B & W Engineering Laboratories, Inc.
P.O. Box 341091 Memphis, Tennessee 38184-1091 (901) 373-7957

SEEPAGE STUDY/
PIEZOMETER INSTALLATION
WOODLAND LAKE DAM
EUDORA, MISSISSIPPI

B & W Engineering Laboratories, Inc.

P.O. Box 341091 Memphis, Tennessee 38184-1091 (901) 373-7957

03 June 2016
Job No. 8654
Serial No. D-2207

Ms. Shirley Harris, President
Woodland Lake Homeowners Association
(662) 429-4085
cell (870) 995-1715
sbharris20@aol.com

Ref: Seepage Study/Piezometer Installation
Woodland Lake Dam
Eudora, Mississippi

Dear Shirley:

The purpose of this investigation was to determine if seepage through the referenced earth dam was such that problems associated with excessive seepage were likely to occur, with particular attention given to the functionality of the toe drain that was installed in the embankment many years ago in order to address seepage problems that were reported prior to its installation. A total of eight piezometers were installed, in two roughly parallel sections through the embankment. Figure Numbers 1-A and 1-B illustrate the approximate locations of the piezometers, in plan and profile; installation details are presented in Appendix B. Prior to piezometer installation, a test boring was drilled at each planned location in order to determine soil characteristics and estimated depths to water; logs of these borings are presented in Appendix A. After installation, vertical and horizontal locations of the piezometers were surveyed by Jones-Davis and Associates (JDA) surveyors; the JDA data is utilized exclusively in this report. The depth to water has been periodically measured in the piezometers, initially by B & W personnel and subsequently by HOA personnel; measured water elevations are presented in Appendix C.

Inspection of the Study Area

The study area has been inspected by B & W personnel on many occasions, dating back to 18 August 2015. Evidence of excessive seepage, such as wet areas on the slope during dry weather, has not been noted. This was apparently not the case about twenty years ago, prior to installation of the toe drain described above.

Completion of Embankment Borings

A total of eight borings, designated borings P-1 through P-8, were completed at the approximate locations indicated on Figure Numbers 1A and 1B, to depths ranging from ten to seventeen feet below the ground surface. All borings were completed using hand

augers, as indicated on the boring logs of Appendix A. Soil samples obtained directly from the hand auger were logged, labeled, and placed in moisture-proof containers in the field. Visual classification and natural water content determinations were performed in the laboratory on all soil samples retrieved from the borings; results are shown on the boring logs. Groundwater depths were measured at the time of drilling and periodically over a several week period in order to determine the optimum piezometer design for each location.

Installation of Piezometers

Two-inch diameter piezometers, also designated P-1 through P-8, were installed in the respective borings after the boreholes were overdrilled using a larger diameter auger, and were terminated at depths that would allow the piezometers to be screened at the appropriate depths. Each piezometer consists of a PVC screen and riser with threaded connections, sand filter, bentonite seal, and concrete protective seal. Construction details of each piezometer are illustrated in Appendix B and are summarized below. Elevations were determined by JDA.

No.	Screened Interval (feet)	Sand Interval (feet)	Bentonite Interval (feet)	Concrete Interval (feet)	Casing Stick-up (feet)	Top of Casing El. (feet)
P-1	7.5-17.5	5.0-18.0	1.0-5.0	0-1.0	2.2	242.183
P-2	4.0-14.0	1.5-15.0	0.5-1.5	0-0.5	2.2	233.351
P-3	3.0-13.0	2.0-15.0	0.5-2.0	0-0.5	2.0	226.068
P-4	3.5-10.0	2.0-12.0	0.5-2.0	0-0.5	2.0	220.562
P-5	8.0-18.0	5.0-18.5	1.0-5.0	0-1.0	2.0	241.766
P-6	4.0-14.0	3.0-15.0	1.0-3.0	0-1.0	2.0	232.367
P-7	2.5-11.0	1.75-12.0	0.75-1.75	0-0.75	2.2	224.303
P-8	2.5-11.0	1.5-12.0	0.5-1.5	0-0.5	2.1	218.645

After installation, each piezometer was “developed” by bailing until relatively sediment free water was obtained. Steel guard posts were also installed around each piezometer.

Groundwater Measurement

Groundwater elevations have been measured on a number of occasions, and will continue to be measured periodically. Measurement data is presented in Appendix C. The average water elevation for those measurements included in Appendix C are presented below.

P-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8
231.97	228.41	223.27	215.94	231.41	227.91	220.29	212.48

Findings of the Investigation

The soils encountered in the borings consist of silty clays and clayey silts. These soils are relatively impermeable, but do allow water to flow through them at low rates. The estimated coefficient of permeability of such soils varies from 10^{-7} to 10^{-5} centimeters per second. No high permeability sands or gravels were encountered in the borings.

The groundwater surface through the two sections represented by the piezometers, based on average groundwater levels that have been measured in the piezometers, are illustrated on Figure Numbers 1-A and 1-B, along with the approximate location of the toe drain described above. The blue profile line of each section connects water elevations at known points, including the woodland lake water surface. As illustrated on each profile, the blue line dips downward between the two piezometers that are separated by the toe drain. The red line of each section is a projection of the upper line segments and illustrates the expected water surface if the toe drain was not functional. The green line of each section illustrates the likely water profile between the lower piezometers, with the expected lowering of a functional toe drain. These profiles, based on piezometer readings made to date, illustrate that the toe drain remains functional. So long as it continues to function properly, the excessive seepage noted prior to its installation will not likely return.

Recommendations

It is recommended that the water levels in the piezometers continue to be measured on a regular schedule; monthly readings should be adequate, unless evidence of excessive seepage is noted. It is also recommended that the readings be annually reviewed by a professional engineer to determine if any trends are developing that may suggest a loss of functionality of the toe drain or development of other seepage related problems.

If there are any questions, or if additional information is required, please advise.

Respectfully submitted,

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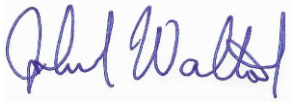
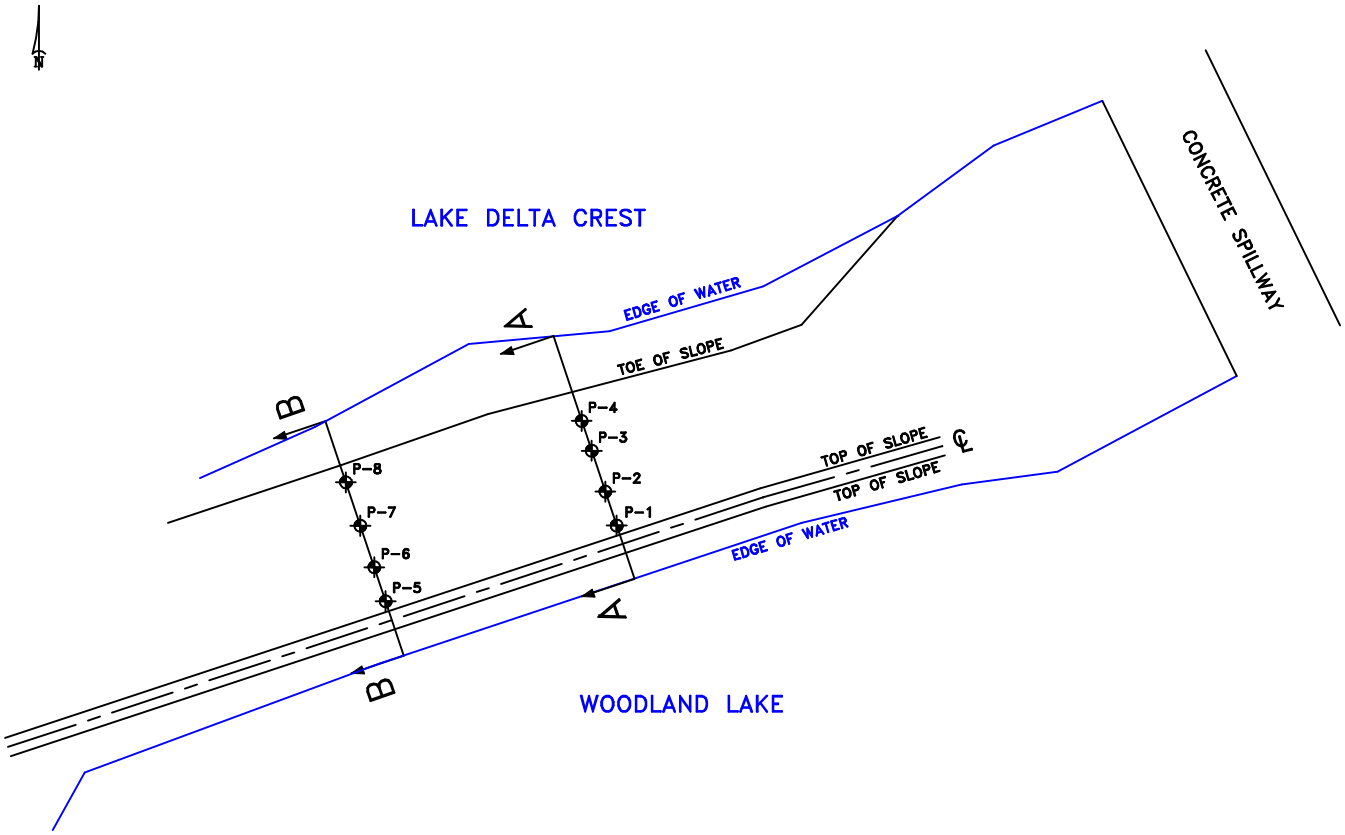


John L. Walton, Sr., P.E.
President

JLW/jw0616

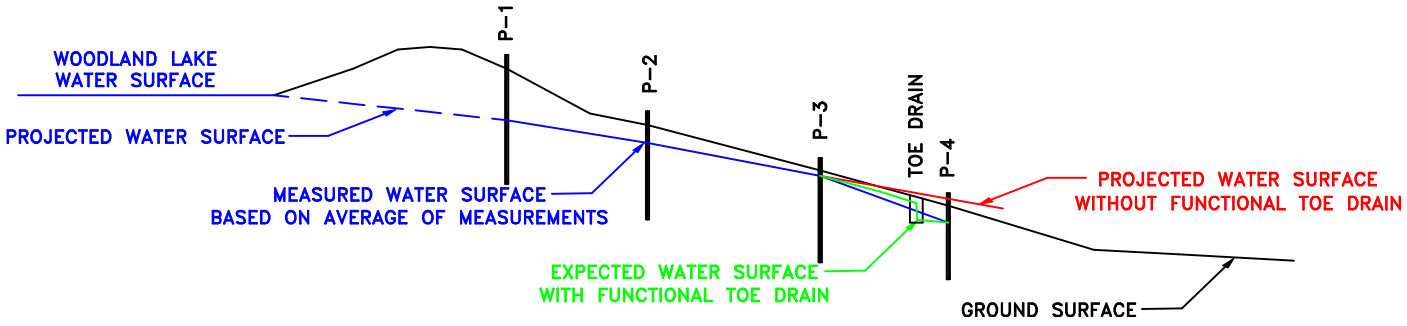


0 120 240

SCALE (FEET)

LEGEND

APPROXIMATE BORING LOCATION



SECTION "A"

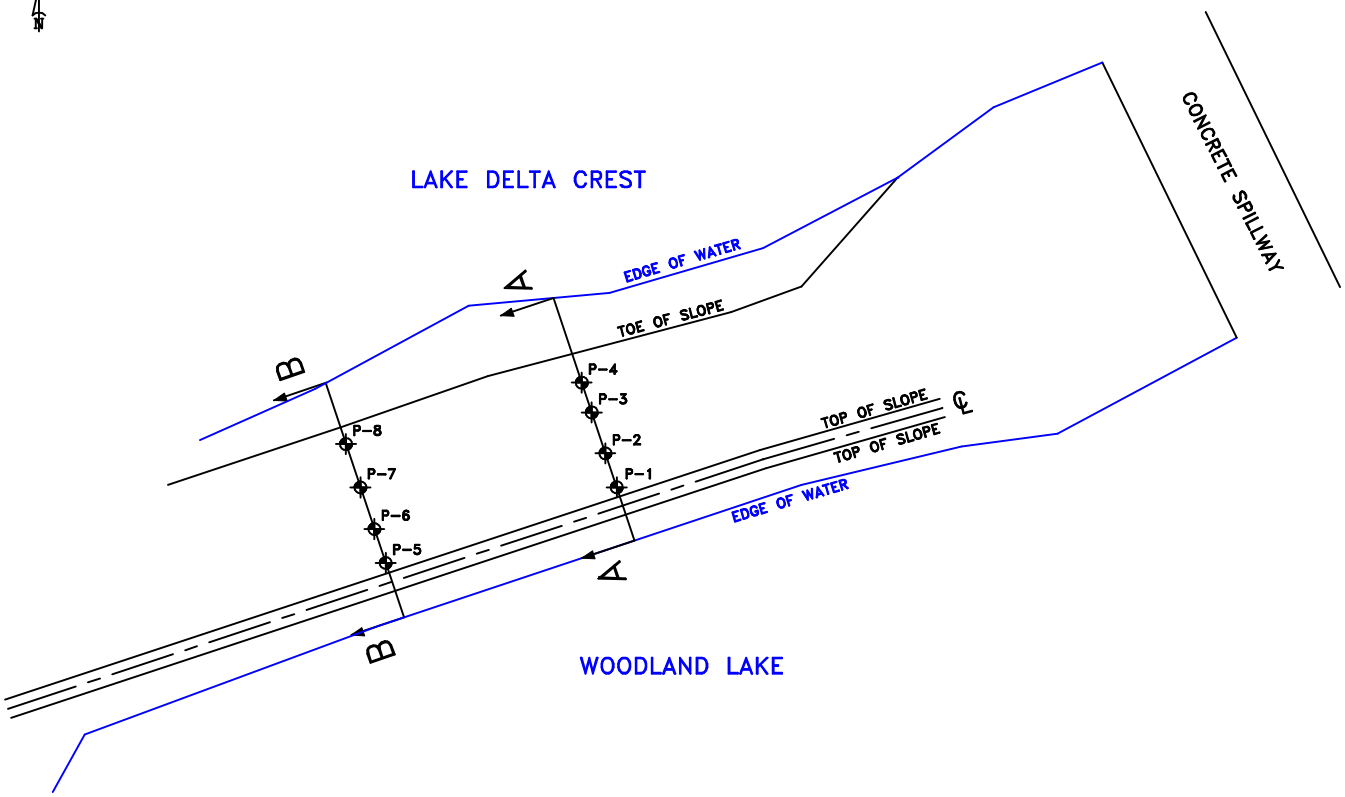
0 30 60

SCALE (FEET)

SEEPAGE STUDY
WOODLAND LAKE DAM
EUDORA, MISSISSIPPI

JOB NUMBER 8654

FIGURE NO. 1–A

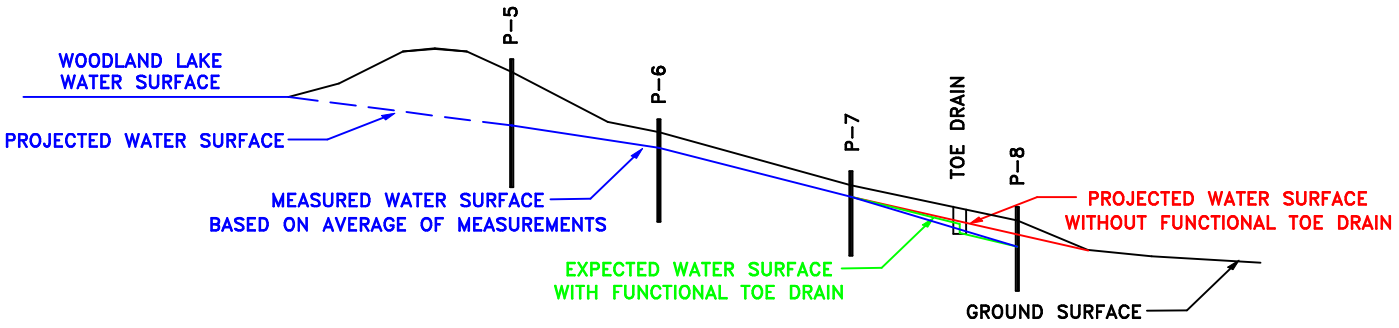


LEGEND

⌖ APPROXIMATE BORING LOCATION

0 120 240

SCALE (FEET)



SECTION "B"

0 30 60

SCALE (FEET)

SEEPAGE STUDY
WOODLAND LAKE DAM
EUDORA, MISSISSIPPI

JOB NUMBER 8654

FIGURE NO. 1–B

APPENDIX A

BORING LOGS

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-1
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 15.0 feet
Groundwater Depth: 14.5' at completion
Boring Type: Hand Auger

Ground El: 240.0 feet
Date: 21 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	22%	Brown Silty CLAY
2	2.0-2.5	22%	Brown Silty CLAY
3	3.0-3.5	24%	Brown Silty CLAY w/trace of Sand
4	4.5-5.0	27%	Brown and Gray Clayey SILT
5	7.0-7.5	30%	Brown and Gray Clayey SILT to 9.0 feet
6	9.5-10.0	30%	Gray Clayey SILT to 12.0 feet
7	13.0-13.5	32%	Brown Silty CLAY
8	14.5-15.0	32%	Brown and Gray Silty CLAY

Piezometer P-1 was installed in overdrilled 5" diameter, 18' deep borehole,
See Figure Number P-1 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-2
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 15.0 feet
Groundwater Depth: 10.1' at completion
Boring Type: Hand Auger

Ground El: 231.2 feet
Date: 21 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	28%	Brown Silty CLAY
2	2.0-2.5	32%	Brown and Tan Silty CLAY
3	3.0-3.5	33%	Brown Silty CLAY
4	4.5-5.0	30%	Brown Silty CLAY to 6.5 feet
5	7.0-7.5	30%	Brown and Gray Silty CLAY
6	9.5-10.0	26%	Gray Silty CLAY to 12.0 feet
7	13.0-13.5	32%	Brown Silty CLAY
8	14.5-15.0	32%	Brown and Gray Silty CLAY

Piezometer P-2 was installed in overdrilled 5" diameter, 15' deep borehole,
See Figure Number P-2 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-3
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 10.0 feet
Groundwater Depth: 3.2' at 24 hours
Boring Type: Hand Auger

Ground El: 224.1 feet
Date: 20 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	25%	Brown and Gray Silty CLAY w/trace of Sand
2	2.0-2.5	25%	Brown and Gray Silty CLAY w/trace of Sand
3	3.0-3.5	33%	Brown and Gray Silty CLAY w/trace of Sand
4	4.5-5.0	33%	Gray Silty CLAY
5	7.0-7.5	32%	Brown and Gray Silty CLAY
6	9.5-10.0	24%	Gray Silty CLAY w/trace of Sand

Piezometer P-3 was installed in overdrilled 5" diameter, 15' deep borehole,
See Figure Number P-3 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-4
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 15.0 feet
Groundwater Depth: 5.5' at 24 hours
Boring Type: Hand Auger

Ground El: 218.6 feet
Date: 20 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	30%	Brown and Gray Silty CLAY w/trace of Sand
2	2.0-2.5	29%	Brown and Gray Silty CLAY w/trace of Sand
3	3.0-3.5	22%	Gray Clayey SILT
4	4.5-5.0	22%	Gray Clayey SILT
5	7.0-7.5	29%	Gray Clayey SILT
6	9.5-10.0	28%	Gray Clayey SILT
7	13.0-13.5	32%	Gray Silty CLAY
8	14.5-15.0	32%	Gray Silty CLAY

Piezometer P-4 was installed in overdrilled 5" diameter, 12' deep borehole,
See Figure Number P-4 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-5
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 15.0 feet
Groundwater Depth: 14.0' at completion
Boring Type: Hand Auger

Ground El: 239.8 feet
Date: 21 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	25%	Brown Silty CLAY
2	2.0-2.5	26%	Brown Silty CLAY
3	3.0-3.5	28%	Brown and Tan Silty CLAY w/trace of Sand
4	4.5-5.0	29%	Brown and Gray Clayey SILT
5	7.0-7.5	32%	Brown and Tan Clayey SILT
6	9.5-10.0	33%	Gray Clayey SILT to 12.0 feet
7	13.0-13.5	32%	Gray Silty CLAY
8	14.5-15.0	32%	Brown Silty CLAY

Piezometer P-5 was installed in overdrilled 5" diameter, 18.5' deep borehole,
See Figure Number P-5 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-6
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 15.0 feet
Groundwater Depth: 8.3' at completion
Boring Type: Hand Auger

Ground El: 230.4 feet
Date: 21 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	30%	Brown and Tan Silty CLAY
2	2.0-2.5	33%	Brown and Tan Silty CLAY
3	3.0-3.5	32%	Brown and Tan Silty CLAY
4	4.5-5.0	31%	Tan Silty CLAY
5	7.0-7.5	25%	Tan and Gray Silty CLAY w/trace of Sand
6	9.5-10.0	31%	Tan and Gray Silty CLAY w/trace of Sand
7	13.0-13.5	33%	Gray Silty CLAY
8	14.5-15.0	32%	Gray Silty CLAY

Piezometer P-6 was installed in overdrilled 5" diameter, 15' deep borehole,
See Figure Number P-6 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-7
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 17.0 feet
Groundwater Depth: 6.2' at 24 hours
Boring Type: Hand Auger

Ground El: 222.1 feet
Date: 20 August 2015
Weather: Clear/Hot
Insp: J. Carter

Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	25%	Brown and Tan Silty CLAY
2	2.0-2.5	21%	Tan and Gray Silty CLAY w/trace of Sand
3	3.0-3.5	30%	Gray Clayey SILT
4	4.5-5.0	29%	Brown and Gray Silty CLAY
5	7.0-7.5	26%	Brown and Gray Silty CLAY
6	9.5-10.0	28%	Brown and Gray Silty CLAY
7	13.0-13.5	26%	Gray Silty CLAY w/trace of Sand
8	14.5-15.0	27%	Gray Silty CLAY w/trace of Sand
9	16.5-17.0	30%	Brown and Gray Silty CLAY w/trace of Sand

Piezometer P-7 was installed in overdrilled 5" diameter, 12' deep borehole,
See Figure Number P-7 for installation details.

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LOG OF BORING

Woodland Lake Dam Piezometers
Woodland Lake
Eudora, Mississippi

Job No.: 8654
Boring: P-8
Sheet 1 of 1

Boring Location: See Figure Number 1
Boring Depth: 15.0 feet
Groundwater Depth: 6.2' at 24 hours
Boring Type: Hand Auger

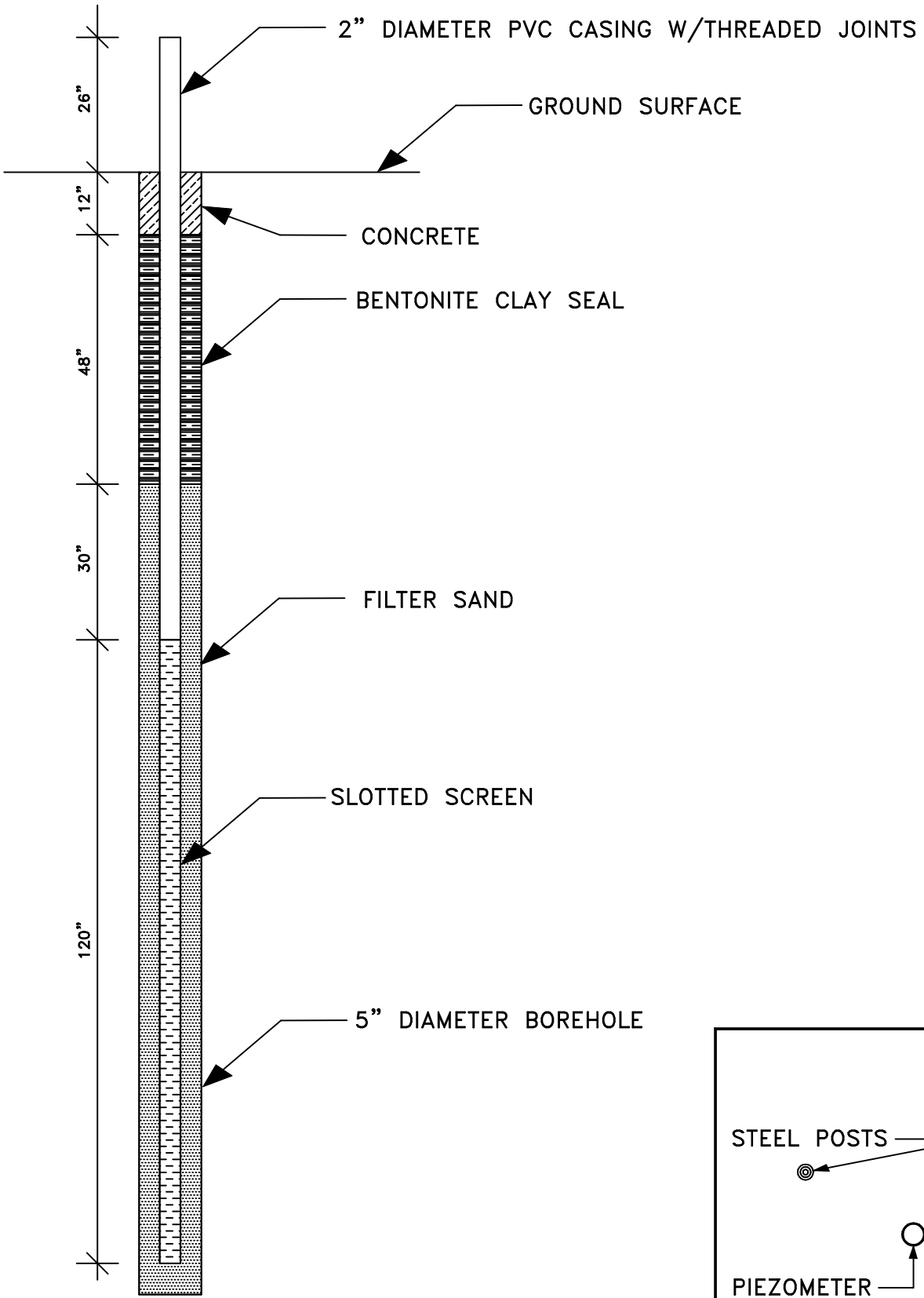
Ground El: 216.6 feet
Date: 20 August 2015
Weather: Clear/Hot
Insp: J. Carter

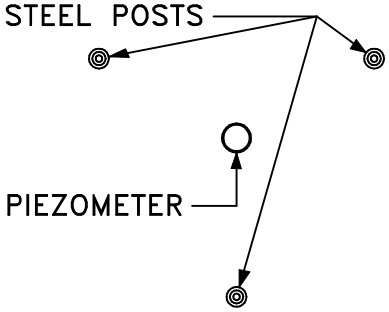
Sample Number	Sample Interval (feet)	Water Content	Sample Description
1	1.0-1.5	22%	Brown and Tan Silty CLAY
2	2.0-2.5	25%	Brown Silty CLAY
3	3.0-3.5	23%	Gray Clayey SILT
4	4.5-5.0	24%	Gray Clayey SILT
5	7.0-7.5	29%	Brown and Gray Silty CLAY
6	9.5-10.0	28%	Brown and Gray Silty CLAY w/trace of Sand
7	13.0-13.5	31%	Brown and Gray Silty CLAY w/trace of Sand
8	14.5-15.0	31%	Gray Silty CLAY w/trace of Sand

Piezometer P-8 was installed in overdrilled 5" diameter, 12' deep borehole,
See Figure Number P-8 for installation details.

APPENDIX B

PIEZOMETER CONSTRUCTION DETAILS

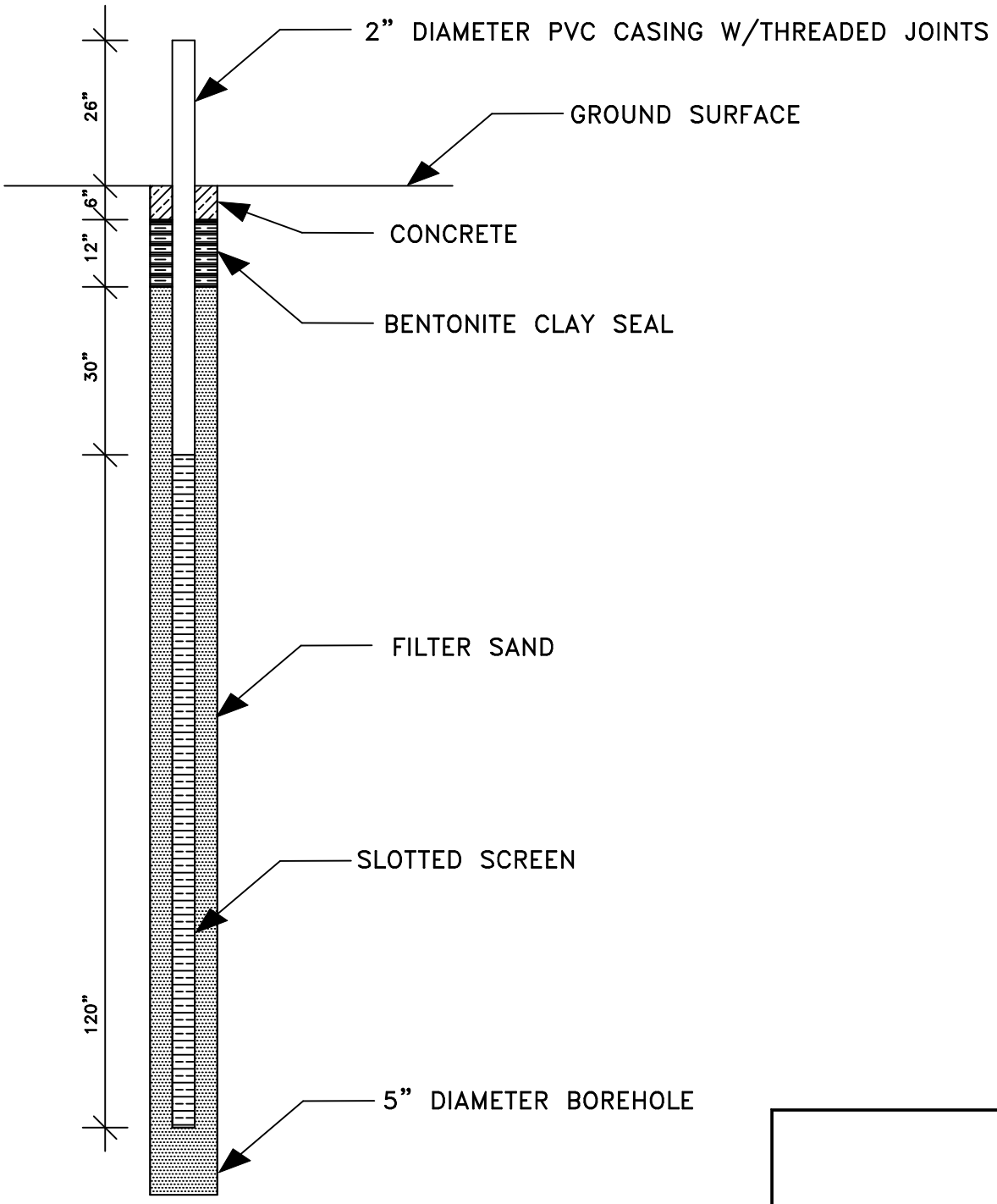


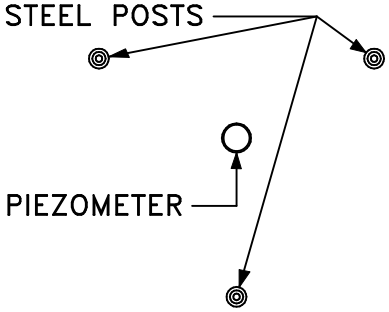


PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-1
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-1

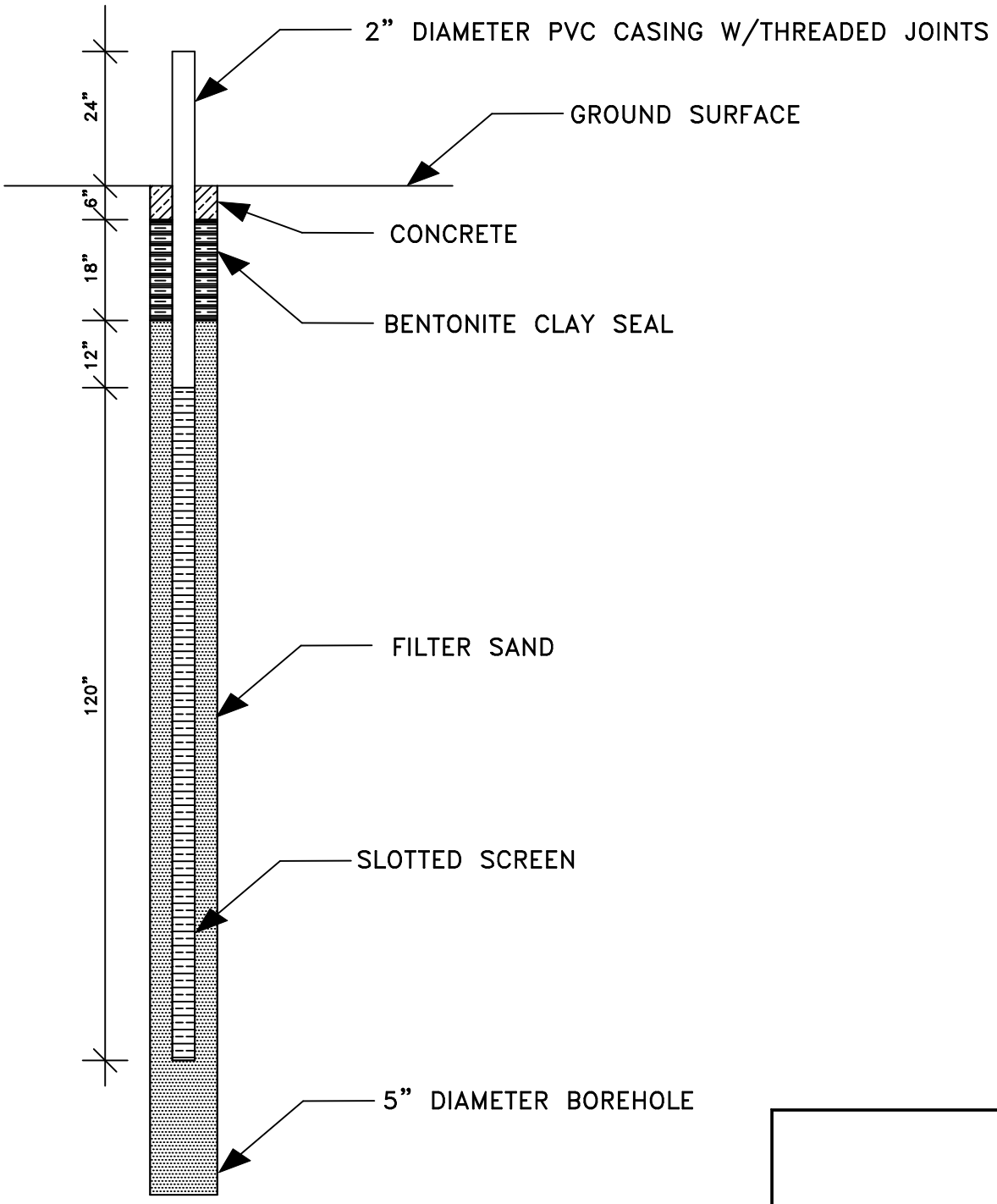


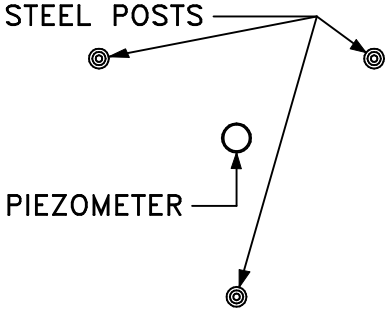


PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-2
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-2

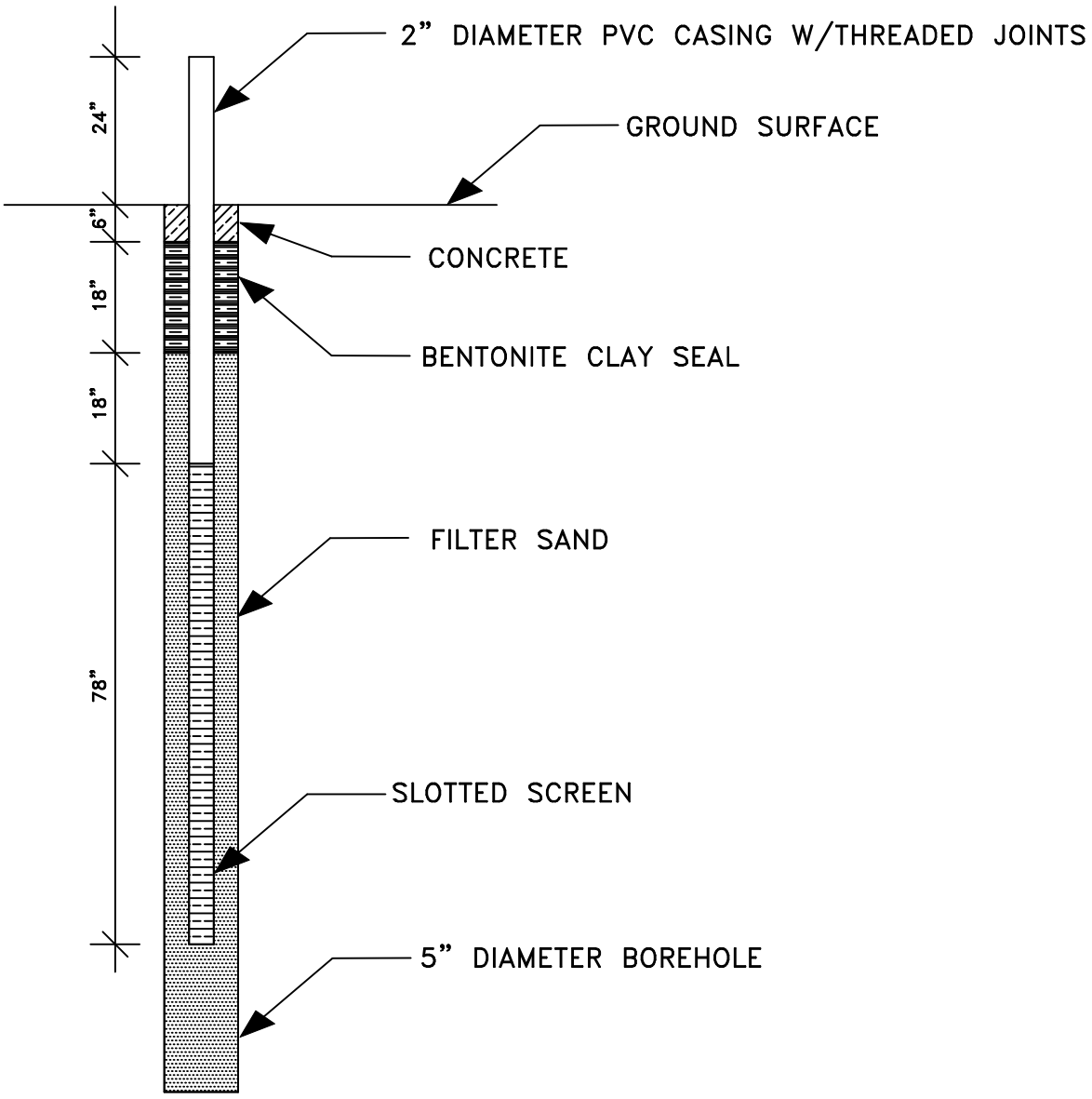


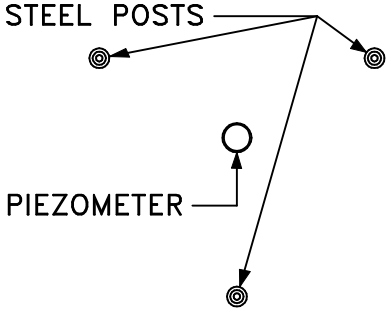


PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-3
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-3

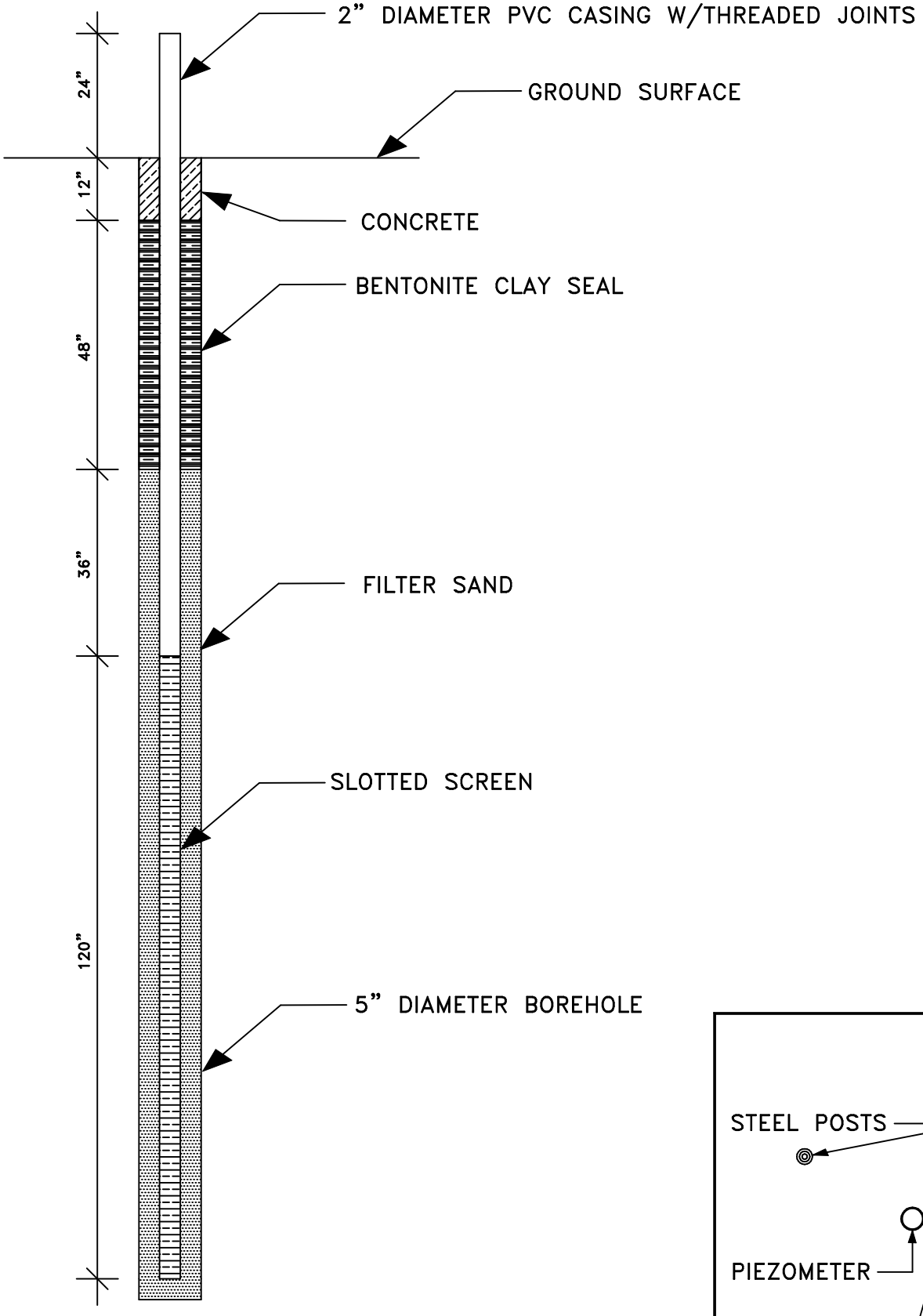




PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-4
WOODLAND LAKE DAM

JOB NUMBER
8654

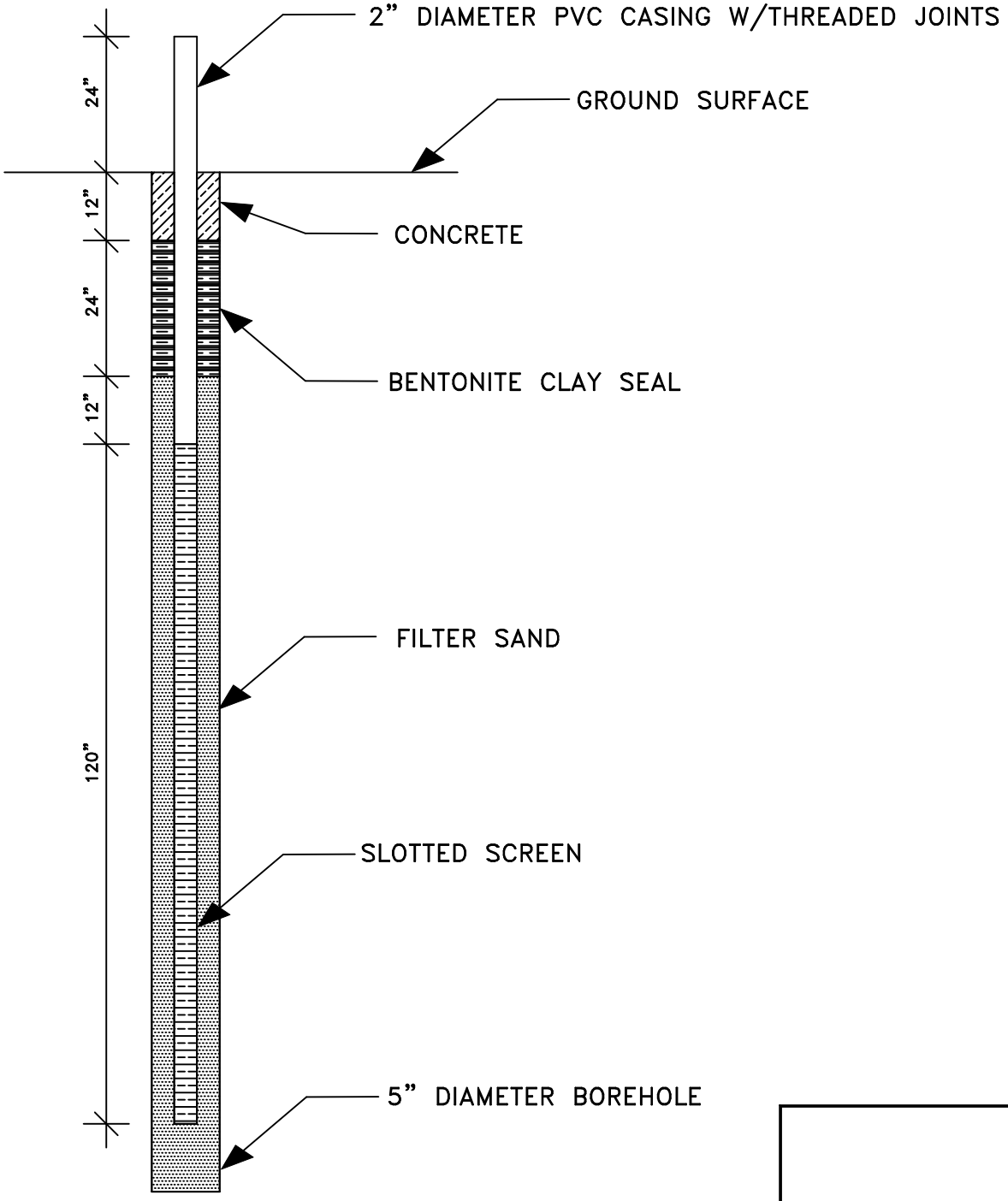
FIGURE NO.
P-4

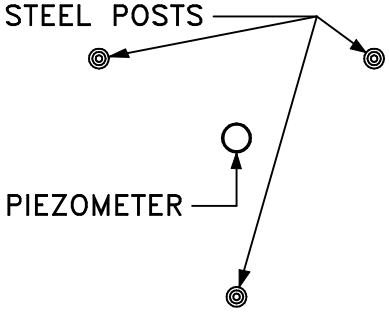


PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-5
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-5

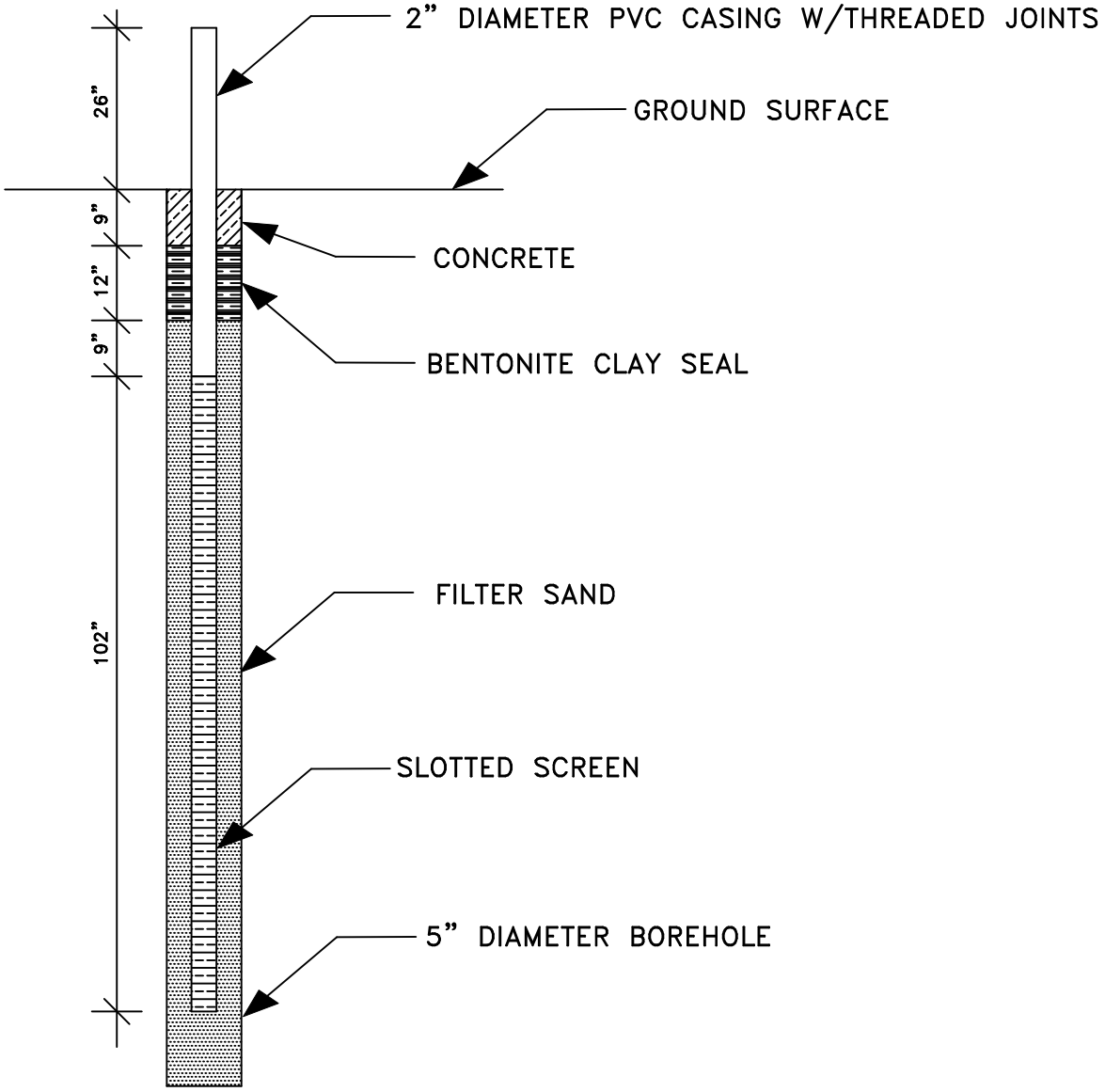


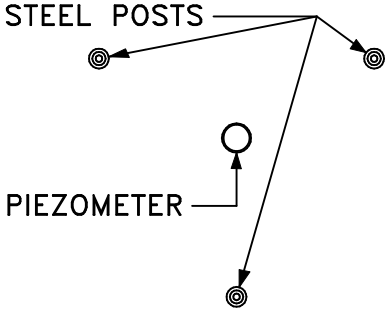


PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-6
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-6

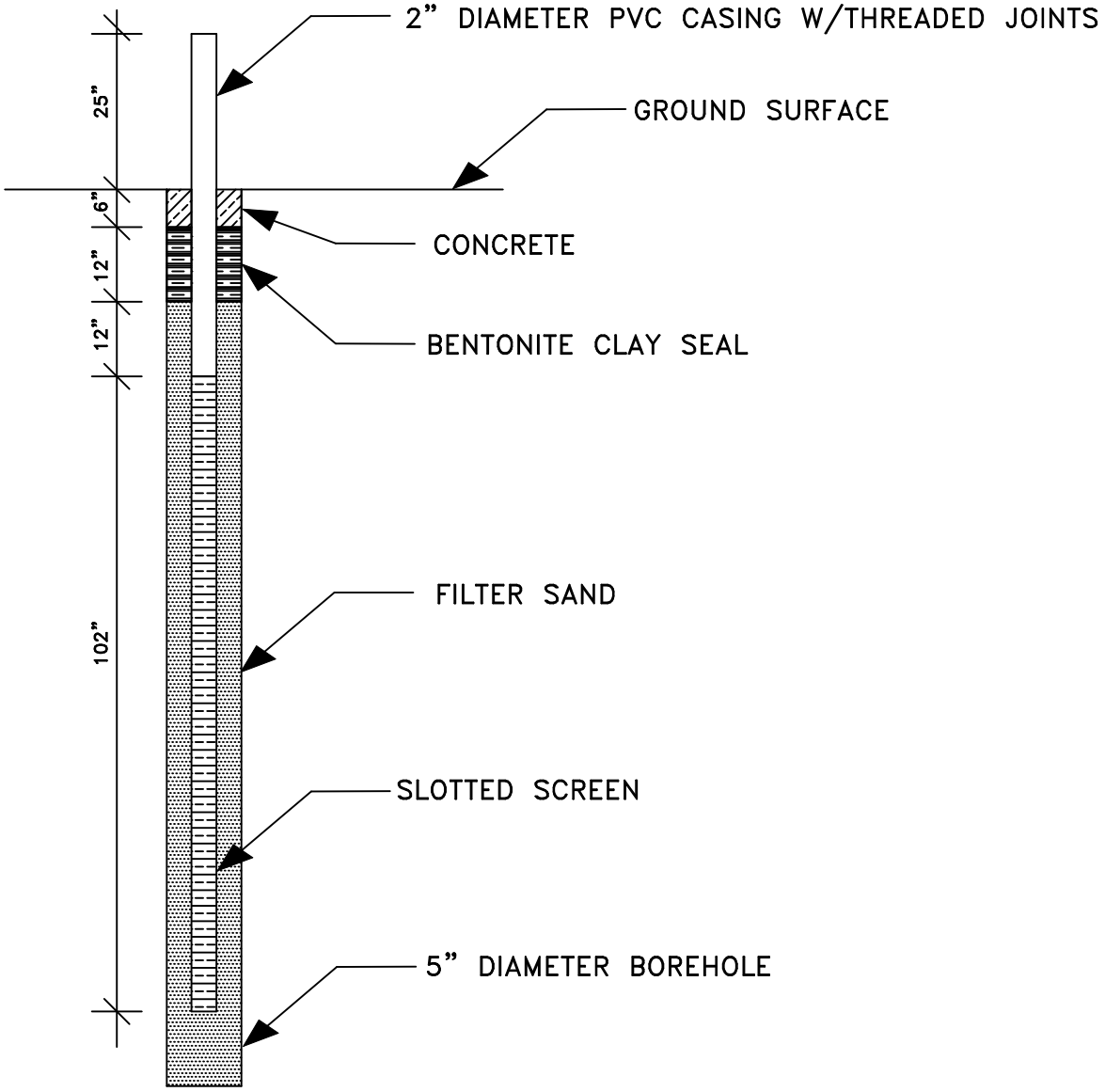


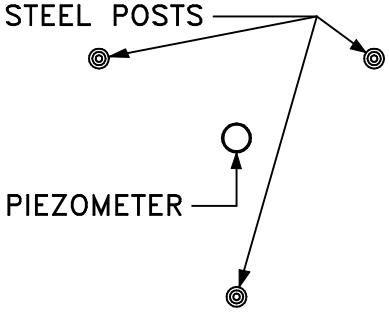


PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-7
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-7





PIEZOMETER CONSTRUCTION DETAILS
PIEZOMETER NUMBER P-8
WOODLAND LAKE DAM

JOB NUMBER
8654

FIGURE NO.
P-8

APPENDIX C

PIEZOMETER READINGS

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 12/17/2015, 1:00 pm

Readings by: J. Carter (B&W)

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	117	232.433	
P2	233.351	55	228.768	
P3	226.068	33	223.318	
P4	220.562	56	215.895	
P5	241.766	117	232.016	
P6	232.367	49	228.284	
P7	224.303	36	221.303	
P8	218.648	72	212.648	

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 02/11/2016

Readings by: Homeowner

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	130	231.350	
P2	233.351	61	228.268	
P3	226.068	36	223.068	
P4	220.562	57	215.812	
P5	241.766	130	230.933	
P6	232.367	60	227.367	
P7	224.303	54	219.803	
P8	218.648	100	210.315	

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 02/21/2016

Readings by: Homeowner

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	120	232.183	
P2	233.351	58	228.518	
P3	226.068	33	223.318	Drained tube from 33" to 55" deep. Two hours later reading was 35 (11)
P4	220.562	54	216.062	
P5	241.766	128	231.099	
P6	232.367	51	228.117	
P7	224.303	50	220.136	
P8	218.648	75	212.398	

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 03/07/2016, 12:30 pm

Readings by: Jamie Cunningham

Stage Gauge Water Level Reading (ft): 4.0 + 231.86 = Water Level Elevation: 235.86

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	125	231.766	
P2	233.351	61	228.268	
P3	226.068	35	223.151	
P4	220.562	55	215.979	
P5	241.766	127	231.183	
P6	232.367	54.5	227.825	
P7	224.303	50.5	220.095	
P8	218.648	70	212.815	

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 03/10/2016, 2:00 pm

Readings by: Tim Cottam

Stage Gauge Water Level Reading (ft): 6.5 + 231.86 = Water Level Elevation: 238.36

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183			
P2	233.351			
P3	226.068	29	223.651	only read this one
P4	220.562			
P5	241.766			
P6	232.367			
P7	224.303			
P8	218.648			

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 03/27/2016, 3:00 pm

Readings by: Tim Cottam/Ralph Terry

Stage Gauge Water Level Reading (ft): 4.0 + 231.86 = Water Level Elevation: 235.86

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	132	231.183	
P2	233.351	68	227.684	
P3	226.068	37	222.985	
P4	220.562	57	215.812	
P5	241.766	133	230.683	
P6	232.367	60	227.367	
P7	224.303	53	219.886	
P8	218.648	75	212.398	

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 05/04/2016, 1:45 pm

Readings by: David Lively

Stage Gauge Water Level Reading (ft): ___ + 231.86 = Water Level Elevation: _____

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	115	232.600	
P2	233.351	53	228.934	
P3	226.068	30	223.568	
P4	220.562	52	216.229	
P5	241.766	114	232.266	
P6	232.367	47	228.450	
P7	224.303	43	220.720	
P8	218.648	61	213.565	

Woodland Lake Piezometer Readings/Calculations

Date/Time of Readings: 05/05/2016, 6:30 pm

Readings by: M. S.

Stage Gauge Water Level Reading (ft): 4.0 + 231.86 = Water Level Elevation: 235.86

Piezo-meter #	**A** Top of Pipe el. (ft)	**B** Measured Depth to Water (in)	**C** Elevation of Water (ft) **A - B/12**	Remarks
P1	242.183	119	232.266	
P2	233.351	58	228.518	
P3	226.068	35.5	223.110	
P4	220.562	57	215.812	
P5	241.766	121	231.683	
P6	232.367	53	227.950	
P7	224.303	51	220.053	
P8	218.648	65	213.231	