1991 with a wick of filter sand which extends upward 7 feet from El. 303.2 to a bentonite seal. The material influencing the piezometer tip is a clayey sand with gravel (SC).

No water levels have been observed in PZ-12B since it was installed. As shown in Figure 56, the phreatic level for normal river conditions at PZ-12B is El. 305 which is 2.3 feet below the piezometer tip. Thus, there is no water level in the piezometer to be measured. The falling head test performed just after installation indicated that the piezometer was working properly.

(19) PZ-13A. PZ-13A is located on the downstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 130 feet. The top of the riser pipe is at El. 376.0. The tip is located in the foundation of the dam at El. 275.6. The piezometer was installed in 1991 with a wick of filter sand which extends upward 10 feet from El. 271.6 to a bentonite seal. The material influencing the piezometer tip is a poorly graded, brown, medium sand (SP).

The normal "average" water level for PZ-13A is about El. 305 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 19; Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 28, the following performance was noted The water level in PZ-13A rose from its average level about 1.3 ft to El. 306.3 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-13A changed slightly from El. 305.7 to 306.2. This change is small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-13A apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-13A appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 49. Based on the linear projection, PZ-13A should rise to El. 312.2 when the pool rises to the spillway crest at El. 389.

(20) PZ-13B. PZ-13B is located on the downstream slope of the dam at Sta. 22+00 and is offset from the dam centerline by 130 feet. The top of the riser pipe is at El. 376.1. The tip is located in the toe drain of the dam at El. 295.6. The piezometer was installed in 1991 with a wick of

filter sand which extends upward 17.8 feet from El. 286.1 to a bentonite seal. The material influencing the piezometer tip is a poorly graded brown gravel with sand (GP).

The normal "average" water level for PZ-13B is about El. 304.1 as noted in Table II for normal river levels ranging from El. 305 to 309. The piezometer did respond to changes in the pool elevation as shown in Fig. 19. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in piezometric level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the piezometer level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 28, the following performance was noted. The water level in PZ-13B rose from its average level about 2.1 ft to El. 306.2 compared to a high pool increase of 23 ft to El. 330. Between 17 and 18 April, however, when the pool rose from El. 316 to 330, PZ-13B only changed slightly from El. 305.7 to 306.0. This change is relatively small and certainly could be affected by accuracy of measurement.

The peak measurement at PZ-13B apparently occurred on 24 April, and thus the upper value of the instrument response time lag might be 6 or 7 days. However, it appears that small changes in the piezometric level occur within a day of major changes in the pool level as noted in the data obtained on 17 and 18 April. Thus the response time probably falls in a range of 1 to 6 days.

The measured water levels in PZ-13B appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 50. Based on the linear projection, PZ-13 should rise to El. 312.5 when the pool rises to the spillway crest at El. 389.

(21) OW-1. OW-1 is located on the rock fill terrace at Sta. 18+00 and is offset from the downstream toe of the dam by approximately 270 feet. At the time of this report, no information was available about the elevation of the observation well screen, the dimension of the wick or the material influencing the observation well screen.

The normal "average" water level for OW-1 is about El. 306.3 as noted in Table II for pool levels ranging from El. 305 to 309. The observation well did respond to changes in the pool elevation as shown in Fig. 16. Under normal river conditions, the river level fluctuates less than four feet. This narrow range results in modest fluctuations in water level that make it difficult to determine a response time for the unit. However, for major changes in the pool level, such as the flood event of April 1993, a 23 foot increase in pool level resulted in a noticeable change in the water level. Therefore, response times can be calculated from this flood event. Based on the available steady state versus the April 1993 flood event shown in Fig. 25, the following performance was noted. The water level in OW-1 rose from its average level about 6.6 ft (El. 312.9) compared to a high pool increase of 23 ft (El. 330). No data was available for the dates 17 and 18 April when the pool rose from El. 316 to El. 330.

The peak measurement at OW-1 apparently occurred on 28 April, and thus the upper value of the instrument response time lag might be 9 or 10 days. However, OW-1 indicated an elevation of El. 312.4 on 31 March 1993 when the pool level was measured to be El. 322.9. Data was not available from the previous weeks in March that would indicate a time lag trend. Thus the response time probably falls in a range of 1 to 10 days.

The measured water levels in OW-1 appear to respond in a nearly linear manner to changes in pool elevation as shown in Figure 51. Based on the linear projection, OW-1 should rise to El. 345.5 when the pool rises to the spillway crest at El. 389.

(c) Profile Evaluations. Time history data for piezometers located on two longitudinal profiles were plotted along with pool elevation so that seepage characteristics could be evaluated. Two profiles were evaluated: a) centerline of the dam and b) downstream toe of the dam. These profiles were plotted for two events: a) historical plots including data from September 1989 through December 1993 and b) the April 1993 event.

(1) Profile on Centerline of Dam. As shown on Figure 14, piezometers PZ-6 and PZ-12A (foundation piezometers) measure approximately the same piezometric level (PZ-12B is dry; no readings have been obtained either during normal river levels or a high pool). The changes in piezometric readings along the centerline of the dam over time reflect the changes in pool elevation and effects of dewatering for conduit repair in the later summer of 1991 and 1992. Under normal run of river operation, it is reasonable that piezometers 6 and 12A measure approximately the same level due to sandy foundation material described in paragraphs 2.b and 2.a. As shown on the April 1993 event plot (Figure 23), both piezometers responded to the changing pool elevation in the same manner but changes were relatively small. Figure 54 shows average, high pool, and projected piezometric levels along the centerline of the dam.

(2) Profile on Downstream Toe of Dam. As shown on Figures 15 and 16, piezometers PZ-1 through PZ-5 generally show the same changes in water levels over time. The changes in piezometer readings along the downstream toe of the dam generally reflect the changes in pool elevation. As shown on Figures 24 and 25, the April 1993 event plots, each piezometer generally responded to the changing pool elevation in the same manner. Figure 55 shows average, high pool, and projected piezometric levels along the downstream toe of the dam.

There is a slight decrease in head along the downstream toe from the right abutment to the left abutment, with PZ-1 measuring the highest piezometric level and PZ-5 measuring the lowest level during normal conditions. This trend may also be seen on the phreatic surface contour plan of normal river conditions as shown in Figure 56 during normal.

(d) Cross Section Evaluations. Data for piezometers located on the same cross section were plotted with pool elevation on time history plots. Two cross sections were prepared and evaluated: Sta. 18+00 and Sta. 22+00, Figures 8 and 9, respectively.

(1) Station 18+00. As shown in Figures 20 through 22, each piezometer in the section records approximately the same groundwater elevation with the exception of PZ-9B (refer to discussion of individual piezometric behavior for comments on PZ-9B). Under normal run of river operating conditions, there is essentially no head loss across the dam (as shown on Figure 52). Therefore, it is reasonable that each piezometer measures approximately the same piezometric level. Except for PZ-9B, the piezometers in this section generally respond to changes in pool elevation. The magnitude of response is typically less than a 3 foot change in piezometric head during a corresponding 10 to 20 foot increase in pool level. For example, as shown in the April 1993 event plotted on Figures 29 through 31, the upstream piezometers, PZ-8A and PZ-8B, measured the highest piezometric level, while the downstream piezometers, PZ-7A and PZ-7B, measured the lowest piezometric level. Figure 52 shows average and projected piezometric levels along Station 18+00.

The 20 to 25 foot lower levels recorded in the late summer in 1991 and 1992 (Figs. 15 through 22) were a result of dewatering required during repairs to the discharge conduits.

(2) Station 22+00. As shown in Figures 17 through 19, each piezometer along the section measures approximately the same groundwater elevation with the exceptions of PZ-11B, PZ-10B and PZ-12B (refer to discussion of individual piezometer behavior for comments on PZ-11B). Piezometers 10B and 12B are dry during normal river levels and 12B did not register data during the time frame of this report. Each piezometer (with the exceptions of PZ-11B, 10B and 12B) showed a drop in elevation in August 1992 during dewatering for conduit repairs. Increase in elevation occurred in each piezometer (with the exceptions of 11B and 12B) during the high pool event in April 1993. As shown in the event plots on Figures 26 through 28, the piezometric readings generally behaved in classic phreatic manner, with the highest pore pressure at the upstream piezometer and decreasing in

the downstream direction in each successive piezometer. There is no significant head loss across the dam during normal river levels.

Figure 53 shows average and projected piezometric levels along the downstream toe of the dam. In general, PZ-10A and PZ-10B had the highest pore pressures and PZ-13A and PZ-13B had the lowest readings. The exception was PZ-11B, which had consistently high piezometric levels representative of slow drainage probably due to "impervious" fill.

(e) Phreatic Surface Elevation Plan. Figure 56 presents a plot of phreatic surface elevations for the normal pool elevation. The plot includes data for all piezometers except PZ-9B and 11B which appear to be located in impervious fill. The water level contours indicate that there is a two foot head differential across the dam. Similar trends in dissipation of head occurred for the event of April 1993 with the total head loss acroos the dam increasing to approximately 20 feet. Upstream, the piezometric level is at El. 307, the normal river levels. There is a very gradual decrease to El. 305 in the downstream slope of the dam. These contours appear to be reasonable, considering that the river is essentially flowing through the dam.

c. Strong Motion Accelerographs.

1. Data Collection. The U.S. Army Corps of Engineers Waterways Experiment Station (WES) maintains all of the New England Division's strong motion instruments. Personnel from WES inspect each site twice per year as part of a maintenance and repair program. Franklin Falls Dam personnel perform a mandatory monthly inspection to check the AC power inside each shelter and record the electromechanical counter reading at each instrument. Their findings are recorded on a standard form and mailed to Geotechnical Engineering Division (GED).

In the event of an earthquake, and in accordance with ER-1110-2-1802, GED directs Franklin Falls Dam personnel to read the counters and perform a visual inspection of the project. Based on

this inspection and the intensity of the event, an engineering team may be dispatched to perform a visual inspection, and the Office of the Chief of Engineers (OCE) may be advised.

WES is also notified so that they can retrieve the earthquake record from any activated accelerographs. GED is required to provide an Earthquake Incident Report of the event.

2. Interpretation and Evaluation. Franklin Falls Dam has experienced five significant seismic events since the accelerographs were installed in 1977. The accelerographs have been activated once during a seismic event. The seismic event was centered in Gaza, New Hampshire and had an intensity (Modified Mercalli Intensity) at the center of 5.2 Other seismic events have not activated the accelerographs at the site. Their respective intensities are listed in Table III, Historic Seismic Data.

5. CONCLUSIONS AND RECOMMENDATIONS

a. General.

Geotechnical instrumentation at Franklin Falls consists of crest survey monuments, piezometers and accelerographs. All instruments appear to be functioning properly except that PZ-12B is dry all year round and PZ-10A is dry except during high pools. The fill material surrounding upstream piezometers PZ-9B and PZ-11B appear to act as an extension of the impervious core and upstream blanket.

b. Crest Monuments.

(1) Schedule. The schedule of crest monument surveys at Franklin Falls Dam is once every five years to coincide with the periodic inspection schedule. The next scheduled survey is to be performed in 1996. If unusual readings are obtained during the next survey or if field evidence of embankment movement is discovered, the monitoring schedule will be adjusted as needed.

(2) Evaluation of Adequacy. Total settlement of all bounds was limited to less than 0.06 feet over a four year period. This settlement could be attributed to the survey accuracy, settlement of the embankment or to the settlement of the bound itself. This small amount of settlement is considered negligible.

The present configuration and number of crest monuments and control points is considered adequate to monitor horizontal and vertical movement of the dam embankment. With the advent of Global Positioning Systems Survey (GPS) such as NAVSTAR, the accuracy of three dimensional movements can be detected at levels of less than 5 millimeters (Ref. ETL 1110-1-133). The implementation of this type of monitoring system within the next five years if recommended if it proves to be cost effective.

c. Piezometers.

(1) Reading Schedule. The current piezometer reading schedule as outlined in paragraph 4.b.1.a of this report should continue to be implemented by project personnel.

(2) Evaluation of Adequacy. The piezometer data manipulation and plots show the seepage patterns within the embankment and foundation of Franklin Falls Dam. The piezometer plots indicate that there is little head loss across the dam during normal pool elevations.

Based on the data collected to date, the piezometers appear to be functioning properly. The present number and configuration of piezometers is adequate to evaluate pore pressures affecting the dam.

The observed instrument response lag time is about one day for piezometers installed beneath the upstream slope compared to approximately 2 to 6 days for piezometers beneath the downstream slope. Also, upstream piezometers are more responsive to changes in pool elevation compared to downstream piezometers.

To further evaluate the response time and sensitivity of piezometers PZ 9B and 11B, a temporary pressure transducer could be sealed inside the riser pipe. This would permit observation of pressure head changes whenever the pool level exceeded the normal elevated head (about El. 330) which remains trapped inside the piezometer standpipes.

d. Strong Motion Accelerographs.

(1) Reading Schedule. The present schedule for reading the strong motion accelerographs at Franklin Falls Dam is once per month with biannual inspections by WES personnel. The present schedule is adequate and should be maintained.

(2) Evaluation of Adequacy. The strong motion instrumentation is sufficient in monitoring movement of the embankment and foundation in the event of an earthquake. Continued maintenance of the current equipment is recommended and no additional accelerographs are required at this time.

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TABLE I

PIEZOMETER SUMMARY
FRANKLIN FALLS DAM

PIEZOMETER NUMBER	APPROXIMATE STATION	APPROXIMATE CENTELINE OFFSET	RISER PIPE TOP ELEVATION	PIEZOMETER TIP ELEVATION	ZONE LOCATED	MATERIAL AT TIP ELEVATION
PZ-1	14+20	275	329.7	269.7	FOUNDATION	Lt. br. SAND w/ gravel (34) and silt (5) (SW)
PZ-2	15+90	275	331.2	252.2	FOUNDATION	Br. gr. SAND w/ silt (10) and gravel (7) (SP-SM)
PZ-3	18+00	275	330.0	233.7	FOUNDATION	Lt. br. silty (24) SAND (SM)
PZ-4	19+50	275	330.1	223.4	FOUNDATION	Cobbles and Boulders
PZ-5	22+60	275	330.7	230.7	FOUNDATION	Gr. silty (20.6) m-f SAND (SM)
PZ-6	17+85	25	419.8	223.8	FOUNDATION	Br. GRAVEL w/ sand (5-20) w/ cobbles (GW)
PZ-7A	18+10	150	370.2	218.0	FOUNDATION	Br. and gr. SAND w/ silt (5.9) (SP-SM)
PZ-7B	18+10	150	370.5	284.5	HORIZONTAL BLANKET DRAIN	Br. gr. GRAVEL w/ sand (20-30) (GP)
PZ-8A	18+00	195	360.4	268.8	FOUNDATION	Orange GRAVEL w/ sand (27.5) and lg. cobbles (GW)
PZ-8B	18+00	195	360.7	301.8	COMPACTED PERVIOUS FILL	Orange m-f SAND w/ silt (6.9) (SP-SM)
PZ-9A	18+00	95	392.0	269.3	FOUNDATION	Orange br. m SAND w/ gravel (28.1) and silt (7.4) (SW-SM)
PZ-9B	18+00	95	392.2	315.3	COMPACTED PERVIOUS FILL	Orange br. m-c SAND w/ gravel (4-7) and silt (7.4) (SP-SM)
PZ-10A	22+00	195	360.3	266.4	FOUNDATION	Br. SAND w/ silt (12.1) (SP-SM)
PZ-10B	22+00	195	360.2	307.4	COMPACTED PERVIOUS FILL	Br. m SAND w/ silt (14.2) (SP-SM)
PZ-11A	22+00	95	390.2	268.4	FOUNDATION	Lt. br. sandy (43.2) SILT (ML)
PZ-11B	22+00	95	390.3	316.4	COMPACTED PERVIOUS FILL	Br. silty (15.3) SAND w/ trace gravel (SM)
PZ-12A	22+00	20	417.9	276.2	FOUNDATION	Br. SAND w/ trace gravel (SP)
PZ-12B	22+00	20	418.1	305.2	CORE	Olive clayey (49.9) SAND w/ trace gravel (SC)
PZ-13A	22+00	130	376.0	275.6	FOUNDATION	Br. m SAND (SP)
PZ-13B	22+00	130	376.1	295.6	TOE DRAIN	Br. GRAVEL w/ sand (0-10) (GP)
OW-1	18+00	270	NA	NA	NA	NA

Notes:
1. All elevations in feet and referenced to National Geodetic Vertical Datum (NGVD).

JANUARY 1995

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TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL El.	PIEZOMETRIC LEVEL (FT, NGVD)																				
		PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
01-Sep-89	304.48	303.7	303.7	302.8	301.5	303.8	303.0	303.4	303.7													
03-Oct-89	306.12	305.1	305.1	304.2	302.7	301.8	304.2	304.8	305.1													
23-Oct-89	323.50	306.1	306.0	306.5	307.5	308.0	307.7	305.8	307.3													
24-Oct-89	314.96	305.9	306.1	306.5	307.2	305.7	306.9	305.8	306.8													
25-Oct-89	310.76	305.4	305.5	305.9	306.4	306.8	306.1	305.3	306.0													
27-Oct-89	307.56	304.4	304.1	305.0	305.1	305.5	304.8	304.0	305.3													
28-Oct-89	307.15	305.3	305.3	305.5	306.8	305.9	305.5	305.1	305.6													
01-Dec-89	306.30	304.8	304.8	304.9	305.3	305.6	304.8	304.9	304.8													
03-Jan-90	306.40	305.5	305.6	305.7	306.0	306.4	305.5	305.6	305.7													
01-Feb-90	307.49	304.8	304.9	305.0	305.5	NA	305.9	305.2	304.9													
02-Mar-90	307.30	305.0	304.9	304.9	308.5	NA	305.0	305.3	304.8													
19-Mar-90	332.46	305.8	306.0	306.8	308.3	309.1	308.8	307.4	306.0													
20-Mar-90	327.55	305.0	304.9	305.6	307.0	307.9	307.6	306.3	304.9													
21-Mar-90	322.14	304.6	304.6	304.1	303.5	303.0	306.2	305.5	304.6													
22-Mar-90	319.55	305.7	305.7	305.0	303.9	303.3	306.7	306.5	305.8													
23-Mar-90	314.87	304.9	304.8	304.2	303.4	302.6	305.6	305.5	304.8													
24-Mar-90	313.24	305.7	305.7	304.9	303.7	302.9	306.0	306.2	305.8													
25-Mar-90	311.80	306.0	306.0	305.3	304.1	303.4	306.1	306.3	306.1													
26-Mar-90	310.26	305.5	305.4	304.7	303.6	302.7	305.5	305.9	306.4													
27-Mar-90	309.54	306.0	305.9	305.4	303.8	302.7	305.7	306.0	306.0													
28-Mar-90	308.70	306.0	306.0	306.2	306.7	307.0	306.4	306.2	306.0													
29-Mar-90	308.03	305.6	305.5	305.7	306.3	306.6	305.9	305.8	305.4													
30-Mar-90	307.72	305.1	304.9	305.1	305.7	306.1	305.5	305.6	304.9													
02-Apr-90	307.06	304.7	304.5	304.8	305.3	305.7	305.0	305.1	304.5													
04-Jun-90	306.23	305.2	305.2	304.4	303.3	302.4	304.8	304.9	305.2													
02-Jul-90	307.21	304.5	304.4	303.6	302.4	301.7	304.2	304.3	304.4													
01-Aug-90	305.76	305.0	305.0	305.1	305.1	304.0	304.9	305.0	304.9													
09-Aug-90	328.05	306.2	306.2	306.9	308.3	309.1	308.6	307.5	306.2													
10-Aug-90	321.28	305.1	305.0	304.8	304.7	305.0	306.8	305.8	305.0													
11-Aug-90	321.85	305.2	305.0	304.5	303.8	303.1	306.2	305.1	305.0													
12-Aug-90	332.27	306.4	306.3	306.1	306.0	305.8	309.0	307.2	306.3													
13-Aug-90	331.62	305.6	305.5	305.3	305.2	304.8	308.2	306.2	305.5													
14-Aug-90	326.72	305.0	304.9	305.7	307.4	308.5	308.0	306.5	304.8													
15-Aug-90	330.30	305.9	306.0	305.9	305.8	305.3	308.5	306.6	306.0													
16-Aug-90	324.73	305.8	305.2	305.0	304.7	304.4	307.3	305.8	305.2													
17-Aug-90	315.47	305.2	305.1	305.6	306.8	307.5	306.9	306.1	305.1													
20-Aug-90	307.44	305.8	305.8	305.5	304.8	304.5	305.8	306.1	305.7													
21-Aug-90	306.77	305.5	305.4	305.7	306.3	306.8	305.8	305.9	305.3													
22-Aug-90	306.48	305.5	305.4	304.7	303.8	303.3	305.4	305.7	305.4													
01-Sep-90	306.13	305.6	305.6	305.5	306.3	306.7	305.7	305.9	305.6													
01-Oct-90	305.77	304.8	304.6	303.8	302.5	301.6	304.2	304.2	304.7													
15-Oct-90	318.25	305.4	305.3	304.7	303.9	303.3	306.1	305.7	305.3													
16-Oct-90	314.00	305.3	305.4	305.9	306.6	307.1	306.2	305.8	305.4													
17-Oct-90	310.65	306.1	306.2	305.4	304.0	303.0	305.9	305.8	306.2													
18-Oct-90	308.99	305.8	305.8	304.9	303.6	302.7	305.5	305.5	305.8													
25-Oct-90	322.54	305.6	305.4	305.8	305.9	306.1	307.3	306.7	305.3													

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HALEY & ALDRICH, INC.

TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL El.	PIEZOMETRIC LEVEL (FT, NGVD)																			
		PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
26-Oct-90	319.30	305.7	305.7	305.5	304.9	304.6	306.9	306.3	305.6													
29-Oct-90	310.13	305.4	305.3	304.7	303.5	302.7	305.5	305.4	305.4													
30-Oct-90	308.98	305.7	305.9	305.7	305.8	305.7	306.0	305.6	305.8													
31-Oct-90	308.40	305.7	305.7	304.9	303.7	302.7	305.4	305.4	305.7													
01-Nov-90	308.00	305.0	304.9	304.9	305.4	305.7	305.1	304.9	304.8													
03-Dec-90	306.16	304.7	304.6	304.8	305.4	305.9	305.0	304.5	304.6													
16-Dec-90	324.10	305.1	304.9	305.4	306.9	307.9	307.2	306.3	304.8													
27-Dec-90	315.70	305.4	305.4	306.1	307.0	307.5	306.7	306.3	305.3													
28-Dec-90	311.10	305.6	305.7	306.2	307.2	307.4	307.1	306.3	305.4													
31-Dec-90	310.25	306.4	306.4	306.7	307.3	307.7	306.9	306.8	306.4													
02-Jan-91	308.67	305.8	305.8	306.0	306.6	307.2	306.3	306.3	305.6													
01-Feb-91	306.27	305.5	305.4	305.5	306.0	306.5	306.7	305.8	305.4													
01-Mar-91	305.86	304.2	303.9	304.1	304.8	306.0	304.4	306.9	305.2													
01-Apr-91	308.49	305.2	305.1	304.3	303.0	302.4	305.1	305.1	305.1													
01-May-91	309.15	304.1	304.4	304.2	303.6	303.5	304.7	304.6	304.2													
31-May-91	306.10	305.2	305.2	305.0	304.6	303.9	305.2	305.2	305.2													
01-Jul-91	305.44	304.5	304.6	303.8	302.9	301.5	304.0	304.1	304.6													
01-Aug-91	305.41	305.0	305.1	304.9	304.1	304.8	305.0	305.1	305.1													
30-Aug-91	306.00	305.6	305.6	305.7	306.0	306.3	305.5	305.8	305.6													
01-Oct-91	307.47	298.3	298.3	298.9	300.0	300.9	299.9	299.3	298.3													
21-Oct-91	317.98	305.7	305.8	306.3	307.2	307.6	307.2	306.5	305.8													
22-Oct-91	312.19	305.9	306.0	305.2	304.1	303.0	305.8	305.5	306.0													
23-Oct-91	307.55	305.6	305.6	305.8	306.3	306.6	305.9	306.0	305.5													
24-Oct-91	306.78	305.6	305.6	305.7	306.2	306.4	305.7	305.9	305.5													
25-Oct-91	306.58	305.4	305.3	305.5	305.9	306.2	305.5	305.7	305.2													
01-Nov-91	306.10	305.4	305.4	305.5	305.8	306.0	305.4	305.6	305.3													
01-Dec-91	306.40	305.5	305.5	305.6	306.0	306.2	305.5	305.7	305.4													
02-Jan-92	307.73	305.4	305.4	304.6	303.3	302.4	304.9	305.0	305.5													
31-Jan-92	306.04	305.2	305.2	305.3	305.7	306.0	305.3	305.2	305.1													
02-Mar-92	305.93	305.3	305.4	304.5	303.1	305.3	304.6	305.0	305.5													
12-Mar-92	318.30	305.8	305.7	305.8	306.7	307.1	306.5	306.0	305.6													
13-Mar-92	321.62	306.2	306.2	306.6	310.1	307.9	307.5	306.8	306.1													
14-Mar-92	312.20	305.6	305.6	306.0	306.7	307.1	306.5	306.1	305.5													
15-Mar-92	305.40	305.6	305.6	305.9	306.6	306.7	306.1	306.0	305.6													
16-Mar-92	308.70	305.3	305.2	305.4	305.9	306.3	305.6	305.4	305.1													
17-Mar-92	307.60	305.3	305.4	305.5	306.0	306.3	305.6	305.4	305.3													
18-Mar-92	306.70	305.0	305.1	304.5	303.5	303.0	305.0	305.0	305.1													
19-Mar-92	306.64	305.7	305.8	305.9	306.3	306.6	305.8	305.8	305.7													
30-Mar-92	314.64	304.6	304.4	304.5	305.1	305.3	305.2	305.5	304.4													
31-Mar-92	310.56	305.2	305.4	304.6	303.6	302.7	305.2	305.0	305.4													
01-Apr-92	309.37	305.9	305.9	305.1	303.9	303.0	305.6	305.6	305.9													
02-Apr-92	307.99	305.3	305.3	305.5	306.0	306.4	305.7	305.5	305.2													
03-Apr-92	307.40	305.8	305.8	305.3	304.2	303.8	306.2	306.1	305.6													
22-Apr-92	317.55	305.5	305.6	305.1	304.3	303.5	306.1	305.4	305.7													
23-Apr-92	320.52	305.5	305.5	305.5	304.2	303.6	306.4	305.4	305.4													
24-Apr-92	321.48	305.5	305.5	306.1	307.3	308.0	307.4	306.4	305.4													
25-Apr-92	319.60	305.5	305.4	306.0	307.1	307.8	307.2	306.3	305.3													

FILE NO.

HALEY & ALDRICH, INC.

TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL El.	PIEZOMETRIC LEVEL (FT, NGVD)																				
		PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
26-Apr-92	317.00	305.3	305.2	305.8	306.8	307.5	307.0	306.0	305.1													
27-Apr-92	316.17	305.3	305.3	304.6	303.9	303.3	305.9	305.2	305.2													
28-Apr-92	312.43	305.4	305.5	305.8	306.5	306.9	306.2	305.8	305.5													
29-Apr-92	310.80	306.0	306.0	305.3	304.3	303.4	306.1	305.9	306.0													
30-Apr-92	309.80	305.9	306.0	305.3	304.1	303.2	305.9	305.9	305.9													
01-May-92	309.74	306.0	306.1	305.3	304.1	303.1	305.8	300.8	306.1													
02-May-92	309.00	306.1	306.0	305.3	304.2	303.3	305.9	305.8	306.0													
03-May-92	312.48	305.9	306.0	305.1	304.0	303.0	306.0	305.7	305.9													
04-May-92	315.20	305.8	305.4	305.3	305.0	305.3	306.7	306.0	305.3													
05-May-92	316.20	306.3	306.2	305.5	304.5	303.5	306.6	306.2	306.3													
07-May-92	310.40	306.0	306.1	306.5	307.1	307.6	306.9	306.5	306.0													
08-May-92	308.40	305.7	305.8	305.1	304.0	303.1	306.6	305.5	305.8													
02-Jun-92	307.80	304.6	304.7	303.9	302.8	302.0	304.8	304.3	304.6	305.8	306.7	305.5	339.3	306.3	NA	305.9	333.9	305.2	NA	304.6	304.6	304.7
01-Jul-92	305.98	305.4	305.5	304.6	303.3	302.4	304.8	305.1	305.4	305.4	306.4	305.3	338.5	305.5	NA	305.6	333.8	305.5	NA	305.5	305.5	305.6
31-Jul-92	304.88	298.3	298.3	298.8	299.9	300.8	299.6	298.8	298.3	301.0	302.8	300.6	337.8	301.9	NA	301.0	333.7	299.8	NA	298.4	298.4	NA
02-Sep-92	306.49	298.1	298.1	297.6	297.1	296.8	299.5	298.1	298.1	300.8	NA	300.4	337.1	301.6	NA	300.7	333.8	299.6	NA	298.4	298.4	NA
05-Oct-92	306.10	305.0	305.1	304.1	302.7	301.5	304.3	304.5	305.1	304.7	302.6	304.5	336.6	304.7	NA	304.9	333.6	305.0	NA	305.1	305.1	305.2
02-Nov-92	306.10	305.2	305.2	305.2	305.6	305.7	304.9	305.2	305.0	305.4	304.9	305.1	336.1	305.6	NA	305.5	333.5	305.3	NA	305.0	305.0	305.1
01-Dec-92	309.07	305.8	305.9	305.2	303.9	302.8	305.6	305.5	305.9	306.3	306.2	306.1	335.7	306.4	NA	306.2	333.6	306.2	NA	306.1	306.0	306.2
04-Jan-93	306.10	305.3	306.7	305.6	305.8	306.0	305.0	305.4	305.4	305.5	306.2	305.3	335.3	305.5	NA	305.6	334.0	305.6	NA	305.5	305.3	305.5
02-Feb-93	305.97	305.3	305.7	305.2	305.6	305.9	305.0	305.3	305.3	305.4	306.2	305.3	335.2	305.3	NA	305.5	333.9	305.6	NA	305.4	305.2	305.5
01-Mar-93	305.91	305.4	305.5	304.5	303.2	301.9	NA	305.2	305.4	305.0	306.2	304.9	334.7	305.0	NA	305.2	333.5	305.2	NA	305.4	305.4	NA
31-Mar-93	322.87	305.6	305.7	305.1	304.1	NA	NA	305.6	305.5	307.9	306.2	307.3	334.4	308.5	NA	307.5	333.3	308.4	NA	305.5	305.7	312.4
01-Apr-93	324.67	305.8	305.8	305.3	304.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
02-Apr-93	322.73	305.6	305.6	305.0	304.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	306.6	NA	NA	NA	NA
03-Apr-93	316.13	304.8	304.8	304.2	303.3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	305.7	NA	NA	NA	NA
04-Apr-93	312.71	303.8	303.6	303.0	302.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	304.5	NA	NA	NA	NA
05-Apr-93	310.53	304.2	304.4	303.9	302.8	NA	NA	304.0	304.2	305.6	306.2	305.3	334.3	305.9	NA	305.3	333.3	304.7	NA	303.9	303.9	NA
06-Apr-93	309.54	305.1	305.2	304.3	303.2	NA	NA	304.6	305.2	306.0	306.1	305.7	334.3	306.2	NA	305.8	333.3	305.5	NA	305.1	305.1	NA
07-Apr-93	309.40	305.1	305.0	304.3	303.3	302.2	NA	304.7	305.0	306.0	306.1	305.7	334.3	306.2	NA	305.8	333.3	305.5	NA	305.0	305.0	NA
08-Apr-93	310.35	305.8	305.8	306.0	306.6	306.8	NA	306.1	305.8	306.8	306.3	306.4	334.3	307.2	NA	306.8	333.5	306.2	NA	305.8	305.7	NA
09-Apr-93	311.71	305.2	305.1	304.4	303.4	302.6	NA	304.8	305.1	306.6	306.4	305.8	334.3	306.9	NA	306.3	333.4	305.7	NA	305.0	305.0	NA
10-Apr-93	314.36	305.5	305.5	304.8	304.0	303.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12-Apr-93	328.97	305.5	305.3	306.1	307.6	308.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13-Apr-93	329.01	304.9	304.8	305.0	304.7	304.5	307.2	305.6	304.7	310.3	308.4	309.1	334.3	311.5	310.2	309.3	333.4	306.8	NA	304.7	304.6	NA
14-Apr-93	326.59	305.2	305.2	304.9	304.7	304.2	307.1	305.6	305.1	309.7	308.6	308.7	334.2	310.6	309.3	308.9	333.5	306.9	NA	305.1	305.0	NA
15-Apr-93	323.36	305.2	305.1	304.8	304.5	304.0	306.6	305.4	305.1	308.9	308.4	308.1	334.2	309.8	308.8	308.3	333.3	306.6	NA	305.1	305.0	NA
16-Apr-93	319.52	305.6	305.6	306.2	307.2	307.6	307.2	306.5	305.5	308.9	308.3	308.3	334.3	309.8	308.5	308.5	333.6	306.9	NA	305.7	305.6	312.6
17-Apr-93	316.38	305.8	305.7	305.6	305.2	306.4	NA	306.4	305.7	308.4	308.5	307.8	334.2	309.2	309.0	308.0	334.1	306.9	NA	305.7	305.7	NA
18-Apr-93	329.84	306.0	306.0	305.9	305.7	305.3	308.2	306.5	306.1	311.1	308.5	309.9	334.2	312.3	309.4	310.1	333.6	308.0	NA	306.2	306.0	NA
19-Apr-93	329.30	305.8	305.8	305.7	305.8	306.1	308.1	306.9	305.6	310.9	309.2	309.8	334.2	312.1	310.2	310.1	333.7	307.8	NA	305.7	305.6	NA
20-Apr-93	324.90	305.3	305.3	304.8	304.4	303.9	306.9	305.5	305.1	309.3	308.9	308.5	334.2	310.2	309.5	308.7	333.5	306.7	NA	305.1	305.1	NA
21-Apr-93	316.50	305.5	305.6	306.1	306.8	306.9	306.7	306.3	305.5	308.5	308.8	307.9	334.2	309.1	309.1	308.1	333.7	306.8	NA	305.6	305.5	312.6
22-Apr-93	315.00	305.8	305.8	305.3	304.7	303.7	306.5	305.7	305.8	308.3	308.9	307.6	334.2	308.8	308.9	307.9	333.8	306.8	NA	305.8	305.8	312.6
23-Apr-93	314.80	305.7	305.7	305.2	304.6	303.9	306.5	305.3	305.6	308.1	308.9	307.6	334.2	308.7	308.9	307.4	334.1	306.6	NA	305.6	305.6	312.6
24-Apr-93	316.10	306.2	306.2	306.6	307.5	307.9	307.5	307.0	306.2	309.0	307.9	308.4	334.1	309.7	NA	308.5	333.2	307.3	NA	306.3	306.2	NA
25-Apr-93	315.30	305.2	305.4	304.6	303.9	303.3	305.9	305.3	305.1	307.6	305.6	307.0	334.1	308.1	NA	307.2	333.5	306.2	NA	305.1	301.8	NA

FILE

HALEY & ALDRICH, INC.

TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL El.	PIEZOMETRIC LEVEL (FT, NGVD)																				
		PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
26-Apr-93	311.90	304.9	304.9	305.3	306.1	306.3	305.8	305.3	304.6	306.9	307.6	306.5	334.2	307.4	NA	306.8	333.6	305.9	NA	304.4	304.4	NA
27-Apr-93	312.80	306.0	306.1	305.2	304.5	303.7	306.4	305.9	305.9	307.7	307.4	307.3	334.1	308.3	NA	307.7	333.5	306.9	NA	305.8	305.9	NA
28-Apr-93	312.00	305.7	305.6	305.9	306.6	307.0	306.4	306.0	305.4	307.7	307.3	307.3	333.5	308.3	NA	307.4	333.6	306.3	NA	305.4	305.3	312.9
29-Apr-93	311.00	304.8	304.7	304.9	305.7	306.3	305.5	305.0	304.5	306.9	307.2	306.5	334.1	307.5	NA	306.7	333.7	305.1	NA	304.4	304.3	312.9
30-Apr-93	308.80	306.1	306.2	305.5	304.4	303.4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	312.8
01-May-93	305.40	306.3	306.2	305.6	304.5	303.7	306.1	306.0	306.2	306.9	307.3	339.5	334.1	307.1	NA	306.9	333.8	306.5	NA	306.3	306.3	312.7
02-May-93	308.40	306.4	306.4	306.6	307.1	307.2	306.7	306.6	306.8	307.3	307.0	307.1	334.1	307.7	NA	307.4	333.6	303.5	NA	306.3	286.6	312.6
03-May-93	308.25	306.3	306.2	305.5	304.3	303.3	305.9	306.0	306.2	306.8	306.9	306.5	334.1	306.9	NA	306.8	333.6	306.4	NA	306.2	306.2	NA
04-May-93	308.00	305.9	305.8	305.0	304.0	303.2	305.6	305.4	305.7	306.6	307.1	306.3	334.1	306.7	NA	306.5	333.9	306.1	NA	305.8	305.7	NA
05-May-93	307.50	304.6	304.4	304.5	304.6	305.2	305.1	304.6	304.3	306.2	307.2	305.8	334.1	306.6	NA	305.8	334.0	305.0	NA	304.3	304.2	NA
02-Jun-93	306.40	305.7	305.6	306.0	306.3	306.6	305.8	305.7	305.7	306.3	306.3	306.3	333.8	306.7	NA	306.5	333.7	306.0	NA	305.8	305.7	305.9
01-Jul-93	306.00	305.2	305.2	304.3	303.1	302.3	304.6	304.7	305.0	305.1	305.8	305.0	333.7	305.2	NA	305.3	333.3	305.3	NA	305.1	305.1	305.3
02-Aug-93	306.55	305.1	305.0	304.1	302.7	301.7	304.4	304.5	304.9	304.9	305.4	304.7	333.5	304.9	NA	305.0	333.2	305.0	NA	305.0	304.9	305.1
03-Sep-93	305.70	305.4	305.3	305.4	306.3	306.2	305.3	305.1	305.6	305.7	305.8	305.7	333.2	305.9	NA	305.8	333.4	305.5	NA	305.2	305.3	305.4
04-Oct-93	306.22	305.2	305.3	304.4	303.1	301.8	304.5	304.8	305.2	305.1	305.9	305.0	333.2	305.1	NA	305.2	333.6	305.2	NA	305.2	305.2	305.4
02-Nov-93	307.74	304.2	304.1	303.3	302.1	301.1	304.9	303.7	304.0	305.6	305.6	305.4	333.1	305.7	NA	305.7	333.3	305.6	NA	304.0	304.0	304.0
30-Nov-93	321.30	306.1	305.8	305.8	305.0	305.1	307.6	306.4	305.6	309.2	307.1	308.6	333.0	310.1	NA	308.8	333.2	307.2	NA	305.6	305.6	305.2
01-Dec-93	311.25	305.5	305.9	305.5	305.2	304.4	306.4	306.0	305.4	307.5	306.8	307.1	333.0	308.0	NA	307.3	333.3	306.4	NA	305.6	305.6	305.9
02-Dec-93	308.38	305.5	305.5	305.7	306.1	306.6	305.9	305.8	305.4	306.9	307.0	306.6	333.0	307.2	NA	306.8	333.7	306.1	NA	305.4	305.3	305.3
03-Dec-93	307.40	304.9	304.8	305.1	305.6	306.0	305.5	305.1	304.7	306.4	307.0	306.1	333.0	306.8	NA	306.3	333.9	305.5	NA	304.7	304.7	304.6
29-Dec-93	306.05	305.6	305.7	305.8	306.1	304.2	305.7	305.8	305.6	306.3	306.4	306.1	342.8	306.5	NA	306.3	333.9	305.9	NA	305.6	305.6	302.8
AVE. LEVEL DURING NORMAL POOL (2.)		305.1	305.1	304.9	304.7	304.5	305.2	305.1	305.1	305.6	306.2	306.9	335.1	305.9	NA	305.7	333.7	305.2	NA	305.0	304.1	

NOTES:
1. NO DATA AVAILABLE FOR PZ-12B FROM 01-SEPT-89 THROUGH 29-DEC-93.
2. AVERAGE LEVEL FOR PIEZOMETERS IS BASED ONLY ON READINGS WHEN THE POOL ELEVATION FALLS BETWEEN EL. 305 AND 309.

29 Nov 1994

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FILE NO.

HALEY & ALDRICH, INC.

TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL			DEPTH (FEET BEFORE 02 JUNE 1992, METERS AFTER 02 JUNE 1992)																			
	STAGE	ELEV	TIME	PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
01-Sep-89	4.48	304.48	1300	25.76	27.17	27.66	28.58	26.80	115.80	66.18	66.08													
03-Oct-89	6.12	306.12	1000	24.38	25.82	26.31	27.40	28.77	114.61	64.73	64.64													
23-Oct-89	23.50	323.50	1300	23.33	24.90	24.05	22.64	22.61	111.10	63.78	62.44													
24-Oct-89	14.96	314.96	1400	23.49	24.77	23.98	22.90	24.94	111.91	63.82	63.00													
25-Oct-89	10.76	310.76	1300	24.02	25.36	24.61	23.66	23.85	112.67	64.27	63.72													
27-Oct-89	7.56	307.56	1400	25.03	26.81	25.46	25.03	25.13	113.92	65.62	64.44													
28-Oct-89	7.15	307.15	830	24.12	25.59	25.03	23.30	24.67	113.29	64.50	64.14													
01-Dec-89	6.30	306.30	1300	24.60	26.12	25.59	24.77	25.00	113.92	64.67	64.96													
03-Jan-90	6.40	306.40	1100	23.90	25.30	24.80	24.10	24.20	113.30	64.00	64.10													
01-Feb-90	7.49	307.49	1045	24.60	26.00	25.50	24.60	NA	112.90	64.40	64.90													
02-Mar-90	7.30	307.30	1000	24.40	26.00	25.60	21.60	NA	113.80	64.30	65.00													
19-Mar-90	32.46	332.46	1300	23.60	24.90	23.70	21.80	21.50	110.00	62.20	63.80													
20-Mar-90	27.55	327.55	1030	24.40	26.00	24.90	23.10	22.70	111.20	63.30	64.90													
21-Mar-90	22.14	322.14	1000	24.80	26.30	26.40	26.60	27.60	112.60	64.10	65.20													
22-Mar-90	19.55	319.55	930	23.70	25.20	25.50	26.20	27.30	112.10	63.10	64.00													
23-Mar-90	14.87	314.87	945	24.51	26.05	26.28	26.74	28.05	113.13	64.05	64.96													
24-Mar-90	13.24	313.24	930	23.69	25.20	25.62	26.38	27.69	112.80	63.42	63.98													
25-Mar-90	11.80	311.80	930	23.43	24.87	25.23	25.99	27.17	112.64	63.26	63.68													
26-Mar-90	10.26	310.26	1430	23.98	25.46	25.85	26.51	27.88	113.22	63.68	63.34													
27-Mar-90	9.54	309.54	1100	23.43	24.97	25.13	26.35	27.95	113.03	63.58	63.72													
28-Mar-90	8.70	308.70	1030	23.45	24.93	24.34	23.42	23.65	112.40	63.35	63.78													
29-Mar-90	8.03	308.03	1300	23.82	25.36	24.77	23.85	24.01	112.86	63.78	64.34													
30-Mar-90	7.72	307.72	1030	24.34	25.95	25.39	24.37	24.47	113.29	64.01	64.89													
02-Apr-90	7.06	307.06	1030	24.77	26.37	25.75	24.83	24.90	113.78	64.50	65.29													
04-Jun-90	6.23	306.23	1100	24.21	25.65	26.08	26.83	28.21	113.92	64.63	64.57													
02-Jul-90	7.21	307.21	1100	24.97	26.51	26.94	27.72	28.91	114.54	65.32	65.39													
01-Aug-90	5.76	305.76	1000	24.44	25.89	25.36	25.00	26.64	113.85	64.60	64.83													
09-Aug-90	28.05	328.05	800	23.26	24.67	23.56	21.82	21.52	110.21	62.11	63.55													
10-Aug-90	21.28	321.28	800	24.31	25.92	25.69	25.39	25.62	112.01	63.78	64.80													
11-Aug-90	21.85	321.85	1330	24.25	25.89	26.02	26.35	27.46	112.60	64.47	64.80													
12-Aug-90	32.27	332.27	1330	23.00	24.61	24.41	24.11	24.84	109.81	62.37	63.49													
13-Aug-90	31.62	331.62	1030	23.88	25.42	25.23	24.93	25.82	110.56	63.42	64.30													
14-Aug-90	26.72	326.72	1445	24.44	25.98	24.77	22.70	22.11	110.79	63.12	64.96													
15-Aug-90	30.30	330.30	1130	23.55	24.90	24.60	24.31	25.26	110.27	62.98	63.74													
16-Aug-90	24.73	324.73	800	23.65	25.66	25.53	25.36	26.22	111.45	63.82	64.57													
17-Aug-90	15.47	315.47	1100	24.25	25.79	24.90	23.30	23.10	111.85	63.52	64.70													
20-Aug-90	7.44	307.44	1045	23.68	25.13	24.96	25.26	26.08	112.96	63.48	64.07													
21-Aug-90	6.77	306.77	800	23.98	25.46	24.77	23.82	23.85	112.93	63.68	64.44													
22-Aug-90	6.48	306.48	745	23.98	25.49	25.76	26.28	27.30	113.33	63.91	64.37													
01-Sep-90	6.13	306.13	830	23.79	25.26	25.03	23.85	23.95	113.06	63.68	64.18													
01-Oct-90	5.77	305.77	1100	24.67	26.31	26.71	27.59	29.00	114.57	65.36	65.10													
15-Oct-90	18.25	318.25	1200	24.08	25.62	25.85	26.24	27.29	112.70	63.84	64.47													
16-Oct-90	14.00	314.00	800	24.15	25.46	24.61	23.46	23.49	112.60	63.75	64.37													
17-Oct-90	10.65	310.65	1000	23.33	24.71	25.07	26.08	27.56	112.83	63.75	63.52													
18-Oct-90	8.99	308.99	1000	23.59	25.07	25.56	26.51	27.95	113.26	64.08	63.95													
25-Oct-90	22.54	322.54	1300	23.85	25.53	24.67	24.21	24.48	111.49	62.90	64.44													
26-Oct-90	19.30	319.30	1300	23.75	25.20	25.03	25.23	25.99	111.85	63.26	64.18													
29-Oct-90	10.13	310.13	1030	24.05	25.56	25.82	26.58	27.86	113.26	64.14	64.31													
30-Oct-90	8.98	308.98	1100	23.69	25.00	24.77	24.31	24.94	112.77	63.98	63.95													
31-Oct-90	8.40	308.40	730	23.69	25.23	25.62	26.44	27.92	113.36	64.18	64.01													
01-Nov-90	8.00	308.00	1030	24.41	26.02	25.62	24.74	24.94	113.65	64.70	64.96													
03-Dec-90	6.16	306.16	1000	24.70	26.30	25.70	24.70	24.70	113.80	65.10	65.20													
16-Dec-90	24.10	324.10	1330	24.38	25.95	25.07	23.23	22.70	111.59	63.32	64.99													
27-Dec-90	15.70	315.70	1130	24.08	25.46	24.38	23.10	23.06	112.05	63.32	64.50													
28-Dec-90	11.10	311.10	830	23.88	25.23	24.28	22.93	23.23	111.65	63.32	64.37													
31-Dec-90	10.25	310.25	1100	23.07	24.51	23.79	22.80	22.90	111.82	62.73	63.32													
02-Jan-91	8.67	308.67	1030	23.62	25.10	24.51	23.46	23.36	112.44	63.32	64.11													

FILE NO.

HALEY & ALDRICH, INC.

TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL			DEPTH (FEET BEFORE 02 JUNE 1992, METERS AFTER 02 JUNE 1992)																				
	STAGE	ELEV	TIME	PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
01-Feb-91	6.27	306.27	1300	23.98	25.46	24.97	24.08	24.15	112.08	63.81	64.37													
01-Mar-91	5.86	305.86	1400	25.26	26.97	26.38	25.33	24.62	114.41	62.63	64.54													
01-Apr-91	8.49	308.49	1030	24.21	25.82	26.22	27.07	28.18	113.65	64.44	64.64													
01-May-91	9.15	309.15	945	25.31	26.51	26.31	26.54	27.06	114.08	64.99	65.52													
31-May-91	6.10	306.10	1300	24.28	25.72	25.46	25.49	26.74	113.59	64.34	64.60													
01-Jul-91	5.44	305.44	1000	24.90	26.25	26.71	27.24	29.14	114.77	65.49	65.13													
01-Aug-91	5.41	305.41	730	24.41	25.79	25.65	25.99	25.77	113.79	64.44	64.70													
30-Aug-91	6.00	306.00	1100	23.85	25.33	24.77	24.08	24.28	113.22	63.75	64.20													
01-Oct-91	7.47	307.47	730	31.10	32.58	31.63	30.12	29.66	118.84	70.31	71.46													
21-Oct-91	17.98	317.98	1400	23.75	25.07	24.21	22.93	22.97	111.55	63.09	63.98													
22-Oct-91	12.19	312.19	730	23.56	24.90	25.26	26.02	27.59	112.93	64.08	63.78													
23-Oct-91	7.55	307.55	800	23.79	25.30	24.71	23.82	24.05	112.90	63.61	64.27													
24-Oct-91	6.78	306.78	900	23.79	25.30	24.77	23.95	24.21	113.10	63.72	64.24													
25-Oct-91	6.58	306.58	930	24.08	25.59	25.00	24.21	24.44	113.26	63.91	64.57													
01-Nov-91	6.10	306.10	1000	24.04	25.52	25.03	24.28	24.57	113.36	64.01	64.44													
01-Dec-91	6.40	306.40	1200	23.95	25.43	24.87	24.12	24.41	113.26	63.88	64.31													
02-Jan-92	7.73	307.73	1130	24.04	25.52	25.91	26.77	28.21	113.85	64.57	64.30													
31-Jan-92	6.04	306.04	1000	24.24	25.72	25.23	24.41	24.60	113.48	64.34	64.70													
02-Mar-92	5.93	305.93	1300	24.11	25.46	25.98	27.00	25.29	114.14	64.60	64.27													
12-Mar-92	18.30	318.30	800	23.68	25.19	24.67	23.42	23.49	112.30	63.55	64.14													
13-Mar-92	21.62	321.62	700	23.28	24.67	23.88	19.98	22.67	111.29	62.76	63.61													
14-Mar-92	12.20	312.20	800	23.82	25.29	24.54	23.39	23.46	112.30	63.49	64.24													
15-Mar-92	5.40	305.40	800	23.88	25.26	24.57	23.55	23.88	112.66	63.58	64.14													
16-Mar-92	8.70	308.70	730	24.15	25.70	25.07	24.25	24.28	113.19	64.14	64.64													
17-Mar-92	7.60	307.60	700	24.11	25.52	25.00	24.11	24.27	113.19	64.17	64.50													
18-Mar-92	6.70	306.70	1300	24.41	25.78	26.01	26.57	27.62	113.81	64.57	64.70													
19-Mar-92	6.64	306.64	1000	23.75	25.10	24.60	23.79	24.02	112.96	63.78	64.08													
30-Mar-92	14.64	314.64	700	24.83	26.44	25.98	25.00	25.29	113.58	64.07	65.35													
31-Mar-92	10.56	310.56	1400	24.21	25.52	25.88	26.54	27.88	113.52	64.53	64.40													
01-Apr-92	9.37	309.37	700	23.49	24.96	25.42	26.24	27.65	113.12	64.01	63.81													
02-Apr-92	7.99	307.99	1100	24.11	25.62	25.00	24.08	24.18	113.06	64.04	64.57													
03-Apr-92	7.40	307.40	1100	23.62	25.13	25.16	25.89	26.77	112.60	63.49	64.14													
22-Apr-92	17.55	317.55	1100	23.91	25.29	25.42	25.82	27.06	112.70	64.17	64.04													
23-Apr-92	20.52	320.52	700	23.95	25.43	25.04	25.92	27.00	112.34	64.14	64.34													
24-Apr-92	21.48	321.48	700	23.95	25.39	24.41	22.83	22.60	111.35	63.22	64.37													
25-Apr-92	19.60	319.60	900	23.98	25.49	24.51	23.00	22.77	111.60	63.32	64.43													
26-Apr-92	17.00	317.00	900	24.11	25.70	24.73	23.30	23.10	111.80	63.61	64.63													
27-Apr-92	16.17	316.17	730	24.15	25.62	25.89	26.25	27.30	112.87	64.34	64.54													
28-Apr-92	12.43	312.43	730	24.05	25.36	24.67	23.62	23.75	112.57	63.75	64.30													
29-Apr-92	10.80	310.80	1300	23.46	24.93	25.20	25.82	27.23	112.70	63.72	63.72													
30-Apr-92	9.80	309.80	1430	23.52	24.90	25.23	25.98	27.36	112.86	63.71	63.81													
01-May-92	9.74	309.74	1100	23.42	24.77	25.23	25.98	27.46	112.93	68.81	63.65													
02-May-92	9.00	309.00	700	23.38	24.86	25.23	25.95	27.29	112.89	63.78	63.71													
03-May-92	12.48	312.48	1500	23.55	24.90	25.39	26.14	27.62	112.76	63.84	63.84													
04-May-92	15.20	315.20	1000	23.68	25.46	25.23	25.09	25.32	112.09	63.58	64.47													
05-May-92	16.20	316.20	800	23.13	24.67	24.96	25.65	27.06	112.21	63.35	63.48													
07-May-92	10.40	310.40	1300	23.45	24.83	24.04	22.96	23.03	111.88	63.09	63.78													
08-May-92	8.40	308.40	1000	23.72	25.09	25.42	26.14	27.49	112.21	64.04	63.97													
02-Jun-92	7.80	307.80	1330	7.56	7.99	8.12	8.33	8.72	34.73	19.88	19.86	16.65	16.47	26.36	16.14	16.41	NA	25.69	17.21	34.35	NA	21.78	21.80	4.99
01-Jul-92	5.98	305.98	1300	7.32	7.74	7.88	8.18	8.60	34.73	19.65	19.60	16.78	16.56	26.41	16.38	16.66	NA	25.80	17.23	34.24	NA	21.51	21.53	4.71
31-Jul-92	4.88	304.88	1430	9.49	9.94	9.66	9.21	9.07	36.31	21.57	21.78	18.10	17.63	27.85	16.60	17.77	NA	27.19	17.25	36.00	NA	23.65	23.70	NA
02-Sep-92	6.49	306.49	900	9.56	9.99	10.02	10.06	10.30	36.34	21.77	21.84	18.18	NA	27.90	16.80	17.86	NA	27.27	17.23	36.05	NA	23.65	23.70	NA
05-Oct-92	6.10	306.10	1030	7.45	7.87	8.04	8.36	8.86	34.90	19.82	19.71	16.99	17.72	26.64	16.97	16.91	NA	26.01	17.30	34.40	NA	21.63	21.64	4.82
02-Nov-92	6.10	306.10	1300	7.40	7.84	7.70	7.48	7.59	34.71	19.62	19.73	16.77	17.01	26.46	17.11	16.62	NA	25.82	17.33	34.32	NA	21.65	21.68	4.85
01-Dec-92	9.07	309.07	1030	7.19	7.60	7.71	7.98	8.48	34.50	19.52	19.45	16.51	16.60	26.18	17.24	16.40	NA	25.60	17.29	34.04	NA	21.33	21.38	4.51
04-Jan-93	6.10	306.10	1300	7.34	7.37	7.60	7.40	7.51	34.67	19.55	19.62	16.75	16.60	26.40	17.35	16.67	NA	25.79	17.18	34.23	NA	21.50	21.58	4.74
02-Feb-93	5.97	305.97	1400	7.34	7.68	7.71	7.48	7.53	34.67	19.58	19.64	16.77	16.62	26.41	17.38	16.71	NA	25.81	17.20	34.21	NA	21.52	21.61	4.75

FILE

HALEY & ALDRICH, INC.

TABLE II
PIEZOMETER DATA
FRANKLIN FALLS DAM

DATE	POOL			DEPTH (FEET BEFORE 02 JUNE 1992, METERS AFTER 02 JUNE 1992)																				
	STAGE	ELEV	TIME	PZ-1	PZ-2	PZ-3	PZ-4	PZ-5	PZ-6	PZ-7A	PZ-7B	PZ-8A	PZ-8B	PZ-9A	PZ-9B	PZ-10A	PZ-10B	PZ-11A	PZ-11B	PZ-12A	PZ-12B (1.)	PZ-13A	PZ-13B	OW-1
01-Mar-93	5.91	305.91	1330	7.31	7.75	7.92	8.20	8.75	NA	19.62	19.60	16.88	16.60	26.52	17.54	16.80	NA	25.92	17.32	34.35	NA	21.52	21.54	NA
31-Mar-93	22.87	322.87	1000	7.26	7.68	7.75	7.93	NA	NA	19.50	19.58	16.00	16.61	25.80	17.63	15.75	NA	25.22	17.40	33.96	NA	21.49	21.47	2.64
01-Apr-93	24.67	324.67	1430	7.21	7.65	7.67	7.76	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
02-Apr-93	22.73	322.73	1415	7.27	7.72	7.76	7.87	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	33.92	NA	NA	NA	NA
03-Apr-93	16.13	316.13	1400	7.50	7.96	8.03	8.18	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34.20	NA	NA	NA	NA
04-Apr-93	12.71	312.71	1300	7.81	8.31	8.38	8.52	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	34.58	NA	NA	NA	NA
05-Apr-93	10.53	310.53	1400	7.68	8.07	8.11	8.33	NA	NA	19.98	19.97	16.70	16.62	26.42	17.65	16.55	NA	25.88	17.40	34.50	NA	22.00	22.02	NA
06-Apr-93	9.54	309.54	1430	7.42	7.84	7.98	8.19	NA	NA	19.80	19.68	16.60	16.65	26.30	17.65	16.46	NA	25.72	17.40	34.24	NA	21.61	21.63	NA
07-Apr-93	9.40	309.40	1245	7.41	7.90	7.98	8.18	8.65	NA	19.78	19.73	16.60	16.65	26.30	17.65	16.46	NA	25.72	17.38	34.26	NA	21.65	21.67	NA
08-Apr-93	10.35	310.35	1300	7.21	7.65	7.46	7.17	7.25	NA	19.35	19.50	16.36	16.58	26.08	17.65	16.15	NA	25.42	17.33	34.05	NA	21.40	21.45	NA
09-Apr-93	11.71	311.71	1315	7.40	7.85	7.95	8.13	8.52	NA	19.75	19.70	16.42	16.54	26.25	17.66	16.25	NA	25.58	17.35	34.20	NA	21.66	21.68	NA
10-Apr-93	14.36	314.36	1430	7.30	7.75	7.82	7.97	8.38	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12-Apr-93	28.97	328.97	1530	7.28	7.79	7.43	6.85	6.78	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
13-Apr-93	29.01	329.01	1245	7.48	7.95	7.76	7.73	7.96	33.99	19.50	19.82	15.29	15.93	25.26	17.67	14.83	15.25	24.66	17.36	33.84	NA	21.73	21.78	NA
14-Apr-93	26.59	326.59	1300	7.39	7.83	7.80	7.74	8.05	34.03	19.51	19.71	15.45	15.87	25.36	17.68	15.10	15.55	24.80	17.33	33.82	NA	21.62	21.66	NA
15-Apr-93	23.36	323.36	1100	7.40	7.85	7.82	7.81	8.10	34.19	19.55	19.71	15.70	15.95	25.57	17.68	15.36	15.68	24.98	17.37	33.91	NA	21.62	21.67	NA
16-Apr-93	19.52	319.52	1430	7.27	7.69	7.40	6.99	7.01	34.00	19.22	19.57	15.70	15.96	25.50	17.67	15.36	15.77	24.92	17.28	33.83	NA	21.45	21.50	2.57
17-Apr-93	16.38	316.38	1000	7.20	7.67	7.60	7.58	7.39	NA	19.24	19.52	15.85	15.91	25.65	17.68	15.54	15.84	25.05	17.13	33.83	NA	21.43	21.46	NA
18-Apr-93	29.84	329.84	1030	7.15	7.57	7.50	7.45	7.72	33.70	19.22	19.41	15.04	15.92	25.00	17.69	14.60	15.50	24.43	17.30	33.50	NA	21.30	21.36	NA
19-Apr-93	29.30	329.30	1230	7.20	7.65	7.55	7.40	7.47	33.73	19.10	19.54	15.10	15.70	25.04	17.69	14.66	15.26	24.43	17.27	33.55	NA	21.44	21.49	NA
20-Apr-93	24.90	324.90	1000	7.36	7.81	7.83	7.83	8.13	34.08	19.52	19.69	15.58	15.77	25.44	17.68	15.22	15.48	24.86	17.32	33.87	NA	21.61	21.64	NA
21-Apr-93	16.50	316.50	1030	7.29	7.69	7.44	7.10	7.22	34.14	19.29	19.59	15.84	15.81	25.63	17.70	15.57	15.60	25.04	17.25	33.85	NA	21.48	21.51	2.57
22-Apr-93	15.00	315.00	1230	7.20	7.65	7.68	7.74	8.20	34.20	19.46	19.50	15.90	15.80	25.70	17.70	15.67	15.65	25.10	17.22	33.85	NA	21.40	21.44	2.57
23-Apr-93	14.80	314.80	1000	7.22	7.68	7.71	7.78	8.15	34.20	19.60	19.54	15.96	15.79	25.72	17.70	15.70	15.65	25.23	17.15	33.90	NA	21.46	21.50	2.57
24-Apr-93	16.10	316.10	800	7.09	7.52	7.28	6.89	6.92	33.92	19.07	19.38	15.69	16.10	25.48	17.72	15.38	NA	24.90	17.42	33.71	NA	21.27	21.32	NA
25-Apr-93	15.30	315.30	830	7.38	7.78	7.88	7.98	8.32	34.40	19.60	19.70	16.10	16.80	25.90	17.71	15.86	NA	25.30	17.32	34.05	NA	21.62	22.66	NA
26-Apr-93	11.90	311.90	1300	7.49	7.93	7.68	7.32	7.40	34.44	19.60	19.85	16.30	16.19	26.04	17.70	16.08	NA	25.43	17.30	34.13	NA	21.82	21.85	NA
27-Apr-93	12.80	312.80	1550	7.14	7.56	7.70	7.81	8.20	34.26	19.40	19.45	16.07	16.25	25.81	17.71	15.82	NA	25.16	17.33	33.82	NA	21.40	21.41	NA
28-Apr-93	12.00	312.00	1400	7.22	7.70	7.50	7.16	7.20	34.24	19.38	19.60	16.06	16.28	25.81	17.91	15.81	NA	25.23	17.30	33.99	NA	21.52	21.57	2.47
29-Apr-93	11.00	311.00	800	7.52	7.98	7.80	7.43	7.41	34.52	19.68	19.90	16.32	16.29	26.05	17.71	16.05	NA	25.47	17.25	34.38	NA	21.82	21.89	2.48
30-Apr-93	8.80	308.80	1700	7.12	7.51	7.62	7.83	8.28	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2.52
01-May-93	5.40	305.40	1200	7.06	7.52	7.59	7.80	8.20	34.35	19.38	19.36	16.30	16.27	16.00	17.72	16.17	NA	25.40	17.22	33.94	NA	21.26	21.28	2.54
02-May-93	8.40	308.40	1230	7.03	7.46	7.29	7.02	7.14	34.16	19.19	19.20	16.18	16.36	25.85	17.73	15.98	NA	25.25	17.28	34.85	NA	21.27	27.28	2.56
03-May-93	8.25	308.25	1300	7.05	7.52	7.63	7.85	8.31	34.39	19.39	19.37	16.36	16.38	26.04	17.72	16.23	NA	25.43	17.30	33.96	NA	21.29	21.31	NA
04-May-93	8.00	308.00	1430	7.18	7.64	7.76	7.96	8.34	34.49	19.55	19.51	16.41	16.32	26.12	17.73	16.29	NA	25.52	17.20	34.08	NA	21.42	21.46	NA
05-May-93	7.50	307.50	1400	7.58	8.06	7.92	7.78	7.75	34.64	19.81	19.95	16.54	16.30	26.25	17.73	16.33	NA	25.72	17.16	34.40	NA	21.88	21.91	NA
02-Jun-93	6.40	306.40	800	7.23	7.69	7.48	7.25	7.33	34.42	19.48	19.52	16.50	16.58	26.12	17.80	16.31	NA	25.53	17.25	34.10	NA	21.42	21.45	4.61
01-Jul-93	6.00	306.00	900	7.40	7.84	7.98	8.23	8.62	34.80	19.77	19.72	16.85	16.72	26.51	17.84	16.74	NA	25.87	17.40	34.32	NA	21.62	21.65	4.81
02-Aug-93	6.55	306.55	800	7.42	7.88	8.04	8.35	8.81	34.87	19.83	19.78	16.91	16.84	26.60	17.91	16.84	NA	25.96	17.41	34.40	NA	21.66	21.69	4.85
03-Sep-93	5.70	305.70	1400	7.33	7.80	7.64	7.24	7.44	34.58	19.65	19.55	16.67	16.73	26.30	17.98	16.53	NA	25.72	17.34	34.24	NA	21.60	21.57	4.76
04-Oct-93	6.22	306.22	930	7.40	7.81	7.96	8.24	8.77	34.82	19.74	19.66	16.86	16.70	26.50	17.99	16.78	NA	25.91	17.28	34.33	NA	21.60	21.60	4.76
02-Nov-93	7.74	307.74	1430	7.69	8.16	8.29	8.54	8.98	34.69	20.07	20.03	16.70	16.78	26.37	18.02	16.61	NA	25.76	17.39	34.22	NA	21.95	21.98	5.18
30-Nov-93	21.30	321.30	1100	7.11	7.65	7.52	7.65	7.76	33.89	19.26	19.54	15.60	16.34	25.40	18.05	15.27	NA	24.82	17.41	33.72	NA	21.47	21.50	4.83
01-Dec-93	11.25	311.25	1530	7.28	7.61	7.62	7.58	8.00	34.24	19.36	19.60	16.14	16.41	25.85	18.06	15.91	NA	25.28	17.39	33.98	NA	21.47	21.50	4.62
02-Dec-93	8.38	308.38	1400	7.30	7.73	7.56	7.30	7.32	34.41	19.44	19.62	16.32	16.37	26.01	18.06	16.13	NA	25.43	17.25	34.08	NA	21.54	21.58	4.80
03-Dec-93	7.40	307.40	1000	7.47	7.94	7.75	7.46	7.50	34.53	19.64	19.82	16.46	16.37	26.16	18.06	16.26	NA	25.58	17.20	34.24	NA	21.74	21.77	5.00
29-Dec-93	6.05	306.05	1330	7.25	7.68	7.52	7.32	8.06	34.46	19.45	19.55	16.51	16.56	26.16	15.08	16.35	NA	25.58	17.20	34.12	NA	21.48	21.48	5.57

NOTES:
1. NO DATA AVAILABLE FOR PZ-12B FROM 01-SEPT-89 THROUGH 29-DEC-93.

29 Nov 1994

F:\11163\004\franklin\task6b.wb1

TABLE III

HISTORIC SEISMIC DATA
FRANKLIN FALLS DAM

SEISMIC EVENT	DISTANCE TO CENTER	INTENSITY * AT CENTER	RECORDED ACCELERATION AT DAM	ESTIMATED ACCELERATION AT DAM
Grand Falls, N.B., Canada (1/09/82)	306 mi.	7.4 (R = 5.8)	N/A	N/A
Gaza, New Hampshire (1/19/82)	11 mi.	5.2 (R = 4.7)	0.14g	0.60g **
Blue Mountain, New York (10/07/83)	130 mi.	6.0 (R = 5.1)	N/A	N/A
Franklin, New Hampshire (10/25/86)	5 mi.	3.6 (R = 3.9)	none estimated	none estimated
Saguenay, Quebec, Canada (11/25/88)	250 mi.	7.6 (R = 5.9)	N/A	N/A

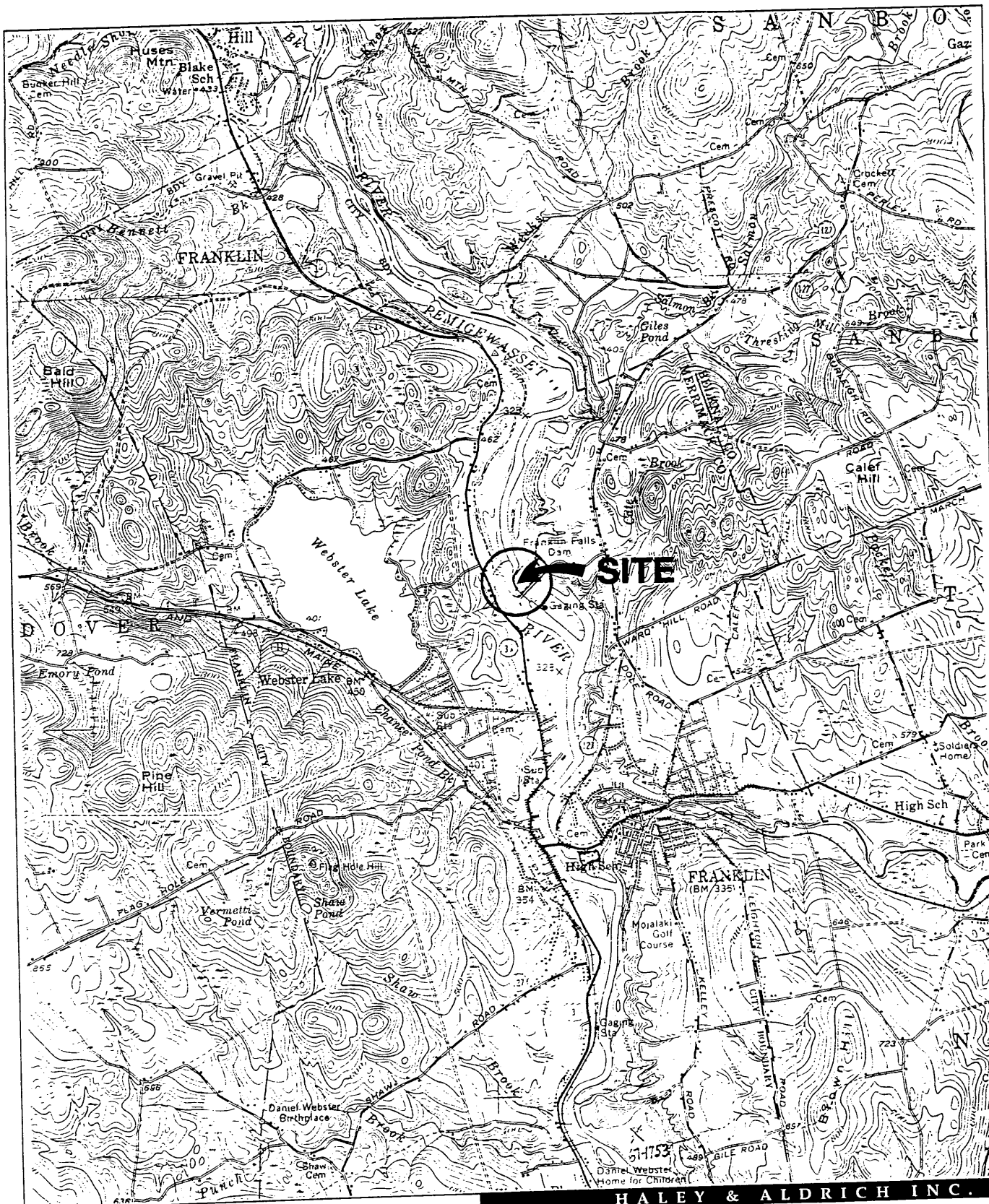
* Intensities correspond to Modified Mercalli Intensity (MMI) = (2 x Richter Magnitude) - 4.2

** COE reference available

N/A = Accelerographs not activated

JANUARY 1995

f:\11163\004\franklin\task8.wb1



HALEY & ALDRICH INC.

Geotechnical Engineers & Environmental Consultants

SITE COORDINATES: 42°28'10"N 71°39'48"W

N

U.S.G.S. QUADRANGLE: PENACOOK,NH

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PROJECT LOCUS

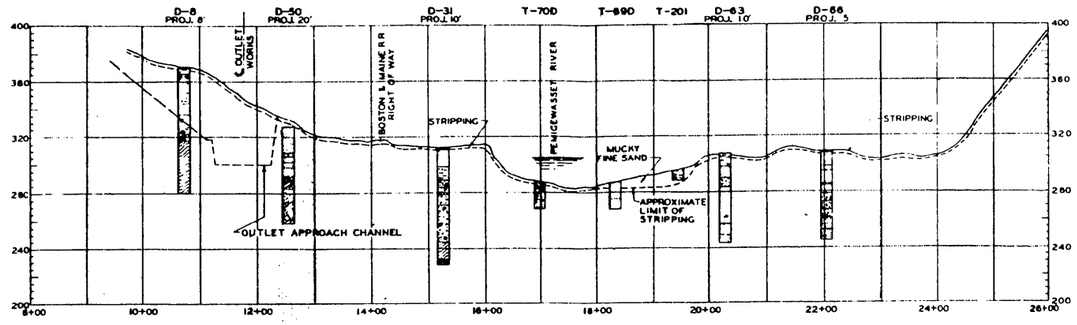
APPROXIMATE SCALE: 1:62,500

NOVEMBER 1994

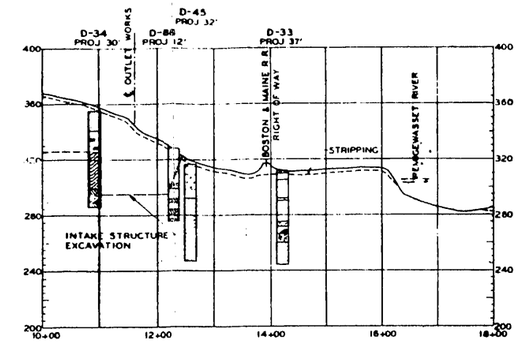
FILE NO. 11163-004 A1

FIGURE 1

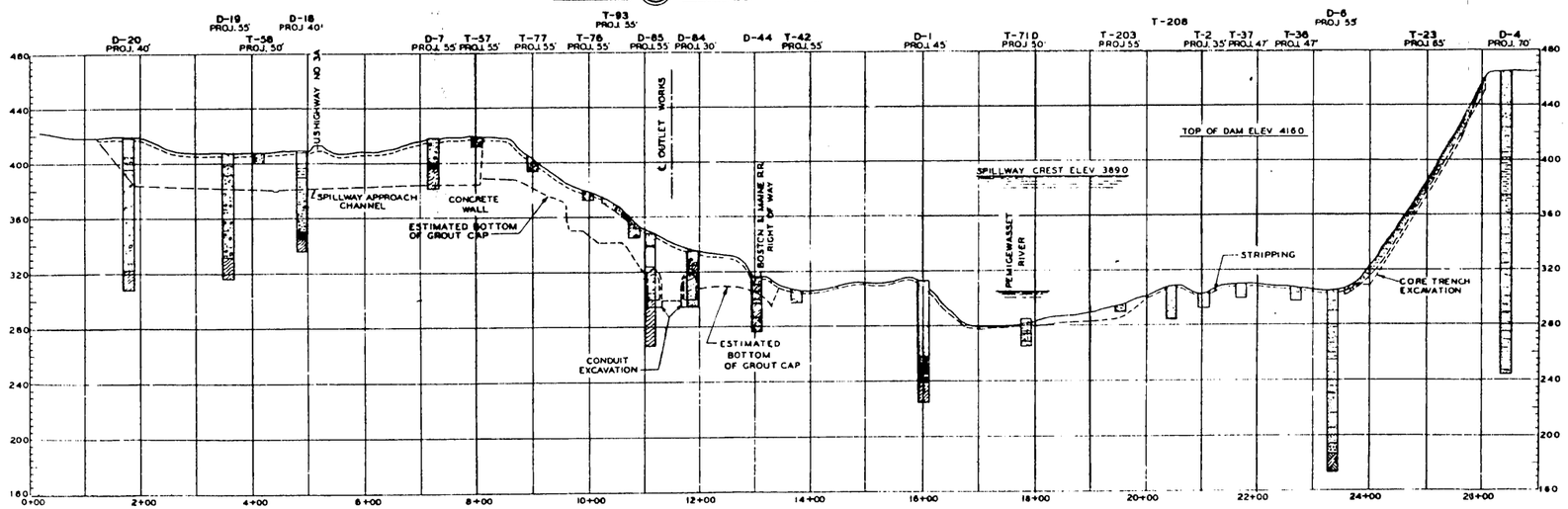
169669



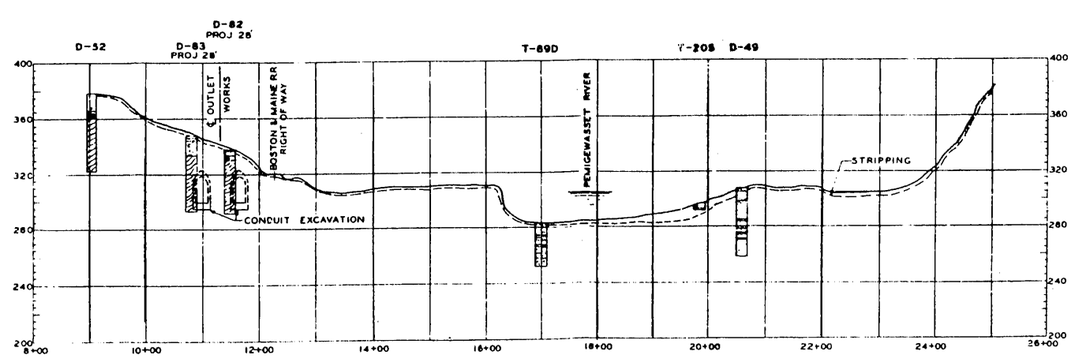
PROFILE (A/4) 345' UPSTREAM



PROFILE (B/4) 255' UPSTREAM



PROFILE (C/4) ℄ OF DAM



PROFILE (D/4) 255' DOWNSTREAM

NOTES:

1. DRAWING PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.

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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

AS BUILT PROFILES

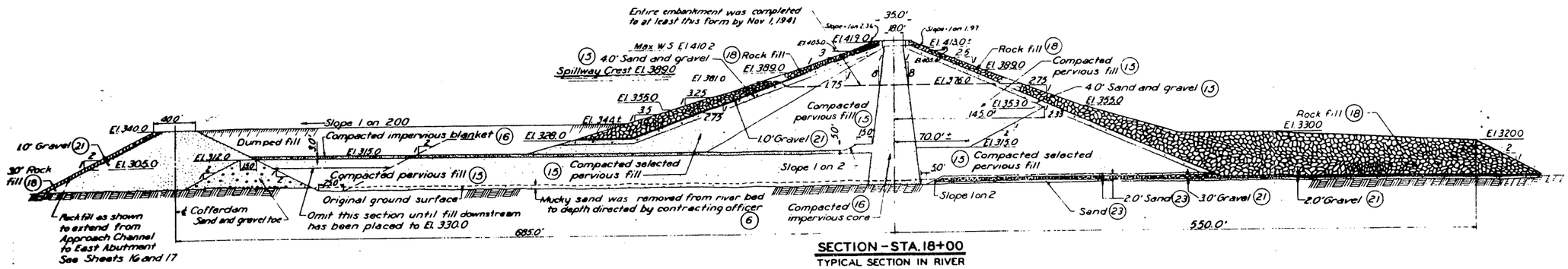
SCALE: AS SHOWN

JANUARY 1995

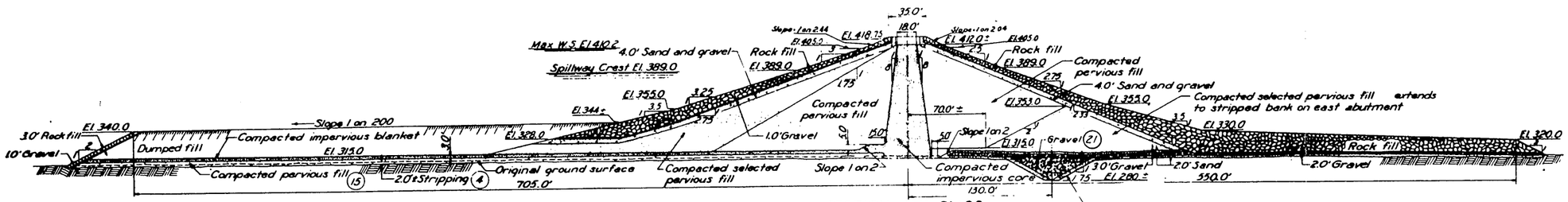
FILE NO. 11163-004

MAKEPEACE

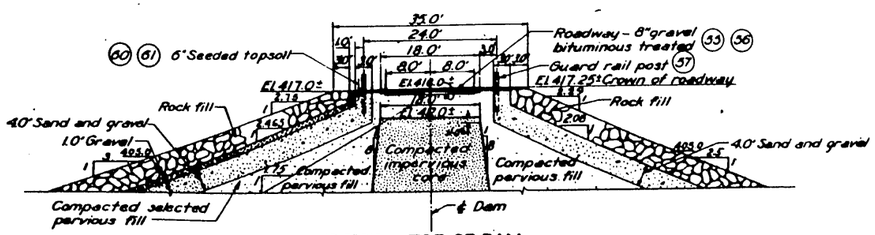
FIGURE 2



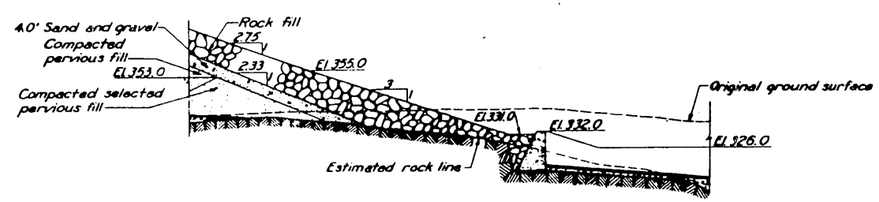
SECTION - STA. 18+00
TYPICAL SECTION IN RIVER



SECTION - STA. 21+00



DETAIL - TOP OF DAM
SCALE: 1" = 10'-0"



SECTION THRU STILLING BASIN HEADWALL
ON ℄ OF OUTLET WORKS
SCALE: 1" = 20'-0"

NOTES:

1. DRAWING PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.

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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

AS BUILT CROSS SECTIONS

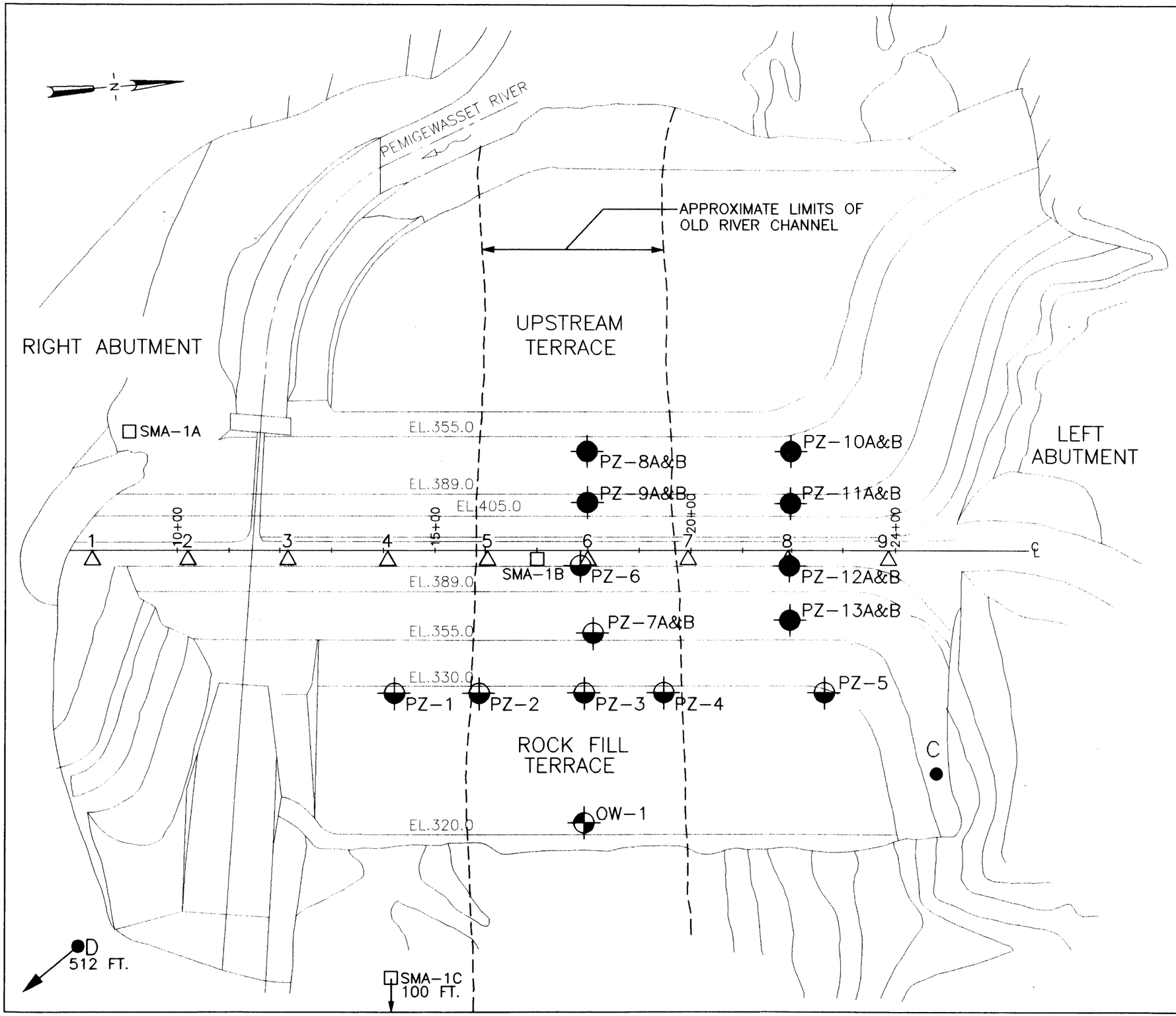
SCALE: AS SHOWN JANUARY 1995

FIGURE 3

169669

FILE NO. 11163-004

MAKEPEACE



LEGEND:

- PIEZOMETER INSTALLED IN 1985 AND 1987
- PIEZOMETER INSTALLED IN 1991 "A" PIEZOMETER IS THE LOWER PIEZOMETER "B" IS THE UPPER PIEZOMETER
- OBSERVATION WELL
- C CONTROL POINT FOR VERTICAL AND HORIZONTAL CONTROL
- △ CREST SURVEY MONUMENT 1991
- □ STRONG MOTION ACCELEROGRAPH SHELTERS

NOTES:

1. PLAN PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.

0 200 400
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

INSTRUMENTATION PLAN

SCALE: 1"=200' JANUARY 1995

11163-004 B2

FIGURE 4

LEGEND FOR GRAPHIC LOGS

FD90-2
1/30/90
EL. 515

Type, year and number of exploration.
Date exploration completed.
Elevation of ground surface at time of exploration.

Maximun artesian head.

Subsurface water level.

Artesian flow encountered.

Range of subsurface water level during period of observation.

SM — Group letter symbol according to ASTM D2487 AND ASTM D2488.

NR — No recovery or unsatisfactory soil samples recovered.

NS — Not sampled

25 — Number of blows per foot of penetration using a 140 lb. hammer falling freely an average drop of 30 inches to drive a sample spoon of 2" O.D – 1-3/8" I.D. in size equipped with bevelled and sharpened drive shoe.

* — Indicates sample taken with a 300 lb. hammer and a drop of 18 inches.

Cobbles or boulders.

Coarse gravel or nested cobbles and boulders.

El. 5.0 Elevation of bedrock surface.

Rock core recovery 0–25%.

Rock core recovery 25–50%

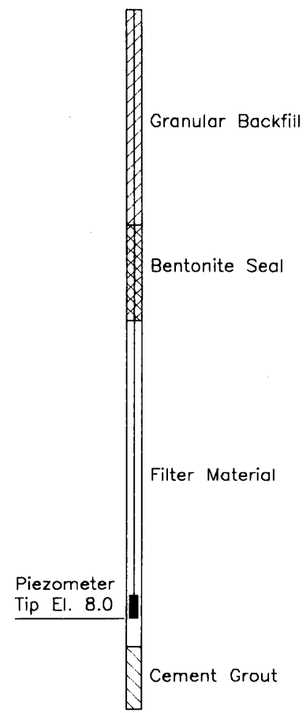
Rock core recovery 50–75%

Rock core recovery 75–90%

Rock core recovery 90– 100%

El. 9.0 Elevation at bottom of exploration.

LEGEND FOR PIEZOMETER



Boring Number	Piezometer Number
FD-85-2	PZ-1
FD-85-3	PZ-2
FD-85-4	PZ-3
FD-85-5	PZ-4
FD-85-6	PZ-5
FD-85-9	PZ-6
FD-87-1	PZ-7A
FD-87-1	PZ-7B
FD-91-5	PZ-8A
FD-91-5	PZ-8B
FD-91-4	PZ-9A
FD-91-4	PZ-9B
FD-91-3	PZ-10A
FD-91-3	PZ-10B
FD-91-2	PZ-11A
FD-91-2	PZ-11B
FD-91-6	PZ-12A
FD-91-6	PZ-12B
FD-91-1	PZ-13A
FD-91-1	PZ-13B

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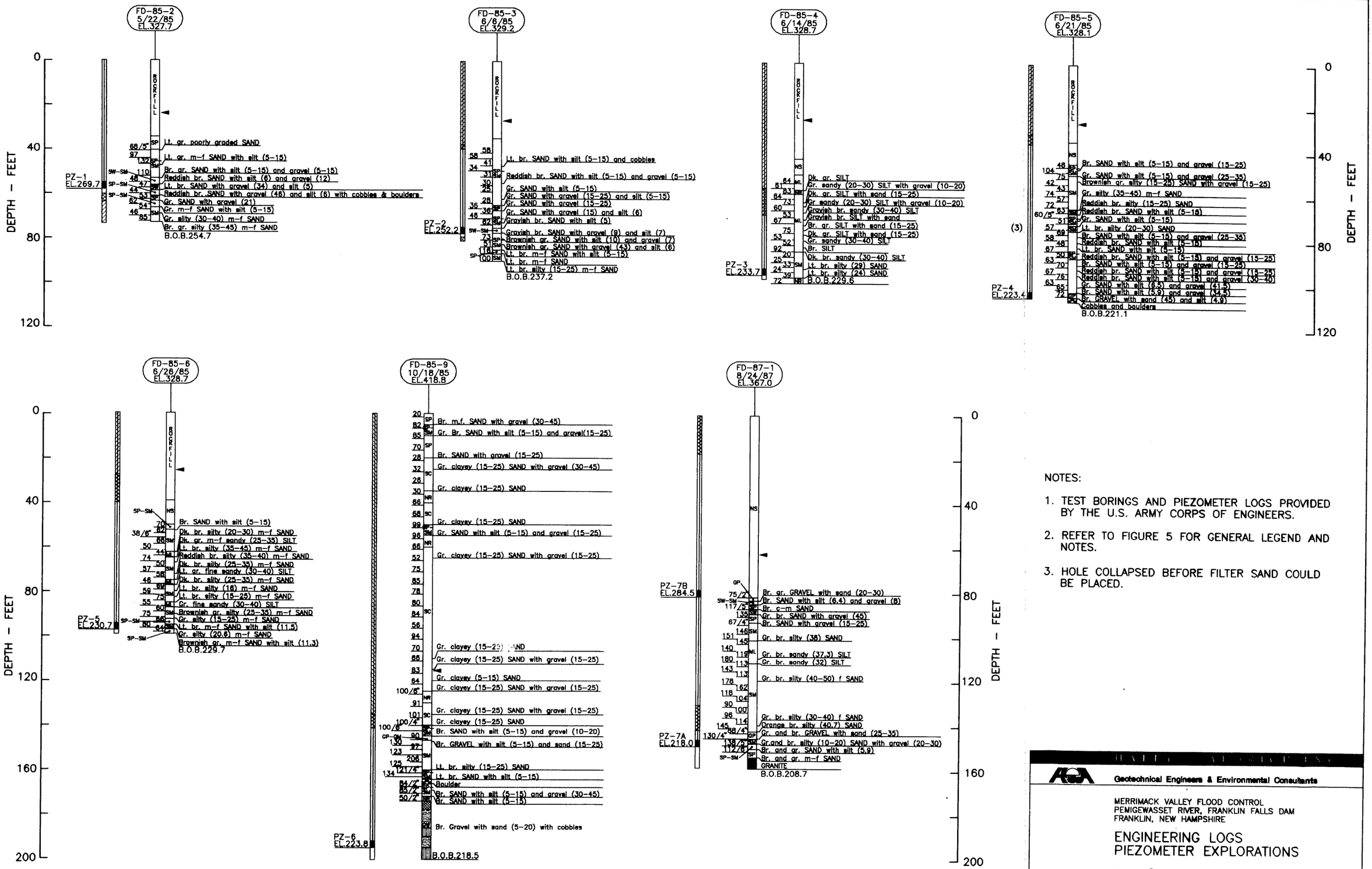
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

GENERAL LEGEND AND NOTES

SCALE: NONE JANUARY 1995

11163-000 B12

FIGURE 5



NOTES:

1. TEST BORINGS AND PIEZOMETER LOGS PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
3. HOLE COLLAPSED BEFORE FILTER SAND COULD BE PLACED.

Geotechnical Engineers & Environmental Consultants

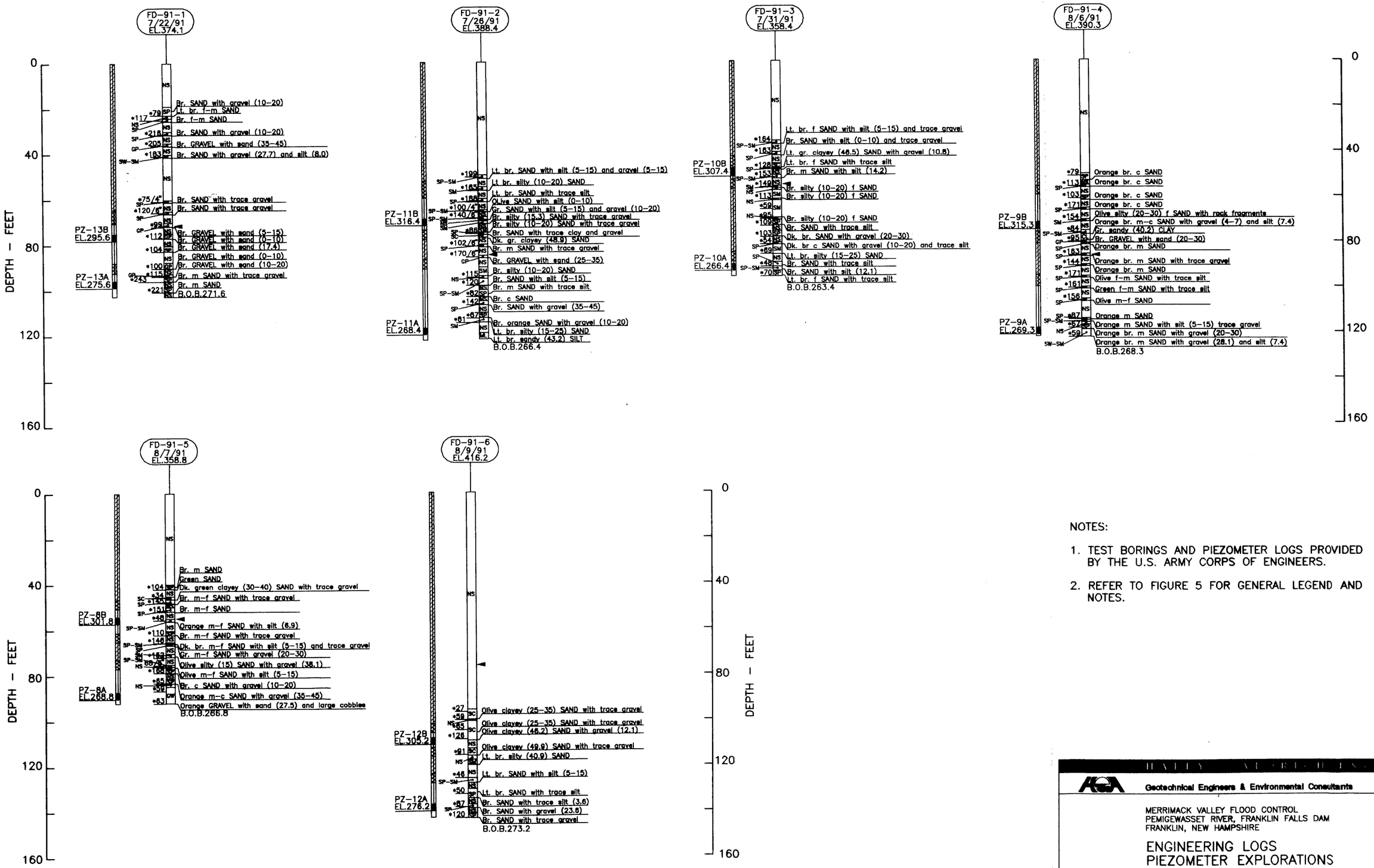
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

ENGINEERING LOGS
PIEZOMETER EXPLORATIONS

SCALE: 1"=40'

JANUARY 1995

FIGURE 6



NOTES:

1. TEST BORINGS AND PIEZOMETER LOGS PROVIDED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.

HAYLEY ASSOCIATES

Geotechnical Engineers & Environmental Consultants

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

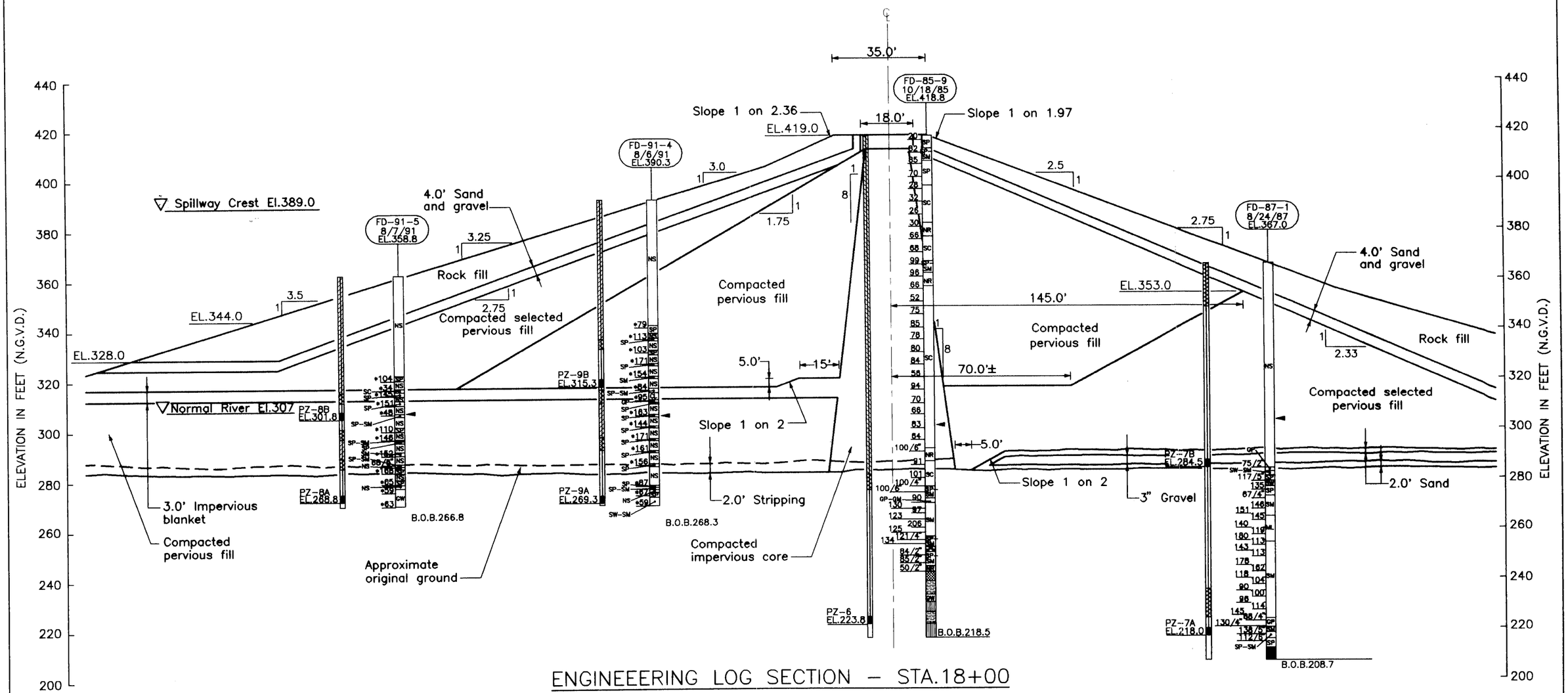
ENGINEERING LOGS
PIEZOMETER EXPLORATIONS

SCALE: 1"=40'

JANUARY 1995

11163-004 B16

FIGURE 7



ENGINEEERING LOG SECTION – STA.18+00

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
4. REFER TO FIGURE 6 AND 7 FOR FULL DESCRIPTION OF ENGINEERING LOGS.

0 40 80
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

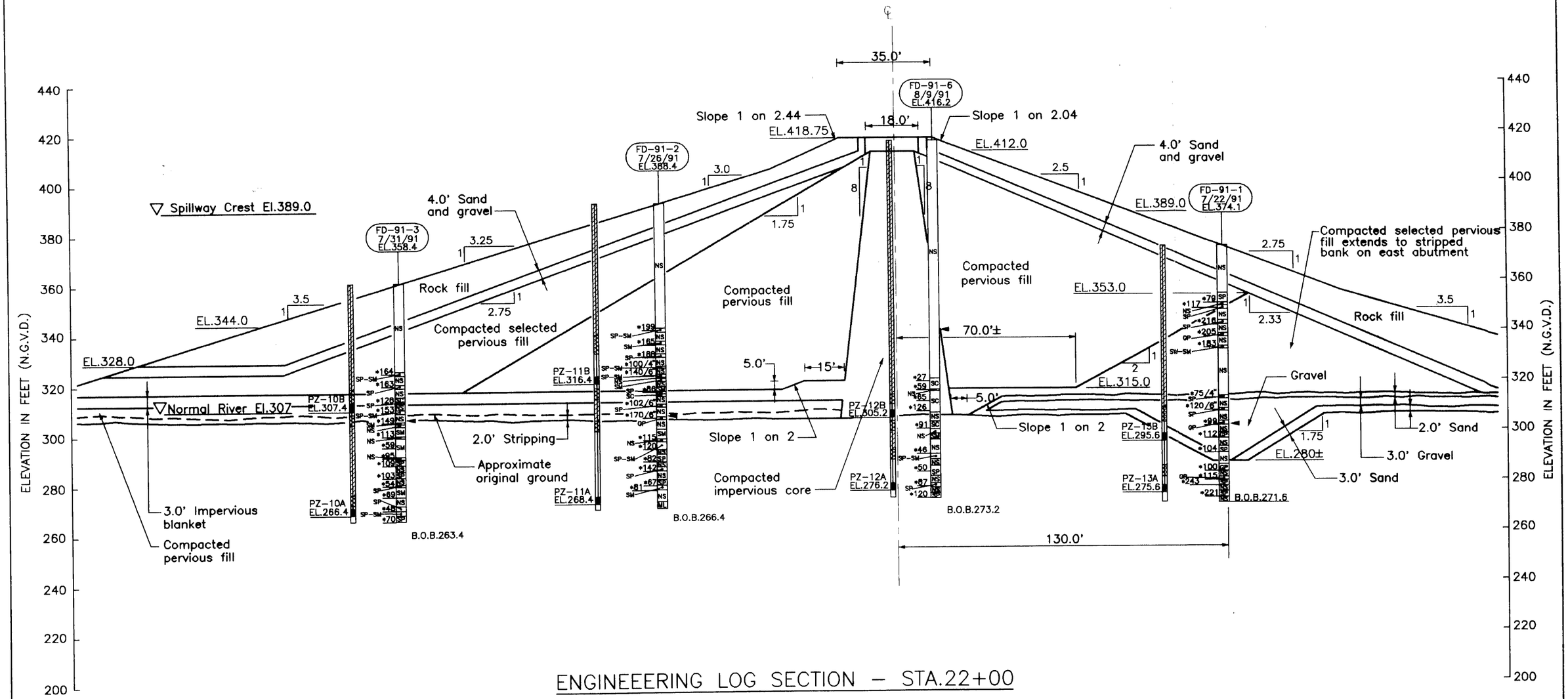
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

ENGINEERING LOG SECTION
STA.18+00

SCALE: 1"=40' JANUARY 1995

11163-004 B3

FIGURE 8



ENGINEEERING LOG SECTION – STA.22+00

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
4. REFER TO FIGURE 6 AND 7 FOR FULL DESCRIPTION OF ENGINEERING LOGS.

0 40 80
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

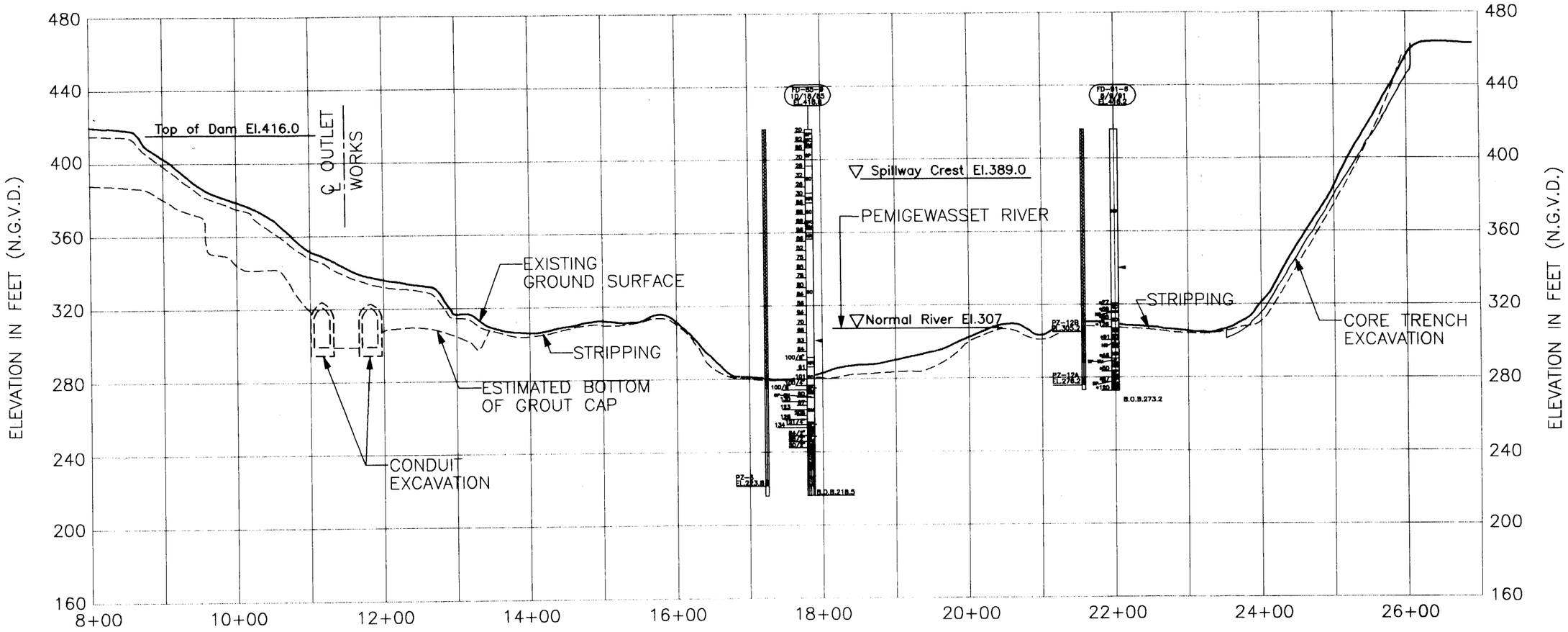
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

ENGINEERING LOG SECTION
STA.22+00

SCALE: 1"=40' JANUARY 1995

11163-004 B4

FIGURE 9



ENGINEERING LOG PROFILE ALONG CENTERLINE OF DAM (LOOKING UPSTREAM)

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
4. REFER TO FIGURE 6 AND 7 FOR DESCRIPTION OF ENGINEERING LOGS.

HORIZ. 0 80 160
VERT. 0 60 120
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

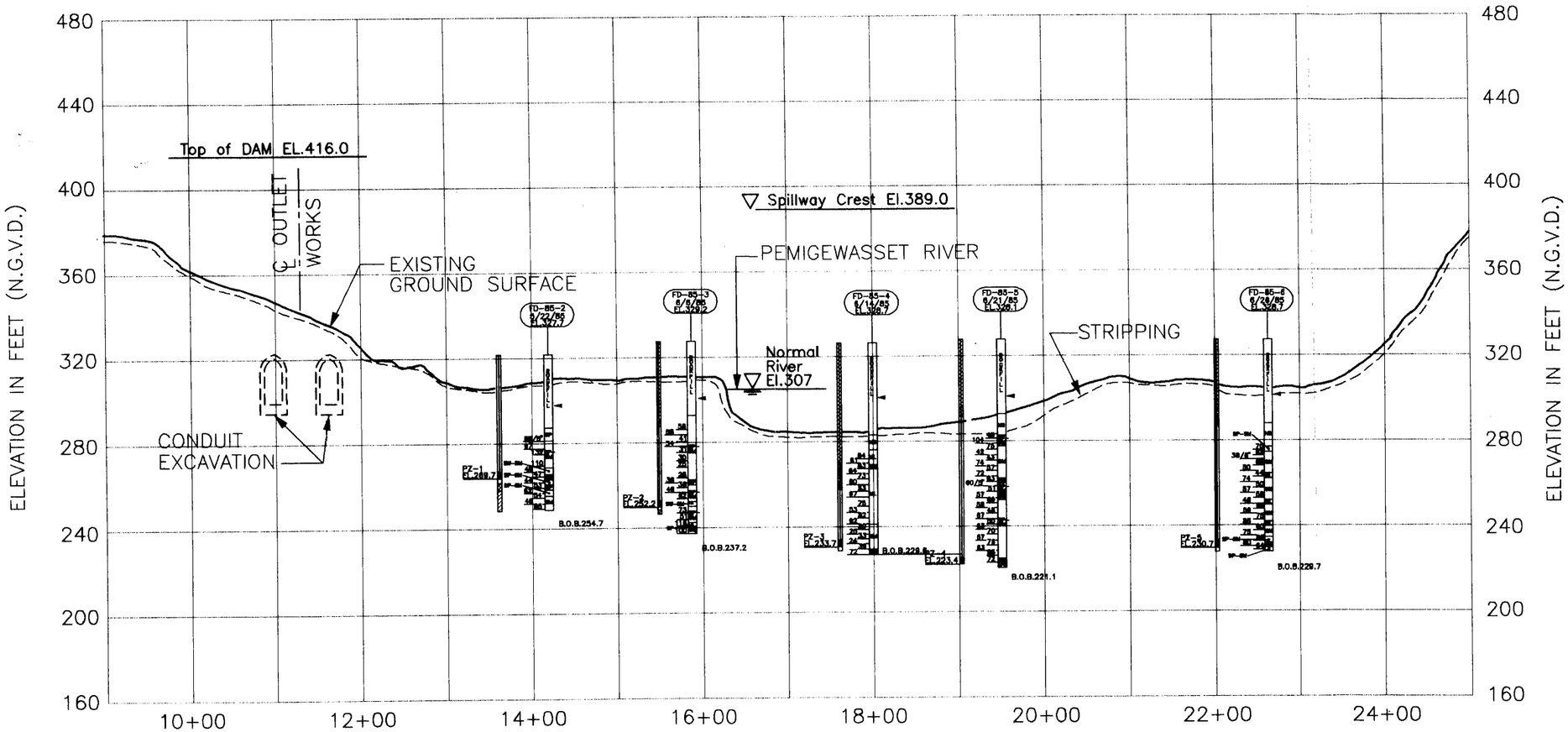
ENGINEERING LOG PROFILE
CENTERLINE OF DAM

SCALE: HORIZ: 1"=80'
VERT: 1"=60'

JANUARY 1995

11163-000 B6

FIGURE 10



ENGINEERING LOG PROFILE DOWNSTREAM TOE OF DAM (LOOKING UPSTREAM)

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
4. REFER TO FIGURES 6 AND 7 FOR DESCRIPTION OF ENGINEERING LOGS.

HORIZ. 0 80 100
VERT. 0 60 120
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

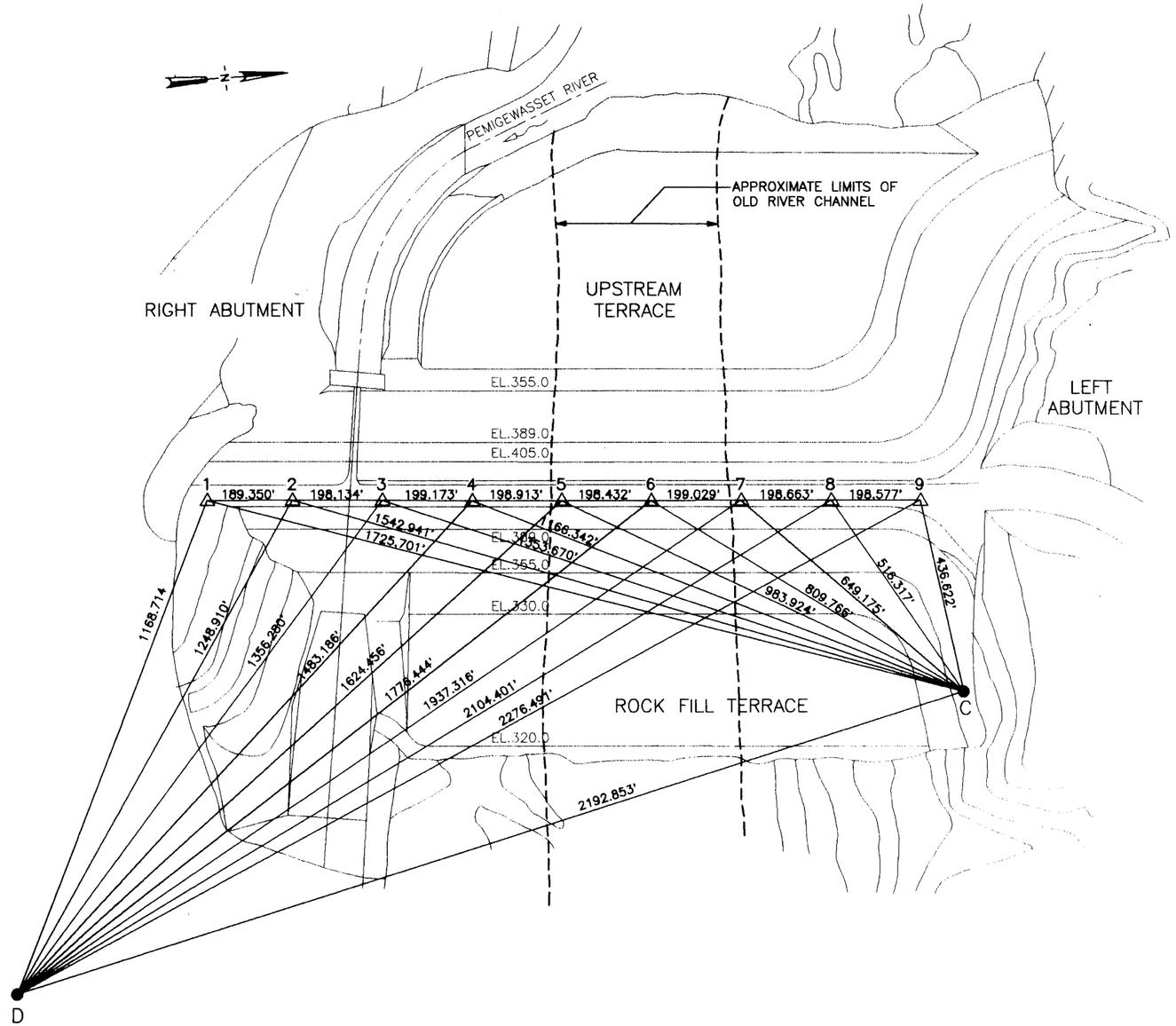
ENGINEERING LOG PROFILE
DOWNSTREAM TOE

SCALE: HORIZ: 1"=80'
VERT: 1"=60'

JANUARY 1995

11163-000 B8

FIGURE 11



LEGEND:

● C CONTROL POINT FOR VERTICAL AND HORIZONTAL CONTROL

△ CREST MONUMENT 1991

NOTES:

1. MEASUREMENTS SHOWN ARE FROM OCTOBER 1991 SURVEY. REFER TO SURVEY BOOK FC349 AND FC640 FOR DESCRIPTION AND LOCATION OF CONTROL POINTS. BOOKS ARE STORED IN SURVEY BRANCH, NED.
2. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET N.G.V.D.

0 300 600
SCALE IN FEET

CREST MONUMENT
SETTLEMENT AND MOVEMENT RECORD

DATE	OCT. 1974 ELEVATION	JUN. 1975 ELEVATION	APR. 1978 ELEVATION	APR. 1982 ELEVATION	AUG. 1987 ELEVATION	SEPT. 1987 NORTHING	SEPT. 1987 EASTING	OCT. 1991 ELEVATION	DEC. 1991 NORTHING	DEC. 1991 EASTING
MON 1	416.242	416.250	416.246	416.270	416.300	352373.32	501220.03	416.270	352373.32	501220.02
MON 2	416.773	416.793	416.789	416.802	416.836	352516.88	501343.45	416.820	352516.90	501343.42
MON 3	416.661	416.684	416.661	416.681	416.707	352667.15	501472.58	416.703	352667.13	501472.59
MON 4	417.619	417.636	417.618	417.626	417.650	352818.21	501602.41	417.643	352818.22	501602.40
MON 5	418.248	418.267	418.234	418.263	418.281	352969.05	501732.04	418.284	352969.05	501732.04
MON 6	418.028	418.049	418.025	418.037	418.051	353119.54	501861.32	418.062	353119.55	501861.32
MON 7	418.508	418.526	418.486	418.515	418.529	353270.48	501991.02	418.517	353270.48	501991.08
MON 8	417.864	417.875	417.847	417.857	417.870	353421.15	502120.49	417.851	353421.16	502120.48
MON 9	416.717	416.737	416.694	416.720	416.728	353571.73	502249.89	416.728	353571.75	502249.88

CONTROL POINTS
LOCATION AND ELEVATION RECORD

CONTROL POINT	NORTHING	EASTING	ELEVATION
B	NA	NA	426.149
C	353363.3	502633.5	NA
D	351345.2	501775.7	NA

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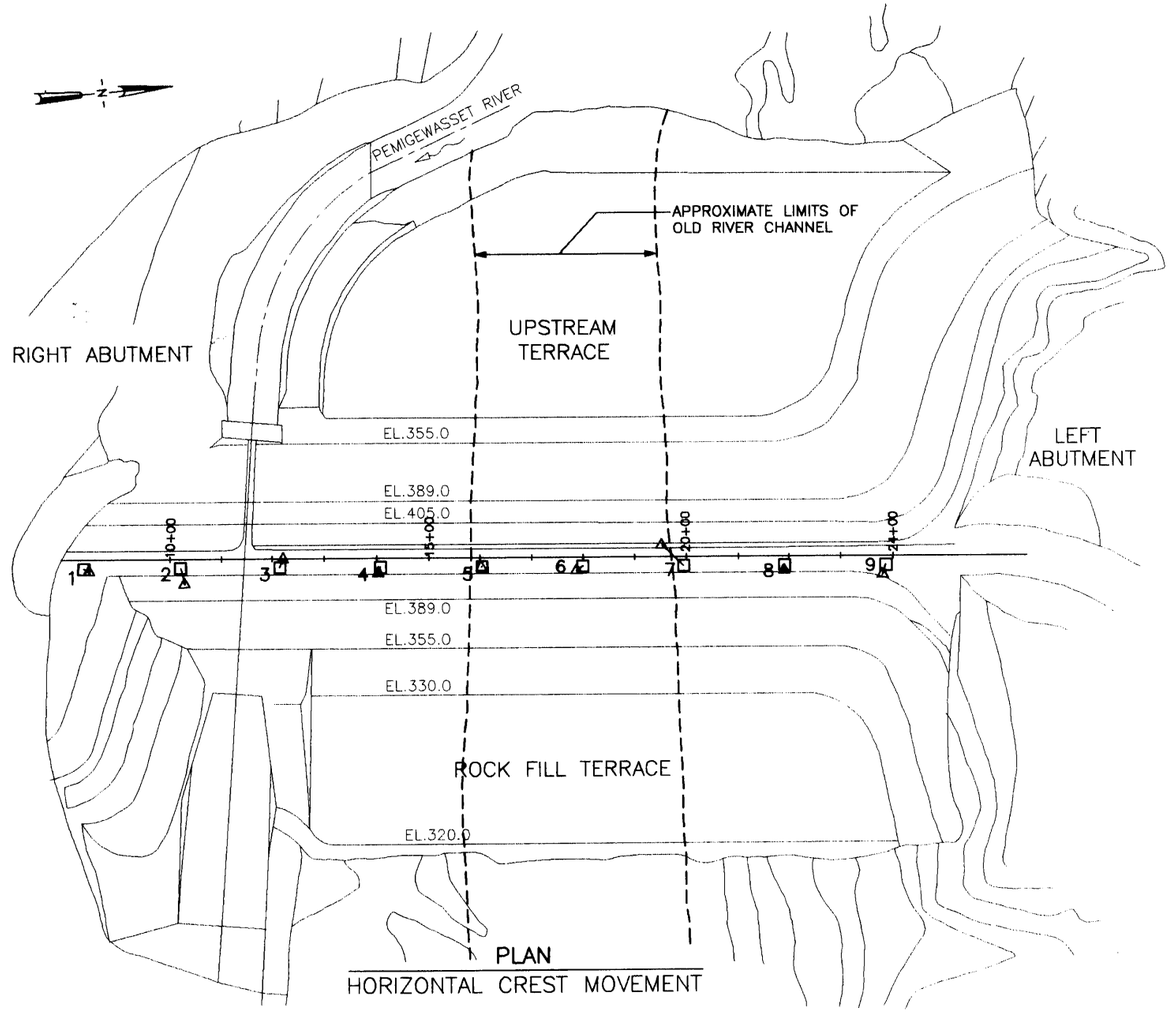
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

GENERAL LAYOUT, LOCATION AND SURVEY

SCALE: 1"=300' JANUARY 1995

11163-000 B11

FIGURE 12



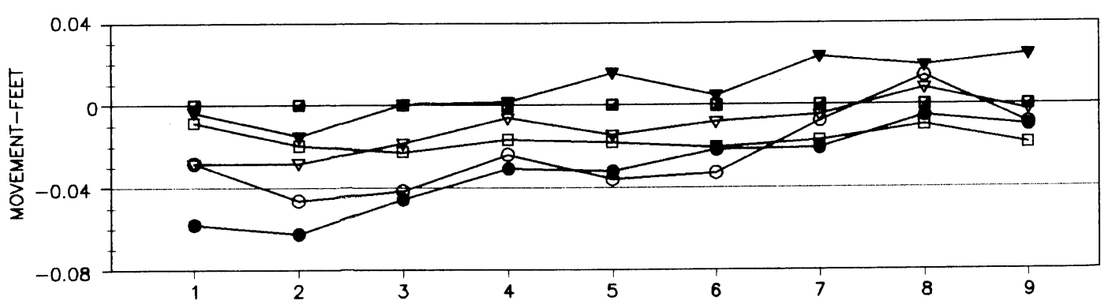
PLAN
HORIZONTAL CREST MOVEMENT

LEGEND:

- □ CREST MONUMENT 1974
- △ CREST MONUMENT 1991
- / DIRECTION OF HORIZONTAL MOVEMENT SCALE: 1 INCH = 0.3 FEET

NOTES:

1. ALL ELEVATIONS SHOWN ON THIS SHEET ARE IN TERMS OF FEET NGVD OR REFERRED TO THE ELEVATIONS SHOWN FOR THE TOP (CREST) OF DAM (ALSO GIVEN IN FEET N.G.V.D.).



ELEVATION
VERTICAL CREST MOVEMENT

LEGEND:

- INITIAL ELEVATION OCTOBER 1974
- ELEVATION AS OF JUNE 1975
- ELEVATION AS OF APRIL 1978
- ELEVATION AS OF APRIL 1982
- ELEVATION AS OF AUGUST 1987
- ELEVATION AS OF OCTOBER 1991

0 300 600
SCALE IN FEET

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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

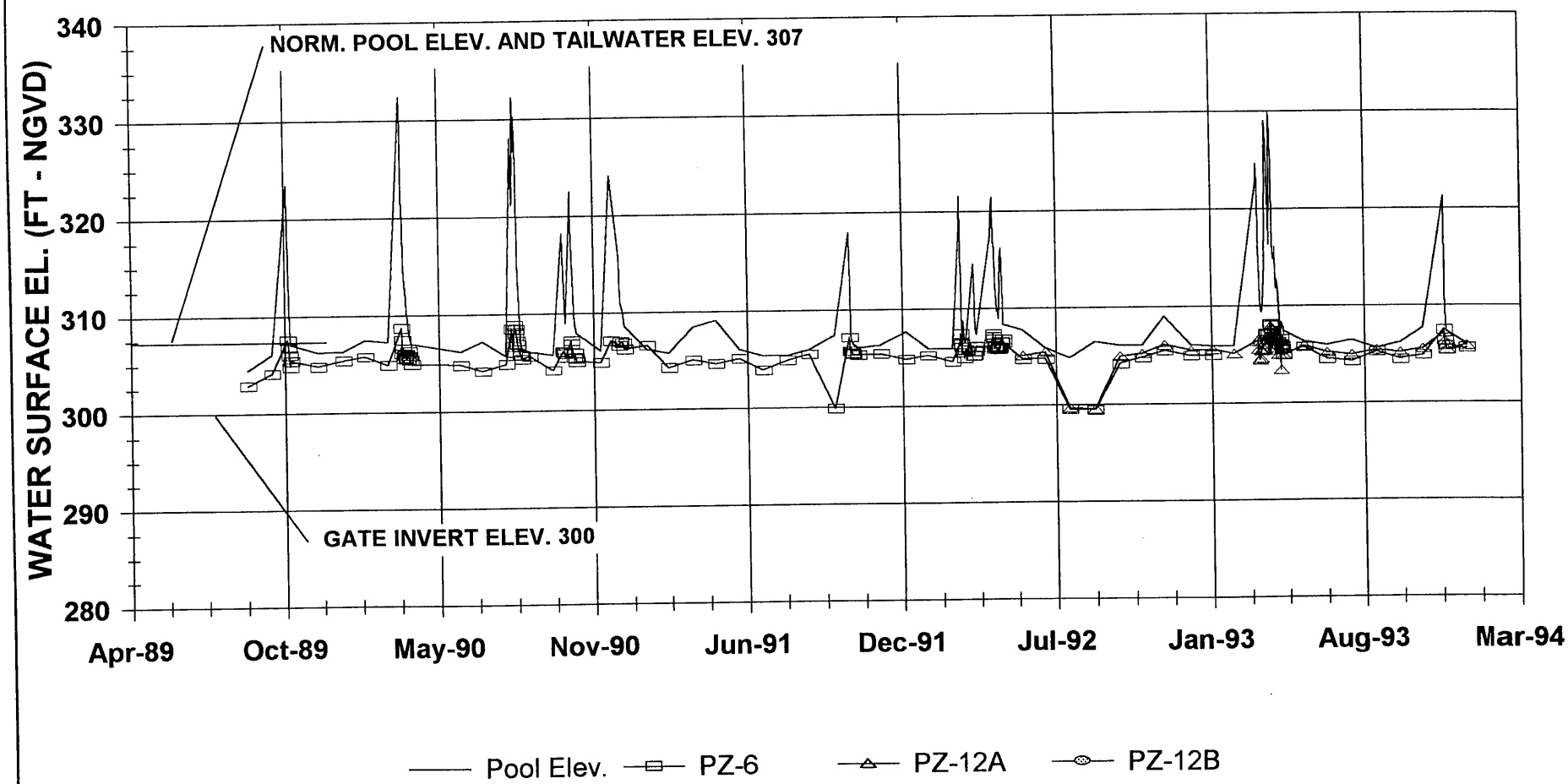
HORIZONATAL AND VERTICAL MOVEMENT

SCALE: 1"=300' JANUARY 1995

11163-000 B10

FIGURE 13

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-6	223.8	419.8
PZ-12A	276.2	417.9
PZ-12B	305.2	418.1

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PEMIGEWASSET RIVER
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FRANKLIN, NEW HAMPSHIRE

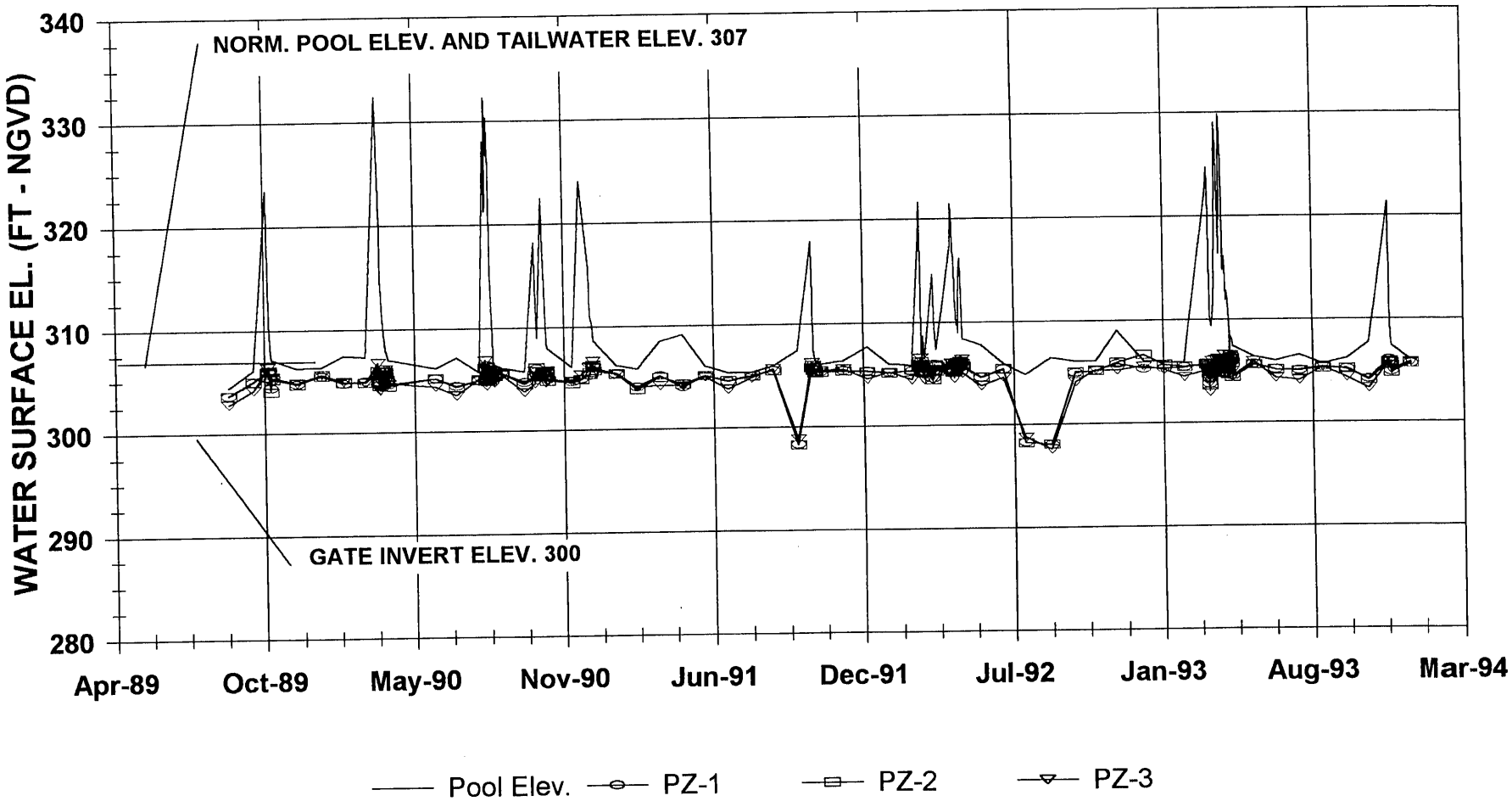
PIEZOMETER DATA
TIME HISTORY PLOTS
CENTERLINE OF DAM

SCALE: AS SHOWN

JANUARY 1995

FIGURE 14

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-1	269.7	329.7
PZ-2	252.2	331.2
PZ-3	233.7	330.0

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FRANKLIN, NEW HAMPSHIRE

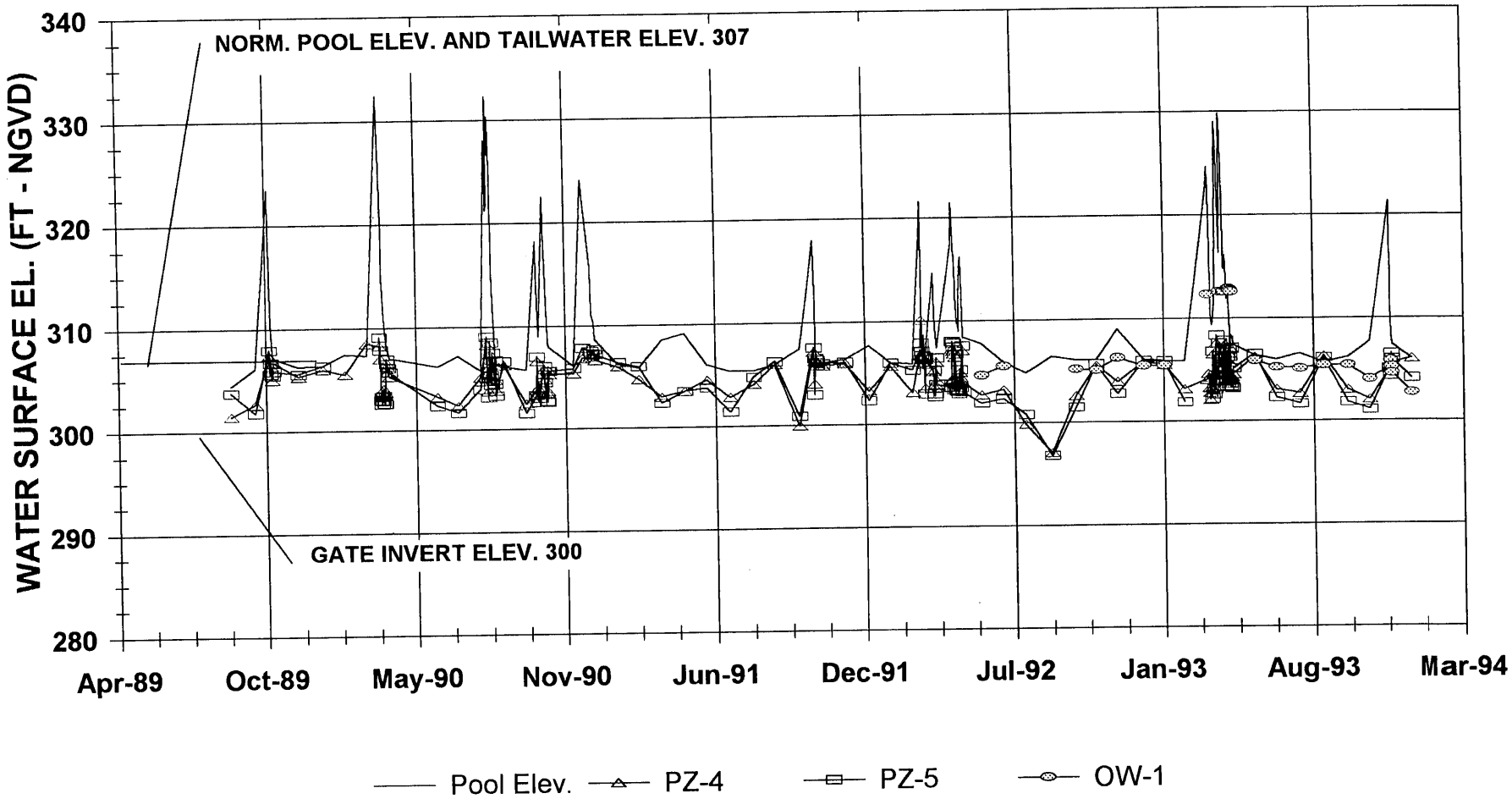
PIEZOMETER DATA
TIME HISTORY PLOTS
DOWNSTREAM TOE OF DAM

SCALE: AS SHOWN

JANUARY 1995

FIGURE 15

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-4	223.4	330.1
PZ-5	230.7	330.7
OW-1	NA	NA

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FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

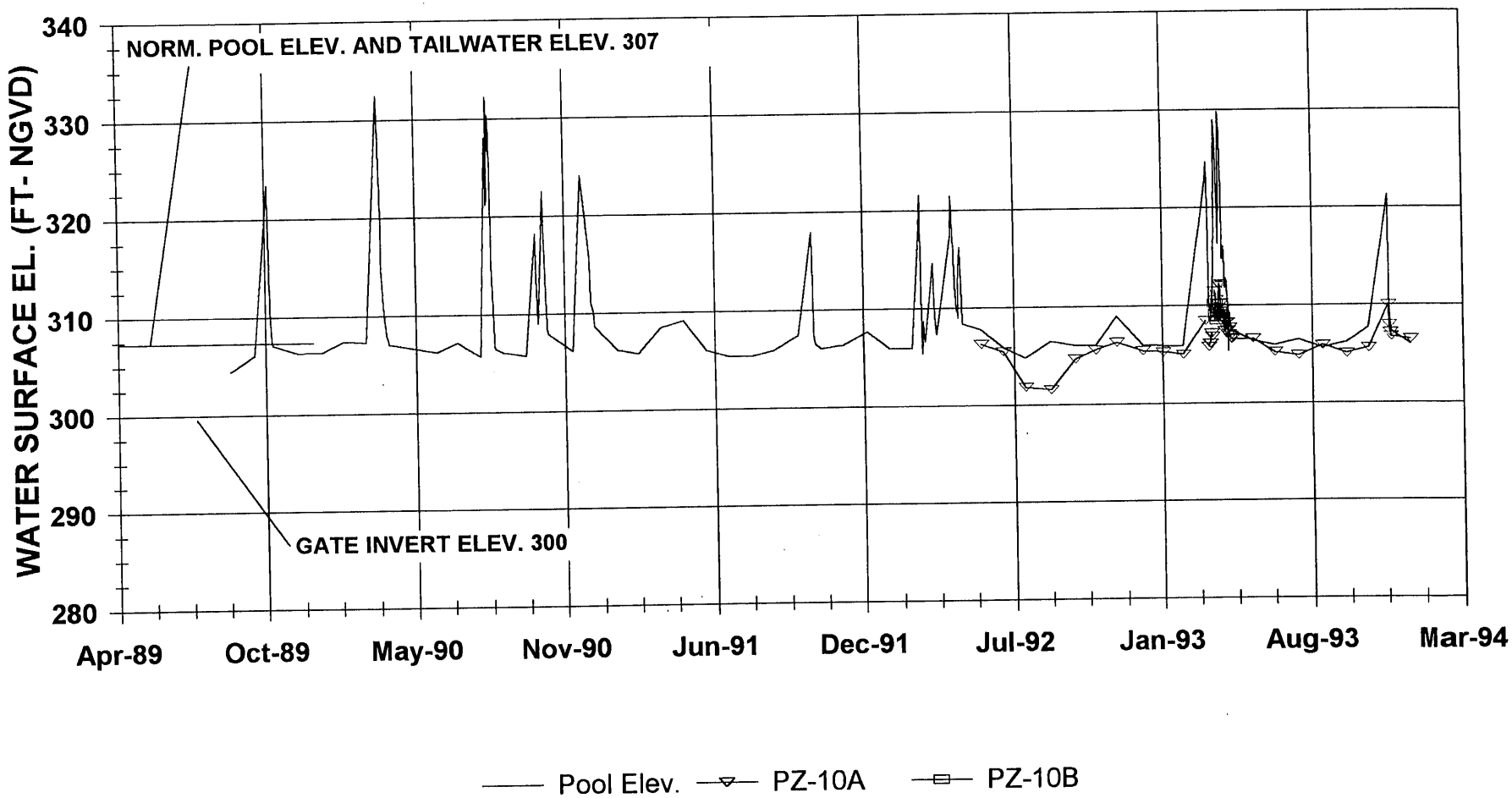
PIEZOMETER DATA
TIME HISTORY PLOTS
DOWNSTREAM TOE OF DAM

SCALE: AS SHOWN

JANUARY 1995

FIGURE 16

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-10A	266.4	360.3
PZ-10B	307.4	360.2

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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

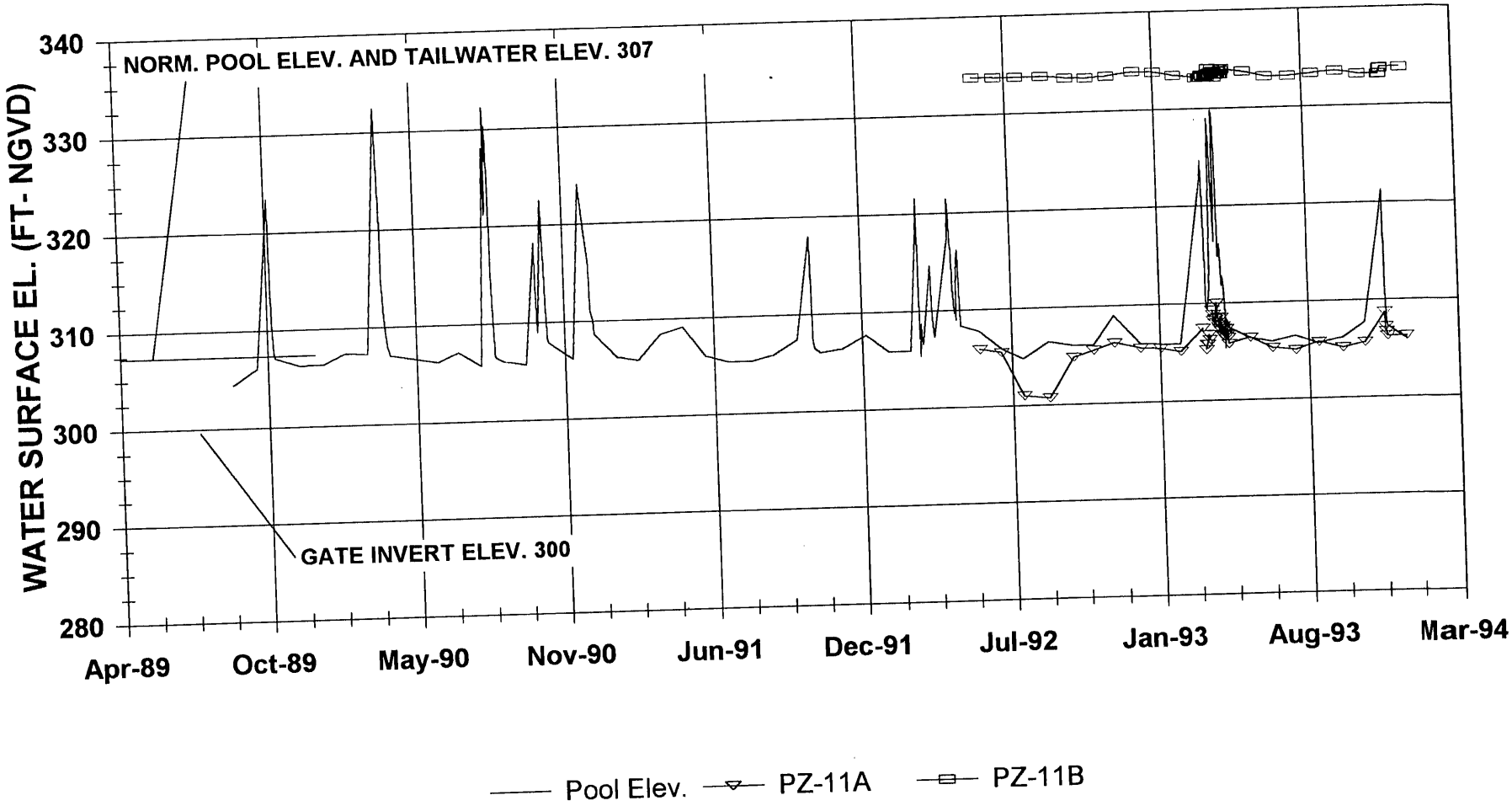
PIEZOMETER DATA
TIME HISTORY PLOTS
STATION 22+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 17

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-11A	268.4	390.2
PZ-11B	316.4	390.3

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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

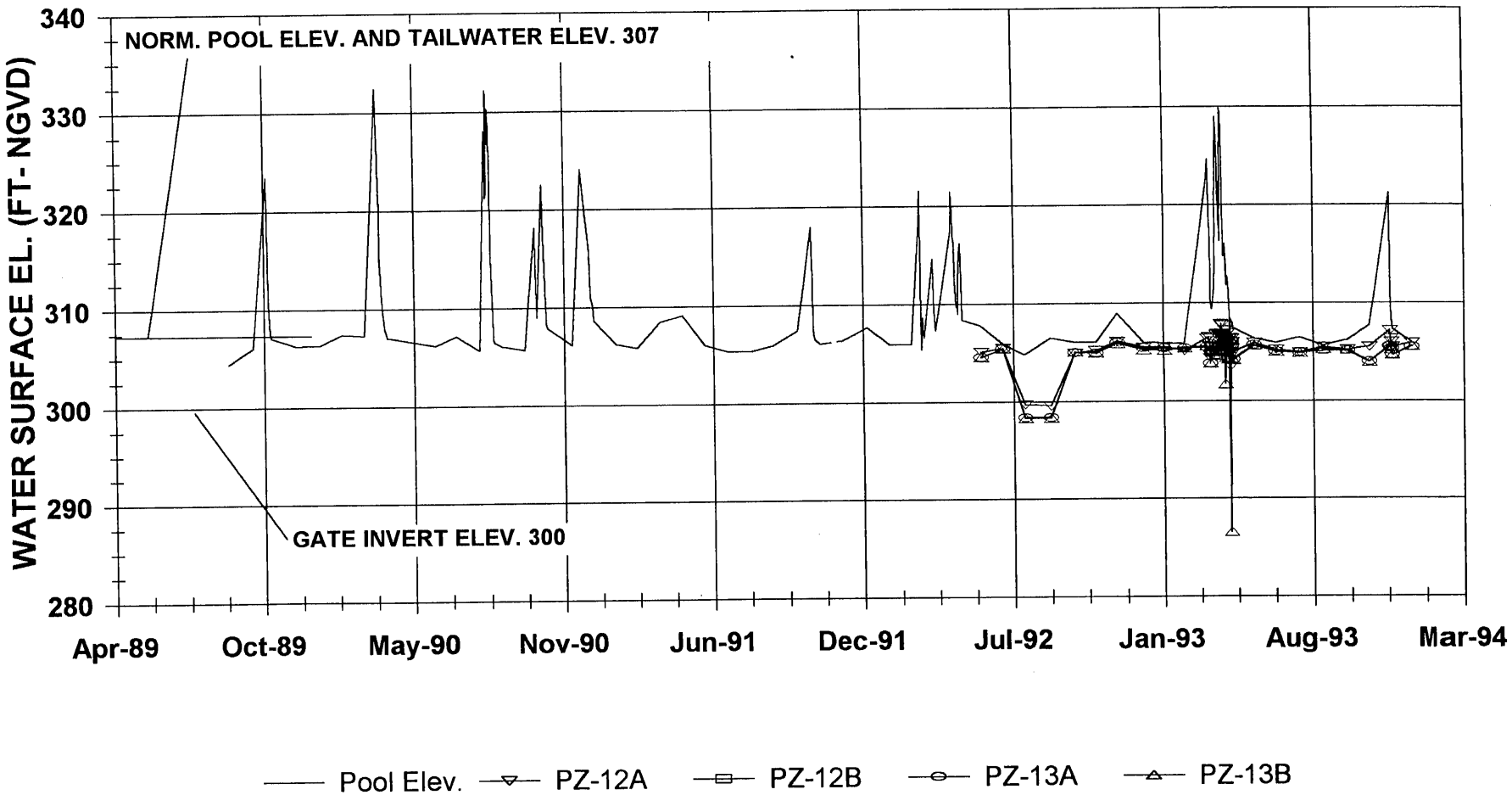
PIEZOMETER DATA
TIME HISTORY PLOTS
STATION 22+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 18

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-12A	276.2	417.9
PZ-12B	305.2	418.1
PZ-13A	275.6	376.0
PZ-13B	295.6	376.1

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FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

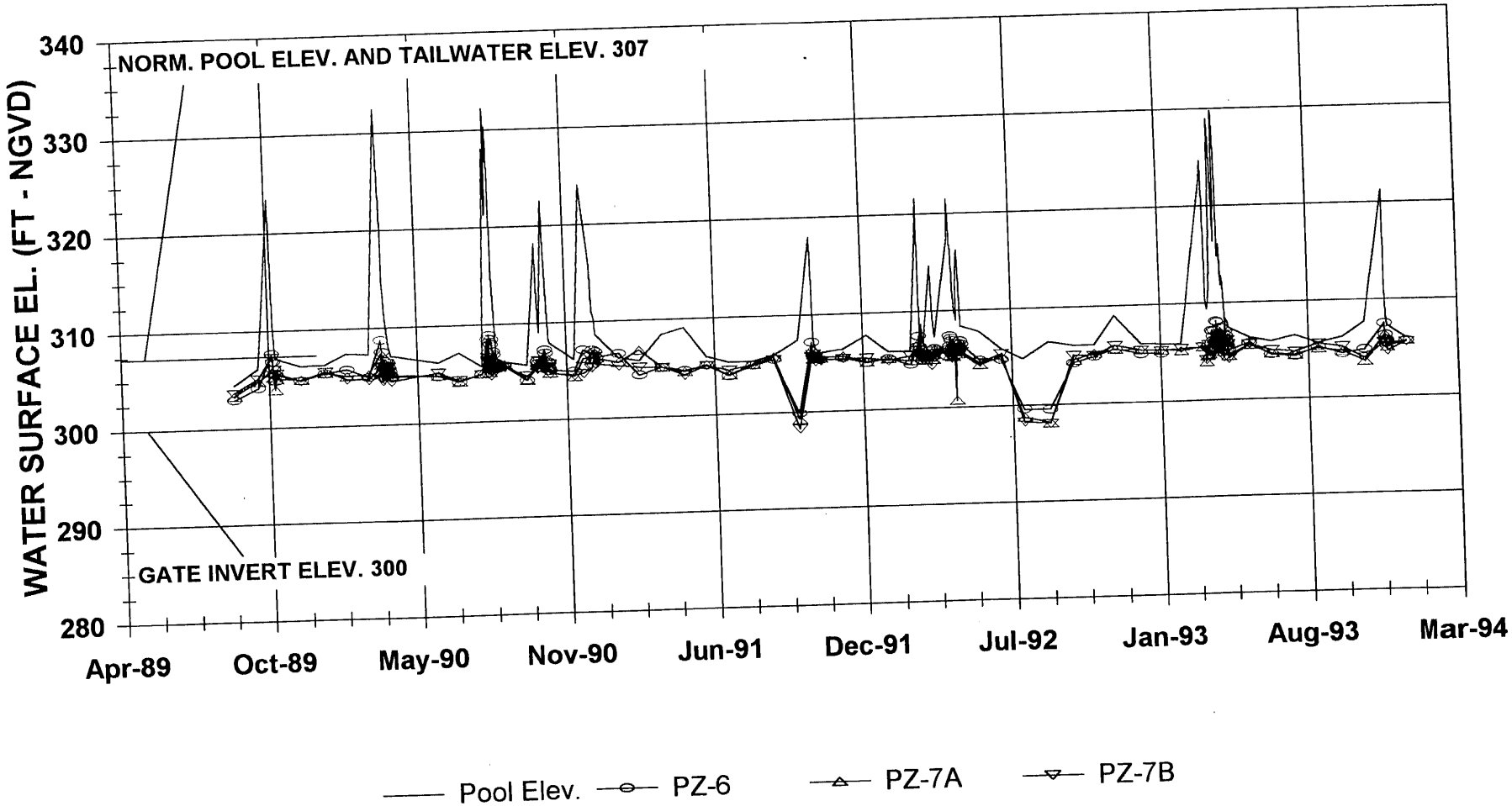
PIEZOMETER DATA
TIME HISTORY PLOTS
STATION 22+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 19

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-6	223.8	419.8
PZ-7A	218.0	370.2
PZ-7B	284.5	370.5

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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

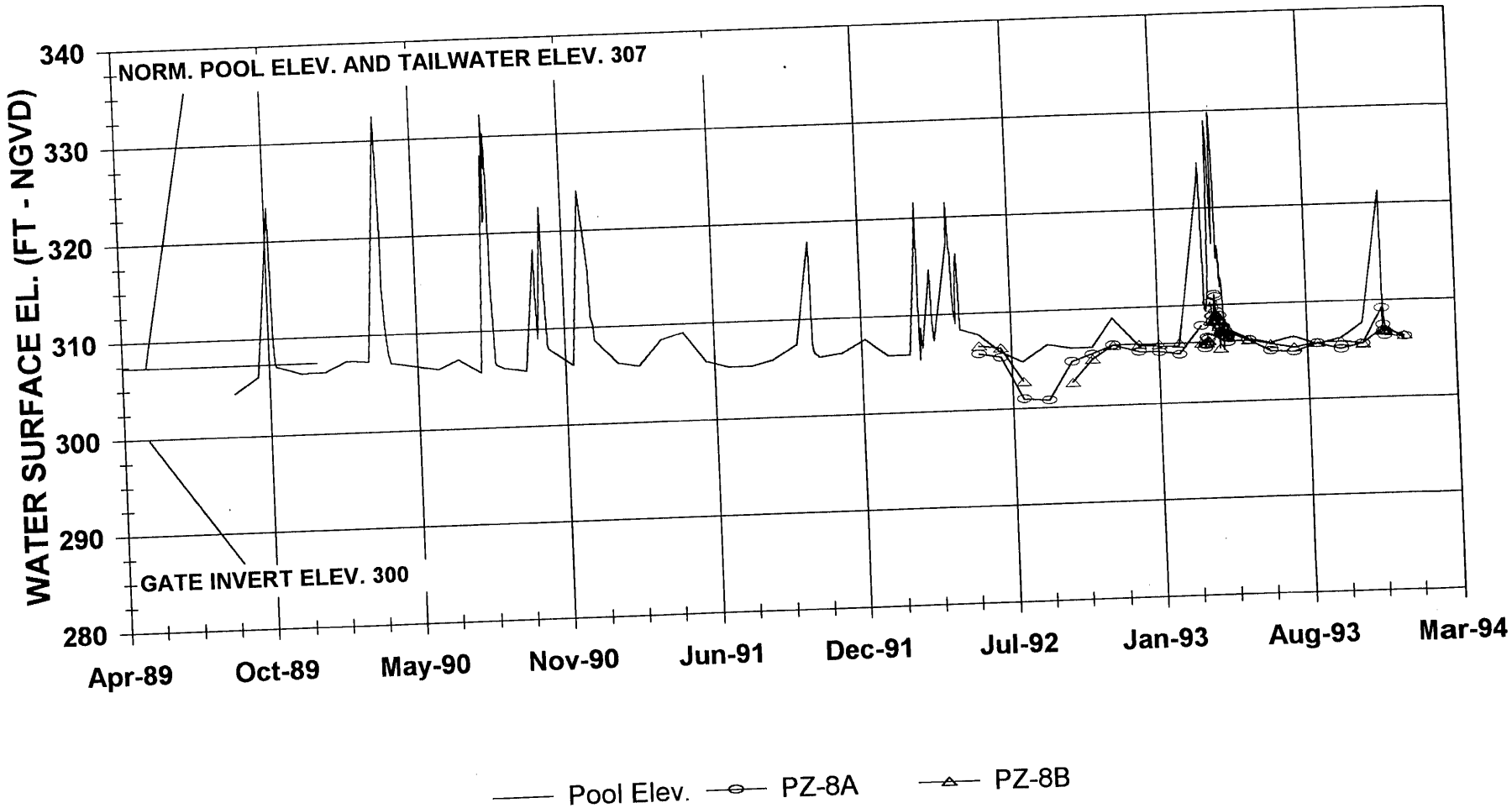
PIEZOMETER DATA
TIME HISTORY PLOTS
STATION 18+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 2

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-8A	268.8	360.4
PZ-8B	301.8	360.7

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FRANKLIN, NEW HAMPSHIRE

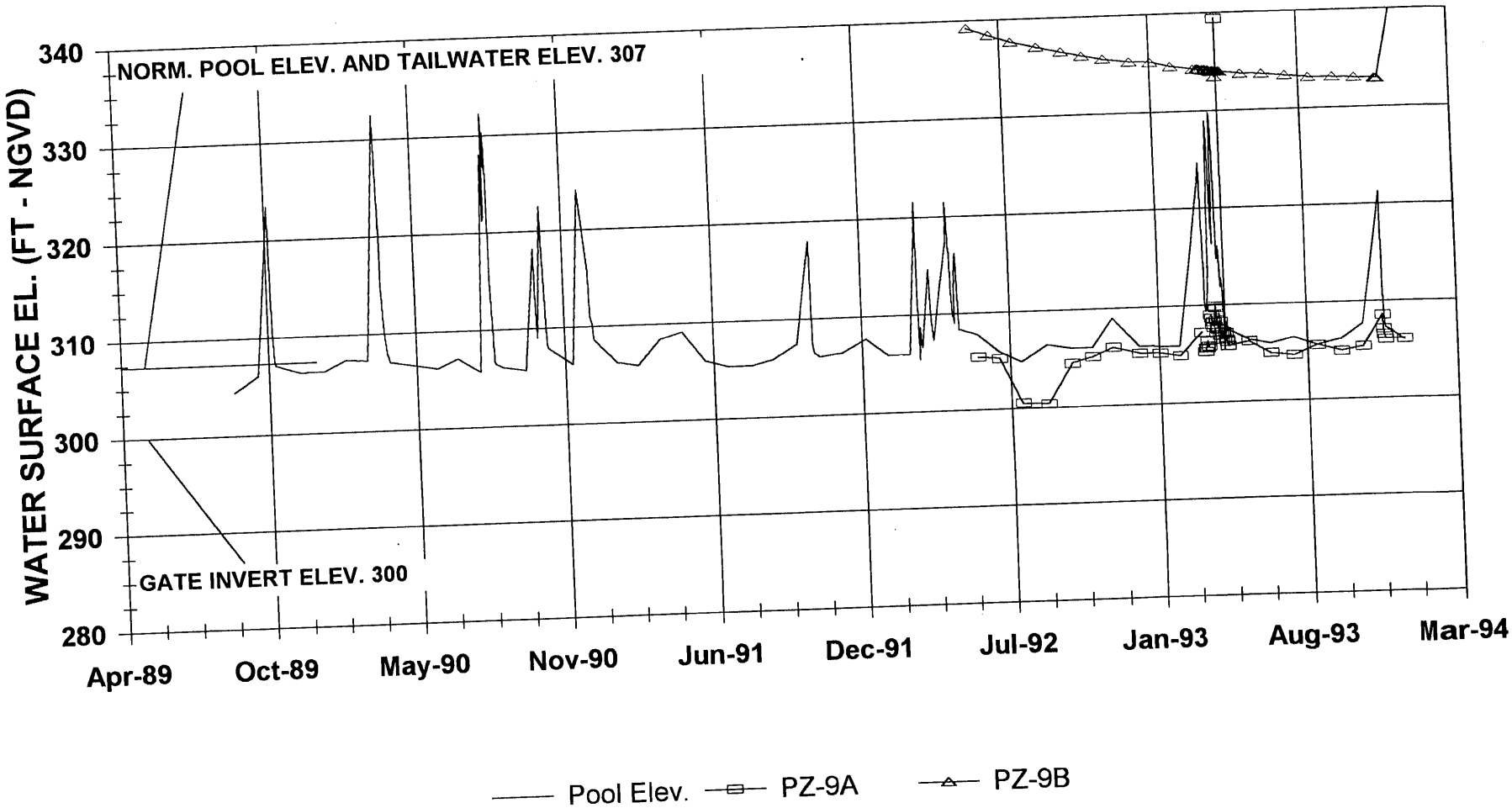
PIEZOMETER DATA
TIME HISTORY PLOTS
STATION 18+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 21

FILE NO. 11163-004



Piezometer No.	Tip Elevation (ft. - NGVD)	Riser Pipe Elevation (ft. - NGVD)
PZ-9A	269.3	392.0
PZ-9B	315.3	392.2

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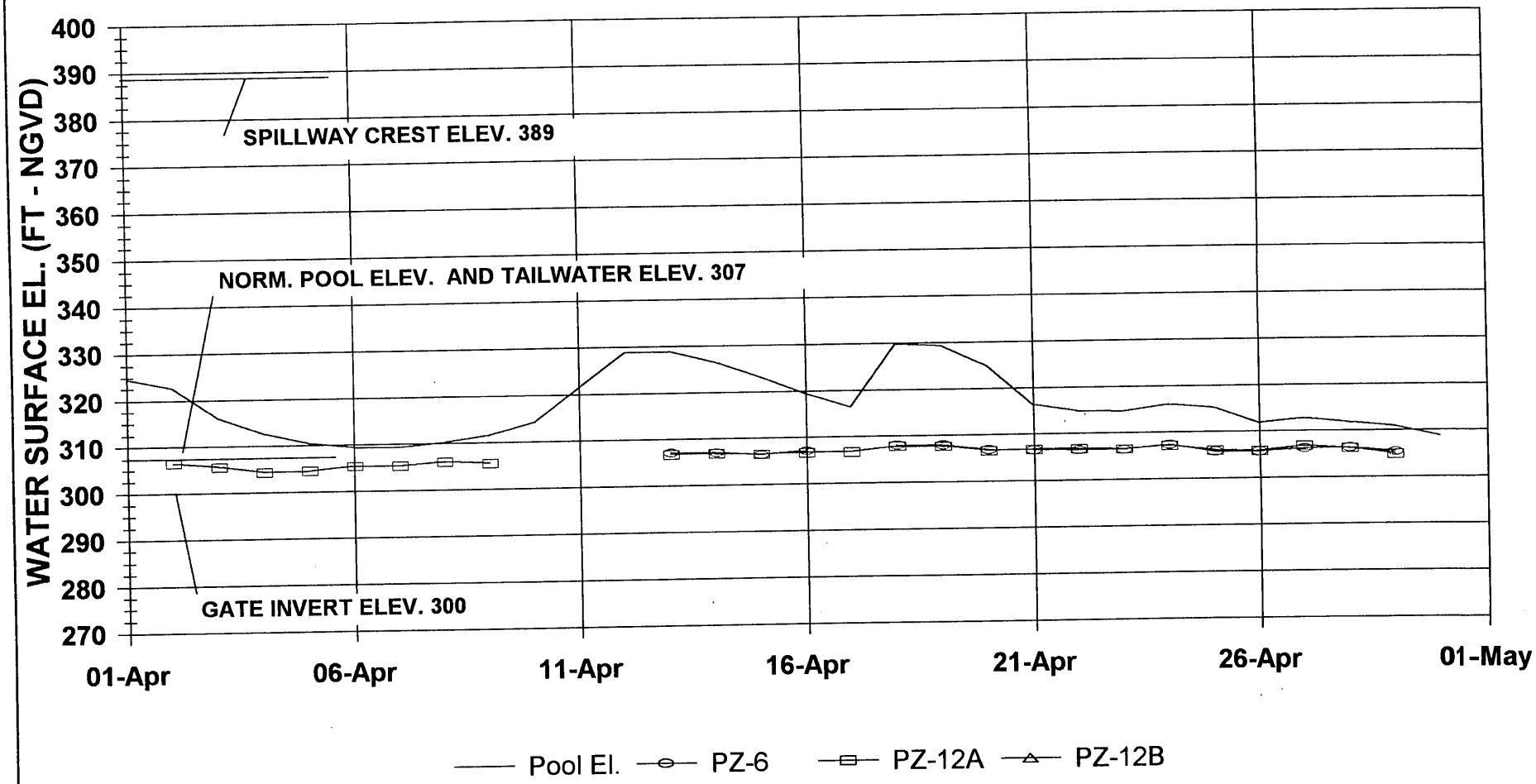
PIEZOMETER DATA
TIME HISTORY PLOTS
STATION 18+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 2

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

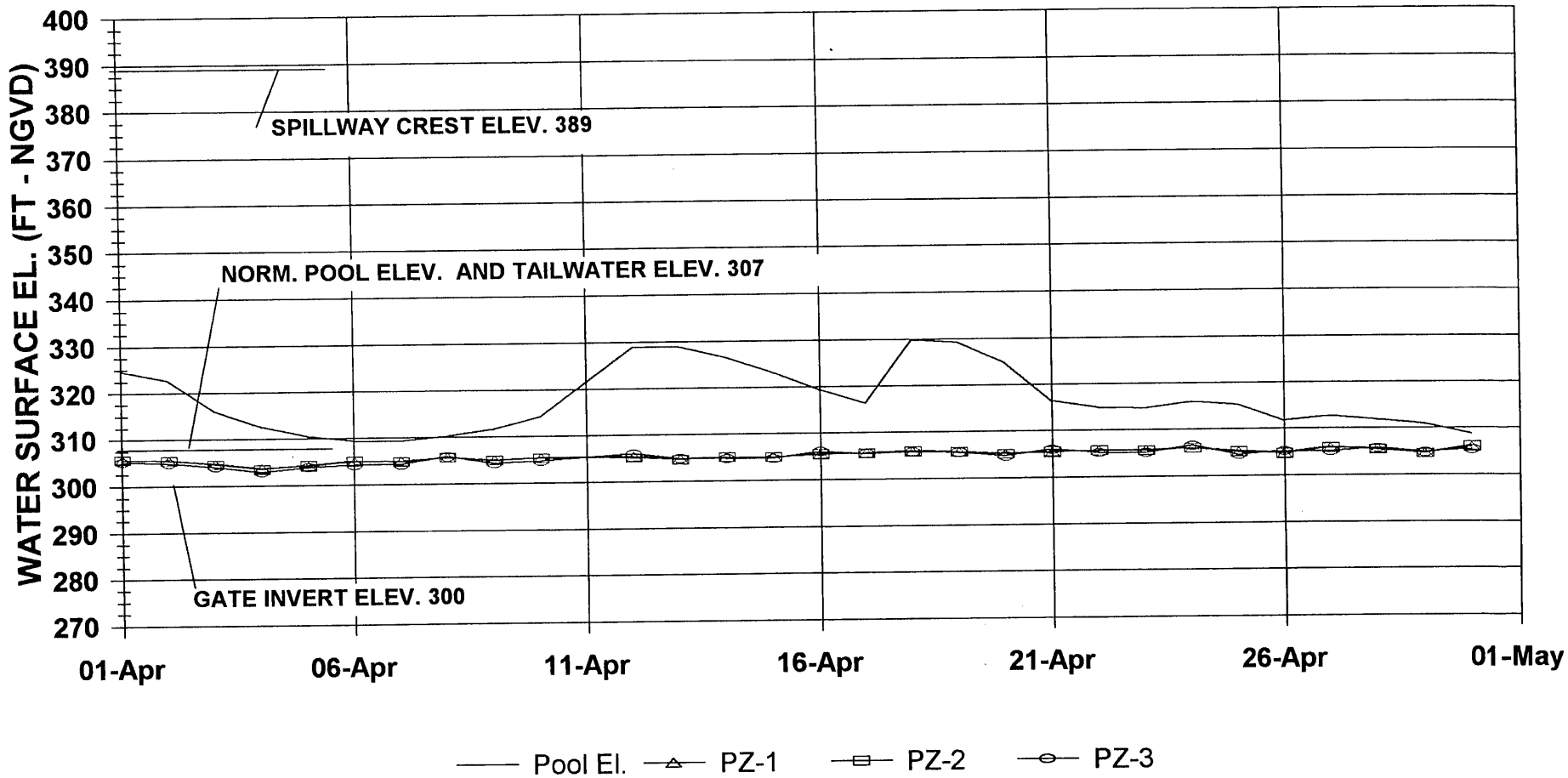
APRIL 1993 EVENT
CENTERLINE OF DAM

SCALE: AS SHOWN

JANUARY 1995

FIGURE 23

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

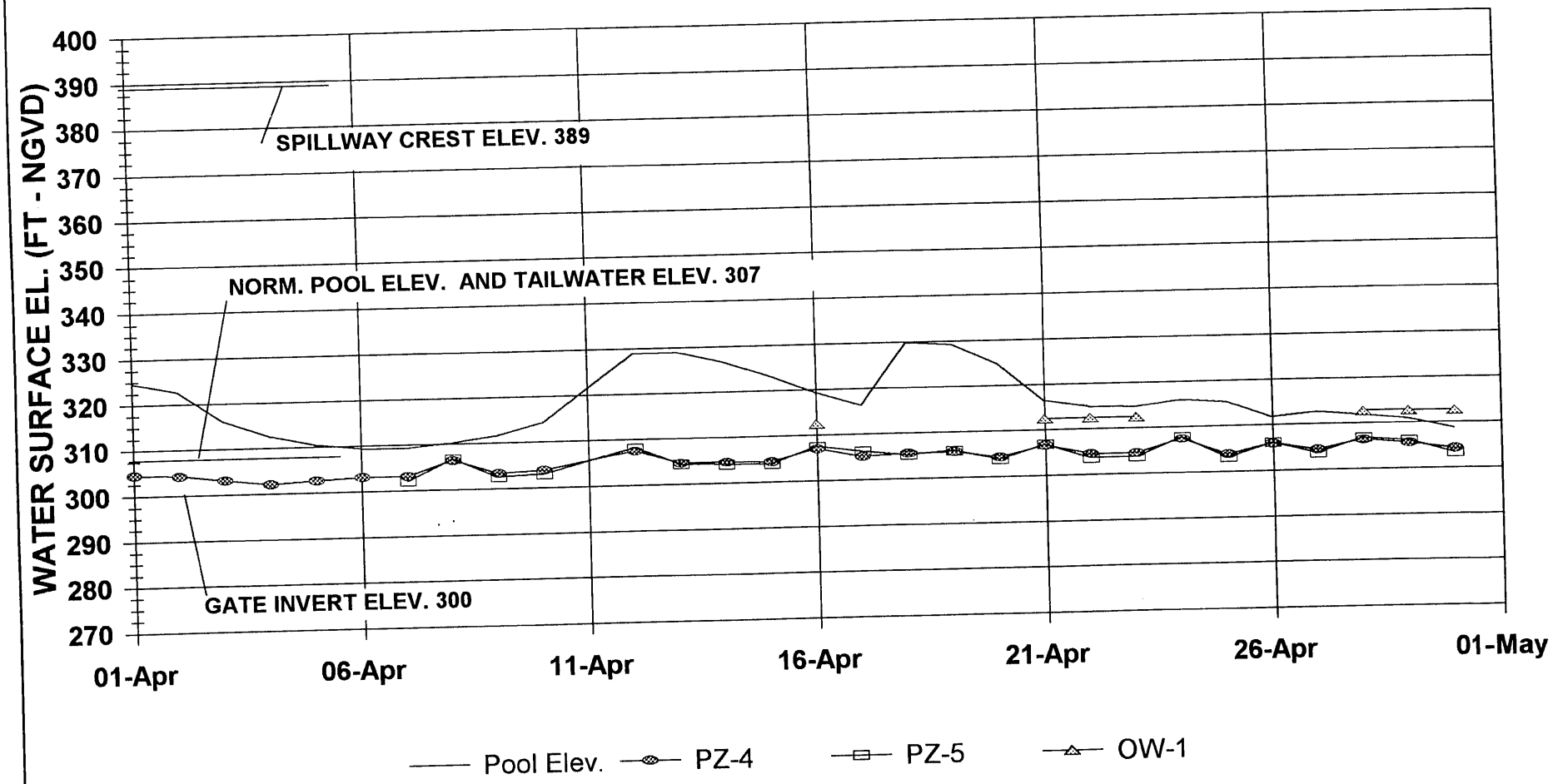
APRIL 1993 EVENT
DOWNSTREAM TOE OF DAM

SCALE: AS SHOWN

JANUARY 1995

FIGURE 24

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

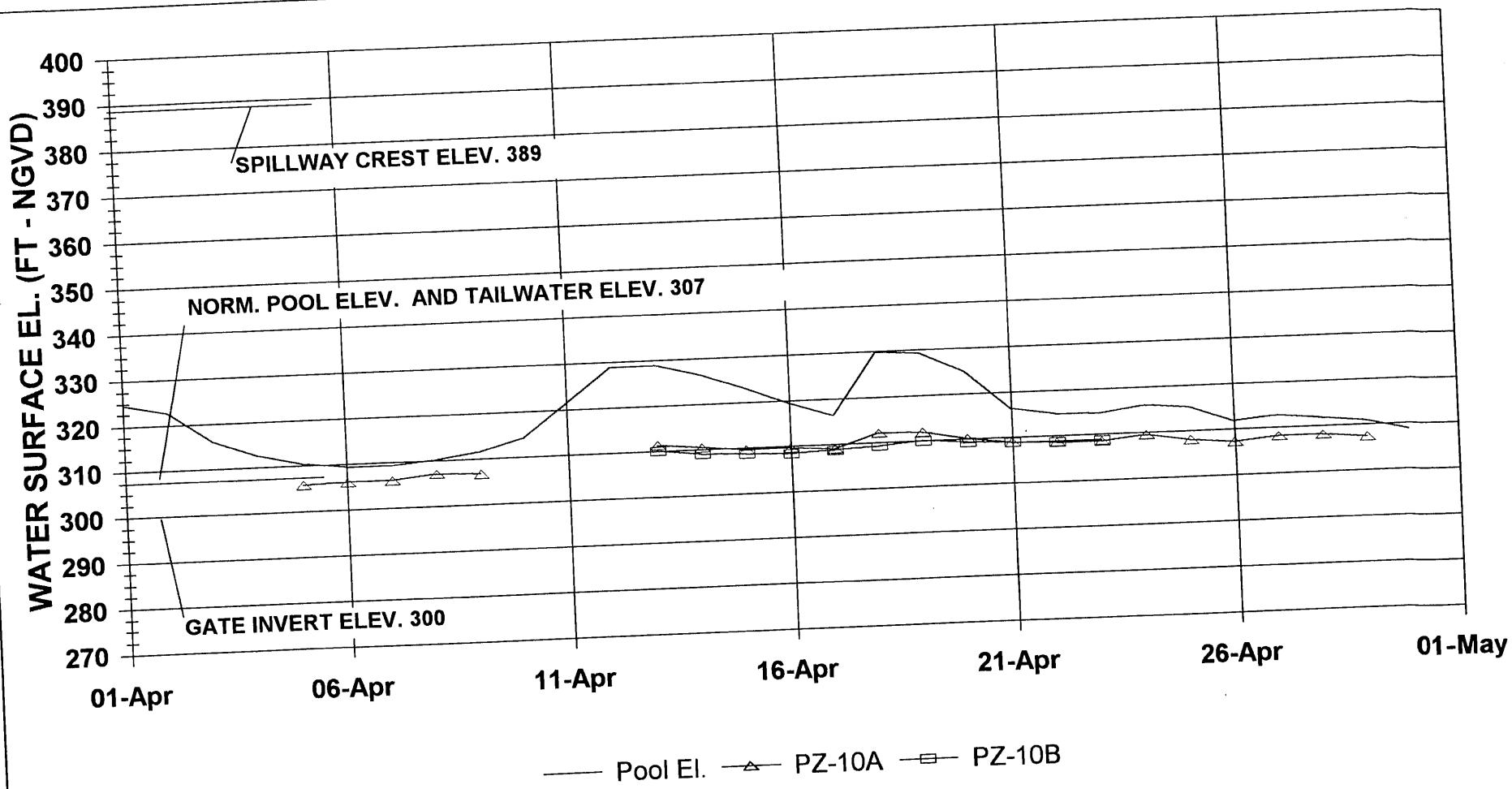
APRIL 1993 EVENT
DOWNSTREAM TOE OF DAM

SCALE: AS SHOWN

JANUARY 1995

FIGURE 2

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

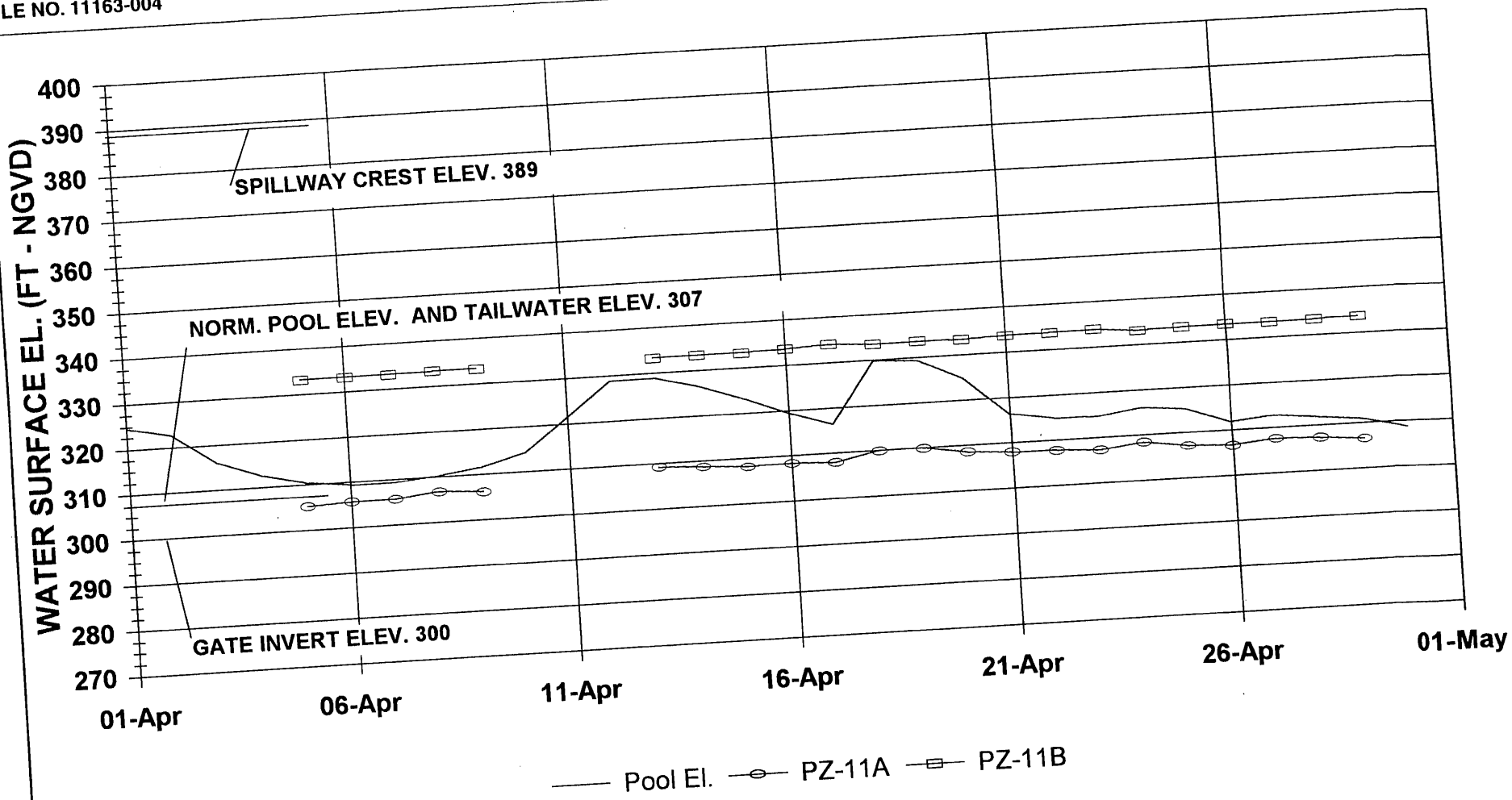
APRIL 1993 EVENT
STATION 22+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 26

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

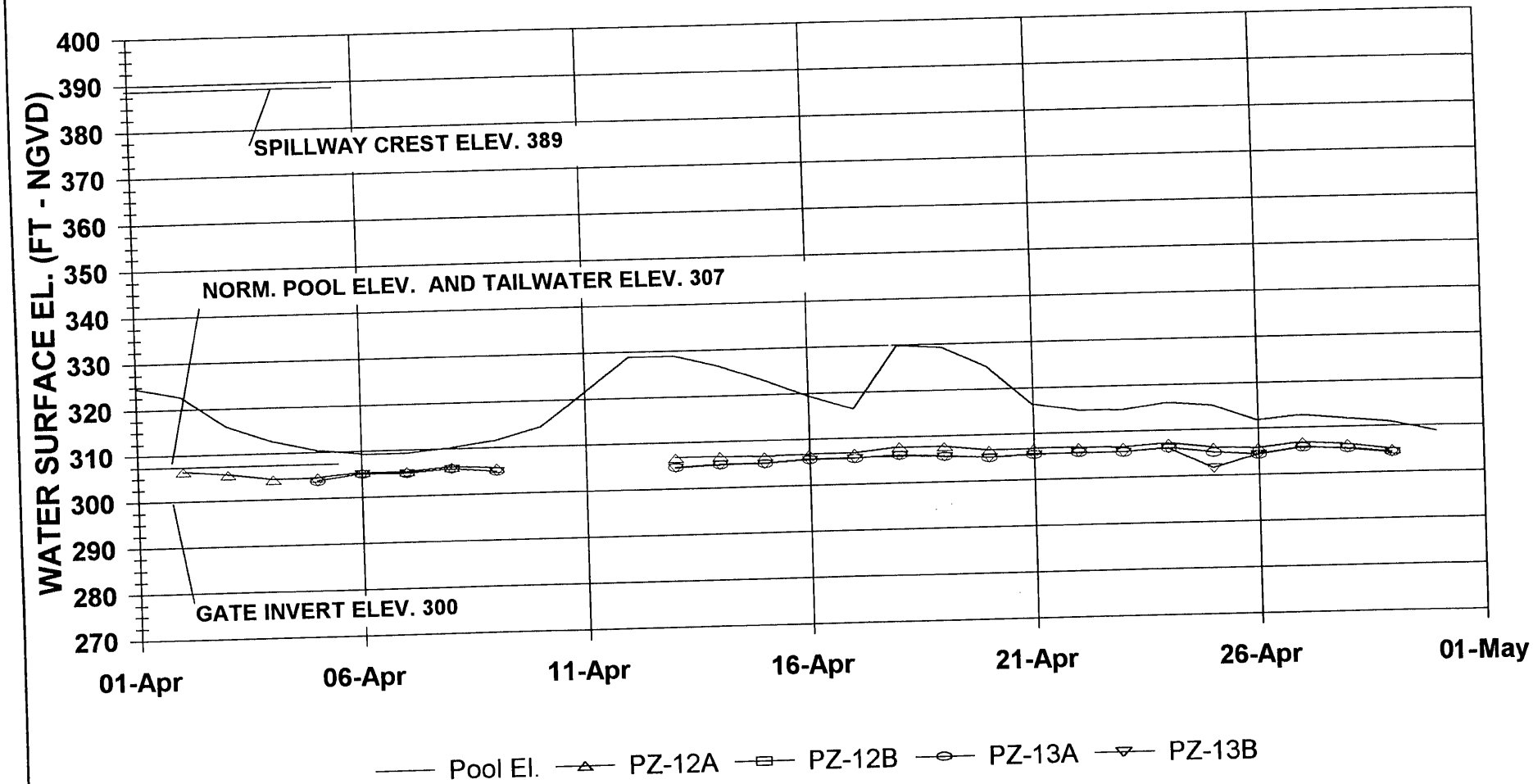
APRIL 1993 EVENT
STATION 22+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE

FILE NO. 11163-004



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FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

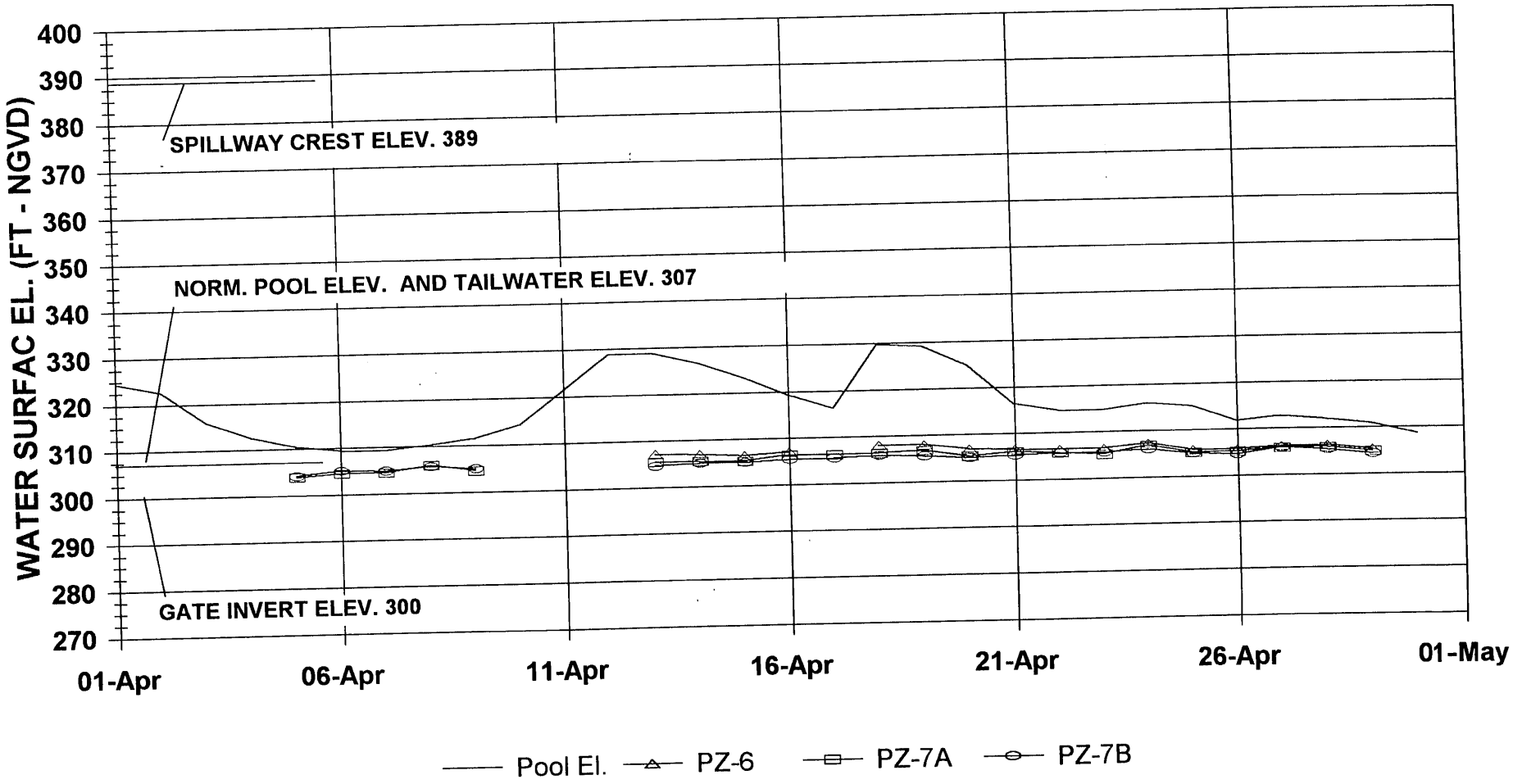
APRIL 1993 EVENT
STATION 22+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 28

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

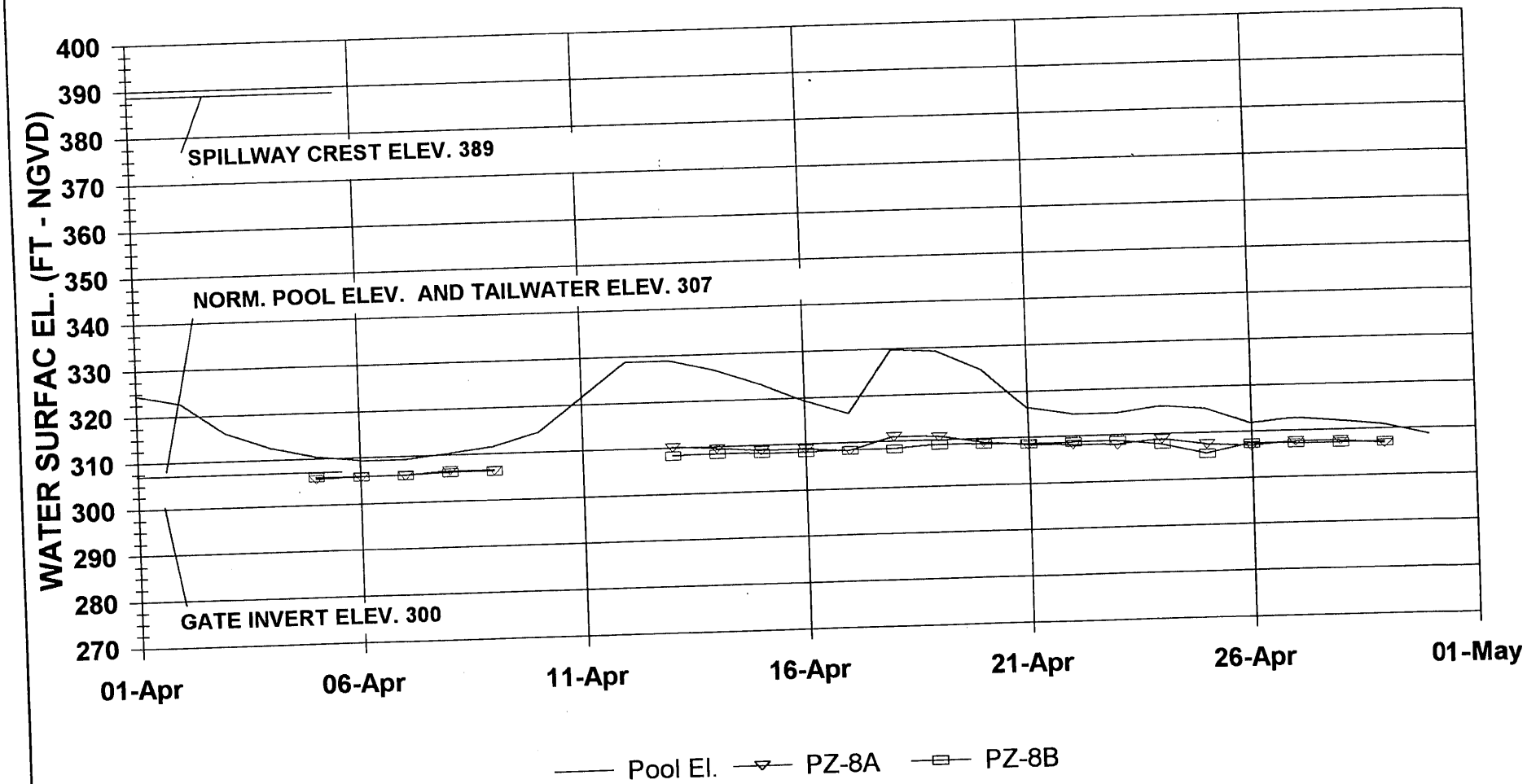
APRIL 1993 EVENT
STATION 18+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 29

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

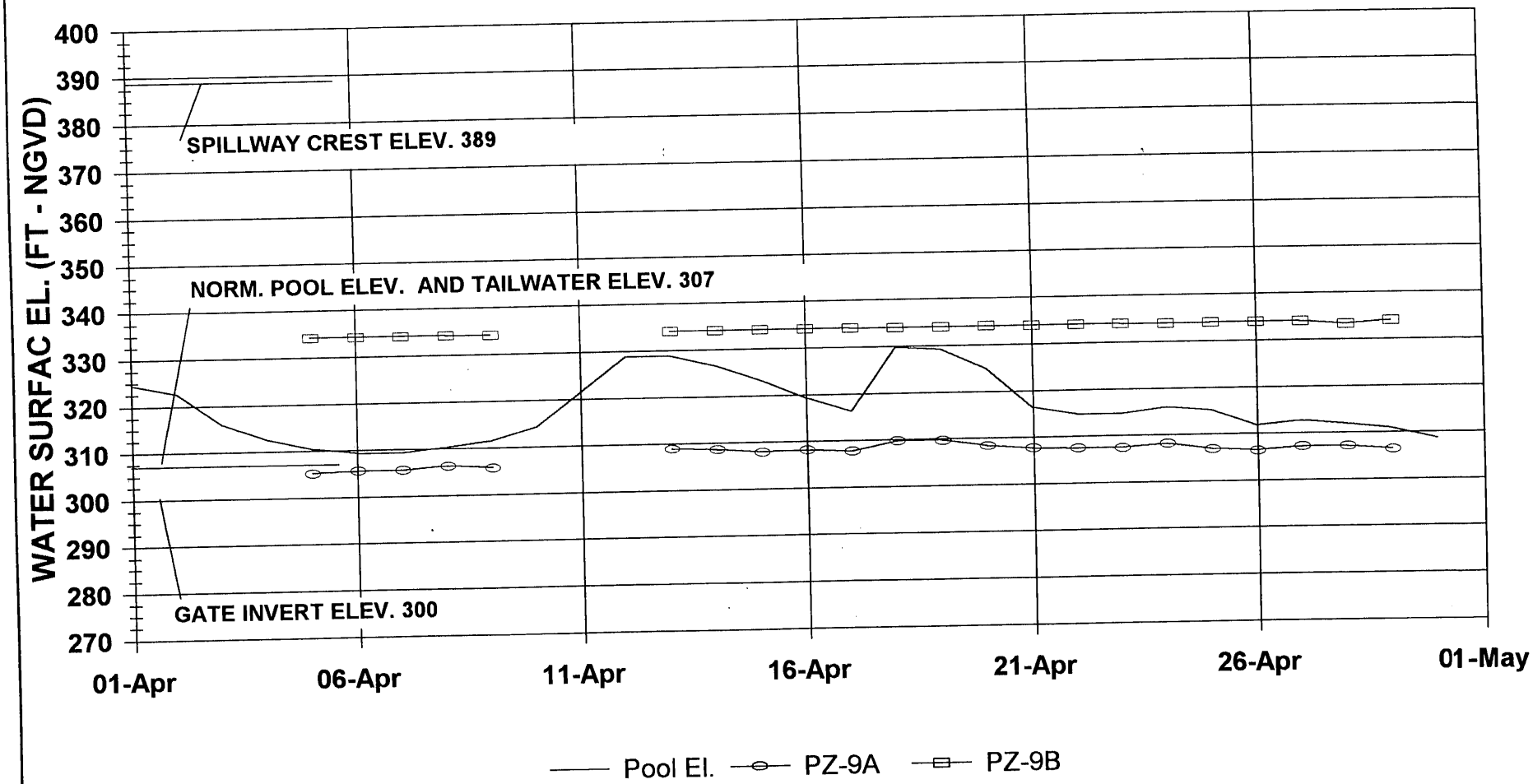
APRIL 1993 EVENT
STATION 18+00

SCALE: AS SHOWN

JANUARY 1995

FIGURE 3

FILE NO. 11163-004



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

APRIL 1993 EVENT
STATION 18+00

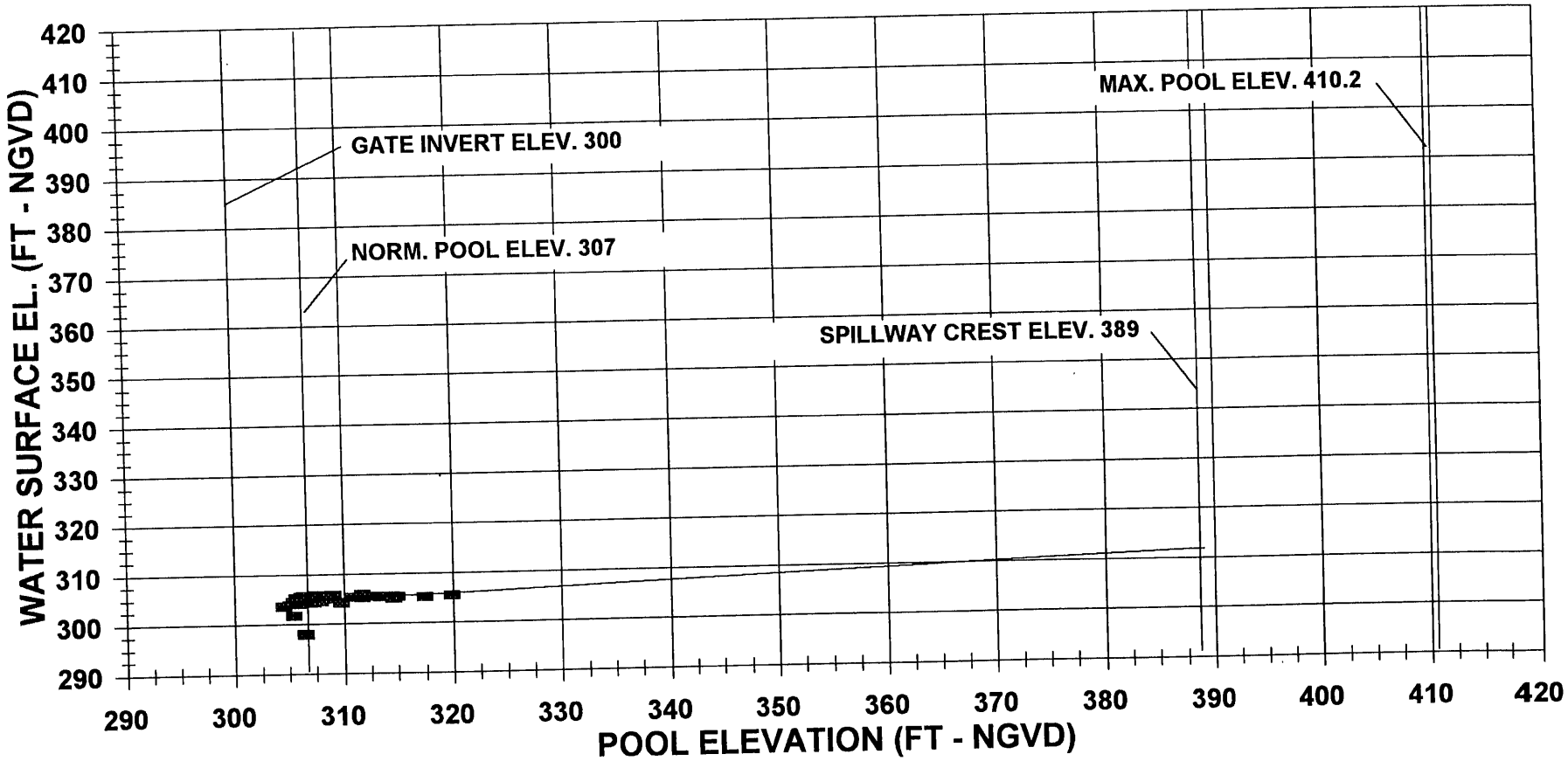
SCALE: AS SHOWN

JANUARY 1995

FIGURE 31

FILE NO. 11163-004

PZ - 1



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-1

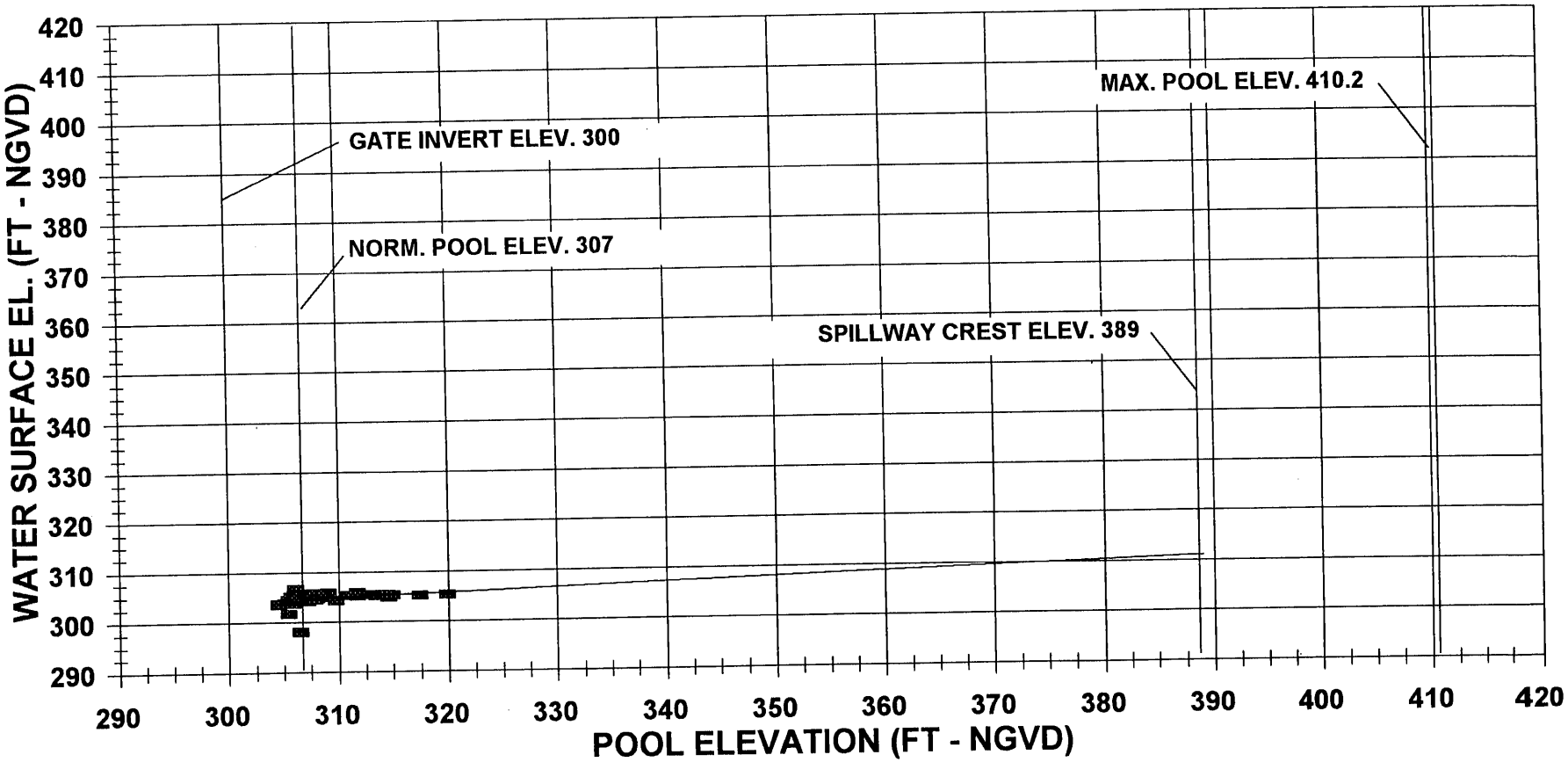
SCALE: AS SHOWN

JANUARY 1995

FIGURE 32

FILE NO. 11163-004

PZ - 2



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FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-2

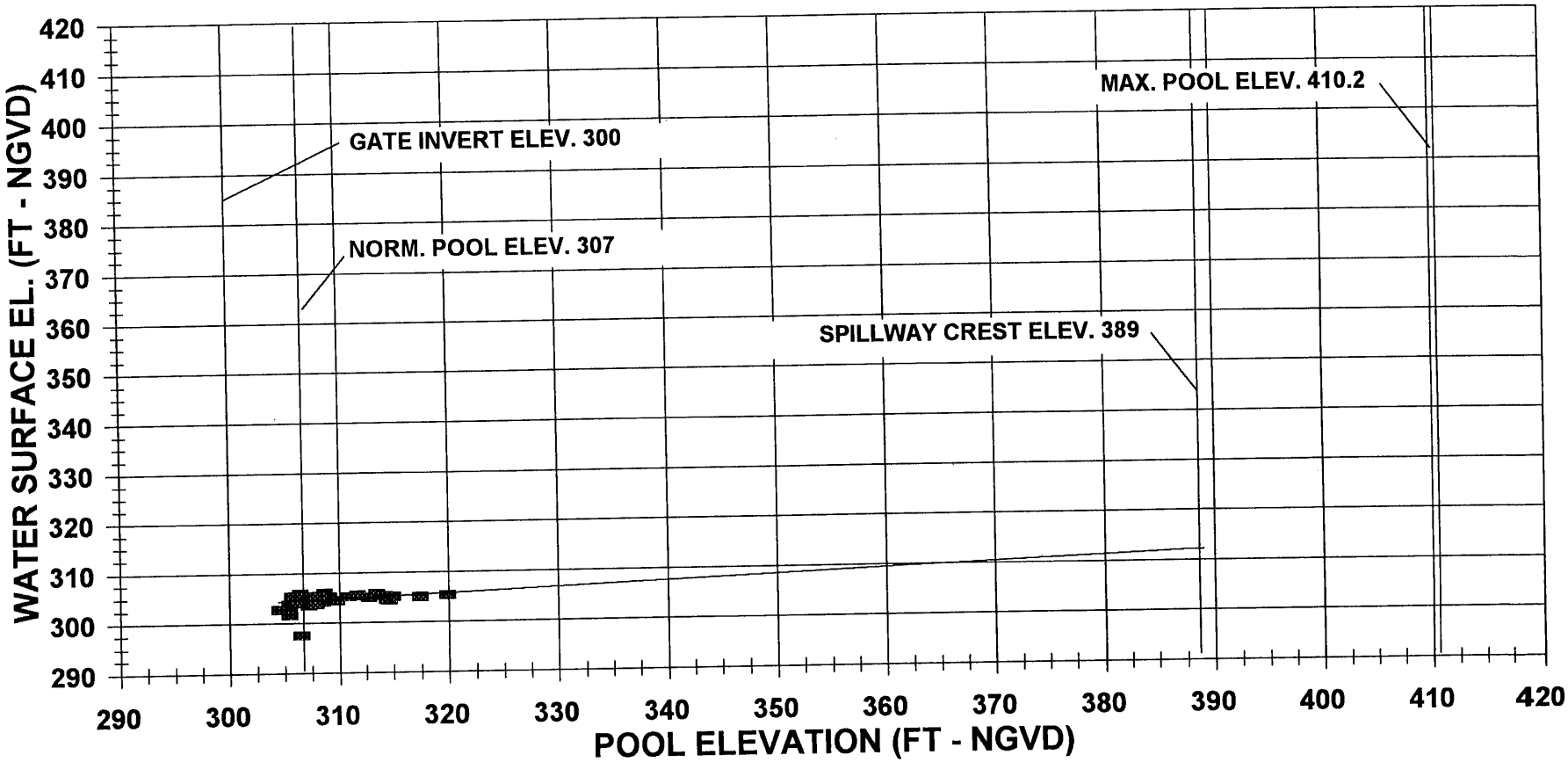
SCALE: AS SHOWN

JANUARY 1995

FIGURE 33

FILE NO. 11163-004

PZ - 3



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-3

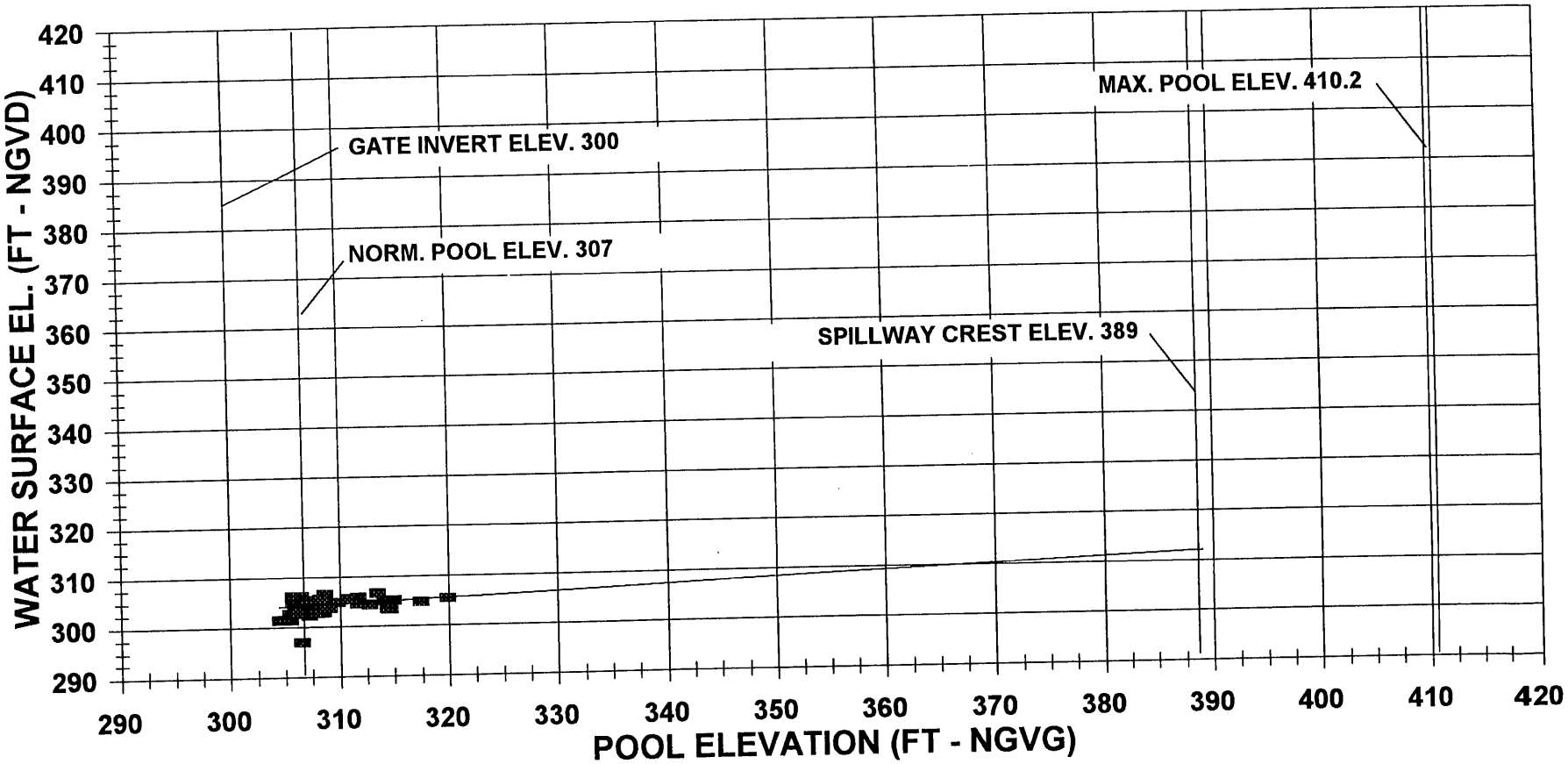
SCALE: AS SHOWN

JANUARY 1995

FIGURE 34

FILE NO. 11163-004

PZ - 4



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

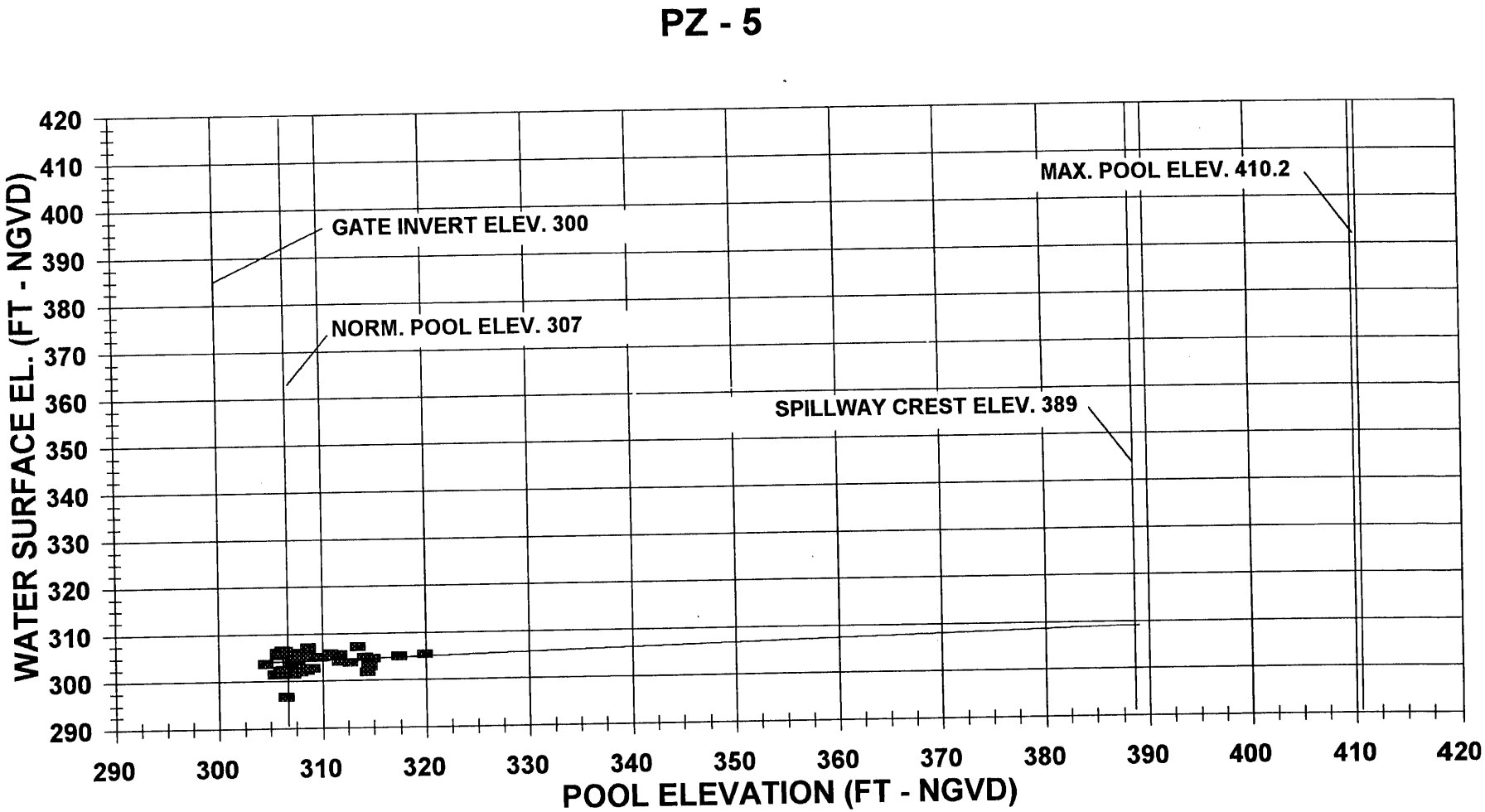
PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-4

SCALE: AS SHOWN

JANUARY 1995

FIGURE 35

FILE NO. 11163-004



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FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-5

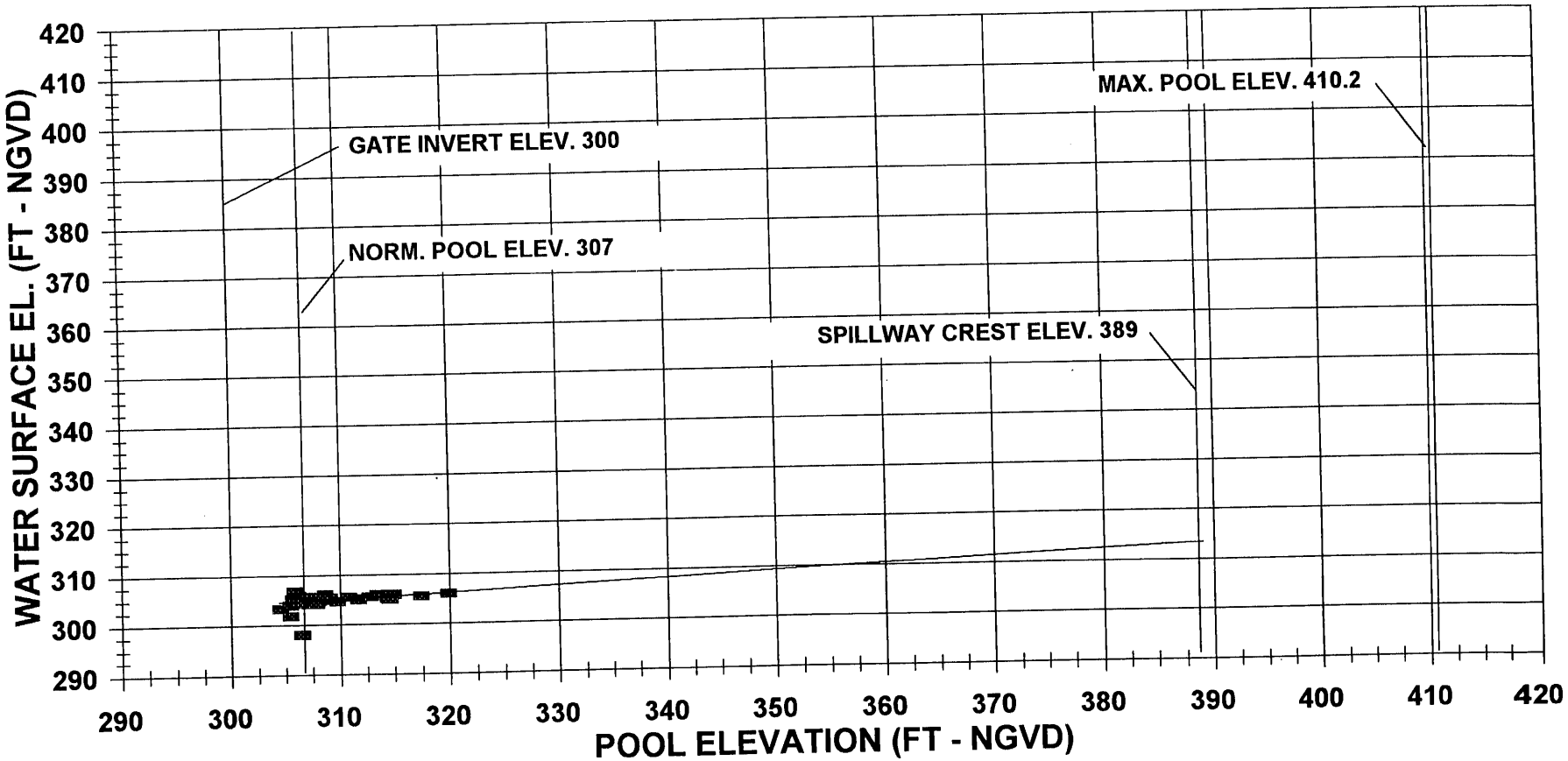
SCALE: AS SHOWN

JANUARY 1995

FIGURE 36

FILE NO. 11163-004

PZ - 7A



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-7A

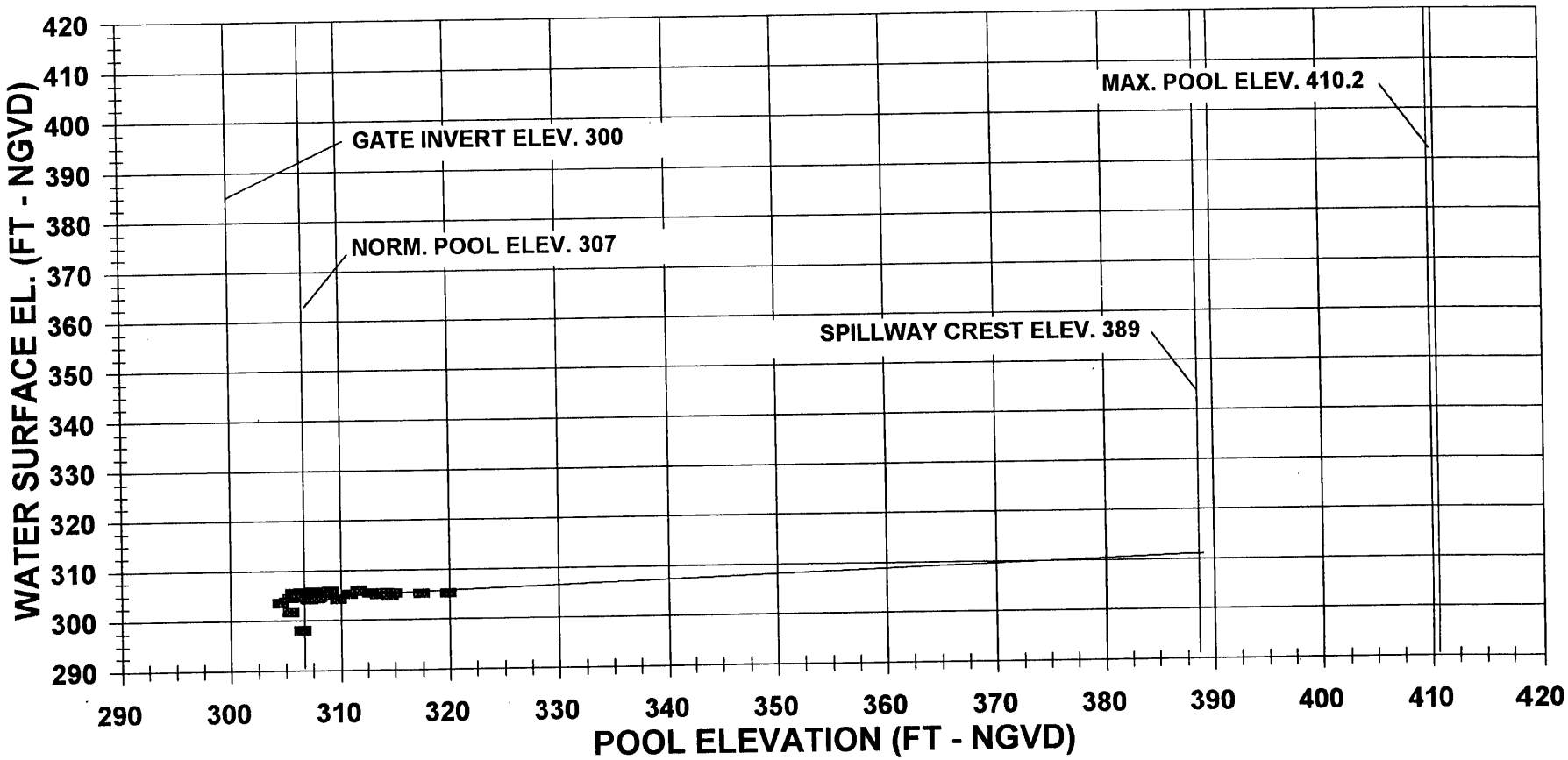
SCALE: AS SHOWN

JANUARY 1995

FIGURE 38

FILE NO. 11163-004

PZ - 7B



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-7B

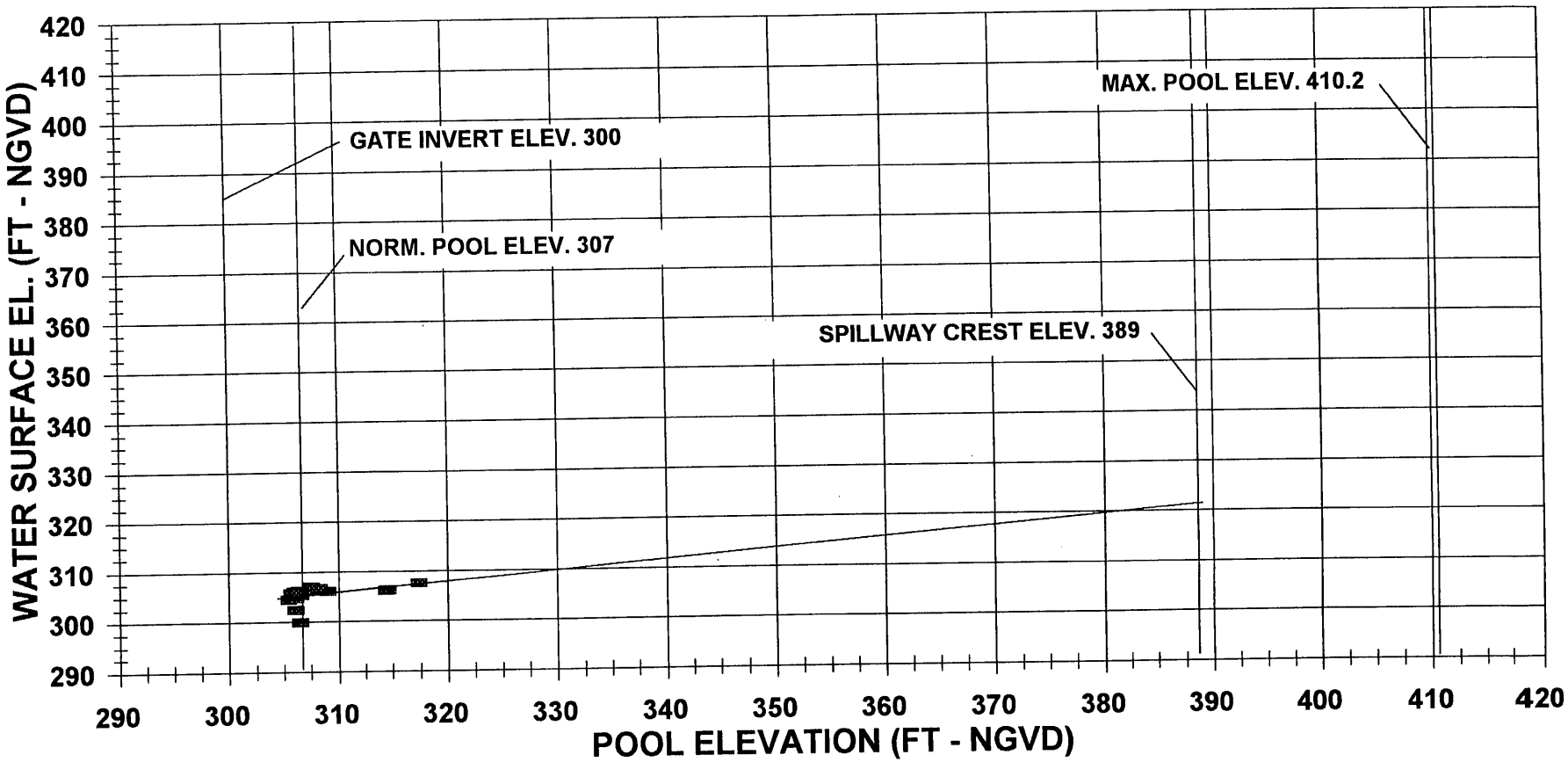
SCALE: AS SHOWN

JANUARY 1995

FIGURE 39

FILE NO. 11163-004

PZ - 8B



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-8B

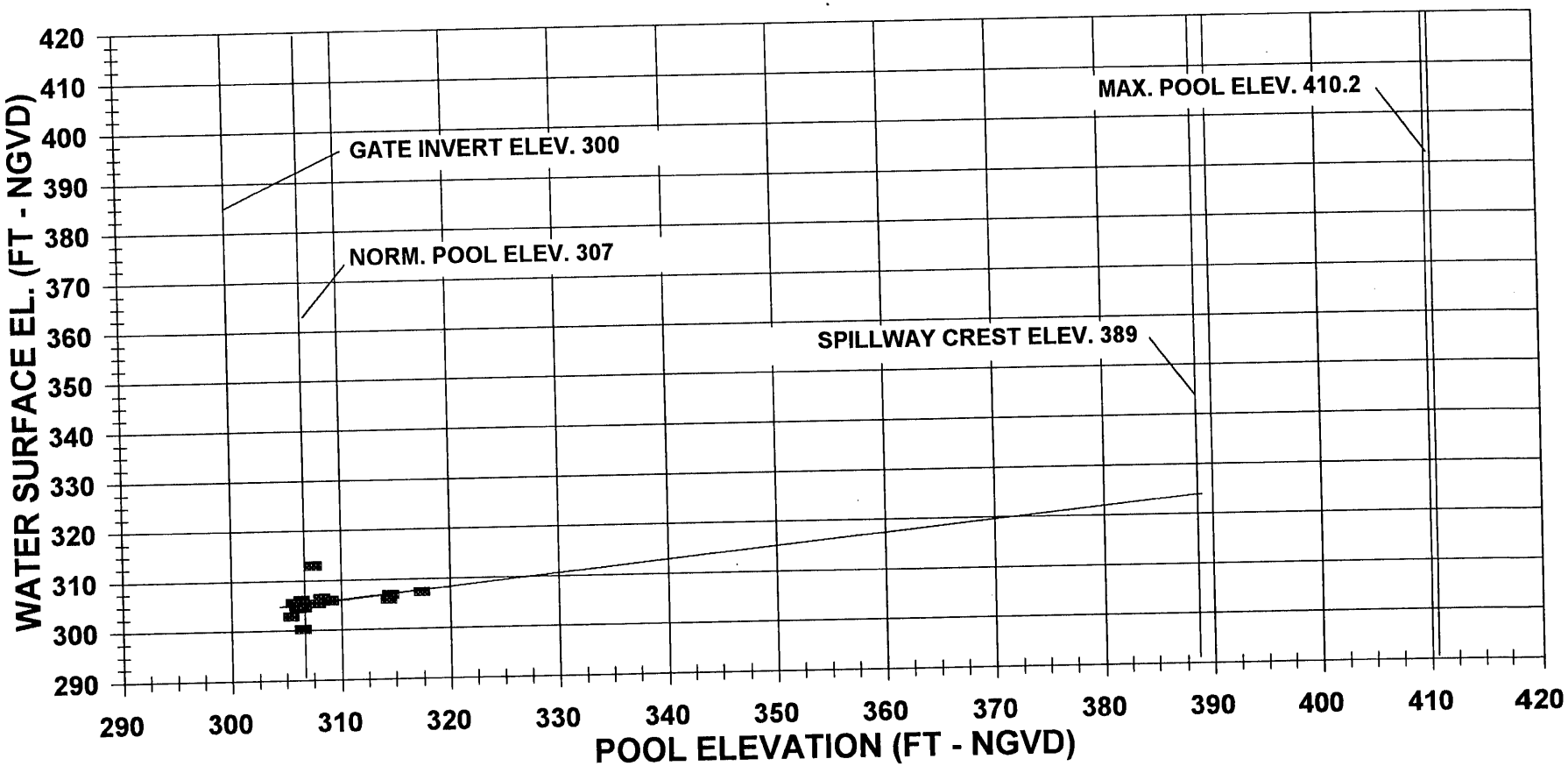
SCALE: AS SHOWN

JANUARY 1995

FIGURE 41

FILE NO. 11163-004

PZ - 9A



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FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-9A

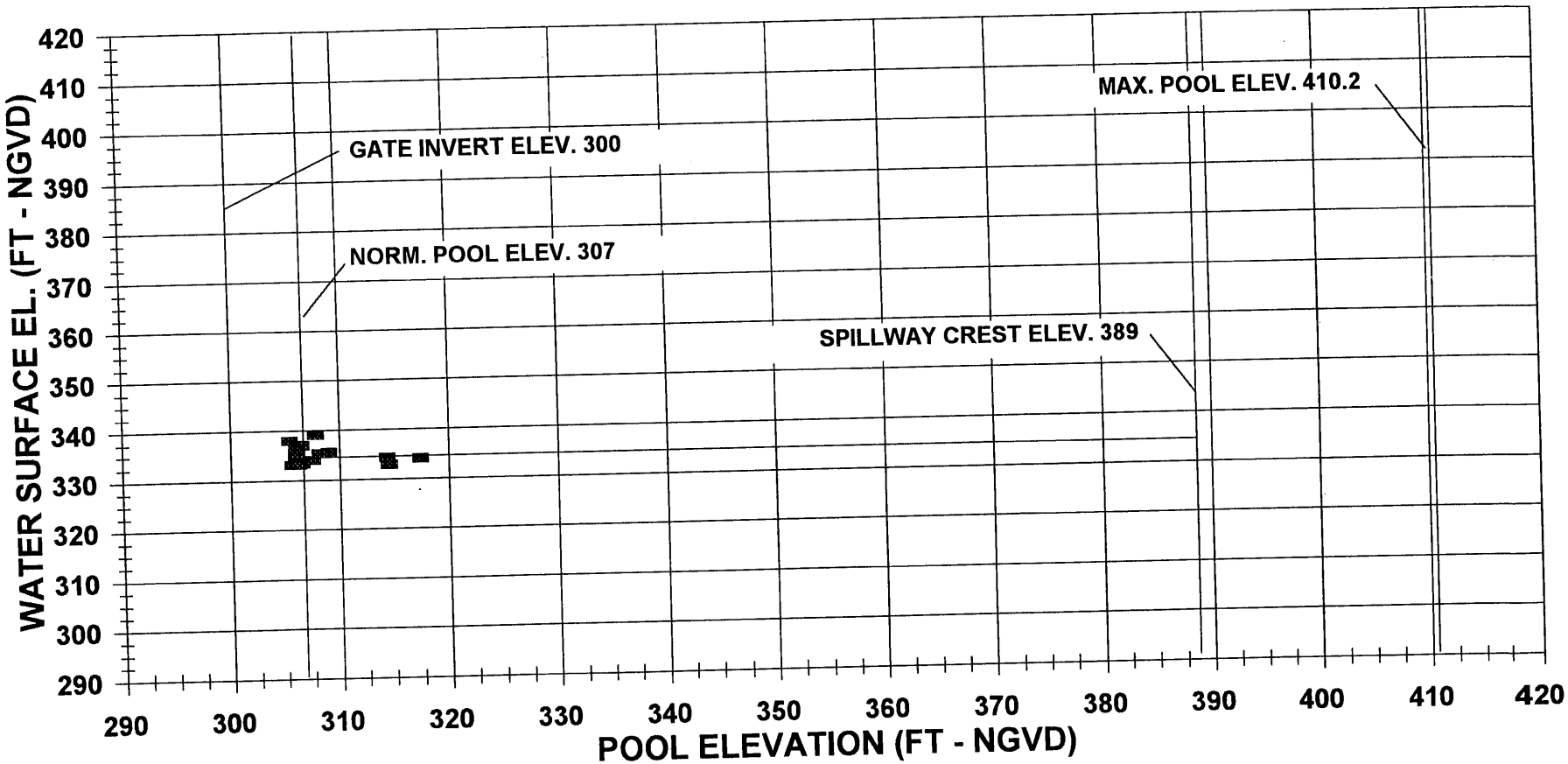
SCALE: AS SHOWN

JANUARY 1995

FIGURE 42

FILE NO. 11163-004

PZ - 9B



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FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-9B

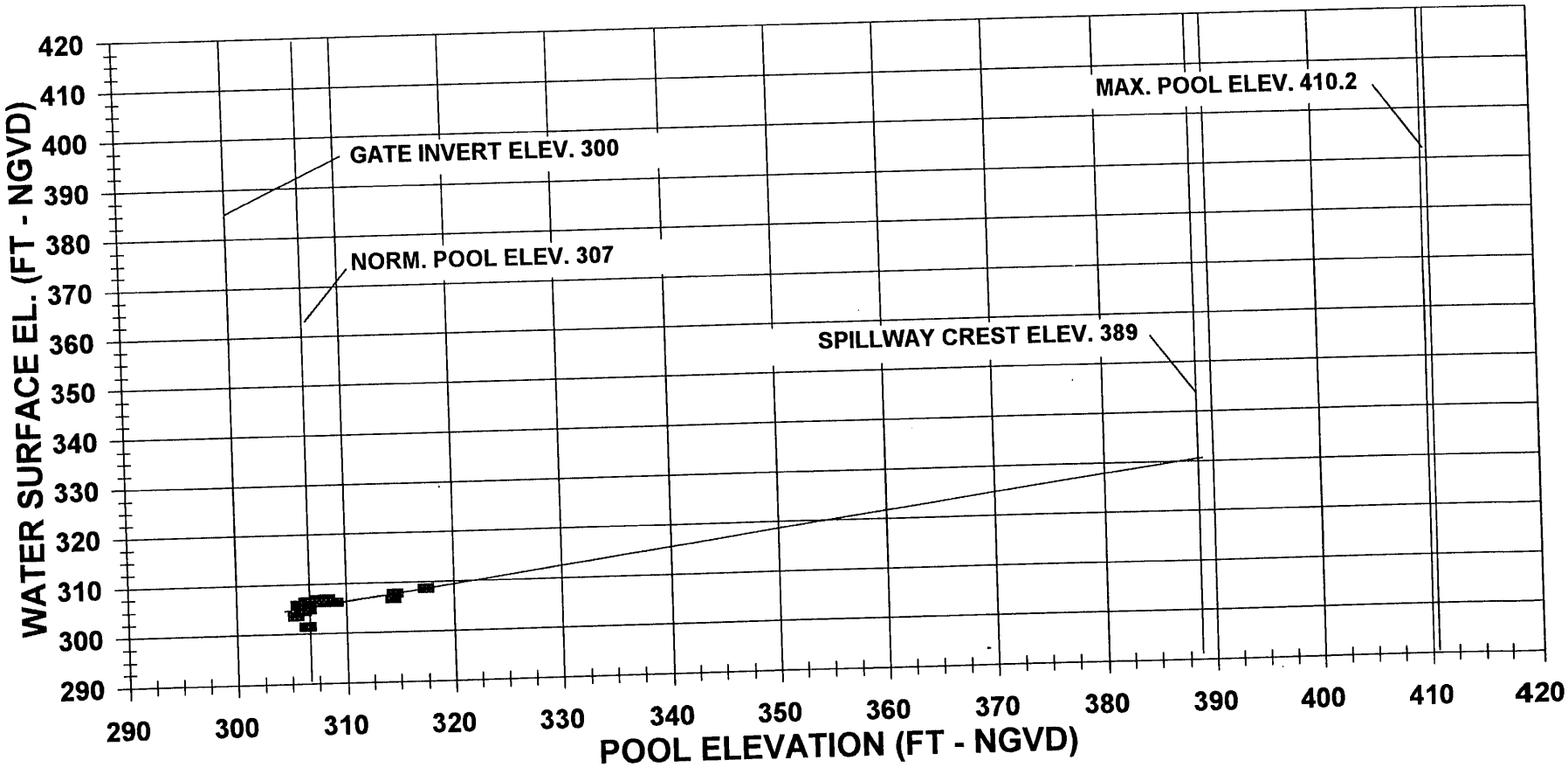
SCALE: AS SHOWN

JANUARY 1995

FIGURE 43

FILE NO. 11163-004

PZ - 10A



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FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-10A

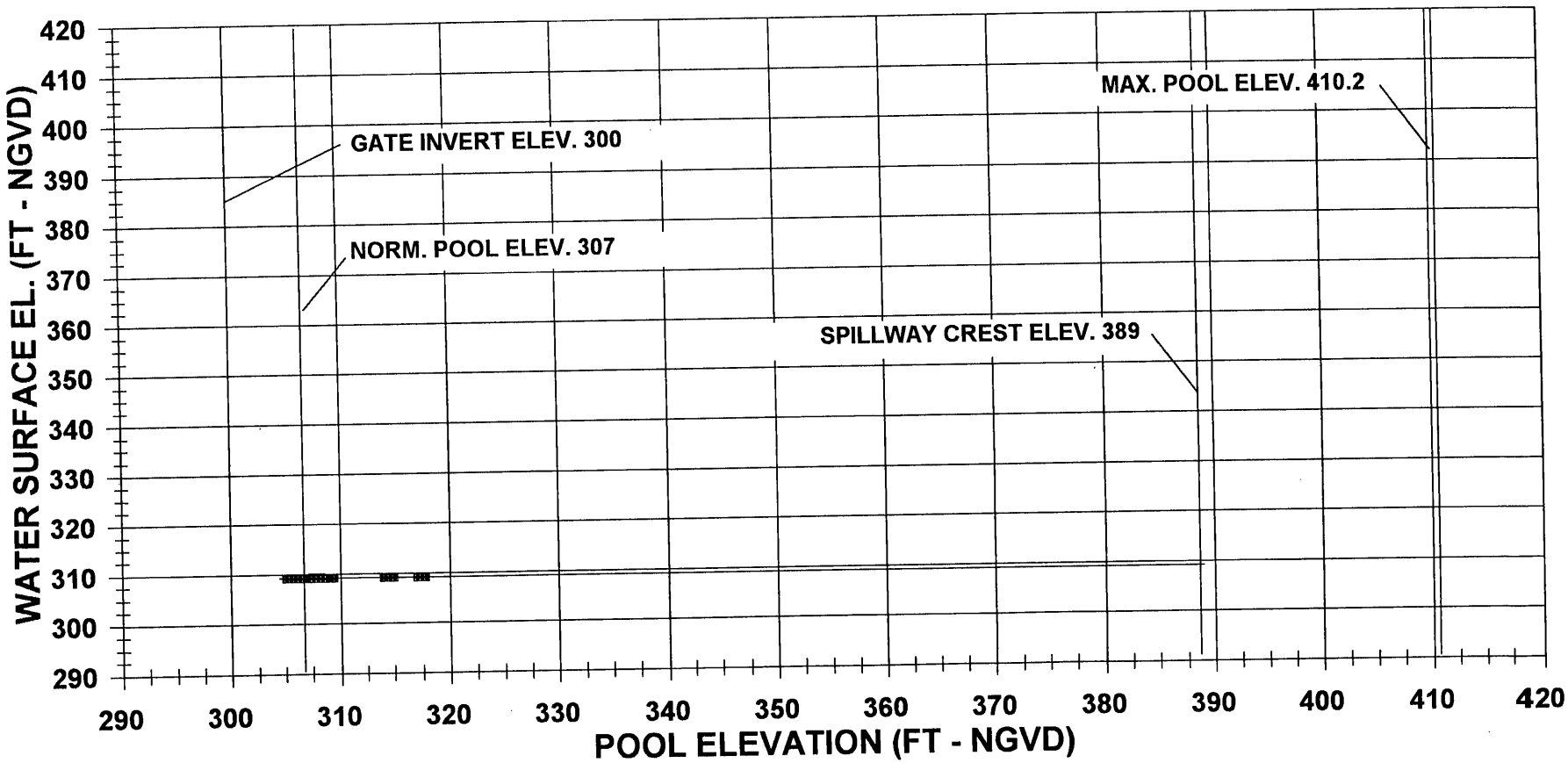
SCALE: AS SHOWN

JANUARY 1995

FIGURE 44

FILE NO. 11163-004

PZ - 10B



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-10B

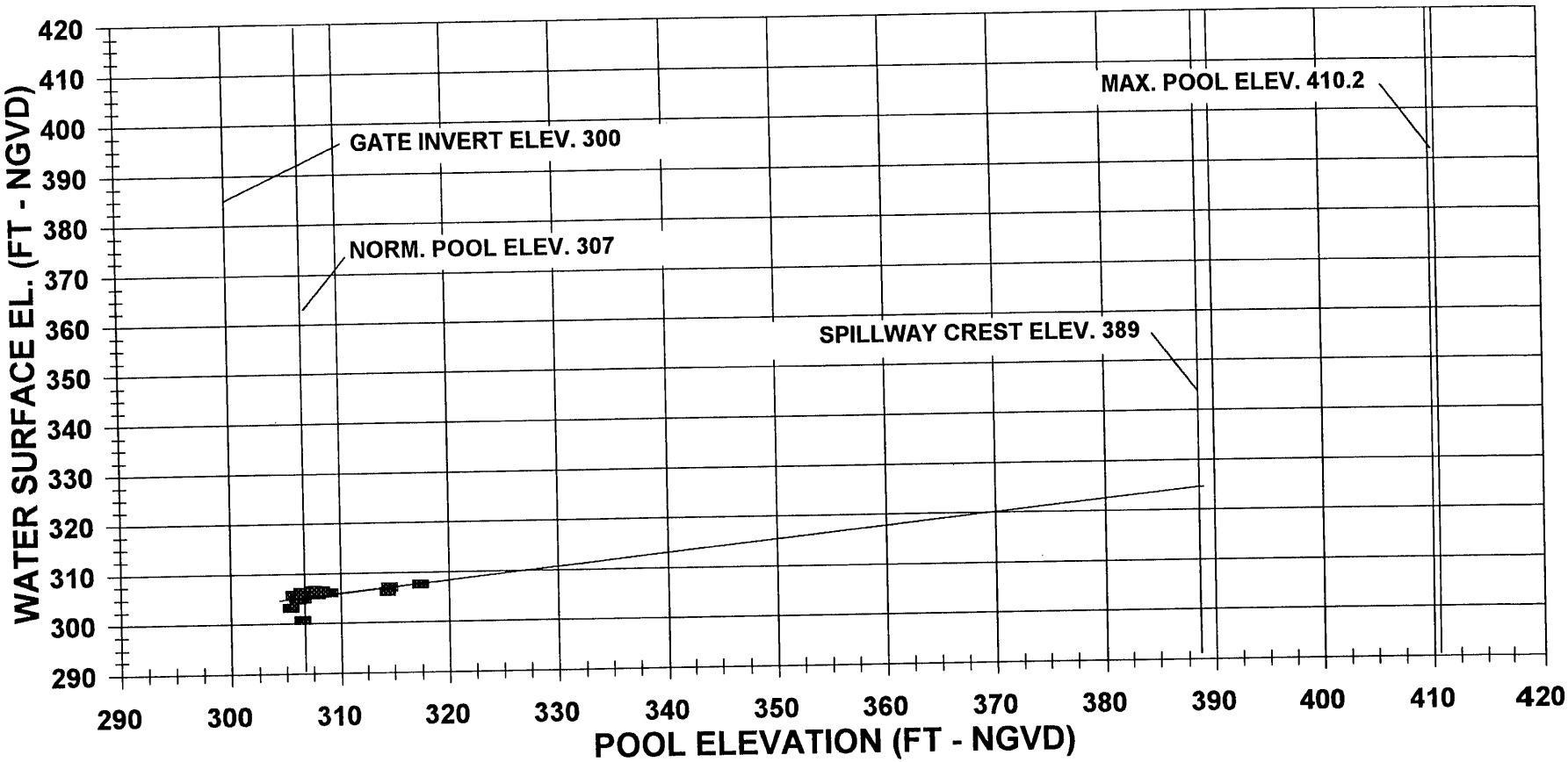
SCALE: AS SHOWN

JANUARY 1995

FIGURE 45

FILE NO. 11163-004

PZ - 11A



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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-11A

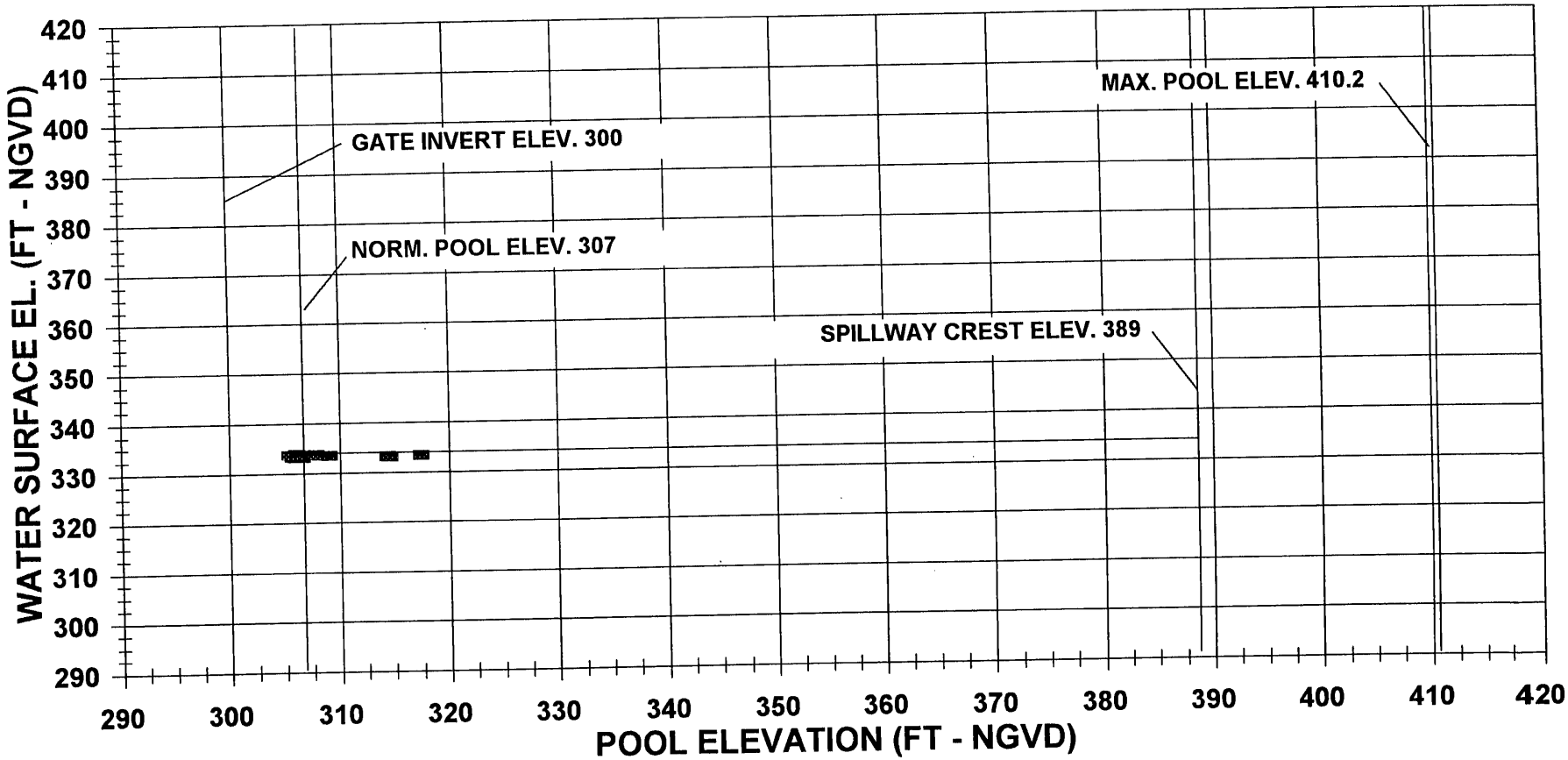
SCALE: AS SHOWN

JANUARY 1995

FIGURE 46

FILE NO. 11163-004

PZ - 11B



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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-11B

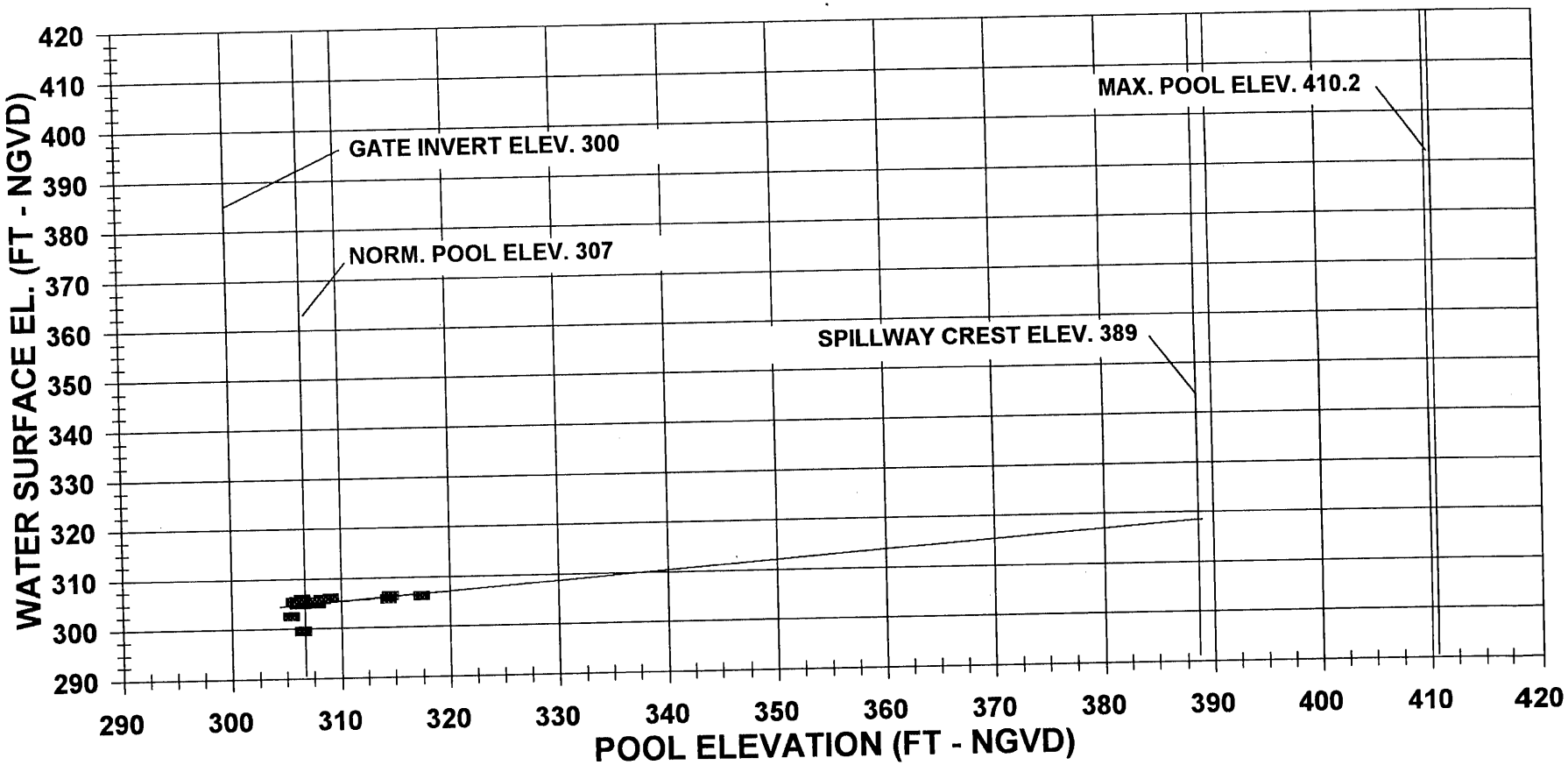
SCALE: AS SHOWN

JANUARY 1995

FIGURE 47

FILE NO. 11163-004

PZ - 12A



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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-12A

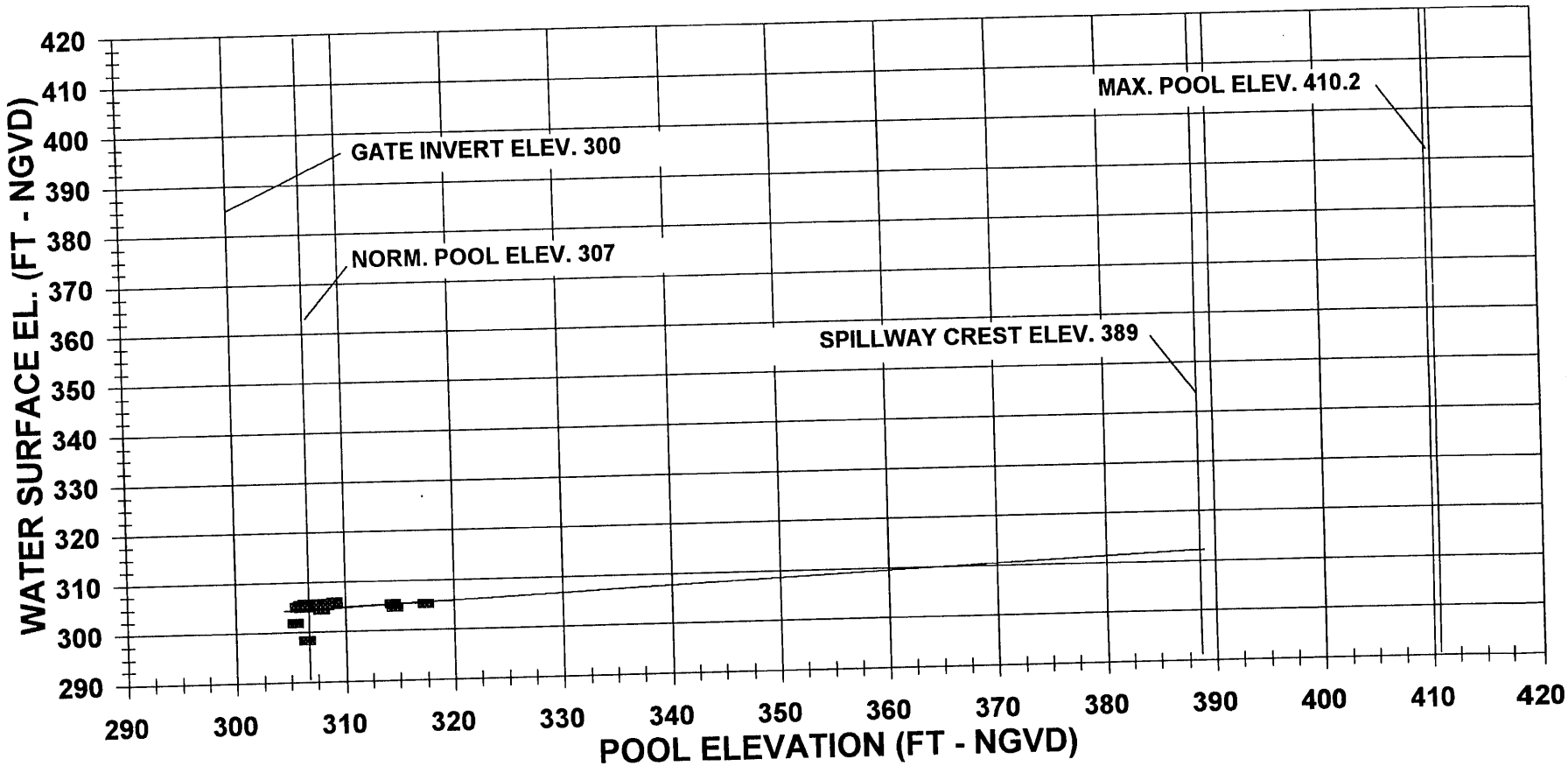
SCALE: AS SHOWN

JANUARY 1995

FIGURE 48

FILE NO. 11163-004

PZ - 13A



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-13A

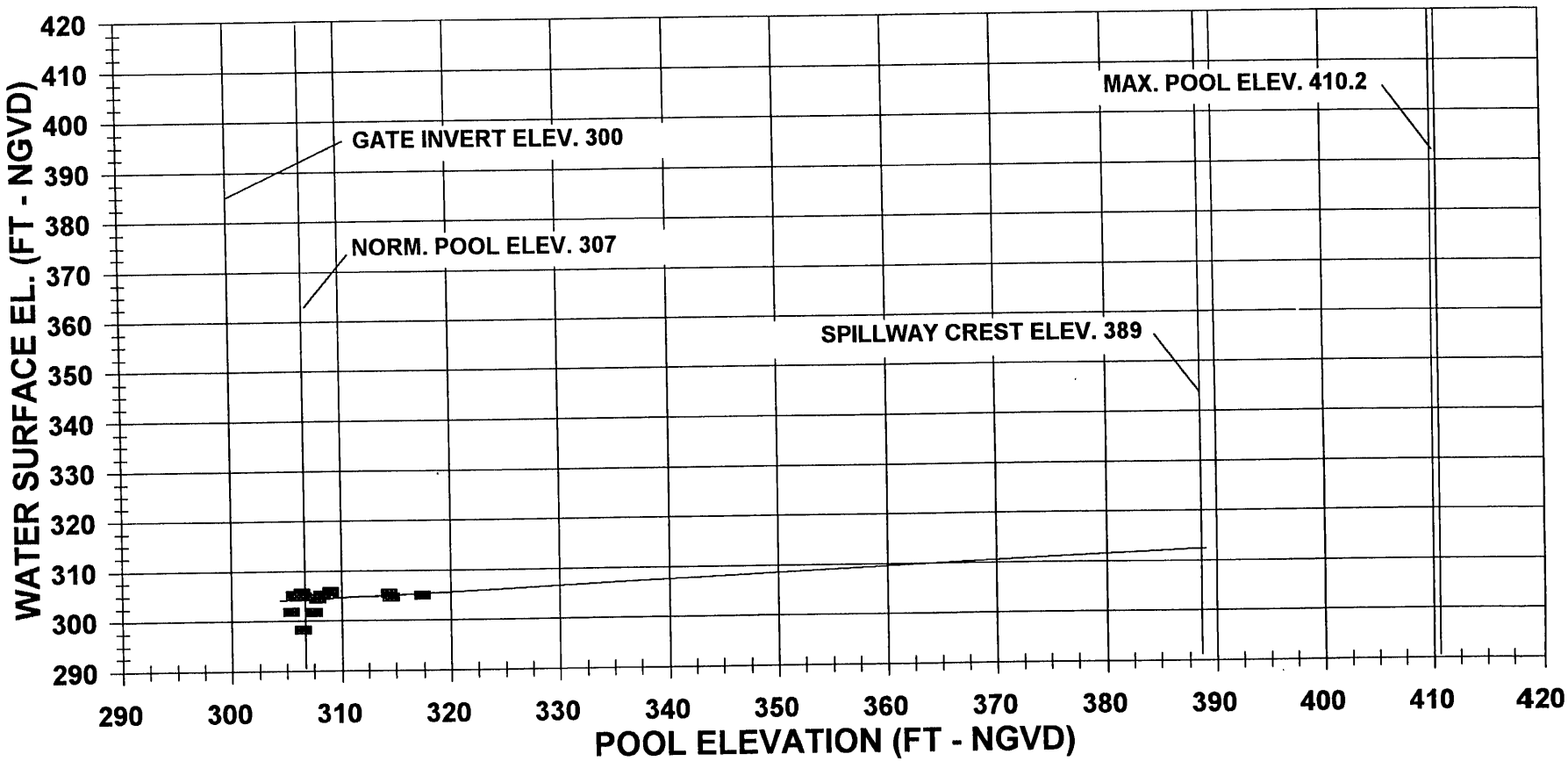
SCALE: AS SHOWN

JANUARY 1995

FIGURE 49

FILE NO. 11163-004

PZ - 13B



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PEMIGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION PZ-13B

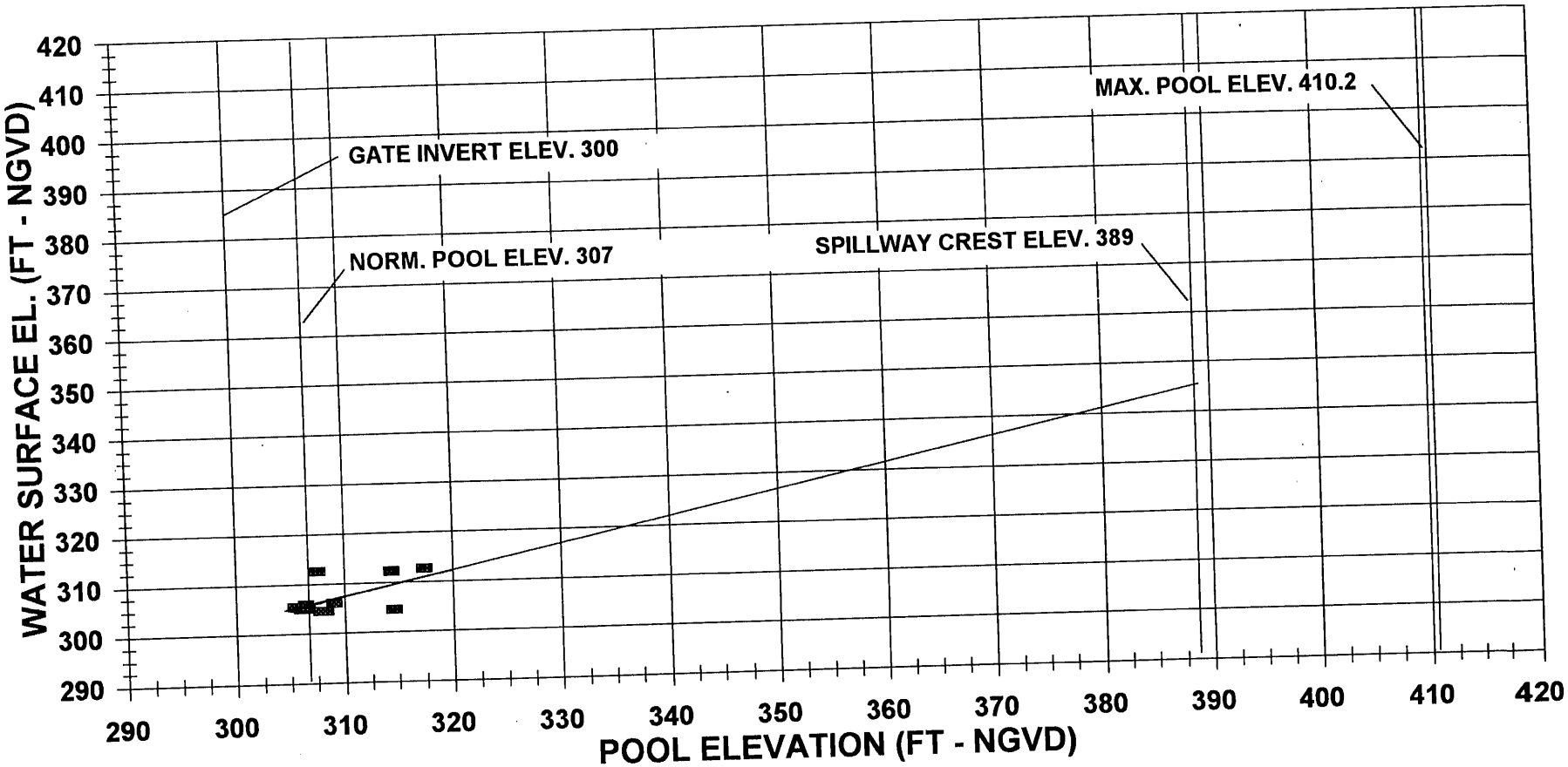
SCALE: AS SHOWN

JANUARY 1995

FIGURE 50

FILE NO. 11163-004

OW-1



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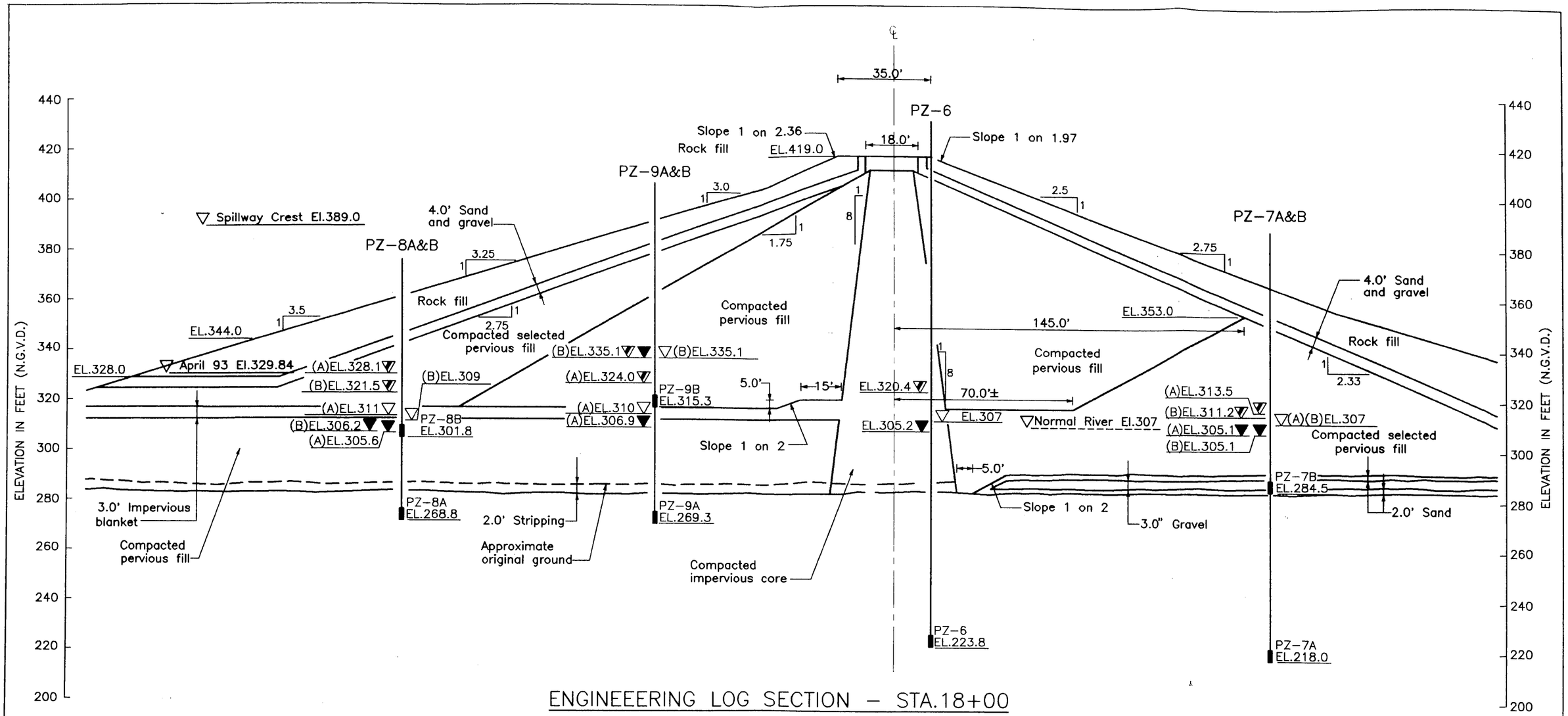
PEMGEWASSET RIVER
FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER ELEVATION vs. POOL ELEVATION OW-1

SCALE: AS SHOWN

JANUARY 1995

FIGURE 51



ENGINEEERING LOG SECTION – STA.18+00

LEGEND:

- ▼ PIEZOMETER LEVEL AT NORMAL RIVER LEVEL
- ▽ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1993

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.

0 40 80
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

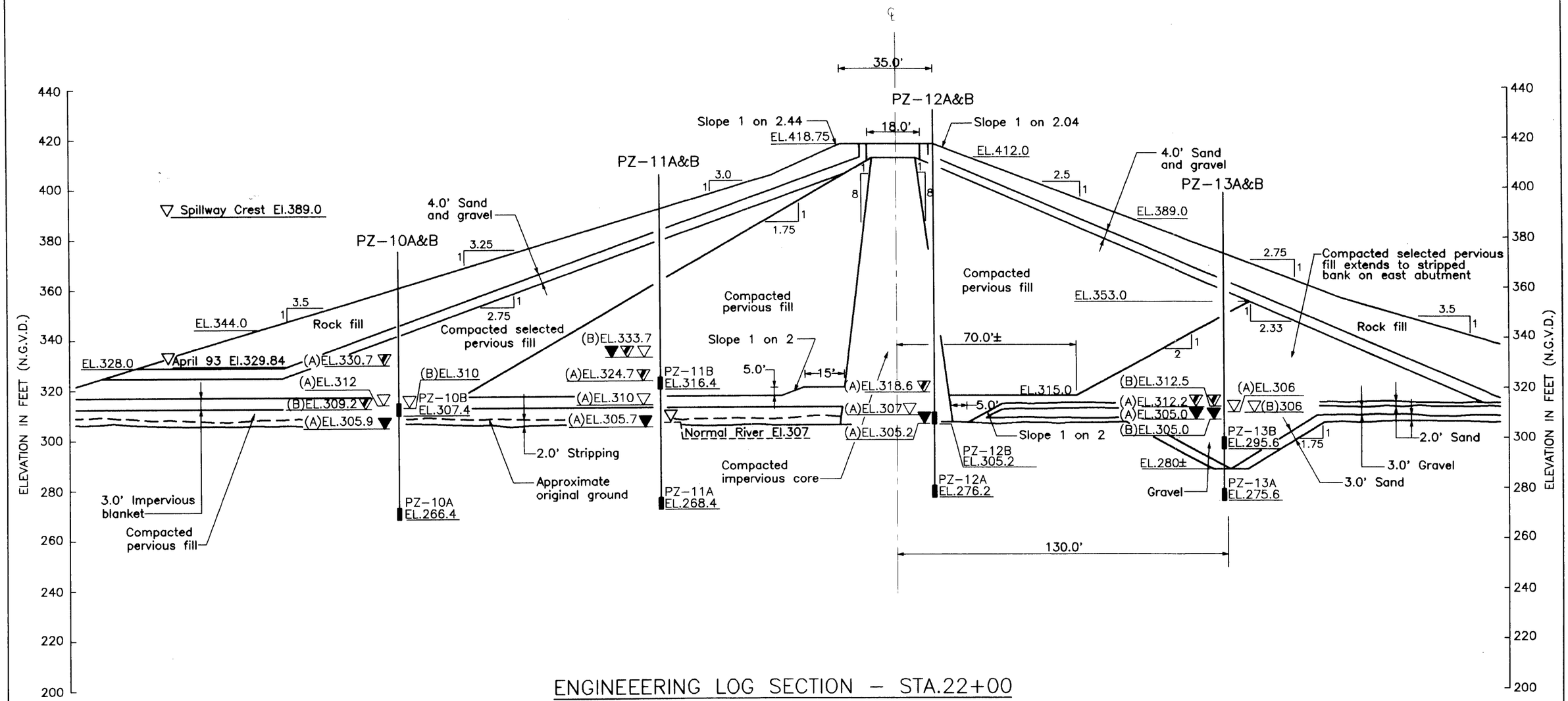
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER LEVEL, NORMAL POOL AND PROJECTED TO SPILLWAY FOR STA.18+00

SCALE: 1"=40' JANUARY 1995

11163-004 B13

FIGURE 52



ENGINEEERING LOG SECTION – STA.22+00

LEGEND:

- ▼ PIEZOMETER LEVEL AT NORMAL RIVER LEVEL
- ▼ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1993

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.
4. PZ-10B AND PZ-12B ARE DRY AT NORMAL POOL ELEVATION.

0 40 80
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

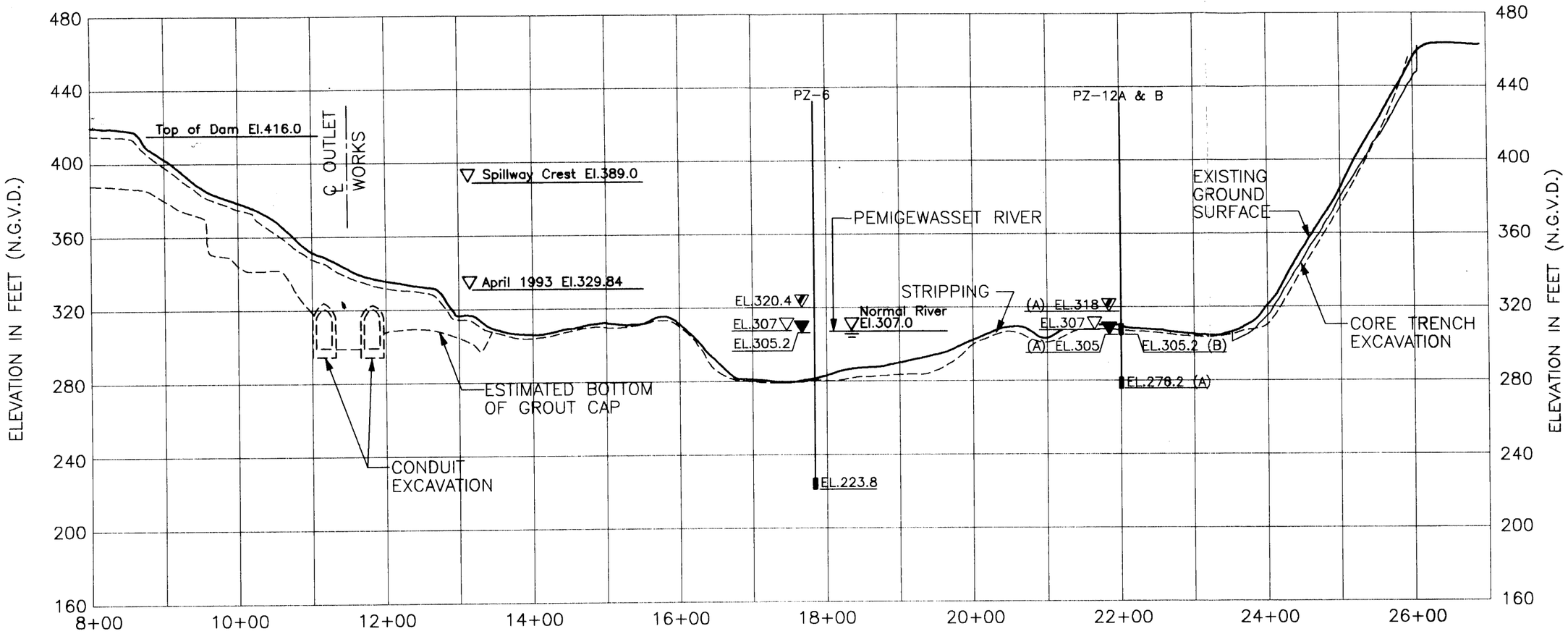
MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PIEZOMETER LEVEL, NORMAL POOL AND PROJECTED TO SPILLWAY FOR STA.22+00

SCALE: 1"=40' JANUARY 1995

11163-004 B14

FIGURE 53



CENTERLINE OF DAM (LOOKING UPSTREAM)

HORIZ. 0 80 160
VERT. 0 60 120
SCALE IN FEET

LEGEND:

- ▼ PIEZOMETER LEVEL AT NORMAL RIVER LEVEL
- ▽ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1993

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.

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MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

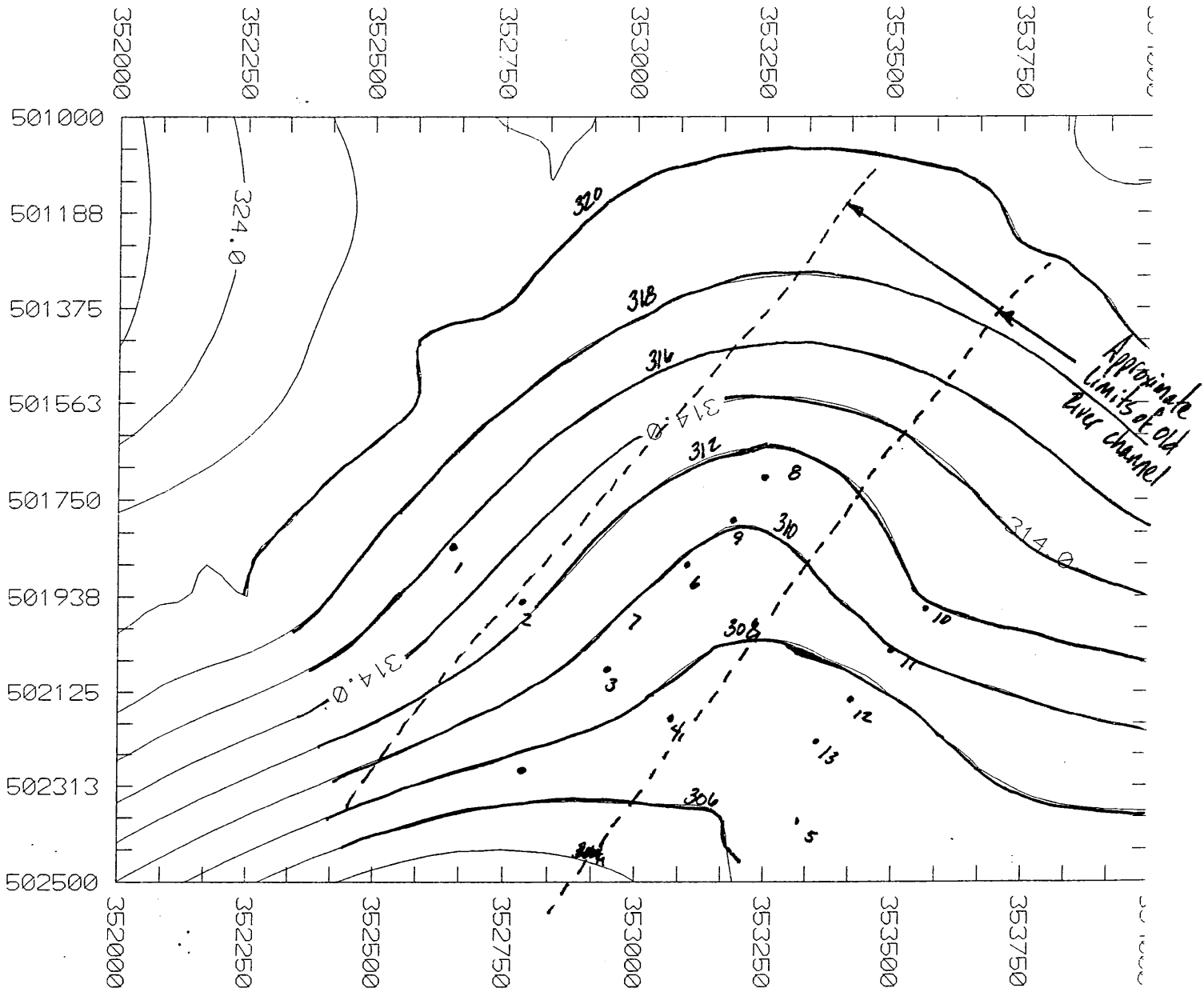
PIEZOMETER LEVELS, NORMAL POOL AND PROJECTED TO SPILLWAY CREST FOR CENTERLINE OF DAM

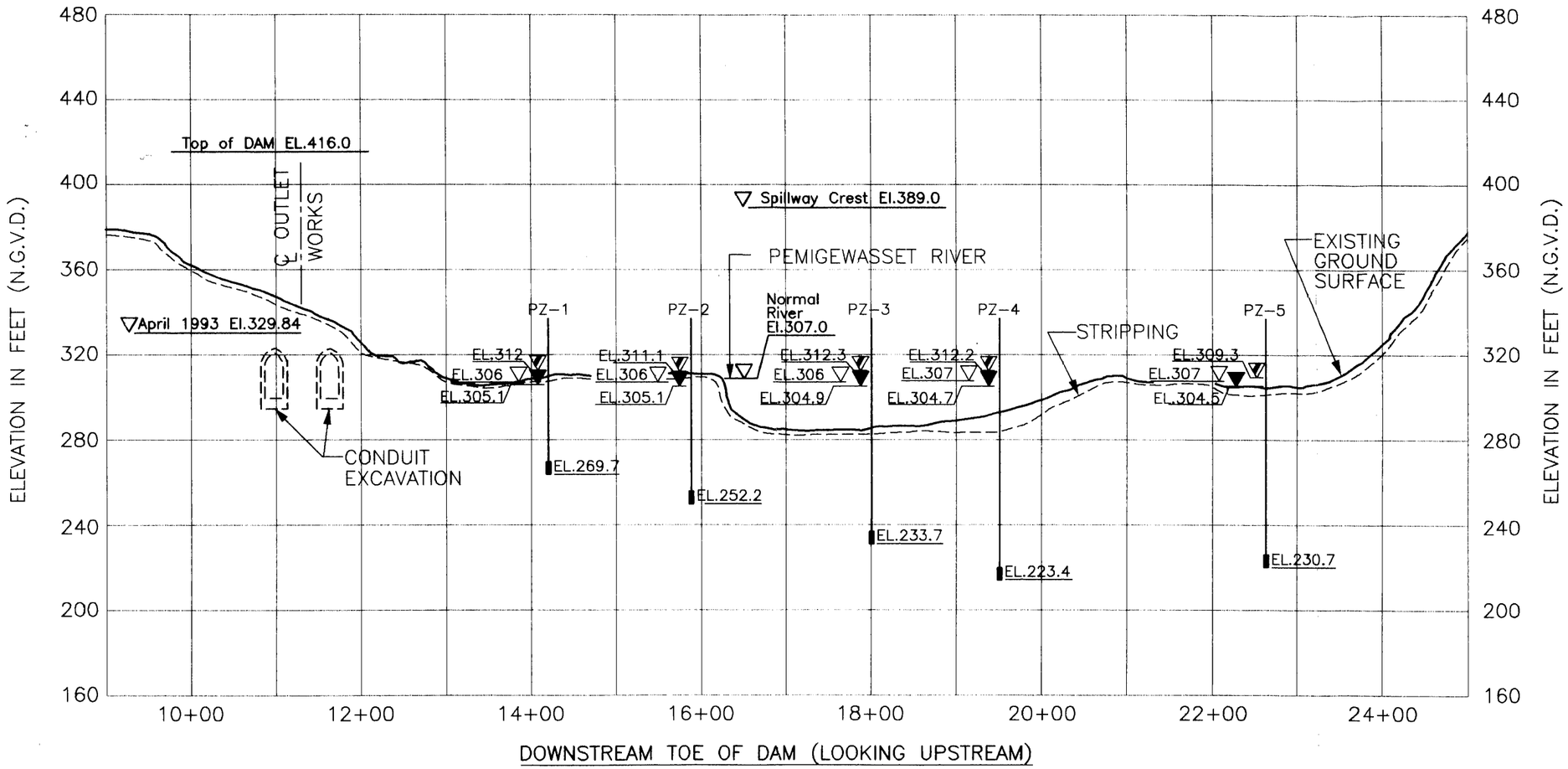
SCALE: HORIZ. 1"=80'
VERT. 1"=60'

JANUARY 1995

11163-000 B7

FIGURE 54


352000
352250
352500
352750
353000
353250
353500
353750
501000
501188
501375
501563
501750
501938
502125
502313
502500
324.0
320
318
316
314.0
312
310
308
306
314.0
314.0
Approximate limits of old river channel
1
2
3
4
5
6
7
8
9
10
11
12
13



LEGEND:

- ▼ PIEZOMETER LEVEL AT NORMAL RIVER LEVEL
- ▼ PROJECTED PIEZOMETER LEVEL WITH POOL AT SPILLWAY CREST
- ▽ APRIL 1993

NOTES:

1. CROSS SECTIONS PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS AND PUBLISHED IN THE REPORT ENTITLED "PERIODIC INSPECTION REPORT NO. 1, FRANKLIN FALLS DAM, MERRIMACK RIVER BASIN, PEMIGEWASSET RIVER, NEW HAMPSHIRE".
2. ALL ELEVATIONS CORRESPOND TO FEET N.G.V.D.
3. REFER TO FIGURE 5 FOR GENERAL LEGEND AND NOTES.

HORIZ. 0 80 160
VERT. 0 60 120
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

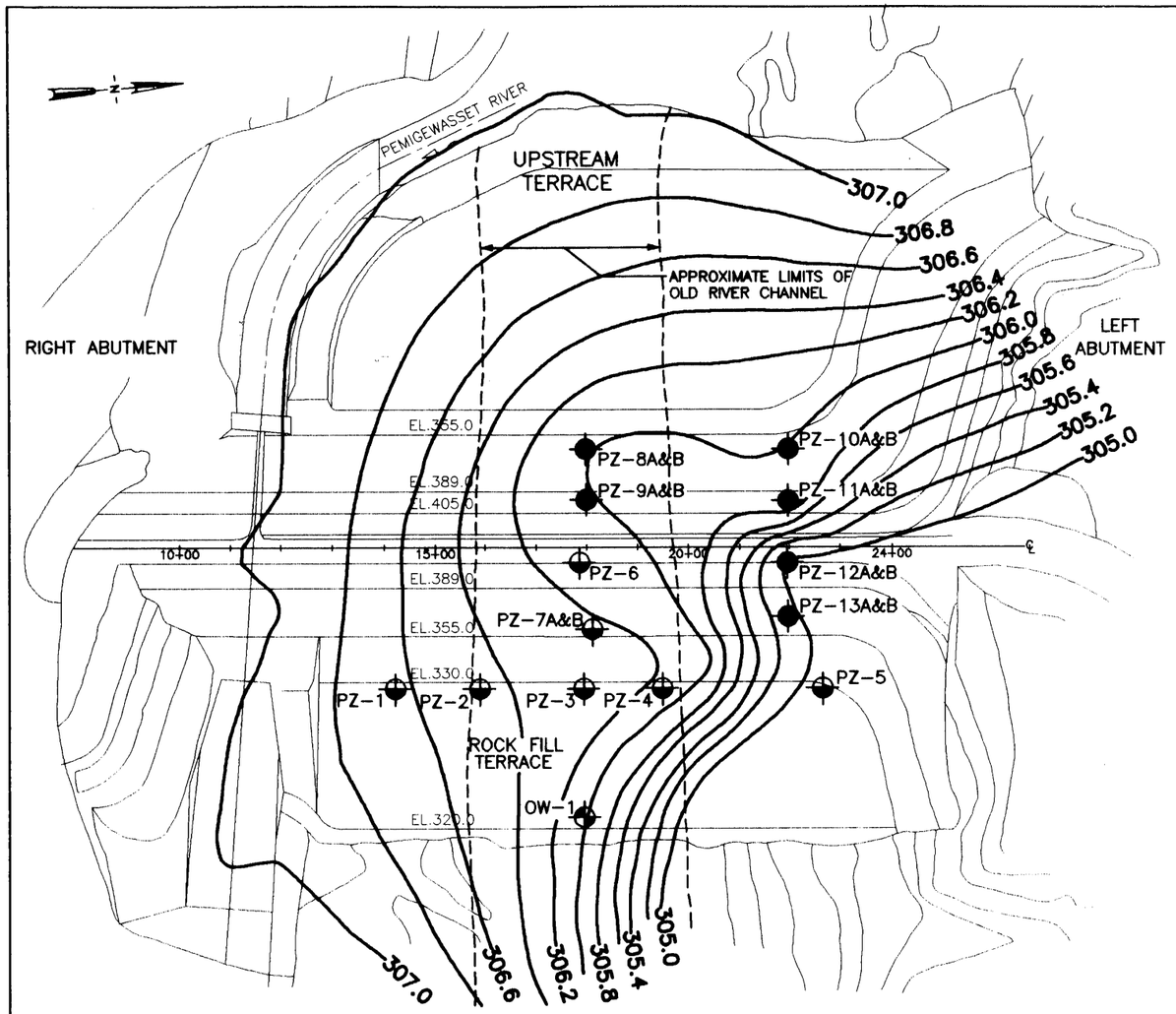
PIEZOMETER LEVELS, NORMAL POOL AND PROJECTED TO SPILLWAY CREST FOR DOWNSTREAM TOE OF DAM

SCALE: HORIZ. 1"=80'
VERT. 1"=60'

JANUARY 1995

11163-000 B9

FIGURE 55



PIEZOMETER NUMBER	APPROXIMATE STATION	APPROXIMATE CENTERLINE OFFSET	RISER PIPE TOP ELEVATION	PIEZOMETER ELEVATION	ZONE LOCATED	MATERIAL AT TIP ELEVATION (3)
PZ-1	14+20	275	329.7	269.71	FOUNDATION	Lt. br. w/ gravel (34) and silt (5) (SW)
PZ-2	15+90	275	331.2	252.24	FOUNDATION	Br. gr. w/ silt (10) and gravel (7) (SP-SM)
PZ-3	18+00	275	330.0	233.65	FOUNDATION	Lt. br. silty (24) SAND (SM)
PZ-4	19+50	275	330.1	223.4	FOUNDATION	Cobbles and Boulders
PZ-5	22+60	275	330.7	230.7	FOUNDATION	Gr. silty (20.6) m-f SAND (SM)
PZ-6	17+85	25	419.8	223.75	FOUNDATION	Br. GRAVEL w/ sand (5-20) w/ cobbles (GW)
PZ-7A	18+10	150	370.2	218.0	FOUNDATION	Br. and gr. SAND w/ silt (5.9) (SP-SM)
PZ-7B	18+10	150	370.5	284.5	TOE DRAIN	Br. gr. GRAVEL w/ sand (20-30) (GP)
PZ-8A	18+00	195	360.4	268.8	FOUNDATION	Orange GRAVEL w/ sand (27.5) and lg. cobbles (GW)
PZ-8B	18+00	195	360.7	301.8	COMPACTED PERVIOUS FILL	Orange m-f SAND w/ silt (6.9) (SP-SM)
PZ-9A	18+00	95	392	269.3	FOUNDATION	Orange br. m SAND w/ gravel (28.1) and silt (7.4) (SW-SM)
PZ-9B	18+00	95	392.2	315.3	IMPERVIOUS BLANKET	Orange br. m-c SAND w/ gravel (4-7) and silt (7.4) (SP-SM)
PZ-10A	22+00	195	360.3	266.4	FOUNDATION	Br. SAND w/ silt (12.1) (SP-SM)
PZ-10B	22+00	195	360.2	307.4	COMPACTED PERVIOUS FILL	Br. m SAND w/ silt (14.2) (SP-SM)
PZ-11A	22+00	95	390.2	268.4	FOUNDATION	Lt. br. sandy (43.2) SILT (ML)
PZ-11B	22+00	95	390.3	316.4	COMPACTED PERVIOUS FILL	Br. silty (15.3) SAND w/ trace gravel (SP-SM)
PZ-12A	22+00	20	417.9	276.2	FOUNDATION	Br. SAND w/ trace gravel (SP)
PZ-12B	22+00	20	418.1	305.2	IMPERVIOUS CORE	Olive clayey (49.9) SAND w/ trace gravel (SC)
PZ-13A	22+00	130	376.0	275.6	FOUNDATION	Br. m SAND (SP)
PZ-13B	22+00	130	376.1	295.6	TOE DRAIN	Br. GRAVEL w/ sand (0-10) (GP)

LEGEND:

- PIEZOMETER INSTALLED IN 1985 AND 1987
- PIEZOMETER INSTALLED IN 1991 "A" PIEZOMETER IS THE LOWER PIEZOMETER "B" IS THE UPPER PIEZOMETER
- OBSERVATION WELL

NOTES:

1. PLAN PREPARED BY THE U.S. ARMY CORPS OF ENGINEERS.
2. ALL ELEVATIONS CORRESPOND TO N.G.V.D.
3. REFER FIGURE 5 FOR GENERAL LEGEND AND NOTES.
4. CONTOURS GENERATED USING SURFER, VERSION 4.15 SOFTWARE DEVELOPED BY GOLDEN SOFTWARE, INC., 1990.
5. WATER LEVELS FROM PZ-9B AND PZ-11B NOT USED TO GENERATE CONTOURS.

0 300 600
SCALE IN FEET

Geotechnical Engineers & Environmental Consultants

MERRIMACK VALLEY FLOOD CONTROL
PEMIGEWASSET RIVER, FRANKLIN FALLS DAM
FRANKLIN, NEW HAMPSHIRE

PHREATIC SURFACE PLAN
NORMAL POOL ELEVATION

SCALE: 1"=300' JANUARY 1995

11163-004 B5

FIGURE 56

ATTACHMENT NO. 1

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 replaced 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 feet. These levels are third order, class I survey with relative accuracies no 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 off the dam structure in areas from which the entire length of the dam is visible. Settlement bounds themselves, with stamped brass disks, were placed on the control points. Horizontal coordinates of the control points are based on the State Plane Coordinate System. Elevations of the control points are based 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 whereby 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.