Research Report
KTC-90-3

EVALUATION OF WICK DRAIN STABILIZATION OF APPROACH FILL FOUNDATION (BULLITT COUNTY)

by

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16. Abstract

The purpose of this study was to document construction procedures and evaluate the effectiveness of prefabricated wick drains for dewatering and stabilizing an approach fill foundation. Construction was observed and photologged. Foundation pore pressure was monitored with pneumatic piezometers. Settlement of the entire structure was monitored by use of control points on the retaining wall and pavement.

Construction procedures were acceptable. Wick drains have functioned as expected and the approach fill has been stable for approximately four years since construction.

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INTRODUCTION

Replacement bridges carrying Interstate 65 over the L & N railroad in Bullitt County were constructed in 1985 and 1986 (Figure 1). Construction was conducted in two phases to maintain traffic flow. The southbound bridge was constructed from April to June of 1985. The northbound bridge was constructed from August to September of 1986. Preliminary geotechnical analyses of the site indicated the clayey foundation would require four to 16 months for 90 percent consolidation. It was decided to accelerate consolidation by dewatering the foundation through the use of prefabricated wick drains. With wick drains, the estimated time for completion of primary consolidation would be from 1.7 to 2.7 months.

As seen in Figure 2, the bridges span 46 feet over the railroad. The approaches are approximately 28 feet in height with Reinforced Earth retaining walls. The foundation area where wick drains were installed extends 111 feet on either side of centerline of Interstate 65, and beginning at the face of each wall, extends 28.5 feet back of each wall.

The drains chosen for installation were the "ALIDRAIN SYSTEM" supplied by Burcan Industries. The specific drain used was the Alidrain. This drain consists of a polyethylene core encased in filter fabric. The core is studded on both sides and perforated. The filter is a polyester fiber fabric. Overall drain dimensions are 3.937 inches in width and 0.276 inches in thickness. Alidrain specifications are listed in Appendix A. A total of 8,034 linear feet was installed at a bid cost of $21.00 per linear foot of drain.

STUDY OBJECTIVES

Because the wick drains were considered an experimental feature, a study was initiated to instrument and monitor the site. Objectives of the study were:

1. to observe construction procedures and obtain experimental data on wick-drain effectiveness,

2. to analyze field behavior using settlement and piezometric data, and

3. to make recommendations as to the effectiveness and future use of this method.

SUBSURFACE AND GEOLOGICAL DATA

This site lies in an area of lacustrine deposits and older alluvium of the Pleistocene series of the Quatenary System. Subsurface sampling conducted during the initial site exploration indicated foundation depths up to 30 feet. The material generally classified as A-7-6 or A-6 by the AASHTO system. Natural moisture contents ranged from 17 to 40 percent. Borings made after construction began indicated formation depths of 14 to 16 feet north of the railroad and 20 feet south of the railroad.

INSTRUMENTATION

Instrumentation at the site included pneumatic piezometers placed near mid-depth of the southbound approach foundations, settlement monitoring gages at the foundation-embankment interface, and elevation monitoring points on the wall. Instrumentation locations are shown in Figures 3 and 4.

Four piezometers were installed prior to wick-drain installation. Two were located under each approach of the southbound bridge. The piezometers under the north approach (Numbers 1 and 2) were vandalized approximately 5 months after installation.

Settlement monitoring gages were destroyed during construction of the reinforced earth wall. Seven settlement monitoring points were placed on the wall (Figures 3 and 4).

CONSTRUCTION

To maintain traffic flow, construction proceeded in two phases. The southbound lanes were constructed first, and these were then used to carry traffic during construction of the northbound lanes. Construction of the southbound approach began in April 1985. The existing embankment was removed to a point that permitted construction of approximately one-half the new embankment. The remaining embankment was retained with driven piling and in some cases wood lagging. The soil was excavated to 1 foot below the bottom of the wall and piezometers were installed at that time.

A geotextile fabric was placed on the foundation and a stone drainage blanket 1 foot thick was placed prior to wick-drain installation. Figure 5 shows the retaining piling, the drainage

blanket partially in place, and the piezometers in the south approach of the southbound lanes. Drainage blanket specifications are included in Appendix B. Wick drains were installed on a 6-foot triangular spacing and extended to bedrock.Drains were cut off at least 6 inches above the drainage blanket. Four hundred and fifty drains totaling 8,034 linear feet were installed. Installation required approximately three working days for an average installation rate of 335 feet per hour. Special notes pertaining to wick-drain installation are included in Appendix C.

A footer for the Reinforced Earth wall was poured and construction of the wall and embankment proceeded after installation of the wick drain. Limestone sand was used to backfill the area behind the wall where the supporting straps lay. Figure 6 shows the construction of the reinforced earth wall.

Construction of the southbound lanes began in mid April of 1985 and was completed in early June of 1985. Construction of the norhtbound lanes began in August of 1986 and was completed in September of 1986. A photograph of the completed structure with the southbound lanes in the foreground is shown in Figure 7.

Design of the wick drains and drainage blanket did not provide for drainage from the blanket. It was decided in the field to provide for drainage from the blanket by extending the drainage blanket to the embankment slope surface or other drainage structures.

FIELD DATA

Piezometer data reflect pore-pressure changes associated with embankment construction. Piezometers 1 and 2 (Figure 8) and 4 (Figure 9) reached their respective highest pressures at about the same time, which coincided with completion of the approach embankments. Piezometers 3 and 4 indicated a rise in pressure coinciding with the construction of the approaches for the northbound lanes. Piezometer 3, nearest the northbound approach, indicated the pore-pressure rise sooner than Piezometer 4.

Pressure increases ranged from 3 to 5 feet of water. By the time Piezometers 1 and 2 were vandalized, pressure at those locations had returned to near initial pressures. Piezomteres 3 and 4 functioned until June 1986 and indicated pressures near initial values.

Early settlement data were obtained on the Reinforced Earth wall (southbound lanes) by inspection personnel. This part of the monitoring effort was maintained for only one month. During that month, beginning when the first wall sections were in place and concluding with completion of the backfill, the north wall settled 0.15 foot and the south wall settled 0.41 foot. These monitoring points were for use during construction only and thus were of a

temporary nature. The points were lost when inspection personnel ceased monitoring them.

When the first sections of wall were being placed under the northbound lanes, monitoring points were placed along the length of the wall. Those points would indicate movement of the eastern half of the wall (northbound) and provide follow-up data on the western half of the wall (southbound). Measured settlement of the western half of the wall ranged from 0.35 foot (Point 2) to 0.62 foot (Point 4) approximately 4.7 years after placement of the wall. Total settlement of this portion of the wall could not be determined due to loss of data for the time between construction monitoring and the placement of permanent monitoring points. Settlement data for the western half of the wall are shown in Figure 10.

Settlement of the eastern half of the wall ranged from 0.54 foot (Point 8) to 0.60 foot (Point 5) approximately 3.3 years after placement of the wall. Settlement data for the eastern half of the wall are shown in Figure 11.

Settlement of the south approach of the southbound bridge was monitored by means of profile elevations along the edge of the pavement. Monitoring began in 1986 but initial data were discarded due to suspected bench mark movement. Data from 1987 through 1989 are plotted in Figure 12. Settlement within 60 feet of the bridge is minimal (0.02 foot) and increases up to 0.16 foot at a distance of 160 feet from the bridge.

CONCLUSIONS AND RECOMMENDATIONS

The use of prefabricated vertical wick drains to dewater the foundation and accelerate primary consolidation was apparently successful. Estimates of up to 2.7 months for 90-percent consolidation are generally supported by settlement data. Piezometers installed in the foundation indicate the initial rises in foundation pore pressures coincided with embankment construction and the subsequent drop in pore pressure with completion of embankment. Foundation pore pressure dropped to, or near, initial levels within approximately 4 months after completion of embankment construction.

The construction cost of $21.00 per linear foot of wick drain is higher by a factor of ten than at a nearby site. A part of the reason for high unit cost is the relatively small amount of drain installed. Mobilization would cause the unit cost to be greater for small jobs. Because no other alternatives were considered, no cost effective comparison information is available.

At this particular site, wick drains were effective in reducing the time of consolidation in the foundation. Therefore, wick drains are recommended for future projects having similar conditions.

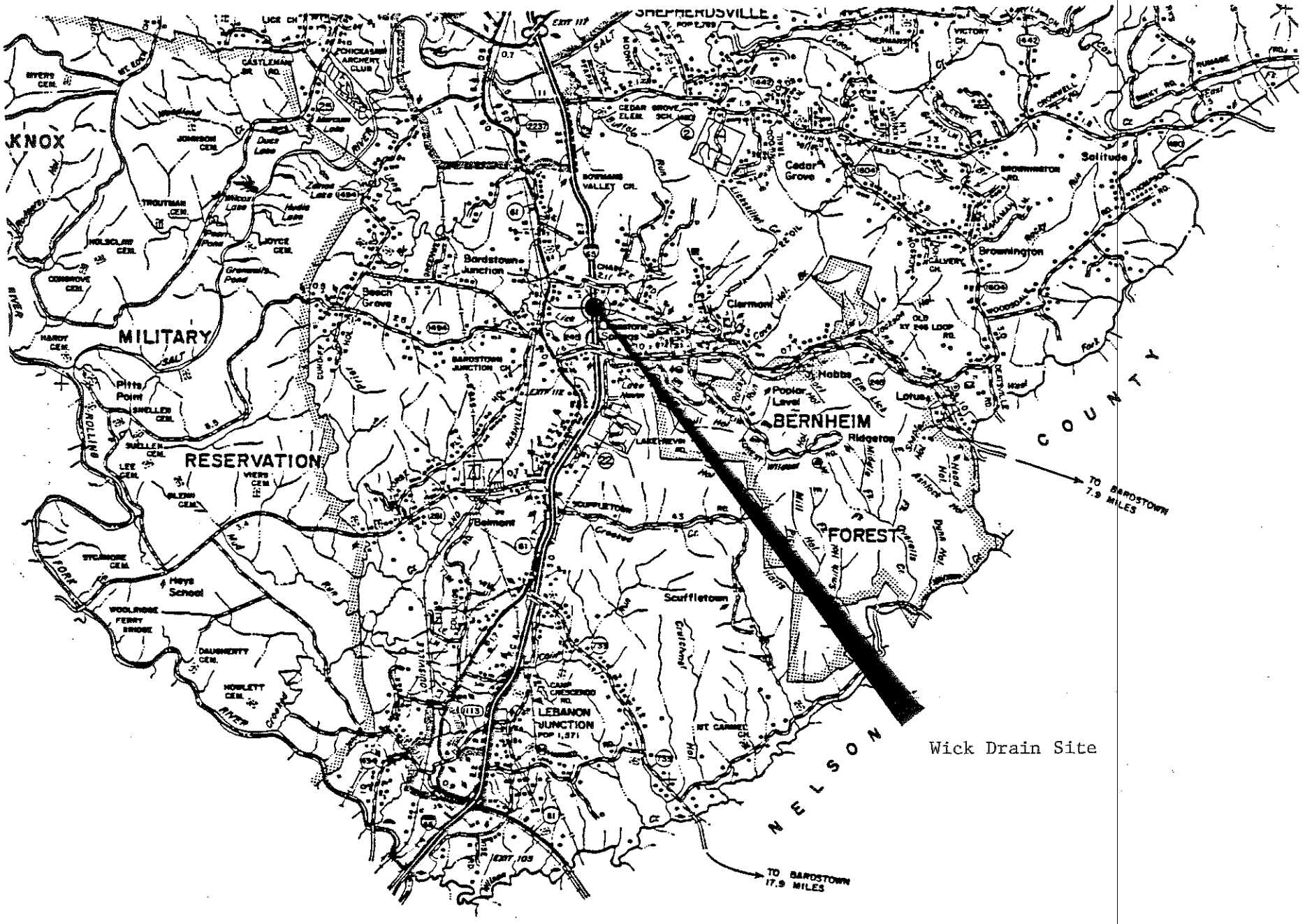

Figure 1. Interstate 65 over Louisville and Nashville Railroad in Bullitt County, Kentucky.

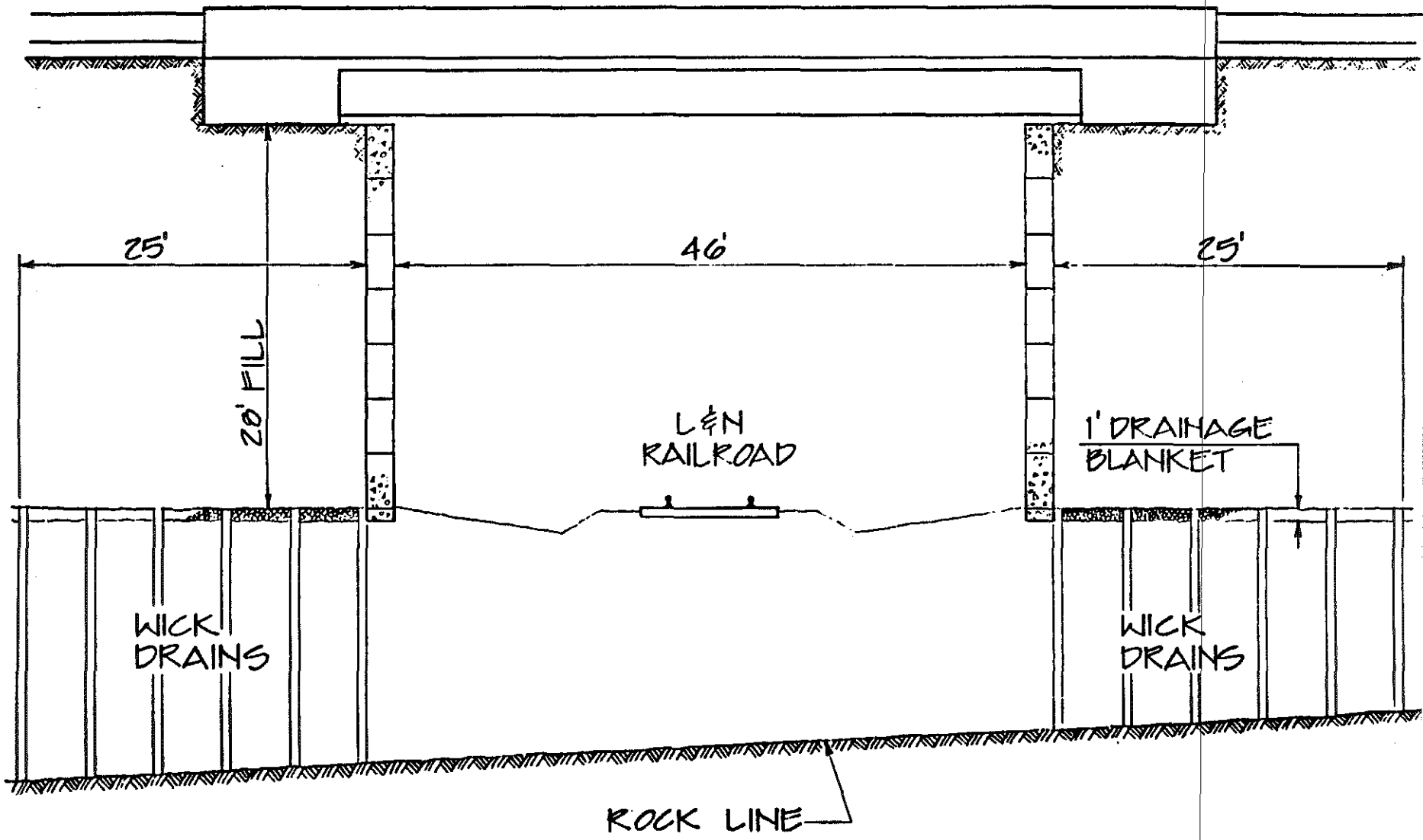

Figure 2. Centerline Section of Site (I 65 over L&N Railroad).

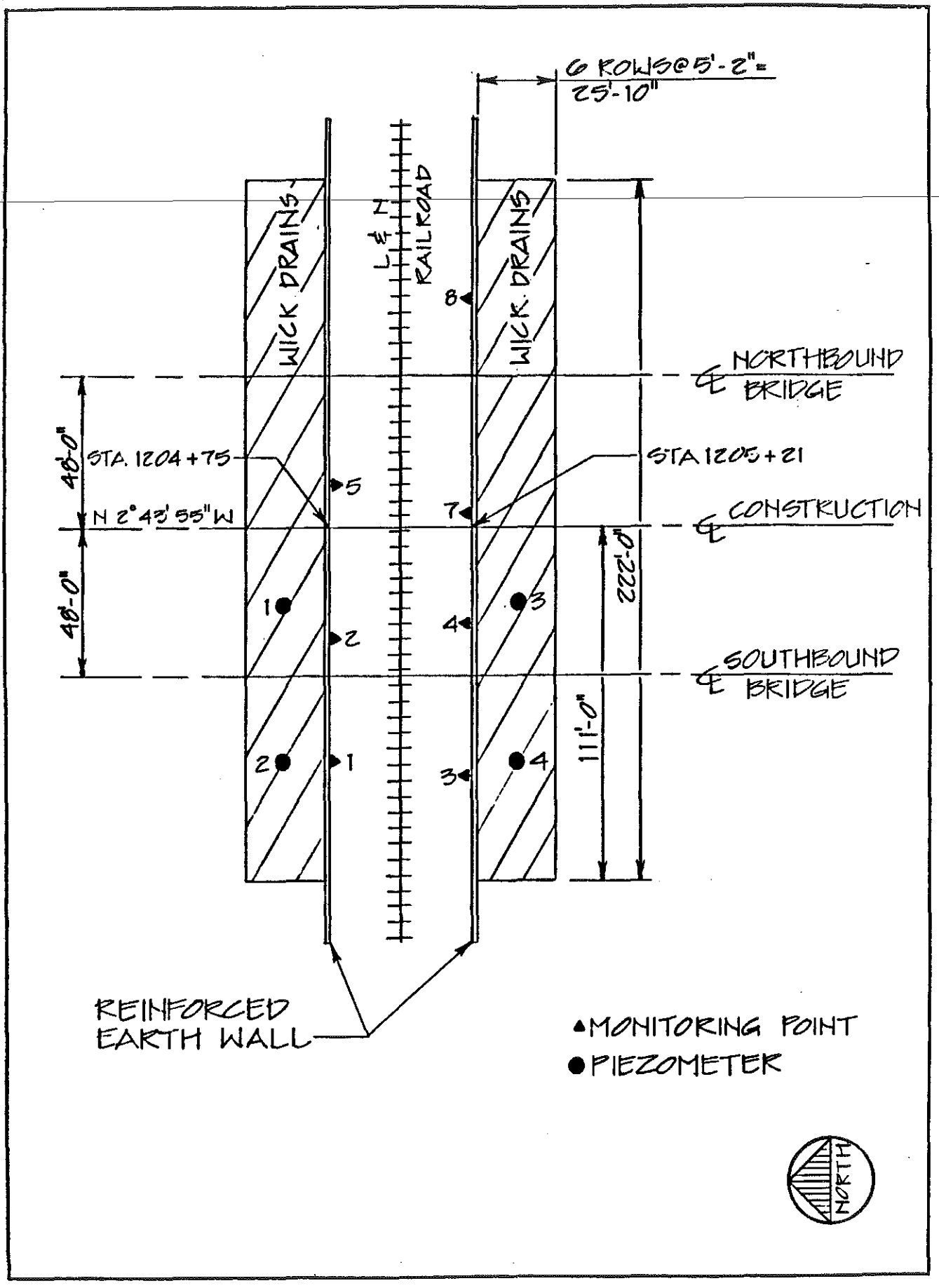

Figure 3. Plan View of Instrumentation Locations.

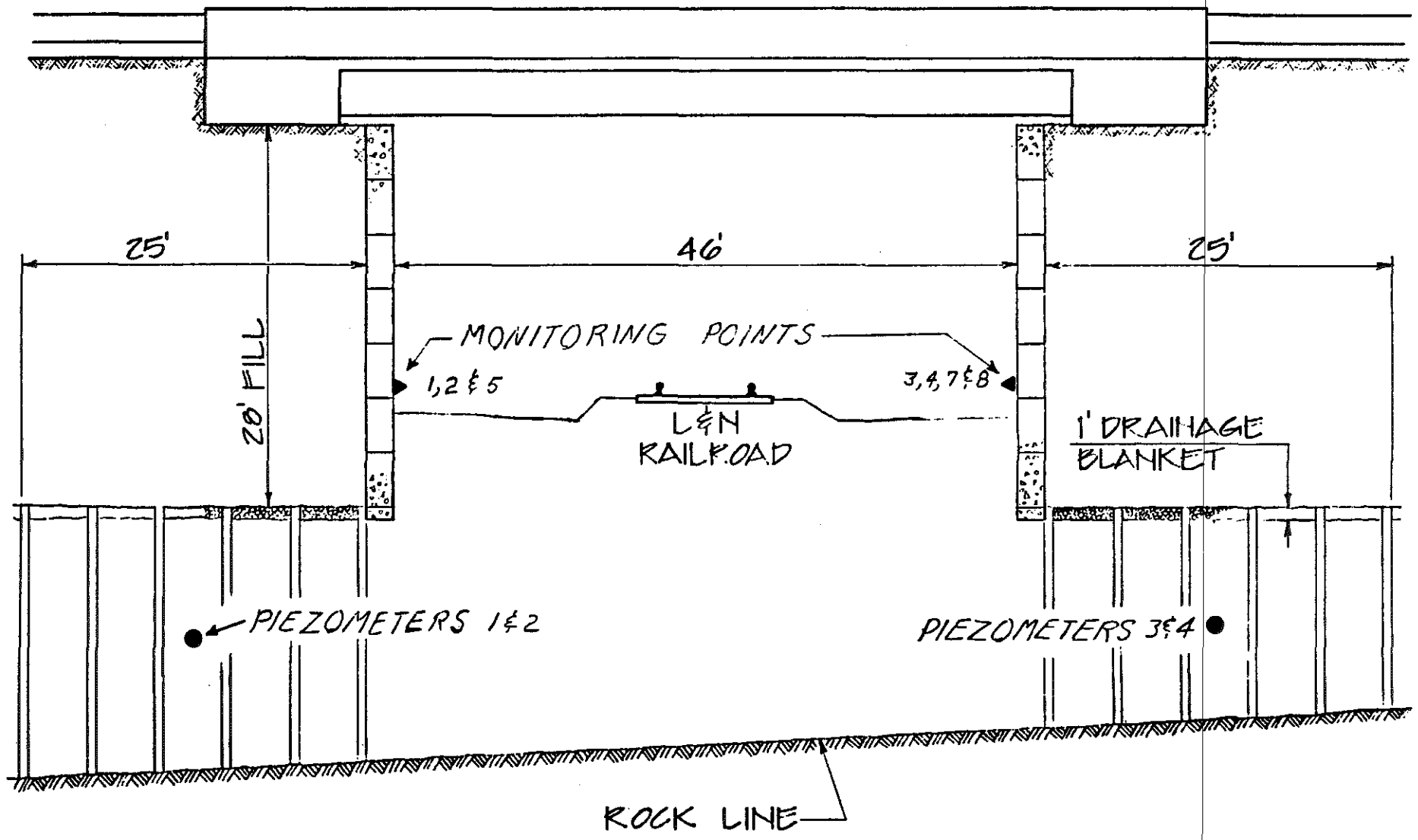

Figure 4. Centerline View of Instrumentation Locations.

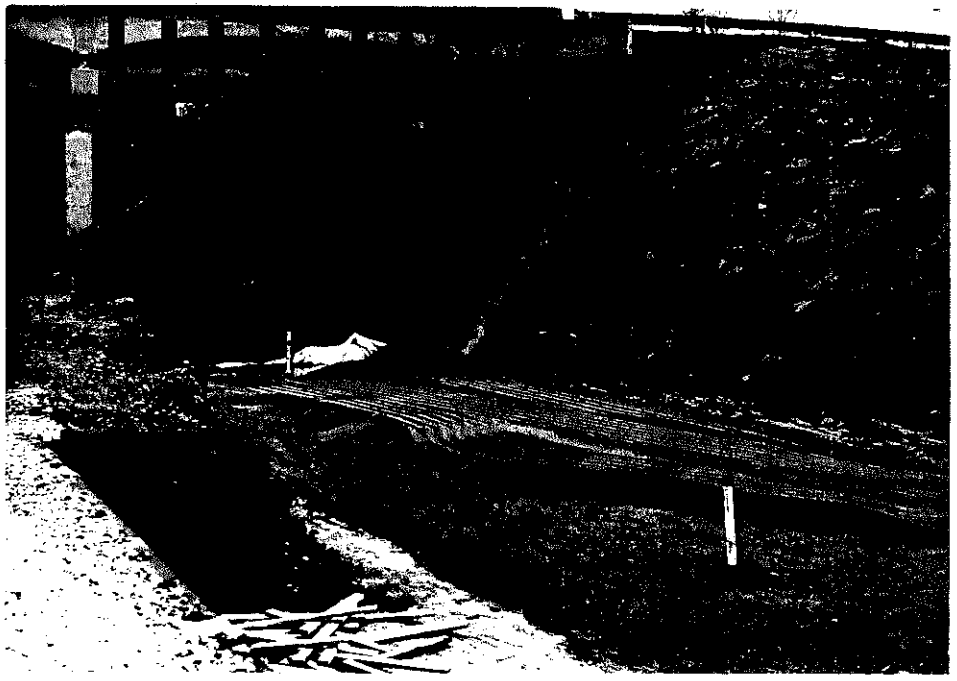

Figure 5. South Approach of Southbound Lanes. Pertinent features include retaining piling at excavation face, geotextile fabric, partially placed drainage blanket, and piezometer locations.

Figure 6. Construction of Reinforced Earth Wall with Supporting Straps in Granular Backfill.

Figure 7 . Completed Structure with Southbound Lanes in Foreground.

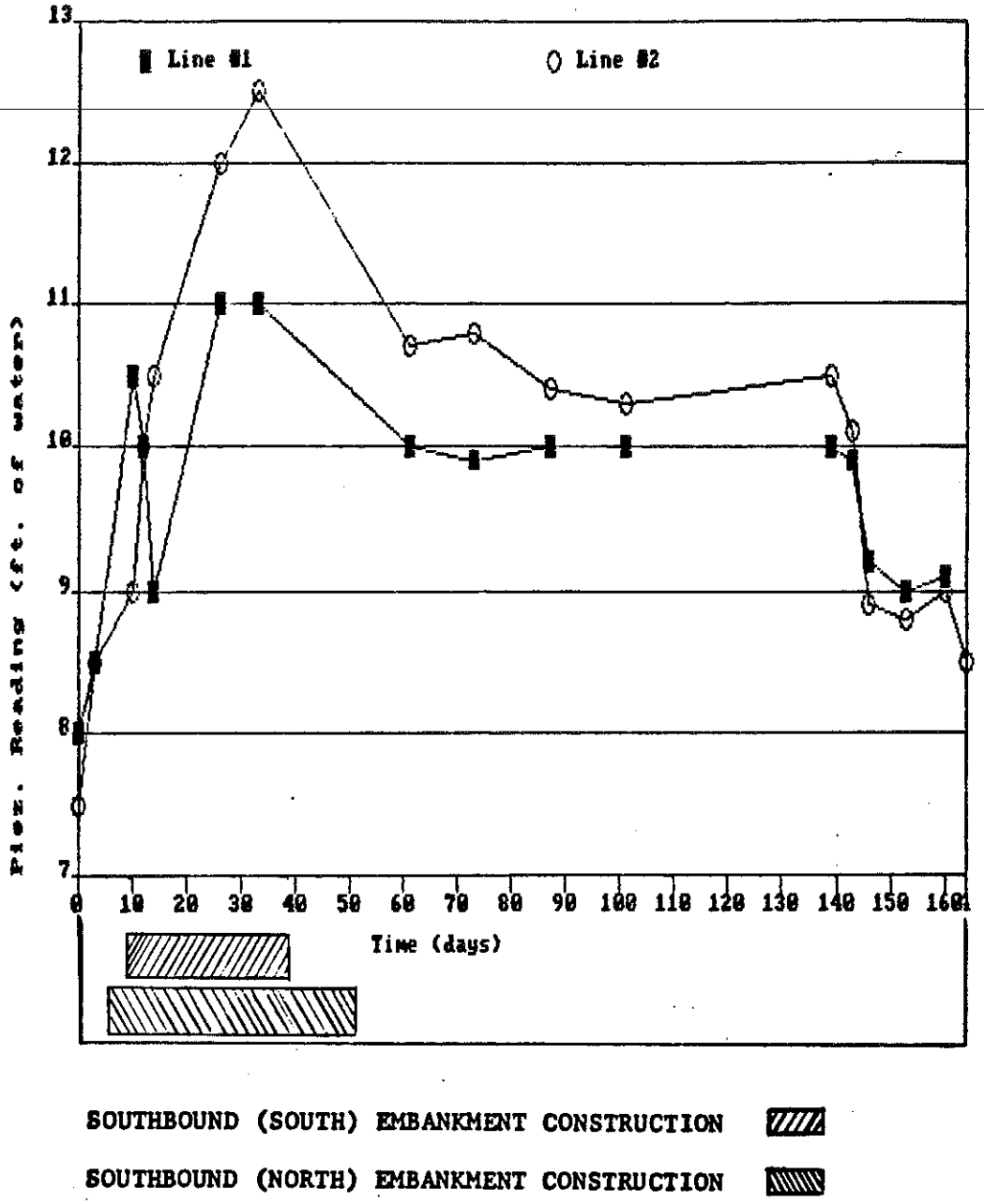

Figure 8. Foundation Pore Pressure -- Piezometers 1 and 2.

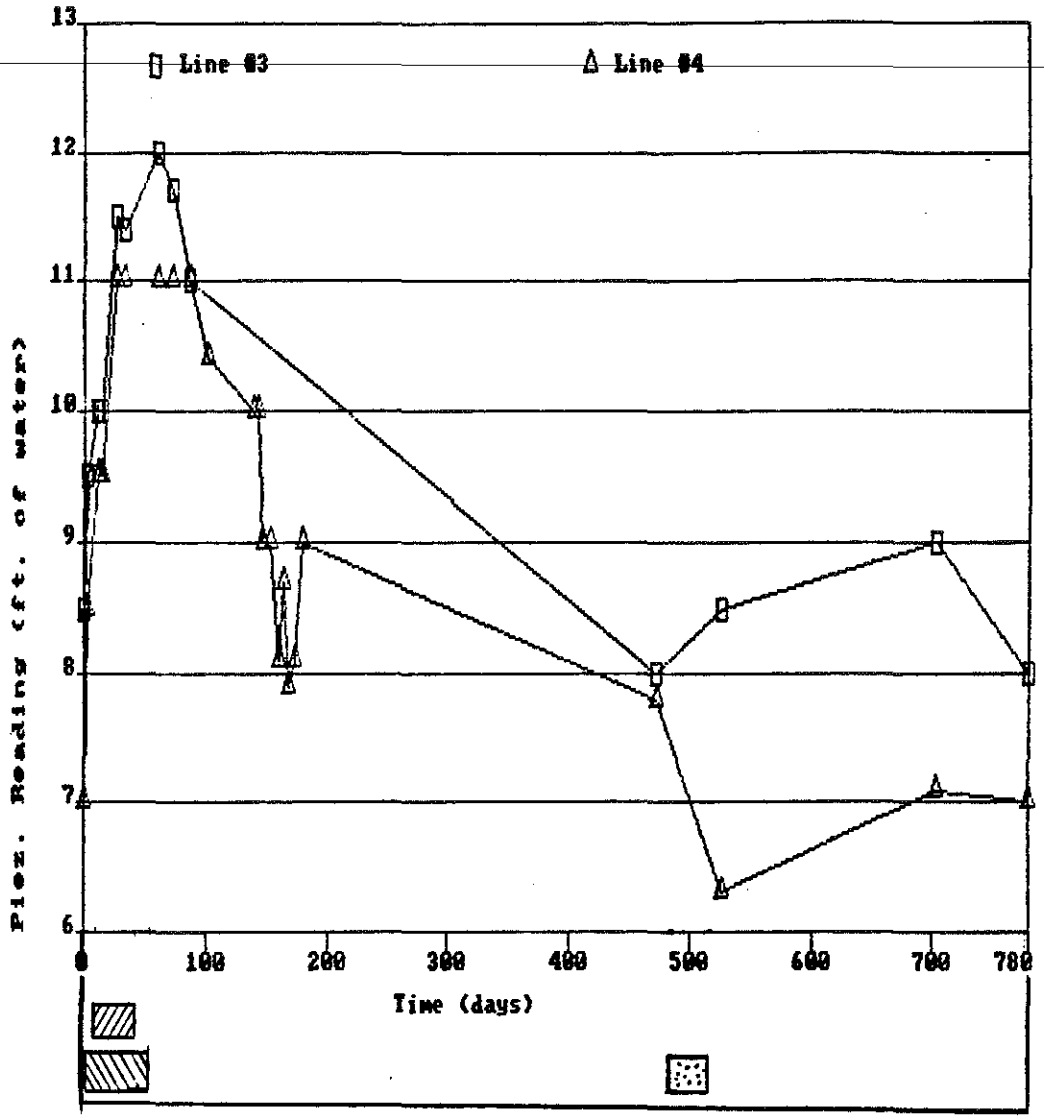

Figure 9. Foundation Pore Pressure — Piezometers 3 and 4.

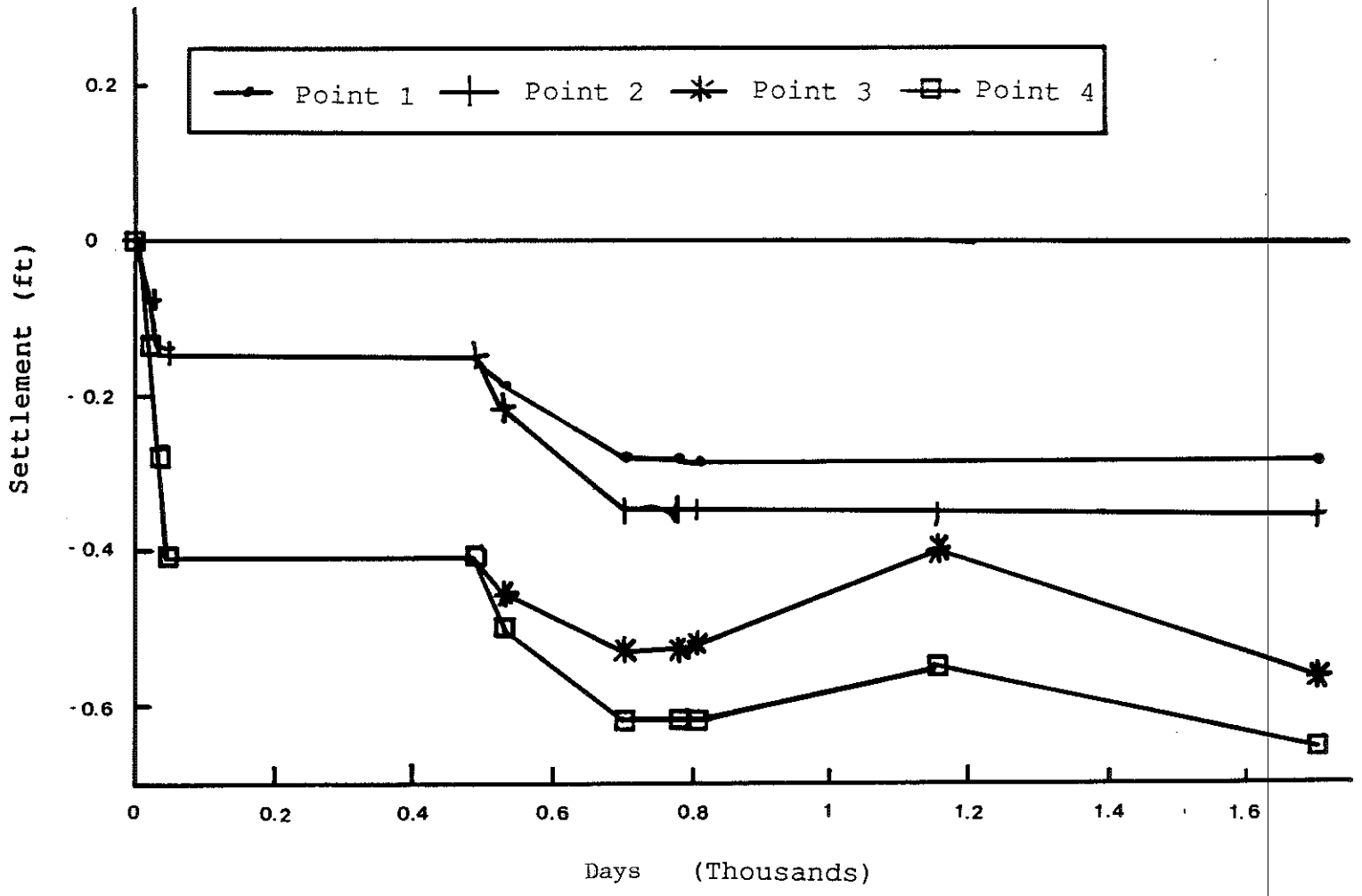

Figure 10. Interstate 65- Reinforced Earth Wall (Southbound)Settlement.

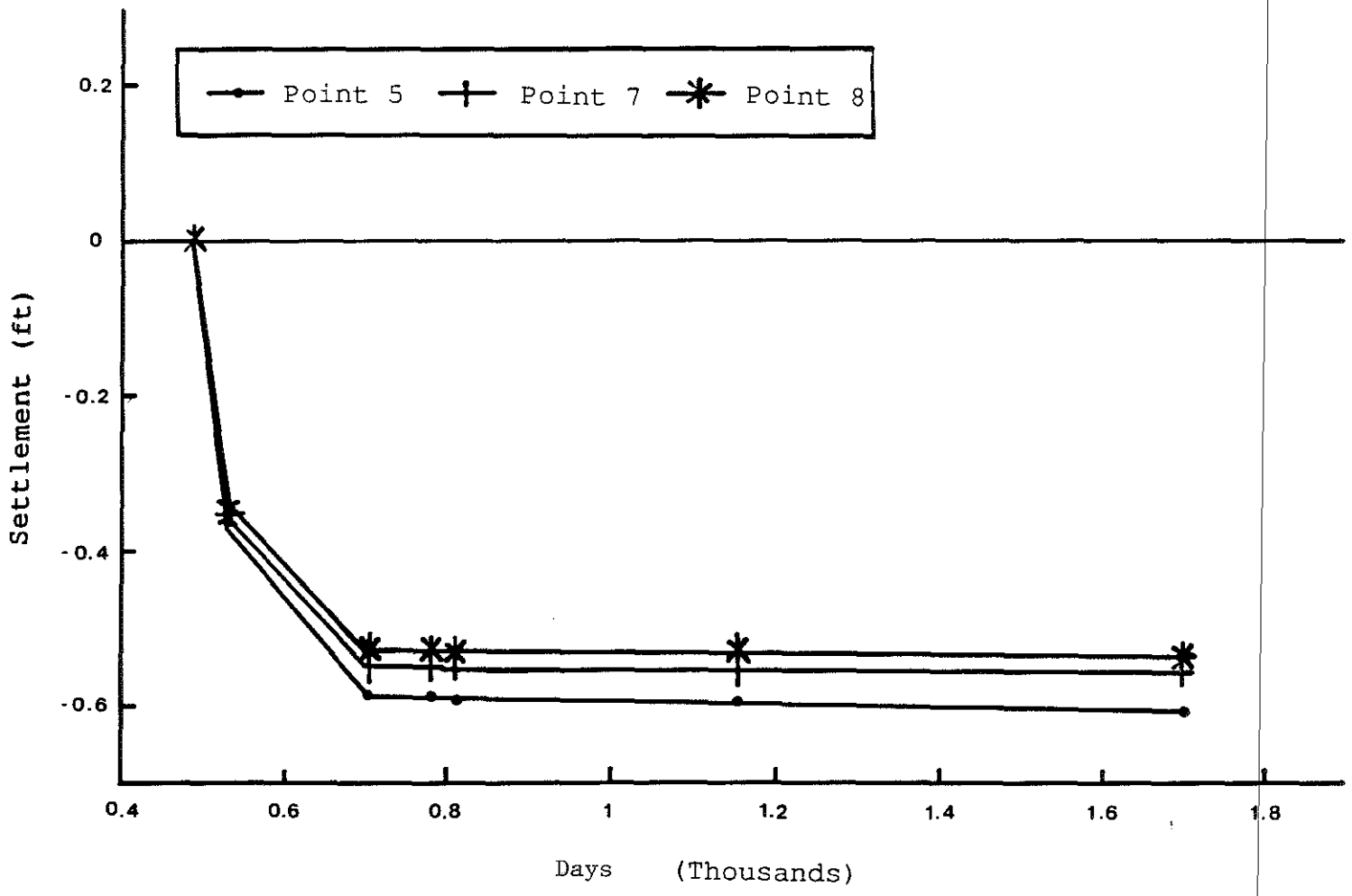

Figure 11. Interstate 65- Reinforced Earth Wall (Northbound) Settlement.

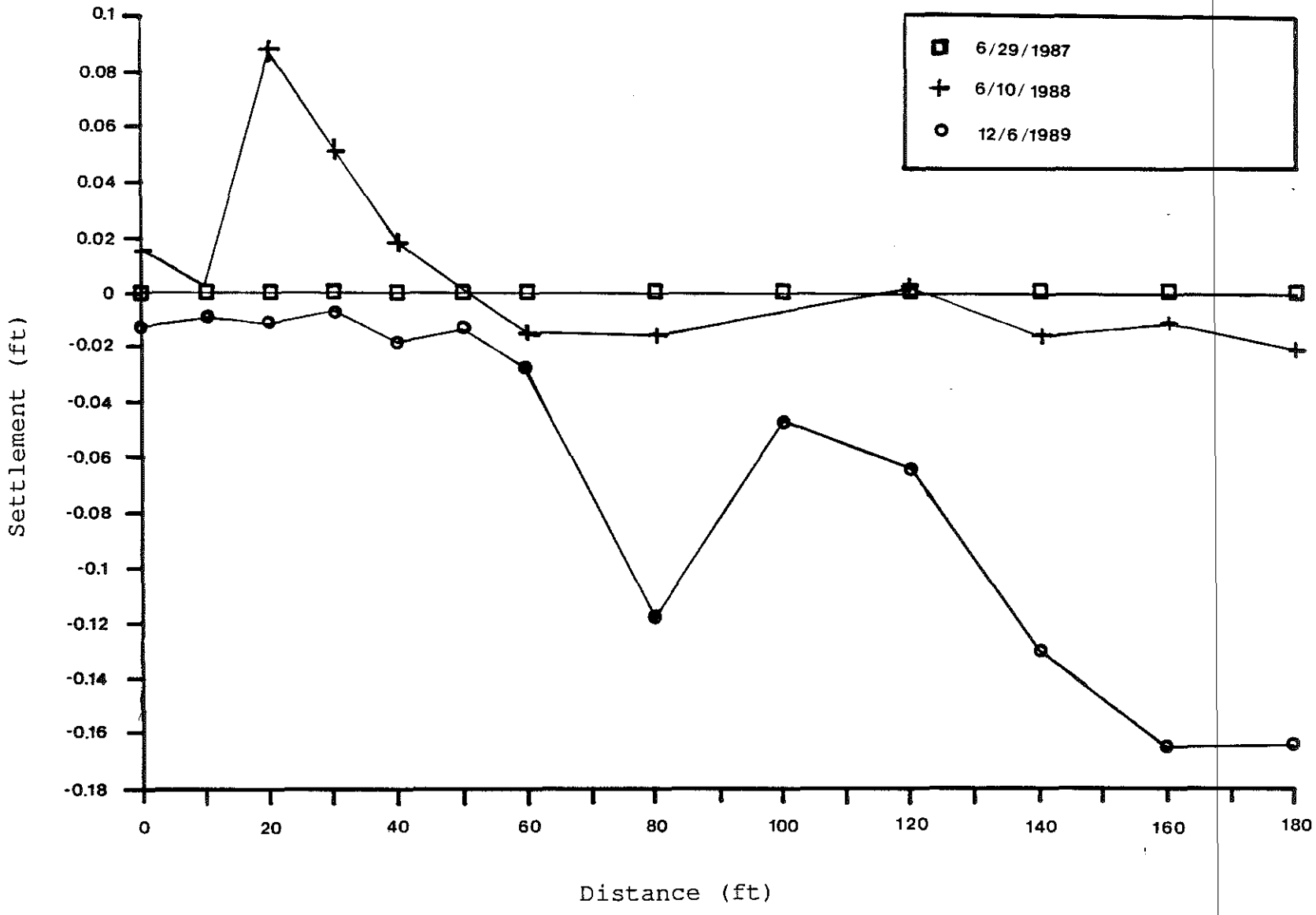

Figure 12. Interstate - 65 (Southbound, South Approach) Pavement Settlement.

APPENDIX A

ALIDRAIN SPECIFICATIONS

burcan INDUSTRIES LTD.

ALIDRAIN SPECIFICATIONS

DRAIN

Width	100 mm
Thickness	7 mm
Free Surface Area	180 mm^2/mm
Free Volume	470 mm^3/mm
Weight (approx.)	165 g/m
1 Roll	140 m
1 Pallet	10 Rolls/235 kg/1.3m^3

CORE

Material	Polyethylene
Type	Studded (both sides), perforated

FILTER

Material	100% Polyester Fibre
Permeability	3×10^{-4} cm/s
Micron Retention	10 - 20 microns

Appendix B

Drainage Blanket Specifications

Memorandum

RECOMMENDATIONS ...

1. Wick drains, in accordance with the Special Note attached to the plans, shall be installed on 6 foot triangular spacing and extending to bedrock in the area of reinforced earth abutments as shown on the attached sketch.

2. Prior to wick drain installation, excavate to 1 foot below bottom of wall and construct a 1 foot thick drainage blanket. Drainage blanket material shall meet the following specifications:

Coarse aggregate, crushed or uncrushed, (including pea gravel), shall meet the quality requirements of Section 805.03 of the 1983 Standard Specifications for Road and Bridge Construction. Gradation shall be uniform and shall meet the following requirements when tested by KM 64-602:

Sieve Size	Percent Passing
4 Inches	100
No. 4	0-75
No. 100	0-4

Natural sand shall have a sand equivalent value not less than 70, and shall meet the following gradation when tested by KM 64-602:

Sieve Size	Percent Passing
3/8 Inch	100
No. 4	75-100
No. 100	0-8

Although any materials meeting these requirements are acceptable, the contractor shall be responsible for furnishing materials that will not affect or impede construction of the wick drains. All soil, mud and other deleterious materials shall be removed from the top of the drainage blanket after wick drain installation and prior to construction of the reinforced earth wall. Any drainage blanket material removed during this operation shall be replaced at no additional cost.

3. Subsurface data indicates some boulders in the area of the existing fill. Preboring in the area of the existing fill may be required for wick drain installation.

4. Geotextile fabric meeting the requirements of Special Provision 39A, Table II, shall be placed between the foundation soil and the drainage blanket.

5. Settlement markers shall be provided on or near the foundation of abutment walls at three or more approximately evenly spaced locations along the walls. The settlement markers shall be monitored during and after construction.

6. The maximum rate of construction for this fill area shall not exceed ten (10) feet per week.

APPENDIX C

WICK DRAIN SPECIAL NOTES

SPECIAL NOTE FOR VERTICAL WICK DRAINS

Description -

This work shall consist of furnishing and placing Prefabricated Vertical Drains at locations shown on the plans or as ordered by the Engineer.

Materials -

The prefabricated drain shall consist of a continuous plastic drainage core wrapped in a non-woven geotextile material. Prefabricated drains used shall be one of the following products:

1. Ali-Drain
2. Amerdrain (Type 407)
3. Colbond (CX-1000)
4. Geodrain
5. Hitek Flowdrain
6. Mebra-Drain
7. SolCompact
8. Vinylex
9. Bando

The above drains shall be accepted based on certification by the manufacturer.

Construction Details -

The prefabricated drain shall be installed within a protective mandrel or sleeve which shall be intruded into the soil and retracted after each drain is installed. The mandrel or sleeve shall have a maximum cross-sectional area of ten (10) square inches.

Prior to the installation of prefabricated drains, the Contractor shall stake out the proposed locations of the drains and then take all reasonable precautions to preserve the stakes. The location of the drains shall not vary by more than six (6) inches from the locations indicated on the plans or as directed by the Engineer. The Contractor shall then demonstrate that his equipment, method and material produce a satisfactory installation in accordance with this specification. For this purpose, the Contractor will be required to install trial drains at locations within the work area designated by the Engineer.

The prefabricated drains shall be installed in a sequence such that equipment will not travel over previously installed drains. Any drains damaged by the Contractor's operations shall be replaced at the Contractor's expense.

The prefabricated drains shall be installed vertical from the working surface to the elevations shown on the plans or as ordered by the Engineer.

The Contractor shall provide the Engineer with a suitable means of verifying plumbness of the equipment and determining the depth of the drain at any time.

Splices or connections of the prefabricated drain material shall be done so as to insure continuity of flow through the prefabricated drain material shall be done so as to insure continuity of flow through the prefabricated drain material as approved by the Engineer. The prefabricated drain material shall be cut such that at least a six (6) inch length protrudes above the working surface at each prefabricated drain location.

It may be necessary to pre-auger or use some other method to clear obstructions and facilitate installation of the drains. The depth to which pre-augering is used shall be subject to approval by the Engineer.

METHOD OF MEASUREMENT -

The quantity of prefabricated drain shall be the number of linear feet satisfactorily installed from the top of the working surface to the design elevation of the tip of the drain.

BASIS OF PAYMENT -

The unit price bid per linear foot shall include the costs of furnishing all equipment, labor and materials to properly install the prefabricated drains. No payment will be made for pre-augering or other methods used to facilitate installation of the drain.

PREFABRICATED VERTICAL DRAIN SOURCES -

Ali-drain	Vibroflotation Foundation Company, United States Steel Bldg., Suite 3993, 600 Grant Street, Pittsburgh, PA 15219 (800) 245-1762
Mebra-drain	L. B. Foster Company, 415 Holiday Drive, Pittsburg, PA 15220 (412) 928-3475
Geodrain	Griffin International, Inc., 100 South Broadway, Irvington, NY 10533 (800) 438-9281
Bando	Harry Fukuzawa & Associates, 6129 Queenridge Drive, Rancho Palos Verdes, CA 90274 (213) 377-4735
Sol Compact	Moretrench American Corporation, P.O. Box 316, Rockaway, NJ 07866 (201) 627-2100
Colbond (CX 1100)	American ENKA Company, Enka, NC 28728 (704) 667-7110
Amerdrain (Type 407)	International Construction Equipment, Inc., Corporate Offices, 301 Warehouse Drive, Matthews, NC 28105 (800) 438-9281
Vinylex	Vinylex Corporation, P.O. Box 7187, Knoxville, TN 37921 (615) 690-2211
Hitek	Vibroflotation Foundation Company, Route 18, Atlasburg, PA 15004 (800) 245-1762