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LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 231026, East Dixfield
Maine

Report No. FHWA-TS-94-23-01

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LTPP Seasonal Monitoring Program

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Section 231026, East Dixfield Maine

Report No. FHWA-TS-94-23-01

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15. Supplementary Notes

The report is a cooperative effort between Maine Department of Transportation Engineering and Technical Services, Long Term Pavement Performance (LTPP) Division Federal Highway Administration, and Pavement Management Systems Limited LTPP North Atlantic Region Coordination Office.

16. Abstract

This report provides a description of the installation of seasonal monitoring instrumentation and initial data collection for the seasonal experimental study conducted as part of the Long Term Pavement Performance (LTPP) program at the General Pavement Study (GPS) section 231026 on US Highway 2 in East Dixfield Maine. This asphalt concrete surface pavement test section was instrumented on September 15, 1993. The instrumentation installed included time domain reflectometry probes for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature, tipping bucket rain gage, piezometer to monitor the ground water table, and an on-site data logger. Initial data collection was performed on September 16, 1993 which consisted of deflection measurements with a Falling Weight Deflectometer, elevation measurements, temperature measurements, TDR measurements, and electrical resistance and resistivity measurements. The report contains a description of the test site and its location, the instruments installed at the site and their locations, characteristics of the installed instruments and probes, problems encountered during installation, specific site circumstances and deviations from the standard guidelines, and a summary of the initial data collection.

17. Key Words	18. Distribution Statement
Instrumentation, Monitoring, Survey, FWD, Profilometer, Time Domain Reflectometry, Thermistor, Piezometer, Electrical Resistance, Electrical Resistivity.	

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I. Introduction

The installation of instrumentation on seasonal site 231026 near East Dixfield Maine was performed on September 15 - September 16, 1993.

The test section is a GPS-1 experiment, located on westbound U. S. Highway 2, on the east limits of East Dixfield, approximately four miles west of Wilton city limits and 20 miles east of Rumford city limits (Figure A-1 in Appendix A). The highway consists of one 3.7m wide lane in each direction with a 2.7m wide paved outside shoulder.

The site is on a slightly elevated grade with an open field on the north side and dense population of trees on the south side. The pavement structure consists of 163mm of asphalt concrete over 447mm of uncrushed gravel base on a coarse sandy material with traces of silt and clay. The depth to bedrock below road surface is more than 7.5m. Pavement structure information from the GPS material drilling logs is presented in Appendix A, Figure A-2. Properties determined from the laboratory material tests are shown in Table 1.

Table A-1 in Appendix A summarizes the distress, IRI values from the Profilometer longitudinal profile measurements, and Falling Weight Deflectometer deflection values as monitored since 1989. The uniformity survey results are summarizes in Table A-2 and the deflection values and analysis results from the FWDCHECK are also presented in Appendix A.

The site is in a wet-freeze zone with a borderline thin AC surface over a coarse subgrade in experimental cell 8 of the seasonal monitoring program. The annual average frost depth is 1.4m and the maximum is 2.0m. This section of pavement is salted on an average of 10 times plus per year for ice control. Below is a summary from the LTPP climate database based on eleven years of data:

Freezing Index (C-Days)	837
Precipitation (mm)	1118
No. of Freeze/Thaw Cycles	115
Days Above 32C	2
Days Below 0C	169
Wet Days	171

The road was opened in 1973. The estimated annual average daily traffic (AADT) in 1982 was 2144 (two way) of which 17% was truck traffic on the GPS lane. The estimated

annual kESALs on the GPS lane in 1989 were 105 and the average number for a period of 18 years is 135 kESALs.

Installation of the instrumentation was a cooperative effort between Maine Department of Transportation, Federal Highway Administration, and Pavement Management Systems Limited (PMSL) LTPP North Atlantic Region Coordination Office staff. The following personnel participated in the instrumentation installation:

Warren Foster	MEDOT
Wilbur Dunphy	MEDOT
Richard Norton	MEDOT
Daniel Ross	MEDOT
Bruce Wilder	MEDOT
Bob Spencer	MEDOT
Paul Gingras	MEDOT
Craig Thompson	MEDOT
Ben Raymond	MEDOT
Brian Davis	MEDOT
Thomas Holbrook	MEDOT
John Klemunes	FHWA LTPP Division
Brandt Henderson	Pavement Management Systems (NARO)
Perry Zabaldo	Pavement Management Systems (NARO)
Mike Zawisa	Pavement Management Systems (NARO)
Doug Marshall	Pavement Management Systems (NARO)

Table 1. Material Properties

Description	Surface	Base	Subgrade
Material (Code)	Dense Graded HMAC (01)	Uncrushed Gravel (302)	Silty Sand (215)
Thickness (mm)	163	447	
Lab Max Dry Density (kg/m^3)		2214	2092
Lab Opt Moisture Content (%)		6.5	9.0
In-situ Wet Density (kg/m^3) *		2371	2039
In-situ Dry Density (kg/m^3) *		2281	1964
In-situ Moisture Content (%) *		3.95	3.85
Bulk Specific Gravity	2.482		
Max Specific Gravity	2.546		
Liquid Limit		0	0
Plastic Limit		0	0
Plasticity Index		NP	NP
% Passing # 200		2.1	11.9

* Note: Test pit @ station 5+60

II. Instrumentation Installation

Site Inspection and Meeting with Highway Agency

This site was one of two sites reviewed for inclusion in the seasonal monitoring program. GPS 231028 near Bethel, ME was reviewed on July 28, 1992. This site was previously instrumented by the Cold Region Research and Engineering Lab (CRREL) during the drilling and sampling of the site during 1989. An asphalt curb and variable shading at the west end (0+00) and a culvert and change in embankment conditions on the east end did not make this an acceptable site.

GPS 231026, near East Dixfield ME, was inspected on August 18, 1992 in conjunction with the FWD uniformity survey. This inspection was done by Doug Marshal (NARO) and Wilbur Dunphy (MEDOT). The FWD uniformity survey indicated the section to be acceptable from a deflection standpoint with the 0+00 end being the most uniform. This end was also preferable from a traffic control perspective as there was better site distance with the west end (5+00) being on a transition of the road curving to the right, along with the close proximity to the junction of state route 17. Pictures providing an overview of site conditions are presented in Appendix E. Discussions with Wilbur Dunphy regarding potential rehabilitation of this site indicated there were no immediate plans, as the traffic was generally low for this section and the pavement was in good condition considering how long it has been open to traffic (1973).

A preliminary planning meeting was held at the Maine State Department of Transportation, Augusta on the morning of July 21, 1993. This meeting was attended by Warren Foster and Wilbur Dunphy of Maine DOT, Bill Phang and Brandt Henderson of Pavement Management Systems, NARO-LTPP. A presentation on the installation of seasonal monitoring instrumentation and monitoring requirements were provided by Bill Phang and Brandt Henderson. This was followed by a review and discussion on the proposed seasonal monitoring site (GPS 231026) near East Dixfield, ME, and the tasks to be done by state resources and material requirements. Although there was a definite desire to go ahead with this project, no firm commitment could be given at this time as the funding for this project would have to be approved. Prior to departing for a visit to the SPS5 project site on I-95 north of Bangor, ME, we met with Theodore Karasopoulos to briefly review the plans for both the seasonal monitoring site and the SPS5. Approval for the installation and monitoring was received on July 27, 1993, contingent on the installation being completed by September 30, 1993. The installation was planned for the week of September 13-17, 1993.

A pre-installation meeting was held on September 14, 1993 at the East Dixfield Division 7 office. Plans for the following day were discussed along with a verification check of the equipment to be used for cutting the asphalt layer for the instrument hole and trench to the equipment cabinet, augering the instrumentation and piezometer hole and the various supplies necessary to complete the installation and patch the pavement. The results of this meeting indicated everything was as expected and we were ready for the installation on September 15, 1993.

Equipment Installed

A permanent bench mark (Elevation 482.822) was installed by the state on the northerly backslope (fence line) of the site near station 1+00. Information on the permanent bench mark is provided in Appendix B.

The equipments installed at the test site included instrumentation for measuring air and subsurface temperature, subsurface moisture content, frost depth, and water table. An equipment cabinet was installed to hold the datalogger, battery pack, and all electrical connections from the instrumentation. Equipments installed are listed in Table 2.

Table 2. Equipment Installed

Equipment	Quantity	Serial Number
Instrumentation Hole		
MRC Thermistor Probe	1	23AT
CRREL Resistivity Probe	1	23AR
TDR Probes	10	23A01-23A10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16550
Campbell Scientific PS12 Power Supply	1	5625
Weather Station		
TE525MM Tipping Bucket Rain Gage	1	12082-693
Campbell Scientific 107-L Air Temperature Probe	1	23AAT
Observation Well/Temporary Bench Mark	1	none
Permanent Bench Mark	1	none

Equipment Check/Calibration

Prior to installation, each measurement instrument was checked or calibrated. The tipping bucket rain gauge was connected to the CR10 datalogger for calibration. A plastic container with 473ml of water was placed in the tipping bucket. The container had a small hole in the bottom, which allowed all the water to be drained out in 45 minutes. For the 473ml of water, the tipping bucket should measure 100 tips $\pm$ 3 tips. The results showed 99 tips, which was in specification.

The air temperature and thermistor probes were connected to the CR10 datalogger simultaneously. They were checked by placing the probes in ice, room temperature, and boiling water. In order for the probes to pass this check, the temperatures for each probe should correspond to the water temperature. The check indicated that the air temperature and thermistor probes were working properly. A second check was done where the air temperature and thermistor probes were connected to the datalogger and run, in air, for 24 hours. The minimum, maximum, and mean temperature for each sensor were checked. All 18 thermistors were similar in their minimum, maximum, and mean readings

respectfully, therefore the probes were considered functioning correctly. The results of the air temperature and thermistor probes along with the spacing between the thermistors are presented in Appendix B.

The wiring of the resistivity probe was checked using continuity measurements between each electrode and the corresponding pins on the connector. The distance between each electrode was measured and recorded as shown in Table B-4 in Appendix B. Contact resistance measurements were performed with the probe immersed in a salt water bath. The results of these measurements are also shown in Appendix B. Due to defects in the manufacturing, clear silicon sealant was used to cover exposed wires to the electrodes. The checks on the resistivity probe indicated all electrodes were functioning.

The functioning of the TDR probes were checked by performing measurements in air, water, methyl alcohol, and with the prongs shorted at the circuit board and the end of the probe. The traces were taken and the dielectric constant was calculated for the water, air, and methyl alcohol. These values were checked against expected dielectric constants for each medium. The test indicated that all probes were functioning properly. Results of the TDR measurements are presented in Appendix B.

Equipment Installation

Final details for the installation and initial monitoring were discussed in a meeting on the afternoon of September 14, 1993. The installation was confirmed for 7:30 a.m. on September 15, 1993. Traffic control was arranged through Bob Spencer, Maintenance supervisor from the Division 7 office in East Dixfield. The pavement surface sawing was done by state personnel through arrangements with Paul Gingras. The augering of the piezometer and instrumentation hole was done by state equipment and drilling crew under the supervision of Bruce Wilder, drilling crew chief. Geotechnical support was provided by Daniel Ross, MEDOT Geologist and sampling of the instrumentation hole materials for moisture content was done by Craig Thompson, MEDOT Engineering Tech III. The installation of the measurement equipment, the observation piezometer, weather station pole, and cabinet was performed by PMSL staff. Assistance was provided by John Klemunes FHWA-LTPP Division, Wilbur Dunphy and Richard Norton from the MEDOT Technical Services group and local division personnel.

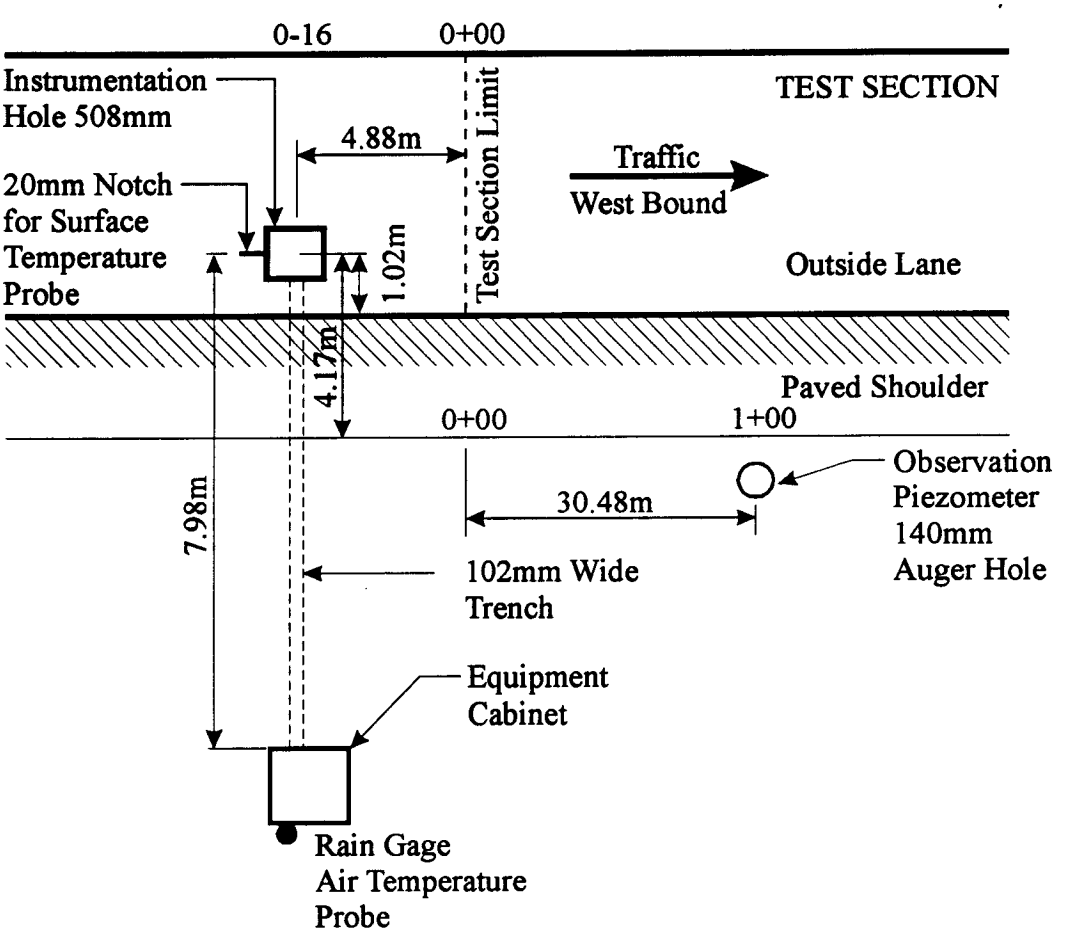
The instrumentation was installed on the east end of GPS 231026, in the eastbound lane of state route 2 on the outskirts of East Dixfield. The combination benchmark/piezometer was placed in the shoulder at station 1+00. The in-pavement instrumentation was installed in the outer wheel path at station 0-16. The cabling from the instrumentation was placed in a 51mm flexible conduit and buried in a trench running from the instrument hole to an equipment cabinet installed on the slope of the roadway embankment, 7.98m from the instrumentation hole. The cabinet was placed close to an open ditch with the instrumentation about 0.75m above the base of the ditch. The weather pole was installed immediately behind the equipment cabinet. Figure 1 provides the location and distances for the various instrumentation and equipment installed.

The installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The combination piezometer/benchmark was installed just off the edge of the paved shoulder to a depth of 4.39m. A 140mm flight auger was used for drilling the hole. A sample of the material was retained from approximately .5 to 1.5m below the surface. The hole was slightly over bored due to material collapsing into the hole. Water was encountered at approximately 3.35m below ground level. The 25.4mm galvanized pipe was firmly pressed into the hole, followed by .75m of filter sand, 1.47m of native soil, a .36m bentonite plug with the remainder of the hole filled with the native material removed. The final elevation for the pipe was 102mm below the natural ground level at the location of the installation. A gate box, held in location by approximately 25kg of set 45 concrete mix, was used to cover and protect the piezometer/benchmark.

A 508mm square hole was cut into the AC surface, located in the outside wheel path, 1.02m from the edge of the travel lane at station 0-16, using a heavy duty portable paving saw. A 20mm notch was cut in the center of the east side of the instrumentation hole to accommodate the stainless steel thermistor probe for measuring the gradient temperature in the AC layer. A 102mm wide saw cut was done between the instrumentation hole and the edge of the paved shoulder to accommodate the instrumentation cabling. This operation went fairly smooth with the exception of a slight slippage of the saw belt. The remainder of the material for the trench was removed with a pick and shovel.

A 300mm flight auger was used to excavate the instrumentation hole. Due to the extensive amount of rocks in the base material it was necessary to loosen the rocks with the point of the auger and remove them either by hand or with a small scoop. At the interface between the base and underlying material, there was a layer of cobbles which had to be pulled loose using hydraulic force from the drill rig and the edge of the auger furrows. Once through this layer the material was removed in approximately 300mm lifts to a depth of 2.0m. Some of the larger stones encountered were broken in the excavation exercise; others were removed from the side wall of the hole. The findings from the excavation of the instrumentation hole at station 0-16 are presented in Figure 2. The material excavated from the instrumentation hole was placed and compacted in order of removal with the exception of that material that could not be replaced/compacted at the side of the instrument hole or due to compaction could not be consolidated to the undisturbed state. This resulted in approximately .0328m^3 (57-68kgs) of material (primarily cobbles) remaining from the installation.

The equipment cabinet and pole for the rain gage and air temperature probe were installed as per manual guidelines. There was some difficulty in excavating the area for the instrumentation cabinet due to a larger boulder that had to be pried loose. This delayed the installation by approximately one hour. The wiring of the instrumentation to the equipment cabinet was completed on the same day as installed.



- Height of Air Temperature Probe (center): 3.10m
- Height of Tipping Bucket Rain Gage (center): 3.02m
- Total Depth of Piezometer: 4.29m
- Distance of Piezometer Below Ground Level: 102mm

Figure 1. Location for Seasonal Monitoring Instrumentation Installed at GPS 231026

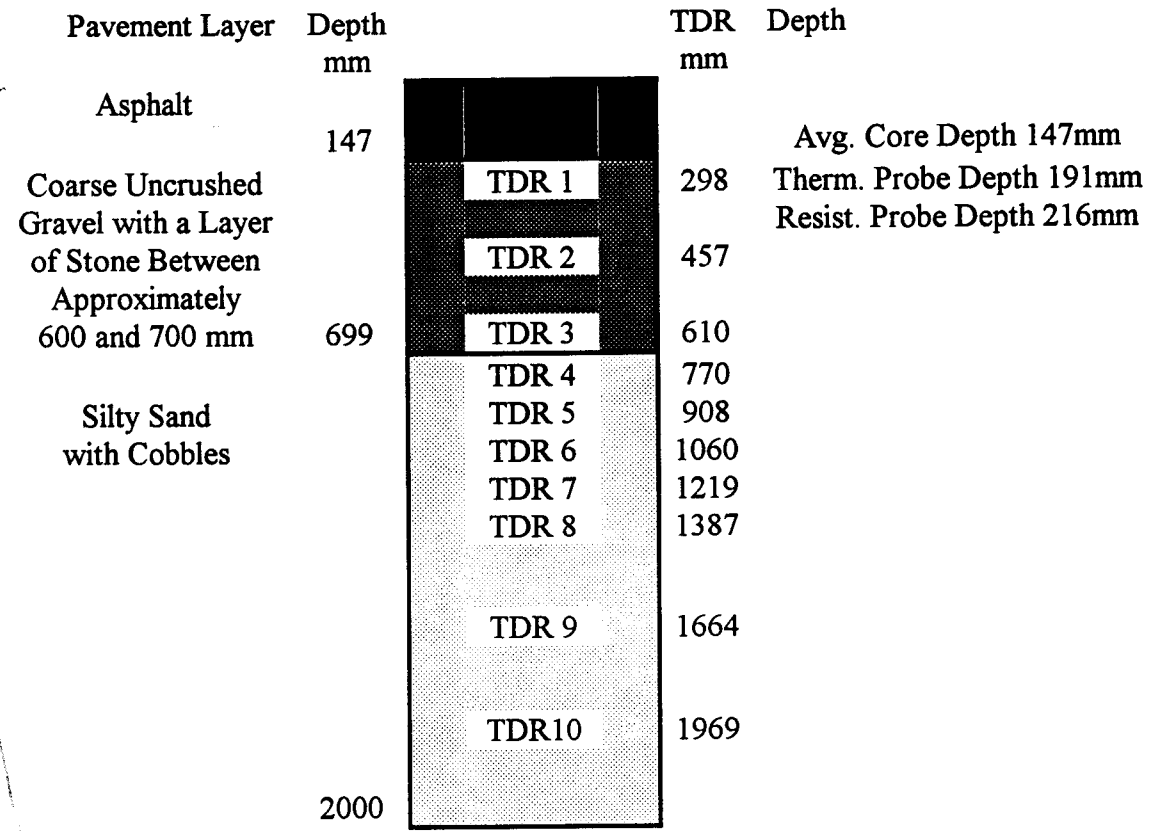


Figure 2. Profile of Pavement Structure and Probe Depths from Surface, Station 0-16

To check for breakage of the TDR probes during installation, each probe was connected to the cable tester and its wave form monitored during compaction of the material around it. The TDR traces are included in Appendix C. By alternating the TDR probes within the instrument hole we were able to keep the cables separate to avoid water from migrating along a bundle of cables attached to the probes placed at various depths. The thermistor and resistivity probes were installed at opposite sides of the instrumentation hole with the thermistor probe .191m and the resistivity probe .216m below the pavement surface. The cables were kept spaced as best as possible until they converged at the opening of the flexible conduit pipe, placed about 50mm from the edge of the core hole. The cables were then tie wrapped and passed through the conduit to the equipment cabinet. The ends of the conduit were plugged with a mastic pipe sealant.

A comparison of the moisture contents from the TDR traces, field and laboratory moisture determination indicate slightly higher moisture content values for the TDR method, especially for the base material. This could be due to the large concentration of rock in or near the probes which may not be tightly covered by material. More accurate moisture readings are generally obtained from probes in full contact with the soil material. The calculation of moisture content from TDR method is also dependent on the calibration inputs for the TDR model.

Tables 3, 4, and 5 present the installed depths of the TDR probes, thermistor sensors, and the resistivity probe respectively. Table 6 gives TDR moisture content, field moisture content, and laboratory moisture content during installation.

Table 3. Installed Depths of TDR Sensors

Sensor #	Depth from Pavement Surface (m)	Layer
23A01	0.298	Base
23A02	0.457	
23A03	0.610	
23A04	0.770	Subgrade
23A05	0.908	
23A06	1.060	
23A07	1.219	
23A08	1.387	
23A09	1.664	
23A10	1.969	

Table 4. Installed Location of MRC Thermistor Sensor

Unit	Channel Number	Depth from Pavement Surface (m)	Remarks
1	1	0.025	This unit was installed in the AC layer.
	2	0.074	
	3	0.122	
2	4	0.211	This unit was installed below the AC layer into the subgrade.
	5	0.289	
	6	0.360	
	7	0.437	
	8	0.511	
	9	0.664	
	10	0.818	
	11	0.968	
	12	1.124	
	13	1.276	
	14	1.427	
	15	1.580	
	16	1.732	
	17	1.883	
	18	2.037	

Table 5. Location of Electrodes of the Resistivity Probe

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
36	1	0.247
35	2	0.293
34	3	0.344
33	4	0.396
32	5	0.449
31	6	0.500
30	7	0.550
29	8	0.602
28	9	0.654
27	10	0.705
26	11	0.756
25	12	0.807
24	13	0.858
23	14	0.909
22	15	0.960
21	16	1.010
20	17	1.060
19	18	1.110
18	19	1.161
17	20	1.212
16	21	1.263
15	22	1.314
14	23	1.365
13	24	1.415
12	25	1.466
11	26	1.517
10	27	1.570
9	28	1.620
8	29	1.671
7	30	1.722
6	31	1.771
5	32	1.821
4	33	1.873
3	34	1.925
2	35	1.974
1	36	2.027

Table 6. TDR, Field, and Laboratory Moisture Content During Installation

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt)*	Field Moisture Content (by wt)*	Lab Moisture Content (by wt)*
23A01	0.298	Base	6.84%	NONE**	4.40%
23A02	0.457		7.11%	3.80%	3.90%
23A03	0.610		7.01%	4.80%	3.50%
23A04	0.770	Subgrade	10.75%	4.34%	4.20%
23A05	0.908		7.93%	9.84%	8.70%
23A06	1.060		10.75%	9.62%	7.60%
23A07	1.219		10.75%	9.03%	7.00%
23A08	1.387		10.11%	8.51%	8.20%
23A09	1.664		11.69%	9.87%	9.40%
23A10	1.969		9.80%	10.37%	9.60%

* Note: Raw data given in Appendix C

** Note: The soil for this sensor was too rocky to measure.

Site Repair and Cleanup

The instrumentation hole was repaired by reinstalling the 500mm square asphalt block. Some juggling was required to get the block level with the existing pavement surface. Once the block was leveled it was removed from the hole and the bottom 100mm was heavily covered with a two part epoxy (PC-7) and reset into the hole forcing the epoxy against the side and up along the wall of the core hole. The weight of the state dump truck, which slowly moved back and forth over the block, was used to firmly seat the block into the hole.

The trench for the cabling from the instrumentation hole to the edge of pavement was leveled with crushed gravel to the existing bottom of the paved layer and a cold mix was compacted to the level of the existing surface. The remainder of the trench was filled with a combination of gravel and native material and compacted, followed by a cleanup of loose material from paved area. Traffic control was removed at 6:00 p.m. and the lane reopened to traffic. During the next day the instrument hole and edge of the trench were sealed using Corning self-leveling 888 crack sealing compound. Removal of the asphalt trench material and other disposable items were handled by the MEDOT division personnel.

Patch/Repair Area Assessment

When the site was visited on November 10 and December 17, 1993 two to three months after installation, the instrumentation hole patch was checked and photos were taken as shown in Appendix E. There was minor settlement in the patched areas and the sealant did not hold properly.

III. Initial Data Collection

The second day activities included initial data collection on the site and checks on functioning of installed equipment. This consisted of examination of the data collected over the day by the onsite datalogger, data collection and check of the mobile CR10 datalogger, deflection testing, and elevation survey.

Air Temperature, Subsurface Temperature, Rain-fall Data

The air temperature, pavement subsurface temperature profile, and rainfall data, collected on September 16 by the CR10 datalogger, were examined. The equipment and datalogger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. Raw data collected at the site are presented in Appendix D. Figure D-1 shows the air temperature data collected from 12:51 (September 16) through 14:01 (September 16). Figure D-2 shows the first set of subsurface temperature for the first 5 sensors. Figure D-3 shows the first set of subsurface temperature for all 18 sensors. There was no precipitation that day. All these results indicated that the onsite CR10 datalogger and measurement equipment were working. Only 70 minutes of data were taken to check for the functioning of the sensors, not to be analyzed at a later time.

The tipping bucket rain gauge was checked by determining the number of tips recorded from 473ml of water discharged into the gauge over a one hour time period. The rain gauge was found to be operating properly.

TDR Measurements

TDR data were collected using the mobile system provided by FHWA. The mobile system contains a CR10 datalogger, battery pack, two TDR multiplexers, and a resistance multiplexer circuit board. Version 1.0 of the MOBILE program was used to collect and record the TDR wave form traced for each sensor. Figures D-4 and D-5 show the initial TDR wave form traces collected with the MOBILE data acquisition system for all 10 sensors. The figures indicate that the multiplexers of the mobile system and TDR sensors were working properly.

Resistance Measurement Data

Resistance data were collected in two modes, automated and manual. The MOBILE data acquisition system automatically performs two point contact resistance measurements and stores the values in terms of millivolts between adjacent electrodes. Figure D-6 shows pavement depth versus measured voltage produced by the MOBILE system.

Manual contact resistance and resistivity measurements were performed using a Simpson Model 420d function generator, a Fluke and a Hewlett Packard digital multimeter and a manual circuit board. The measured contact resistance data are plotted in Figure D-7 and

in Figure D-8 for the 4-point resistivity. Tables D-2 and D-3 in Appendix D show the raw data for the 2-point and the 4-point resistance respectively.

Comparison between Figure D-6 (contact resistance results from automated mode) and Figure D-7 (contact resistance results from manual mode) indicates that there was a problem with either the mobile system or the manual test setup. By the data collected from a previous site, it indicated that the problem was probably in the multimeters, not the mobile system. Figure D-8 (4-point resistance results from manual mode) indicates that the 4-point test setup was probably not working correctly either. This could be due to problems with the test circuit board or the multimeters. If the reading equipment is working correctly, all the resistance/resistivity outputs will have similar shapes, although the values will be somewhat different based on the energy applied and distance between sampled electrodes.

Deflection Measurement Data

Deflection measurements followed procedures described in the Guidelines. The analysis results from the FWDCHECK program from the day of installation and the following day are presented in Appendix D. Since then, seven more measurements have been collected with the FWD, the first on November 10, 1993, then January 10, February 28, March 24, April 11, May 2, and the seventh on May 23, 1994.

Longitudinal Profile Data

According to the guidelines, since this is in a frost area, the survey should be performed on five different occasions; one survey during the middle of each season and one survey during the late winter period (fully frozen condition). Two surveys have already been performed on this site, the first during the fully frozen condition, February 19, and the second during the spring season, April 11, 1994.

Elevation Surveys

One set of the surface elevation survey was performed following the guidelines. It was assumed that the elevation at the top of the piezometer pipe was 1.000 meters. The survey was conducted on September 16, 1993, the day after the installation, and the results are presented in Appendix D. Since then, four more sets of the surface elevation surveys were performed, on January 10, February 7, February 28, and on April 11, 1994.

Water Depth

During drilling of the piezometer test hole, water was encountered at approximately 3.35m below ground level. A check on the piezometer on the following day indicated the water level to be slightly higher at 3.0m. As there was significant disturbance from the drilling and installation, some time will be required before the water level in the piezometer stabilizes with the surrounding conditions.

IV. Summary

The installation of the seasonal monitoring instrumentation at the GPS site 231026 on state route 2 near East Dixfield and state route 17, was completed on September 15, 1993. A check of the equipment and initial data collection was completed on September 16, 1993. The instrumentation, permanently installed at the site, were:

- Time domain reflectometer probes for moisture measurements
- Electric resistivity probes for frost location
- Thermistor probes for soil gradient temperature measurements
- Air temperature thermistor probe and tipping bucket rain gage to record local climatic conditions, and
- Combination piezometer (well) and bench mark to determine changes in water level and pavement elevations.
- Permanent bench mark installed by the state

The pavement gradient temperature and local climatic data are to have continuous data collection stored in an on-site datalogger. The moisture and electrical resistivity are to be collected during each site visit (14 times per year) using a mobile datalogger system. The water level and elevation data are to be collected manually during site visits.

The test section is on eastbound route 2, approximately 4 miles west of Wilton city limits and 20 miles east of Rumford, ME. The section is on a two lane road consisting of 3.7m wide travel lanes with 2.7m paved shoulders. The pavement structure consists of 147mm of asphalt concrete over 552mm of coarse gravel base on a silty sand material with cobbles as evident from the material log at the instrumentation hole. Although somewhat similar to the drilling and sampling logs, there are some variations in thickness and material description. The slightly raised grade may consist of a fill material with some similarities to the native material. The hole augered for the piezometer/bench mark revealed a slightly darker brown sandy loam as progressed with depth. Changes in material, if any, were not recorded in detail.

All instrumentation was checked prior to installation at the PMSL facility in Amherst, NY. These initial checks indicated that the instrumentation was within specifications, as required for the seasonal monitoring program. Operational checks during installation and the following day indicated that all instrumentation was functioning properly. The manual resistivity checks did not provide expected results; this could be due to a number of factors. The switching box was a proto type for which we were experiencing some switching problems, and the Hewlett Packard multimeter was questionable when set to read amperage. Improvements in equipment and procedures are required to ensure reliable results for this test.

Although the installation generally went as expected and all instrumentation was in working order at the completion, a few problems were encountered, in particular, with removal/replacement of material from the instrument hole and excavation of material for

placement of the equipment cabinet. The large rocks and cobbles made it extremely difficult to progress smoothly through the base and underlying material and made for a variable diameter instrument hole. The placement of the TDR sensors required some selectivity in terms of location and materials compacted around the probes to avoid damaging the probes and ensuring a good contact with the material. Due to the large quantities of stone in the base material, we may have ended up with some voids around the probe location. We were also left with a nearly full 19 liter pail of mainly gravel and cobbles from the instrument hole. Most probably we were able to compact most of the material input into the instrument hole to a level consistent with the existing, although there are potential voids on the side wall of the hole as it is questionable we were able to obtain sufficient side compaction to fill these voids. Also in replacing the layer of rock at the bottom of the base layer, they may not have been replaced as tightly bound as the existing material. Only time will tell if we are going to have some consolidation and settlement in the area of the instrument hole. Additional time was required to remove a large boulder residing at the location of the equipment cabinet. This was accomplished with the assistance of the MEDOT drilling crew. Overall the installation went as expected with only a few delays.

The ongoing monitoring of this section, except for the problems encountered due to weather and technical difficulties with the FWD, has gone fairly well. Traffic control has been available at 7:30 in the morning and for the most part, full days of testing have been the norm.

APPENDIX A

Test Section Background Information

Appendix A contains the following supporting information:

Figure A-1	Site Location Map
Figure A-2	Profile of Pavement Structure
Table A-1	Site Performance Summary
Table A-2	Uniformity Survey Results
Figure A-3	Deflection Profiles from FWDCHECK (Test Date August 18, 1992)
Table A-3	Subgrade Modulus and Structural Number from FWDCHECK (Test Date August 18, 1992)

shrp

FHWA–LTPP MAINE TEST SITE LOCATIONS
GPS–SPS PAVEMENT STUDIES

PMS™ PAVEMENT MANAGEMENT SYSTEMS LIMITED

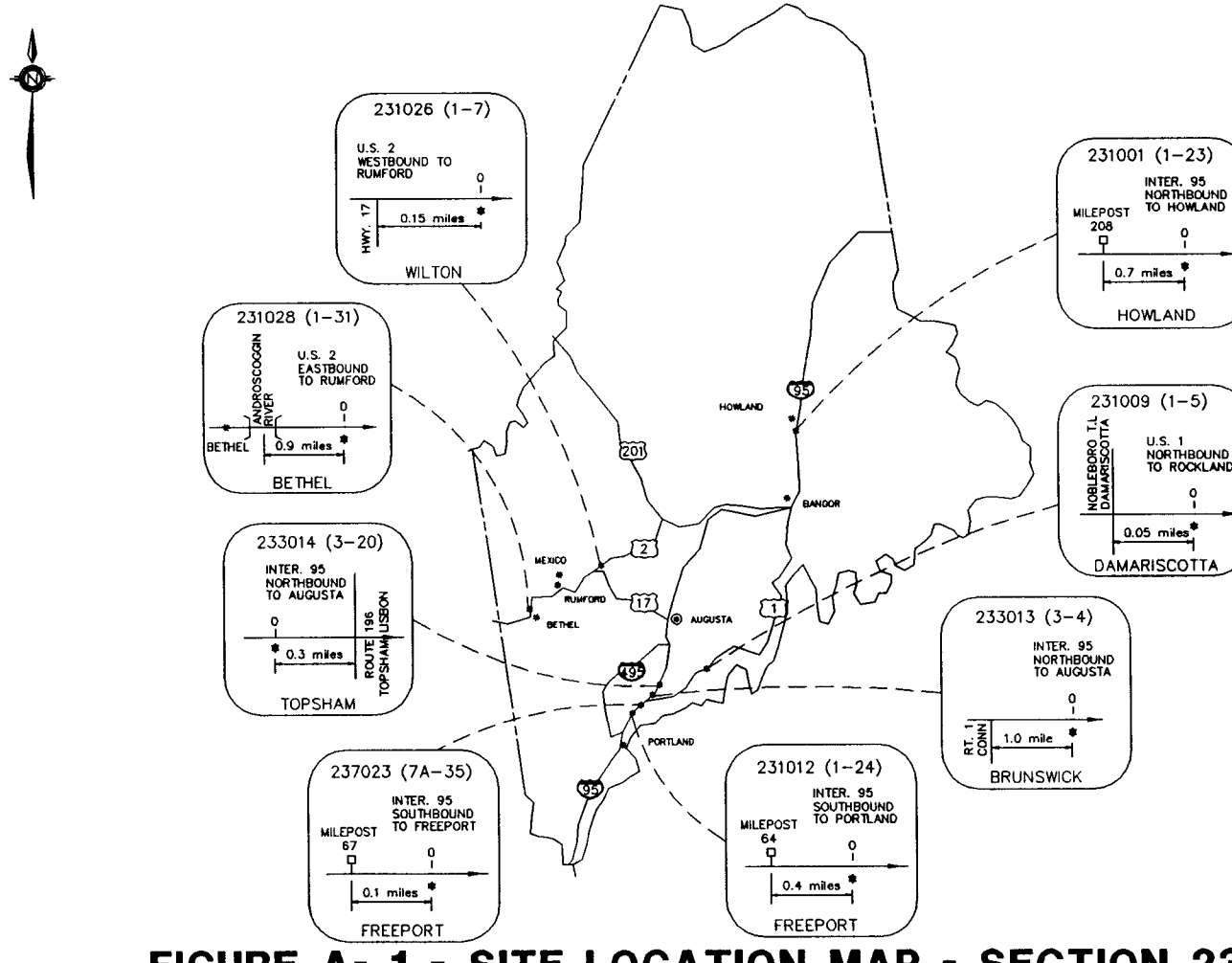


FIGURE A- 1 - SITE LOCATION MAP - SECTION 231026

MAINE

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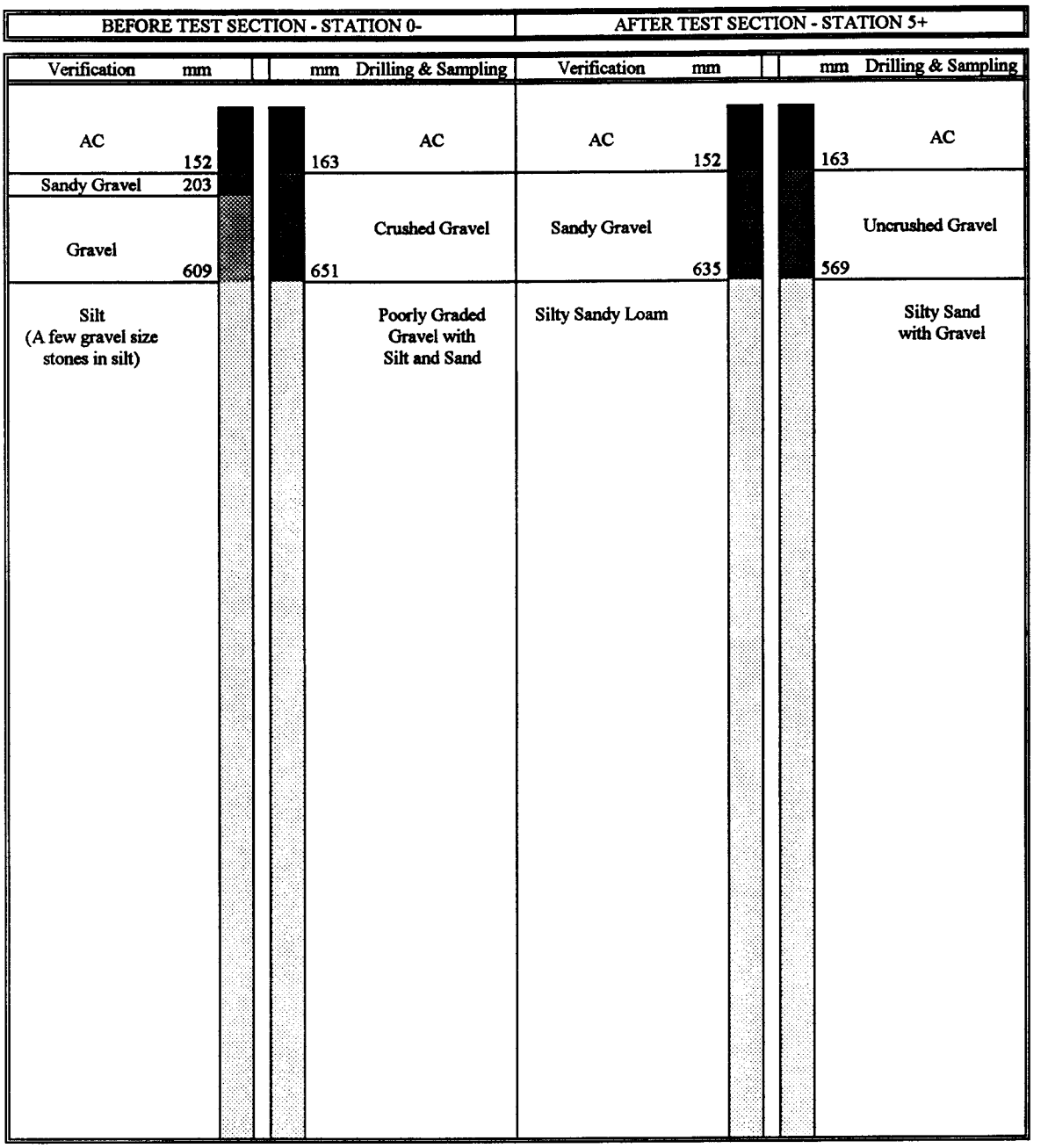


Figure A-2. Profile of Pavement Structure

Table A-1. Site Performance Summary

Distress and Profile Summary		
Distress Summary 1990	Profile Summary	
	Date (mm-dd-yy)	IRI (in/mi)
Mod. Sev. Trans. Cracks - 1 @ 13.32 ft.	10-19-89	89.85
Low Sev. Trans. Cracks - 6 @ 28.69 ft.	10-05-90	95.13
	08-16-91	85.54
	09-26-92	86.08
	09-17-93	91.77

Falling Weight Deflectometer Data Summary						
Date	Mean Value for Drop HT 2 (mils)					
	Sensor 1	Sensor 1 std. dev.	Sensor 7	Sensor 7 std. dev.	Mean Temp D1 (F)	Min/Max TempD1(F)
07-06-89	9.35	0.59	1.03	0.07	85	81/90
08-18-92	9.02	0.49	1.20	0.11	68	68/68

	Effective SN	SN std dev	Subgrade Modulus (psi)	Modulus std dev (psi)	Test Pit Mod. (psi)	
					1	2
07-06-89	5.70 6.00	0.16 0.04	38577 36665	2968 809	35998	36885
08-18-92	5.63	0.18	32897	2903	-	-

Table A-2. Uniformity Survey Results

Seasonal Uniformity Survey	Falling Weight Deflectometer Data Collection and Processing Summary
Site Number: 231026	
Date Surveyed: August 18, 1992	

Section Interval (ft)	Mean Deflection Values for HT 2 (mils) - Corrected							
	Sensor 1	Sensor 1 std dev	Sensor 7	Sensor 7 std dev	Subg modulus (psi)	Subg modulus std dev	Effective SN	SN std dev
-100 to 0	9.24	0.49	0.94	0.10	32191	6379	5.59	0.12
0 to 250	9.10	0.37	1.16	0.11	33992	2989	5.58	0.14
250 to 500	8.96	0.58	1.24	0.10	31901	2553	5.68	0.20
500 to 600	9.36	1.13	1.30	0.09	28401	4300	5.68	0.25

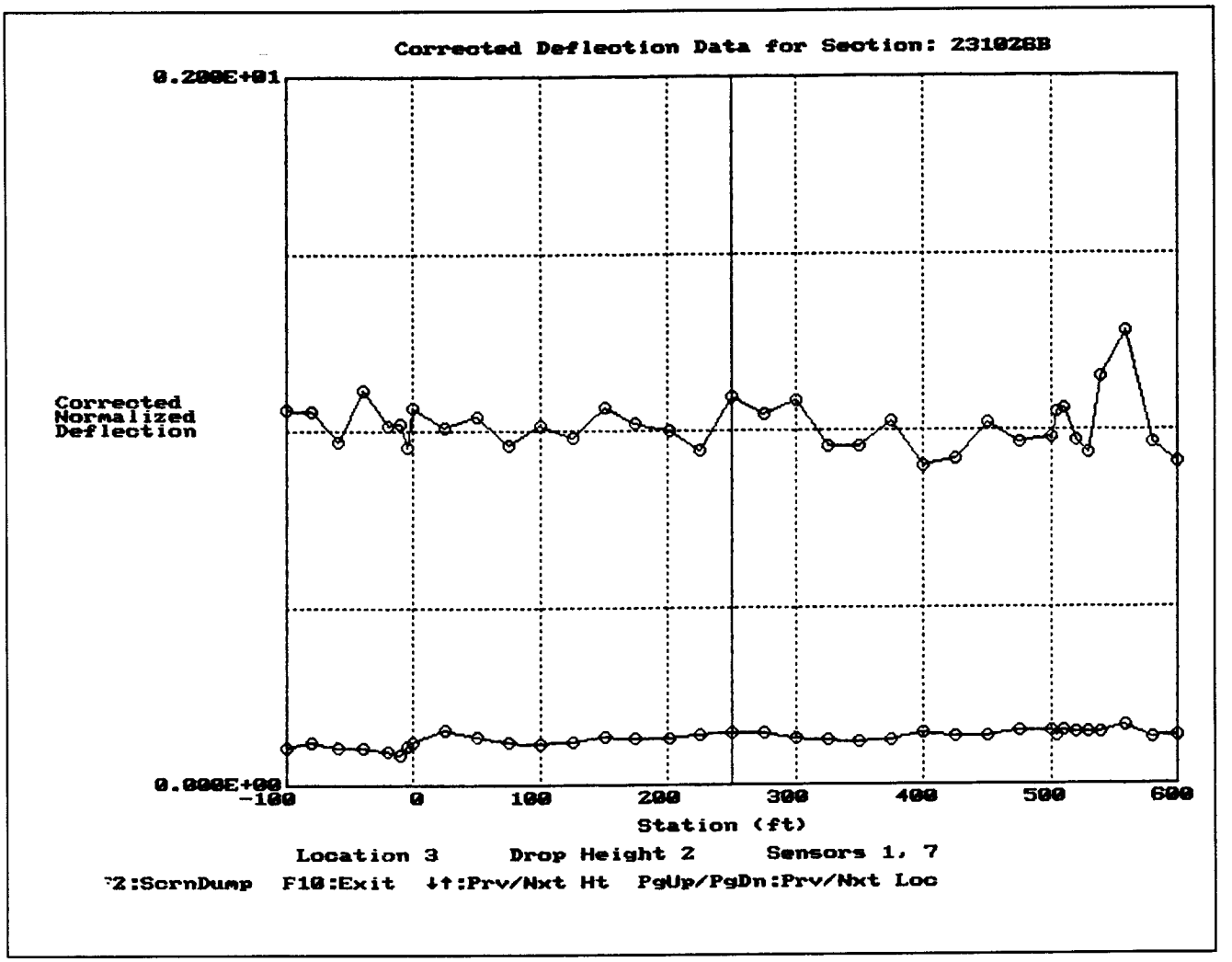


Figure A-3. Deflection Profile from FWDCHECK
(Test Date August 18, 1992)

Table A-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date August 18, 1992)

Flexible Pavement Thickness Statistics - 231026B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	0	35759	5.40
	25	28125	5.75
	50	32792	5.50
	75	36645	5.65
	100	38112	5.45
	125	36964	5.55
	150	32452	5.45
	175	33696	5.55
	200	33861	5.60
	225	31515	5.85
2	250	30435	5.45
	275	29699	5.60
	300	32967	5.40
	325	34509	5.70
	350	35992	5.65
	375	35359	5.50
	400	29990	6.05
	425	32075	5.90
	450	32031	5.60
	475	29228	5.85
	500	28629	5.80
Subsection 1	Overall Mean	33992	5.58
	Standard Deviation	2989	0.14
	Coeff of Variation	8.79%	2.55%
Subsection 2	Overall Mean	31901	5.68
	Standard Deviation	2553	0.20
	Coeff of Variation	8.00%	3.55%

Note: No test pit data found, therefore no results exist...

APPENDIX B

Supporting Site Visit and Installed Instrument Information

Appendix B contains the following supporting information:

Correspondence from the Site Inspection and Planning Meeting

Table B-1. Air Temperature Thermistor Calibration

Table B-2. MRC Probe Calibration

Table B-3. Description of MRC Thermistor Probe and Sensor Spacing

Table B-4. Resistivity Probe and Sensor Spacing

Table B-5. Contact Resistance Calibration

Table B-6. TDR Probes Calibration

Figure B-1. TDR Traces Obtained During Calibration

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION BUILDING
STATE HOUSE STATION 16 AUGUSTA, MAINE 04333

DANA F. CONNORS
Commissioner

DATE REC. MAR 11 1991
JOB #
FILE #

March 5, 1991

COPY

Bill Phang
Pavement Management Systems
415 Lawrence Bell Drive, Unit # 3
Amherst, NY 14221

Dear Mr. Phang:

File Ref: 12.01.1

This is in answer to your recent memo to Warren Foster of our Department. According to your request in the memo, we would be pleased to nominate GPS-1 sites 231026 and 231028 and GPS-3 site 233013 for the one year FWD seasonal testing plan.

Very truly yours,

Ted Karasopoulos

Theodore H. Karasopoulos
Engineer of Technical Services

THK/jcg

PAVEMENT MANAGEMENT SYSTEMS

MEMORANDUM

TO:	Wilbur Dunphy	**DATE:**	May 20, 1992
FROM:	Bill Phang	**PROJECT:**	50450732
SUBJECT:	Seasonal Testing - 231028 Bethel	**FILE:**	12.01.1
		COPIES TO:	B. Henderson

Regarding our telephone conversation of 5/20/92 on seasonal testing, while we would like to keep the concrete pavement at 233014 as a seasonal testing site, we would be happy to replace it with 231028, the flexible pavement site at Bethel should you so desire.

I am enclosing a revised GPS Test Site Location sketch map for your use.

415 LAWRENCE BELL DRIVE
UNIT #3
AMHERST, N.Y. 14221
TEL. (716) 632-0804
FAX (716) 632-4808

PAVEMENT
MANAGEMENT
SYSTEMS

July 7, 1993

Mr. Wilbur Dunphy
Maine State Department of Transportation
Transportation Building
State House Station #16
AUGUSTA, ME 04333

Dear Wilbur:

Please find enclosed a copy of the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". This is a pre-distribution "draft" copy. An updated version is to be distributed in early August which will form the basis for the installation and data collection for the seasonal monitoring program.

In preparation for the preliminary planning meeting scheduled for July 21, 1993, the installation guidelines (pages II 23 - 39, 44 - 54) will provide an idea of the requirements/activities involved in the installation of the seasonal monitoring program test sites.

A summary of the information available for GPS 231026 should be forwarded to you early next week. In the meantime, if you have any questions or require additional information, please do not hesitate to call the undersigned or Bill Phang at your convenience.

Yours truly,

PAVEMENT MANAGEMENT SYSTEMS LIMITED

Brandt Henderson
Manager, Field and Data Operations

BH/lh
Encl.

Copies: Bill Phang
Ivan Pecnik

415 LAWRENCE BELL DRIVE
UNIT #3
AMHERST, N.Y. 14221
TEL. (716) 632-0804
FAX (716) 632-4808

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION BUILDING
STATE HOUSE STATION 16 AUGUSTA, MAINE 04333

DANA F. CONNORS
Commissioner

July 27, 1993

Mr. Ivan Pecnik, P.E.
Regional Engineer
415 Lawrence Bell Drive - Unit #3
Amherst, New York 14221

Dear Ivan:

After discussing the installation and monitoring of the proposed Maine seasonal LTPP section, Number 231026, in Wilton, the Maine DOT has decided to participate in that experiment if the installation can be completed by September 30, 1993. After that date the maintenance forces are committed to preparations for the winter season, and are very busy.

In preparation for the possibility that section 231026 does become a seasonal experiment, we would appreciate any information you can give us concerning the cover/cap assembly for the well. If commercially available, we will purchase the assembly.

Very truly yours,

Warren

Warren T. Foster
Research & Development Engineer

cc: W. Phang
T. Karasopoulos
file

Brandt, 8/2/93

- Wilbur Dunphy reports he has a 14" core barrel and a 12" auger. He has a 5½" auger for the piezometer.
- He will be setting up a bench mark at the 0+00 end of ~~231026~~, Wilton.
- The Madison hotel is recommended.

Bill

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION BUILDING
STATE HOUSE STATION 16 AUGUSTA, MAINE 04333-0016

COPY

DANA F. CONNORS
Commissioner

August 2, 1993

REC. AUG 05 1993
JOB #
FILE #

Mr. William Phang
Program Manager NARCO
Pavement Management System
415 Lawrence Bell Drive - Unit #3
Amherst, New York 14221

Dear Bill:

As a follow up of our letter of July 27, 1993, we are enclosing a completed Site Information form nominating the Wilton LTPP Section, 231026, as a seasonal site. Based upon the conversation of July 21st, we are planning on the installation of instrumentation to be completed September 15 and 16, 1993.

In conversation with the Geotechnical Engineer in charge of the drill rigs and one of the crew leaders, we have been told we have available a 14 inch diameter core barrel, and a 12 inch diameter auger, with about five feet of flights. We also have a five or 5 1/2 inch diameter auger available. Hopefully that will be of sufficient diameter to complete the well and rain gage installation.

A permanent bench mark is scheduled to be set near the beginning (0+0 end) of Section 231026 the first of this week. This will be nearly as readily available as the top of the observation well, so you can check the well elevation each time you complete a level survey if you wish.

Done

We are also enclosing maps locating motels, hardware stores, building supply yards and an electrical supply store. Prints of the telephone directory pages listing these are also attached. A State Highway Map and mileage log are included to give you an idea of how far each is from the site.

Very truly yours,

Warren

Warren T. Foster
R&D Engineer

Encl. 8

cc: Ivan Pecnik
file

COPY

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION BUILDING
STATE HOUSE STATION 16 AUGUSTA, MAINE 04333-0016

mdot

DANA F. CONNORS
Commissioner

DATE REC. AUG 23 1993
JOB #
FILE #

August 18, 1993

Mr. William Phang
Program Manager NARCO
Pavement Management System
415 Lawrence Bell Drive - Unit #3
Amherst, New York 14221

Dear Bill:

As you requested of Wilbur on the 18th, enclosed is a print of the description of the bench mark set recently at the Wilton seasonal site (231026).

Will meet you at the Dixfield Division 7 office at 1:00 p.m. on September 14, 1993.

Very truly yours,

Warren

Warren T. Foster
Research & Development Engineer

WTF/dg

Enclosure: 1

Brandt,
For your info.

ORIGINAL

STATE OF MAINE
DEPARTMENT OF TRANSPORTATION
TRANSPORTATION BUILDING
STATE HOUSE STATION 16 AUGUSTA, MAINE 04333-0016

mdot

DANA F. CONNORS
Commissioner

REC. OCT 01 1993
JOB #
FILE #

September 24, 1993

Mr. Brandt Henderson
Program Manager NARCO
Pavement Management System
415 Lawrence Bell Drive - Unit #3
Amherst, New York 14221

Dear Mr. Henderson:

During the recent installation of the seasonal monitoring equipment on GPS site 233026, Wilton, you requested that we determine the water content of 10 soil samples. The results arrived recently, and are enclosed. Although these samples were obtained by you and your crew, the name of Craig Thompson is indicated on the test report because samples won't be tested unless sampled by a Technical Services Division employee. The highlighted number is the number you assigned to each container.

Best regards.

Sincerely yours,

Warren

Warren T. Foster
Engineer of Technical Services Division

WTF/dg

Encl. (9)

Table B-1. Air Temperature Thermistor Calibration

LTPP Seasonal Monitoring Study	State Code	[2 3]
Air Temperature Thermistor Calibration	Test Section Number	[1 0 2 6]

Before Operation Checks	Calibration Date mm-dd-yy	09-09-93
	Probe S/N	23AAT
	Operator	PZ & MZ

Mobile Datalogger (24 hour)	Water Room Temperature	Ice Bath 0 C (+/- 1 C)	Hot Water 50 C (+/-)	ok

Mean	Min.	Max.	Reading	Time	Reading	Time	Reading	Time	y/n
22.15	19.44	22.84	22.80	15:49	-.005	16:54	47.80	13:26	y

Probe Accepted	PZ&MZ	(Initials)

Table B-2. MRC Probe Calibration

LTPP Seasonal Monitoring Study	State Code	[23]
MRC Probe Calibration	Test Section Number	[1026]

Before Operation Checks	Calibration Date mm-dd-yy	09-09-93
	Probe S/N	23AT
	Operator	PZ & MZ

	Mobile Datalogger (24 hour)			Water Room Temp Time 15:49	Ice Bath 0 C(+/- 1 C) Time 16:57	Hot Water 50 C (+/-) Time 17:55	ok
No.	Mean	Min.	Max.	Reading	Reading	Reading	y/n
1	22.25	21.02	22.72	22.2	0.85	41.1	y
2	22.3	21.26	22.85	22.3	2.08	41.8	y
3	22.45	21.42	23.01	22.5	3.32	41.9	y
4	22.55	22.02	23.08	23.0	3.87	45.3	y
5	22.54	21.97	22.98	23.1	1.39	44.9	y
6	22.52	21.94	22.98	23.2	0.88	45.1	y
7	22.44	21.86	22.93	23.1	1.06	44.9	y
8	22.43	21.9	22.98	23.0	0.99	45.2	y
9	22.49	21.9	23.14	23.0	1.17	45.2	y
10	22.42	21.91	22.93	22.9	1.39	45.1	y
11	22.39	21.91	22.85	22.8	1.39	45.5	y
12	22.34	21.91	22.8	22.6	1.36	45.3	y
13	22.39	21.78	22.88	22.5	1.36	45.5	y
14	22.39	21.7	22.82	22.3	1.79	45.0	y
15	22.43	21.76	22.85	22.1	1.72	45.2	y
16	22.45	21.65	22.85	22.0	2.47	45.1	y
17	22.33	21.6	22.64	21.9	2.22	44.8	y
18	22.01	21.52	22.25	22.0	2.15	44.9	y

Probe Accepted:	PZ&MZ	(Initials)
Probe Length:	1.8542	(meters)

Thermistor distance from top of probe:						(meters)			
4	.0206	7	.2461	10	.6271	13	1.0859	16	1.5415
5	.0984	8	.3207	11	.7779	14	1.2367	17	1.6923
6	.1699	9	.4731	12	.9335	15	1.3891	18	1.8463

Table B-3. Description of MRC Thermistor Probe and Sensor Spacing

Unit	Channel No.	Distance from Top of Unit(m)	Remarks
1	1	.0127	0.3302m long by 63.5mm stainless steel probe installed in the AC layer
	2	.1651	
	3	.3175	
2	4	.0206	1.854m long by 25.4mm PVC tube installed in the base and subgrade.
	5	.0984	
	6	.1699	
	7	.2461	
	8	.3207	
	9	.4731	
	10	.6271	
	11	.7779	
	12	.9335	
	13	1.0859	
	14	1.2367	
	15	1.3891	
	16	1.5415	
	17	1.6923	
	18	1.8463	

Table B-4. Resistivity Probe and Sensor Spacing

Connector Pin No.	Electrode Number	Continuity x	Measure-ment	Spacing (mm)			Dist. from Top (m)
				Line 1	Line 2	Avg.	
36	1	x	Top-1	31	32	31.5	.031
35	2	x	1-2	46	48	47.0	.077
34	3	x	2-3	51	52	51.5	.128
33	4	x	3-4	52	52	52.0	.180
32	5	x	4-5	52	51	51.5	.232
31	6	x	5-6	51	51	51.0	.283
30	7	x	6-7	50	50	50.0	.333
29	8	x	7-8	52	51	51.5	.385
28	9	x	8-9	51	51	51.0	.436
27	10	x	9-10	51	50	50.5	.487
26	11	x	10-11	51	51	51.0	.538
25	12	x	11-12	51	50	50.5	.589
24	13	x	12-13	51	52	51.5	.640
23	14	x	13-14	51	51	51.0	.691
22	15	x	14-15	51	50	50.5	.742
21	16	x	15-16	50	51	50.5	.792
20	17	x	16-17	50	50	50.0	.842
19	18	x	17-18	50	52	51.0	.892
18	19	x	18-19	51	50	50.5	.943
17	20	x	19-20	51	51	51.0	.994
16	21	x	20-21	51	50	50.5	1.045
15	22	x	21-22	51	52	51.5	1.096
14	23	x	22-23	51	51	51.0	1.147
13	24	x	23-24	50	51	50.5	1.197
12	25	x	24-25	51	51	51.0	1.248
11	26	x	25-26	51	51	51.0	1.299
10	27	x	26-27	53	51	52.0	1.352
9	28	x	27-28	50	51	50.5	1.402
8	29	x	28-29	51	51	51.0	1.453
7	30	x	29-30	51	51	51.0	1.504
6	31	x	30-31	49	49	49.0	1.553
5	32	x	31-32	50	51	50.5	1.603
4	33	x	32-33	52	51	51.5	1.655
3	34	x	33-34	52	52	52.0	1.707
2	35	x	34-35	49	49	49.0	1.756
1	36	x	35-36	53	53	53.0	1.809
			36-End	22	22	22.0	1.831

Table B-5. Contact Resistance Calibration

LTPP Seasonal Monitoring Study					State Code		[23]
Data Sheet R1							
Contact Resistance Measurements					Test Section Number		[1026]
1. Date (Month - Day - Year)							[09-14-93]
2. Time Measurements Began (Military)							[10:15]
3. Comments							In Salt Water Prior to Installation

Test Position	Connections		Voltage (ACV)		Current (ACA)		Notes
	I V	I V	Range Setting	Reading	Range Setting	Reading	
1	1	2	mV	129.6	uA	735.0	
2	3	2	mV	128.9	uA	740.0	
3	3	4	mV	117.6	uA	751.0	
4	5	4	mV	120.5	uA	751.0	
5	5	6	mV	118.6	uA	753.0	
6	7	6	mV	117.1	uA	755.0	
7	7	8	mV	104.9	uA	764.0	
8	9	8	mV	92.7	uA	770.0	
9	9	10	mV	101.6	uA	764.0	
10	11	10	mV	108.1	uA	761.0	
11	11	12	mV	97.8	uA	768.0	
12	13	12	mV	106.4	uA	763.0	
13	13	14	mV	115.3	uA	759.0	
14	15	14	mV	103.6	uA	764.0	
15	15	16	mV	100.9	uA	765.0	
16	17	16	mV	97.4	uA	769.0	
17	17	18	mV	95.8	uA	770.0	
18	19	18	mV	108.3	uA	758.0	
19	19	20	mV	109.4	uA	758.0	
20	21	20	mV	102.2	uA	763.0	
21	21	22	mV	94.2	uA	768.0	
22	23	22	mV	97.1	uA	766.0	
23	23	24	mV	134.6	uA	734.0	
24	25	24	mV	139.8	uA	728.0	
25	25	26	mV	104.8	uA	757.0	
26	27	26	mV	93.8	uA	766.0	
27	27	28	mV	106.2	uA	758.0	
28	29	28	mV	105.9	uA	758.0	
29	29	30	mV	93.3	uA	766.0	
30	31	30	mV	96.1	uA	761.0	
31	31	32	mV	95.9	uA	761.0	
32	33	32	mV	92.2	uA	765.0	
33	33	34	mV	103.6	uA	756.0	
34	35	34	mV	105.8	uA	756.0	
35	35	36	mV	95.7	uA	761.0	
36	37	38	mV	333.7	uA	597.0	
37	38	39	mV	212.5	uA	638.0	
38	39	40	mV	1.8	uA	874.0	

Preparer :	Michael Zawisa	Employer :	PMSL

Table B-6. TDR Probes Calibration

LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probes	Test Section Number	[1026]

Before Operation Checks	P.Z.	Initial	Calibration Date (mm-dd-yy)	09-08-93
			Seasonal Site	23SA

No.	Probe (S/N)	Resistance (ohms)		Probe Shorted		Air	Alcohol	Water
		Core	Shield	Begin Length	End Length	Begin Length	Begin Length	Begin Length
1	23A01	0.600	0.800	16.490	16.660	16.490	16.520	16.530
2	23A02	0.500	0.400	16.800	17.000	16.790	16.850	16.850
3	23A03	0.800	0.700	16.820	17.000	16.820	16.860	16.860
4	23A04	0.800	0.300	16.730	16.900	16.730	16.760	16.760
5	23A05	0.600	0.400	16.750	16.920	16.740	16.780	16.780
6	23A06	0.600	0.400	16.830	16.990	16.830	16.860	16.860
7	23A07	0.800	0.300	16.670	16.860	16.670	16.710	16.710
8	23A08	0.700	0.500	16.630	16.810	16.630	16.680	16.680
9	23A09	0.800	0.500	16.870	17.030	16.850	16.890	16.890
10	23A10	0.700	0.500	16.680	16.850	16.690	16.710	16.710

NOTE: Record lengths from TDR

Calculation of Dielectric Constant

Probe Length .203 m

V_p Setting .99 V_p

$$\varepsilon = \left[\frac{TDRL}{(PL)\,(V_p)} \right]^2$$

No.	Air			Alcohol			Water		
	TDR Length	Dielectric Constant	In Spec. (?)	TDR Length	Dielectric Constant	In Spec. (?)	TDR Length	Dielectric Constant	In Spec. (?)
1	.18	.78	y	1.18	33.81	y	1.83	81.31	y
2	.20	.97	y	1.17	33.23	y	1.85	83.09	y
3	.17	.70	y	1.17	33.23	y	1.84	82.19	y
4	.17	.70	y	1.17	33.23	y	1.84	82.19	y
5	.17	.70	y	1.17	33.23	y	1.85	83.09	y
6	.17	.70	y	1.17	33.23	y	1.84	82.19	y
7	.19	.88	y	1.16	32.67	y	1.85	83.09	y
8	.18	.79	y	1.15	32.10	y	1.84	82.19	y
9	.18	.78	y	1.18	33.81	y	1.86	83.09	y
10	.17	.70	y	1.17	33.23	y	1.84	82.19	y

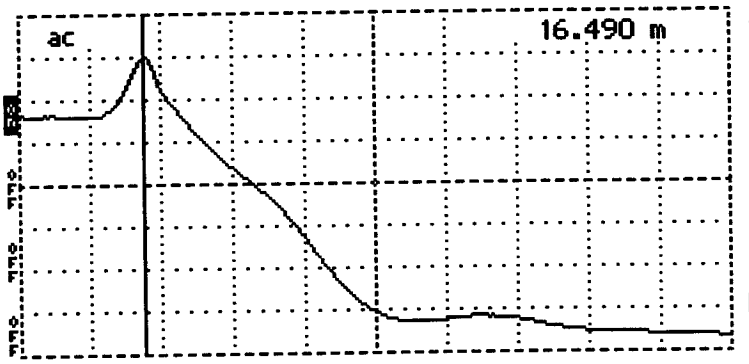
LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

efore Operation Checks
- Calibration Date 9/8/93
- Probe S/N 23A01

Probe Number 1

DR Trace 1 - Beginning Probe Shorted

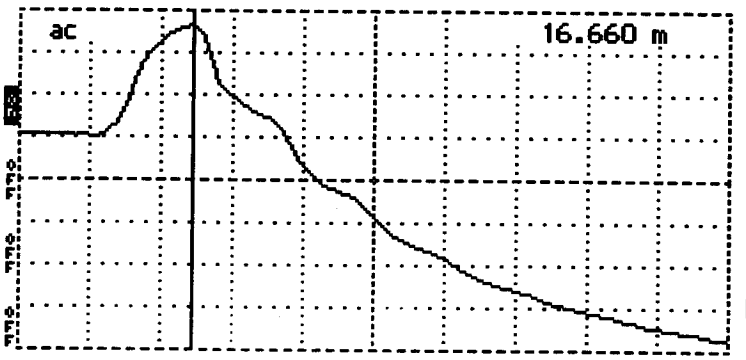
rsor ..... 16.490 m
stance/Div..... .25 m/div
rtical Scale.... 154 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 1
Notes Shorted @ CB
Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted

ursor ..... 16.660 m
stance/Div..... .25 m/div
rtical Scale.... 154 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

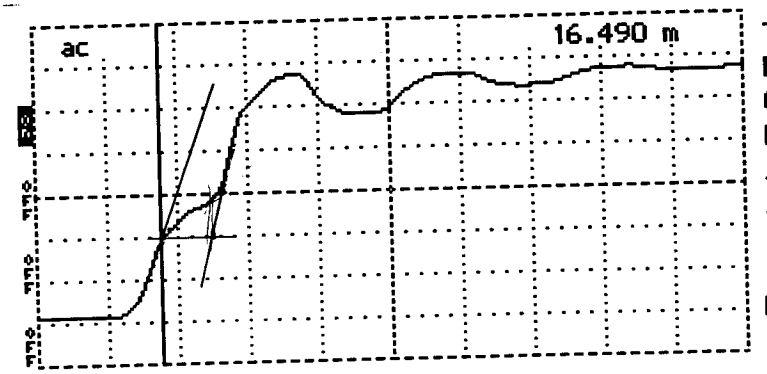


Tektronix 1502B TDR
Date 9/8/93
Cable 1
Notes Shorted at end
Input Trace
Stored Trace
Difference Trace

Figure B-1. TDR Traces Obtained During Calibration

race Number 3 - Probe in Air

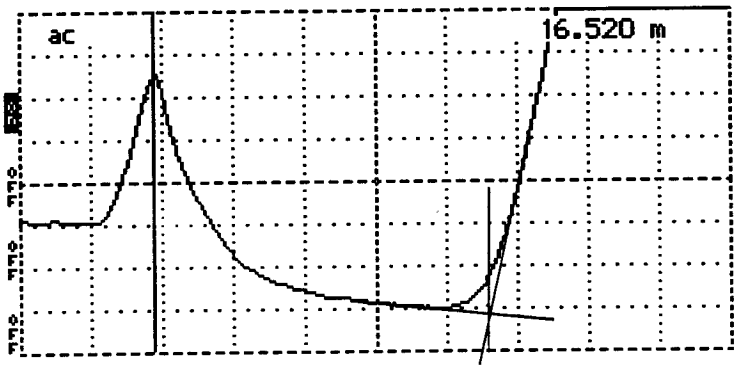
ursor ..... 16.490 m
istance/Div..... .25 m/div
ertical Scale.... 154 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 1
Notes IN AIR
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

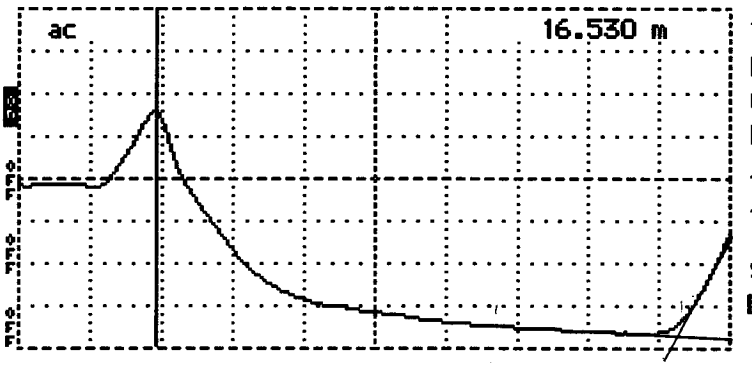
:or ..... 16.520 m
ıstance/Div..... .25 m/div
ertical Scale.... 54.5 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 1
Notes IN Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

sor ..... 16.530 m
tance/Div..... .25 m/div
tical Scale.... 88.9 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 1
Notes IN H_2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

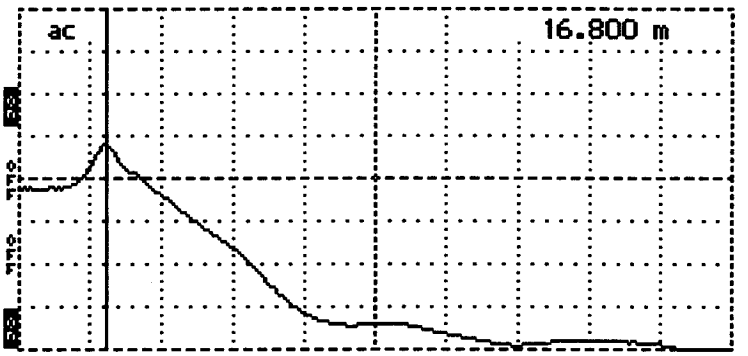
LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

efore Operation Checks
- Calibration Date 9/8/93
- Probe S/N 23AD2

Probe Number 2

DR Trace 1 - Beginning Probe Shorted

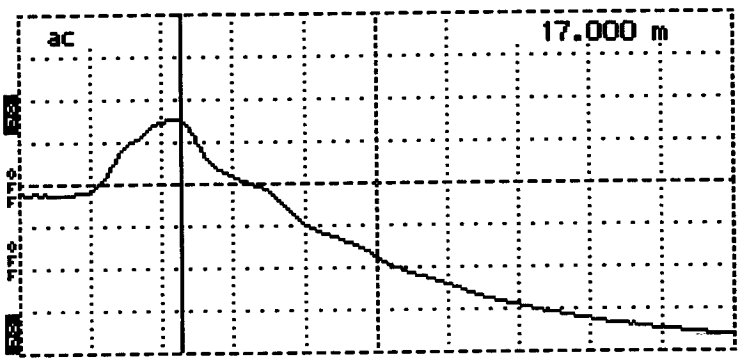
rsor ..... 16.800 m
stance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/9/93
Cable 2
Notes Shorted at CB
Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted

or ..... 17.000 m
ance/Div..... .25 m/div
ical Scale.... 217 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac

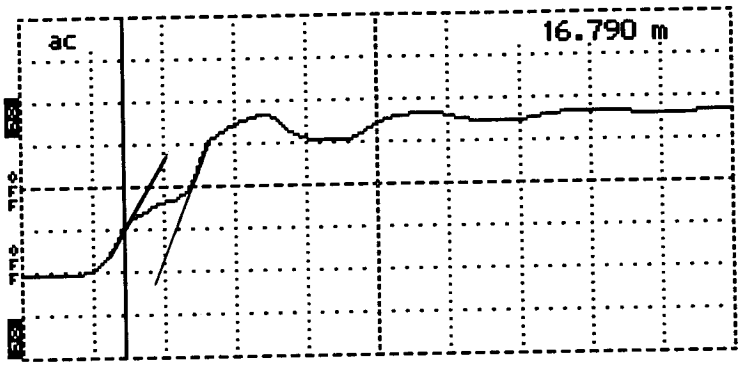


Tektronix 1502B TDR
Date 9/8/93
Cable 2
Notes Shorted @ end
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

race Number 3 - Probe in Air

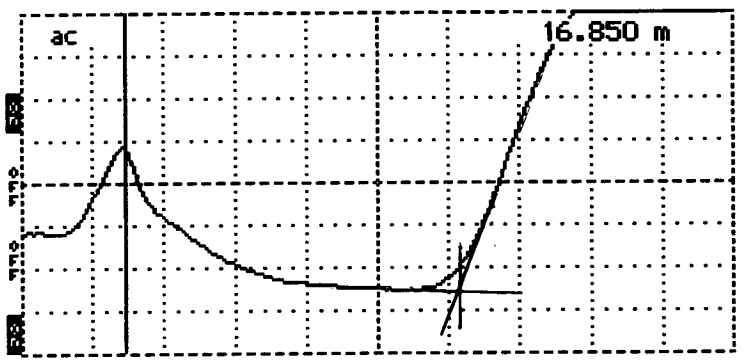
rsor ..... 16.790 m
tance/Div..... .25 m/div
rtical Scale.... 230 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 2
Notes In Air
Input Trace
Stored Trace
Difference Trace

race Number 4 - Probe in Alcohol

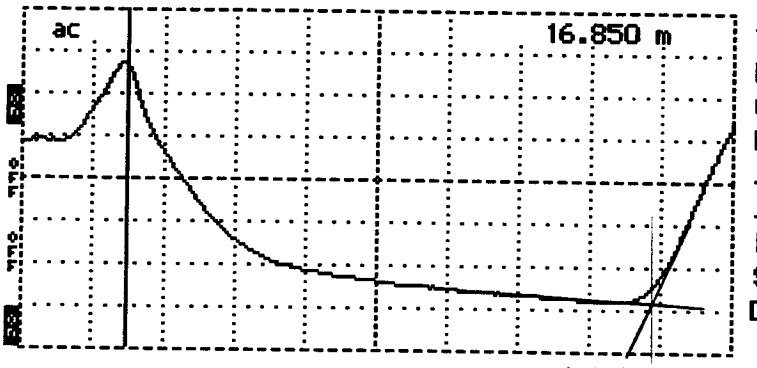
rsor ..... 16.850 m
ance/Div..... .25 m/div
ertical Scale.... 83.9 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 2
Notes In Alcohol Methyl
Input Trace
Stored Trace
Difference Trace

race Number 5 - Probe in Water

Cursor ..... 16.850 m
Distance/Div..... .25 m/div
Vertical Scale.... 83.9 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 2
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

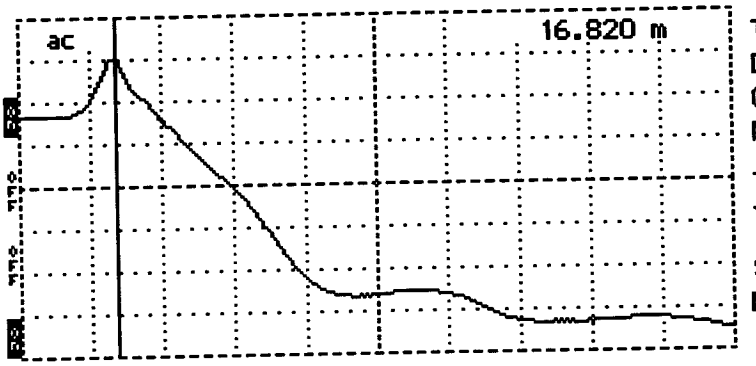
efore Operation Checks

- Calibration Date 9/8/93
- Probe S/N 23A03

Probe Number 3

DR Trace 1 - Beginning Probe Shorted

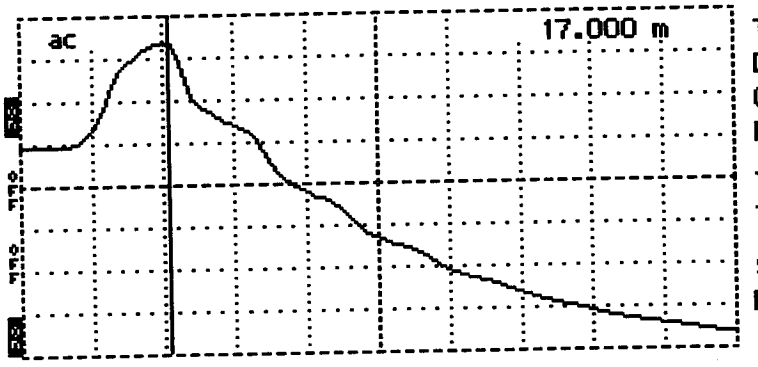
sor ..... 16.820 m
tance/Div..... .25 m/div
rtical Scale.... 163 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 3
Notes Shorted at CB
Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted

rsor ..... 17.000 m
tance/Div..... .25 m/div
rtical Scale.... 163 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

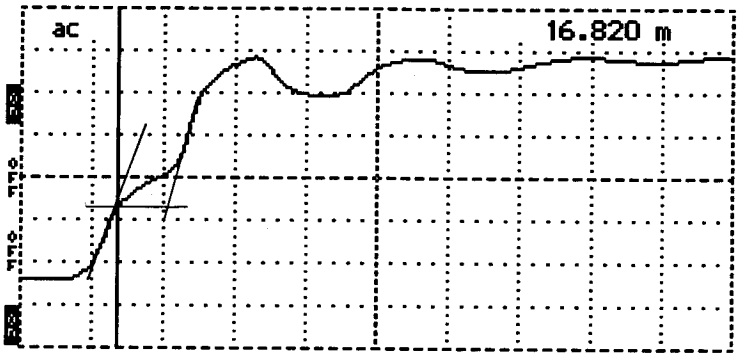


Tektronix 1502B TDR
Date 9/8/93
Cable 3
Notes Shorted at End
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

race Number 3 - Probe in Air

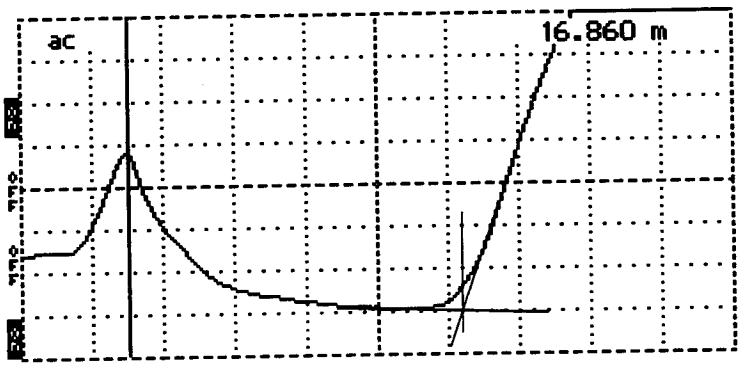
ursor ..... 16.820 m
istance/Div..... .25 m/div
ertical Scale.... 163 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 3
Notes In Air
Input Trace
Stored Trace
Difference Trace

race Number 4 - Probe in Alcohol

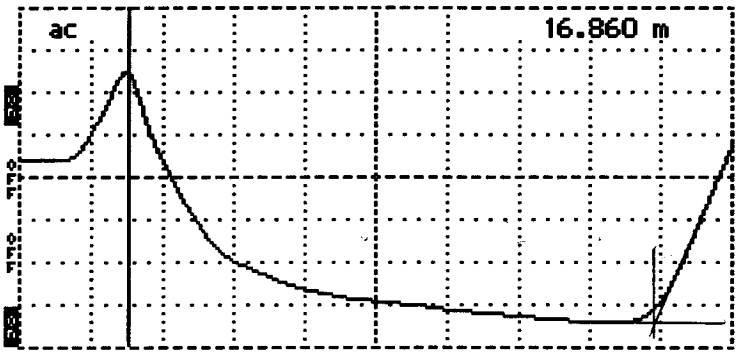
rsor ..... 16.860 m
ıce/Div..... .25 m/div
ıcal Scale.... 79.2 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 3
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

race Number 5 - Probe in Water

rsor ..... 16.860 m
stance/Div..... .25 m/div
rtical Scale.... 81.6 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 3
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

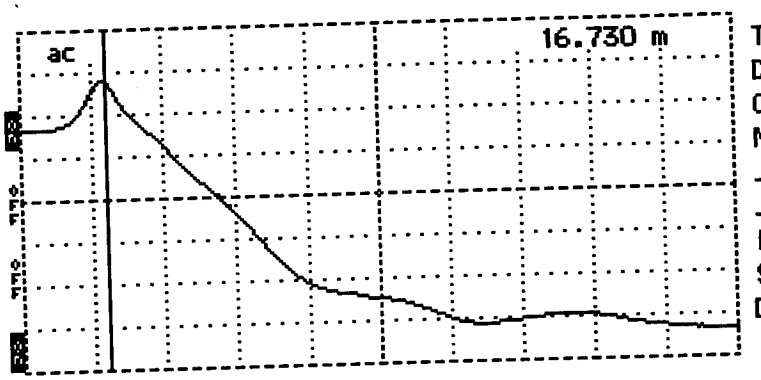
LTPP Seasonal Monitoring Study	State Code	[25]
TDR Probe Calibration	Test Section Number	[1025]

efore Operation Checks - Calibration Date 9/8/93
- Probe S/N 23A04

Probe Number 4

DR Trace 1 - Beginning Probe Shorted

sor ..... 16.730 m
tance/Div..... .25 m/div
tical Scale.... 167 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac

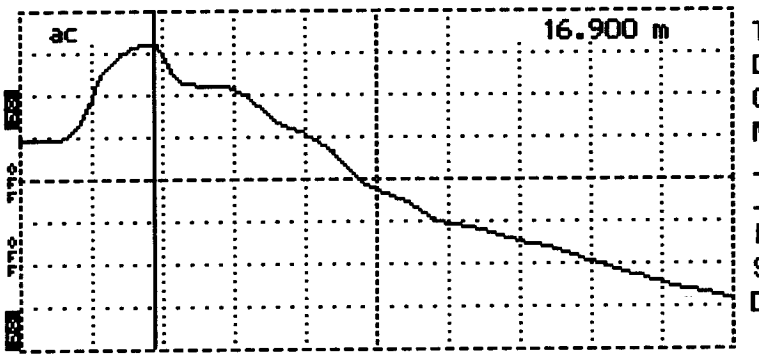


Tektronix 1502B TDR
Date 9/8/93
Cable 4
Notes Shorted @ CD

Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

sor ..... 16.900 m
tance/Div..... .25 m/div
tical Scale.... 167 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



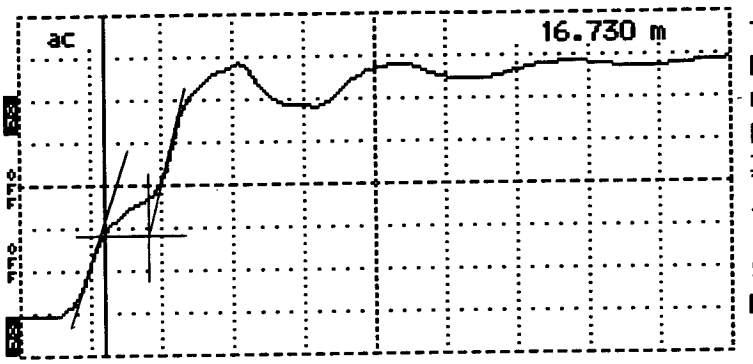
Tektronix 1502B TDR
Date 9/8/93
Cable 4
Notes Shorted @ End

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

ace Number 3 - Probe in Air

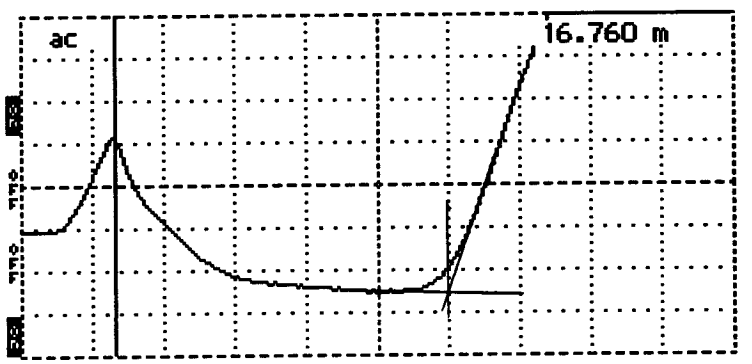
rsor ..... 16.730 m
tance/Div..... .25 m/div
rtical Scale.... 145 mΩ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 4
Notes In Air
Input Trace
Stored Trace
Difference Trace

race Number 4 - Probe in Alcohol

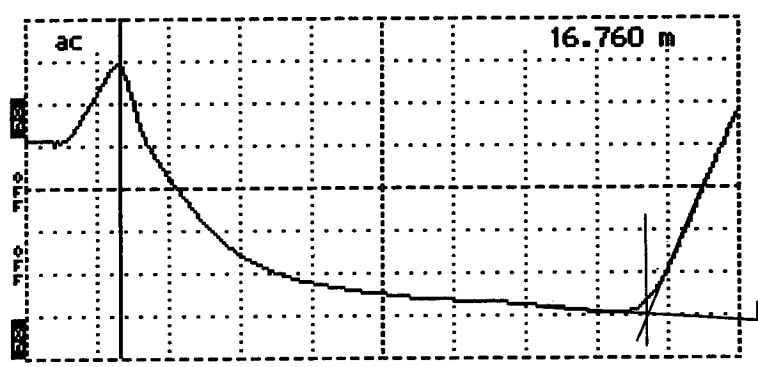
ror ..... 16.760 m
nce/Div..... .25 m/div
rtical Scale.... 79.2 mΩ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/9/93
Cable 4
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

race Number 5 - Probe in Water

rsor ..... 16.760 m
stance/Div..... .25 m/div
rtical Scale.... 79.2 mΩ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 4
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

efore Operation Checks - Calibration Date 9/8/93
- Probe S/N 23A05

Probe Number 5

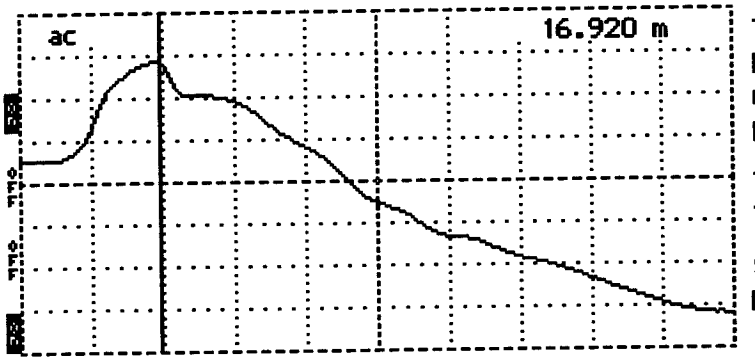
DR Trace 1 - Beginning Probe Shorted

sor ..... 16.750 m
tance/Div..... .25 m/div
tical Scale.... 188 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac

Tektronix 1502B TDR
Date 9/8/93
Cable 5
Notes Shorted@ CB
Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted

rsor ..... 16.920 m
tance/Div..... .25 m/div
tical Scale.... 167 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac

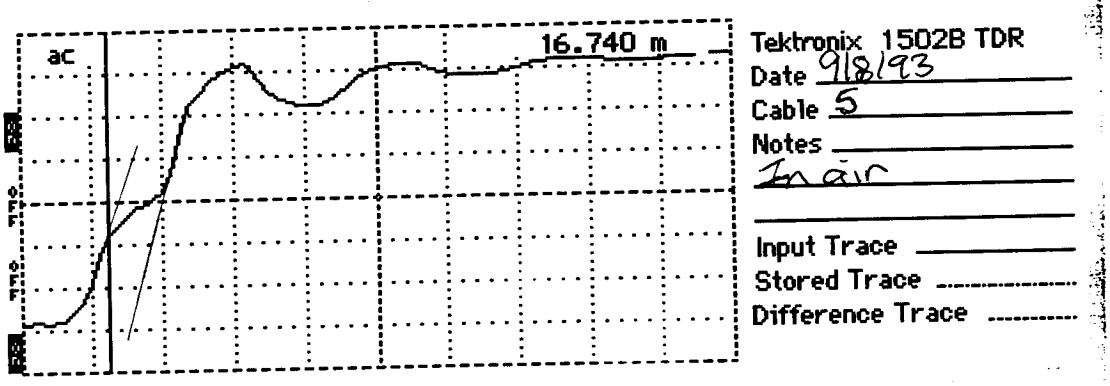


Tektronix 1502B TDR
Date 9/8/93
Cable 5
Notes Shorted@ end
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

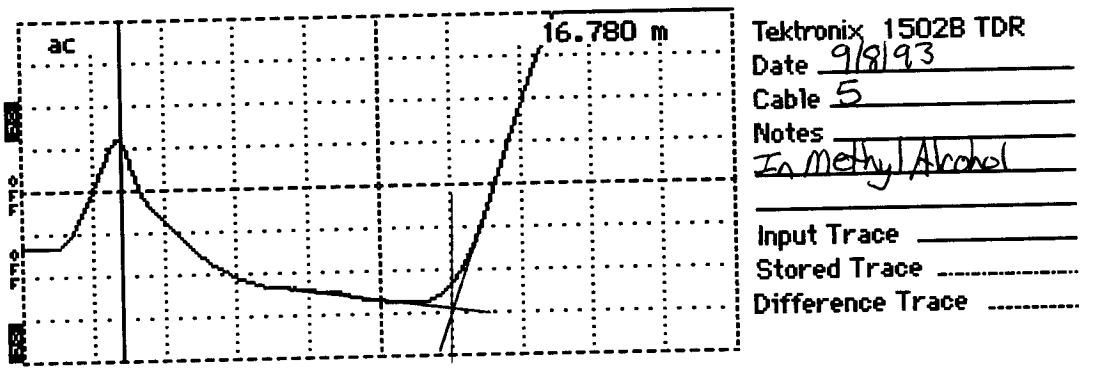
race Number 3 - Probe in Air

rsor ..... 16.740 m
tance/Div..... .25 m/div
rtical Scale.... 141 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



race Number 4 - Probe in Alcohol

rsor ..... 16.780 m
nce/Div..... .25 m/div
rtical Scale.... 70.6 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



race Number 5 - Probe in Water

rsor ..... 16.780 m
stance/Div..... .25 m/div
rtical Scale.... 72.7 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

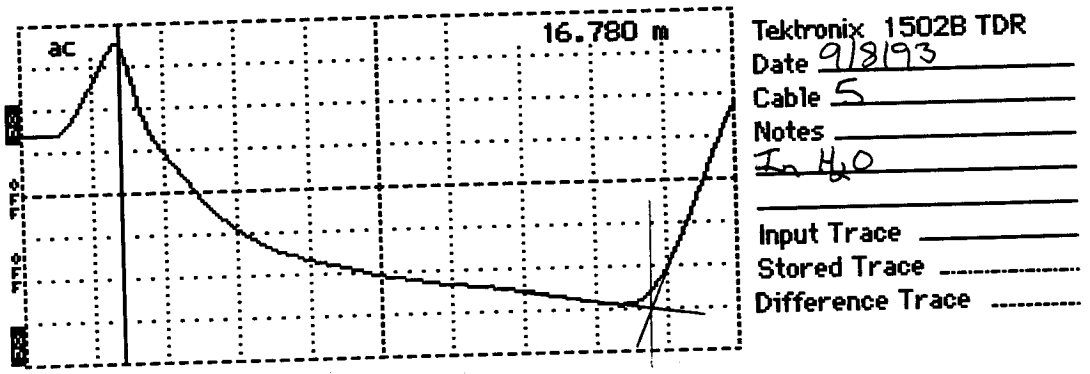


Figure B-1(cont.). TDR Traces Obtained During Calibration

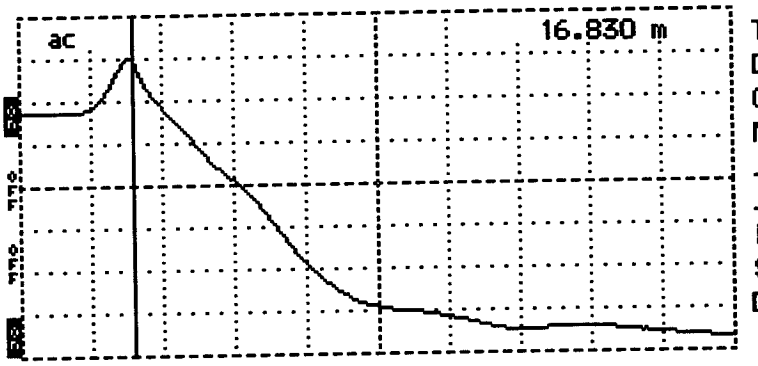
LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

efore Operation Checks

- Calibration Date 9/8/93
- Probe S/N 23A06

Probe Number 6

DR Trace 1 - Beginning Probe Shorted

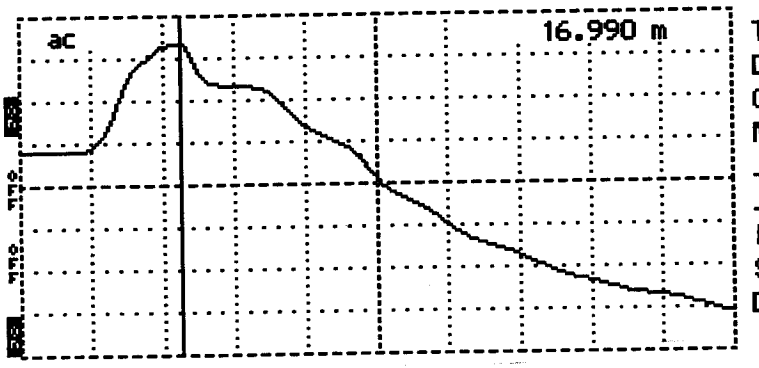


rsor ..... 16.830 m
stance/Div..... .25 m/div
rtical Scale.... 154 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

Tektronix 1502B TDR
Date 9/8/93
Cable 6
Notes Shorted at CB

Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted



rsor ..... 16.990 m
stance/Div..... .25 m/div
rtical Scale.... 154 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

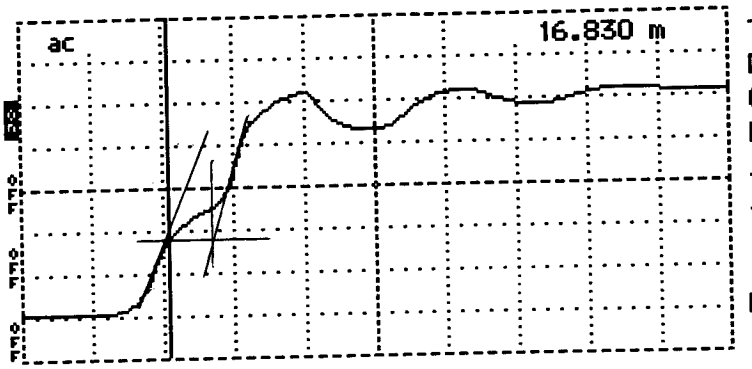
Tektronix 1502B TDR
Date 9/8/93
Cable 6
Notes Shorted @ end

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

race Number 3 - Probe in Air

rsor ..... 16.830 m
stance/Div..... .25 m/div
rtical Scale.... 167 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable #6
Notes in air
Input Trace
Stored Trace
Difference Trace

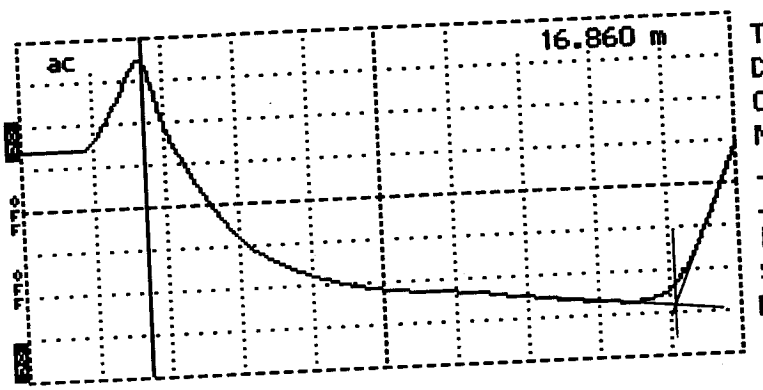
race Number 4 - Probe in Alcohol

or ..... 16.860 m
tance/Div..... .25 m/div
rtical Scale.... 74.8 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

Tektronix 1502B TDR
Date 9/8/93
Cable 6
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

race Number 5 - Probe in Water

sor ..... 16.860 m
tance/Div..... .25 m/div
tical Scale.... 77.0 mρ/div
..... 0.99
se Filter..... 1 avg
r..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 6
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

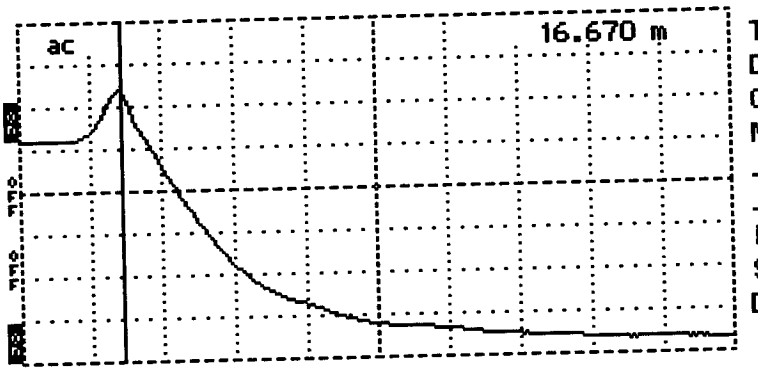
LTPP Seasonal Monitoring Study	State Code	[2 3]
TDR Probe Calibration	Test Section Number	[1 0 2 5]

efore Operation Checks
- Calibration Date 9/8/93
- Probe S/N 23A07

Probe Number 7

DR Trace 1 - Beginning Probe Shorted

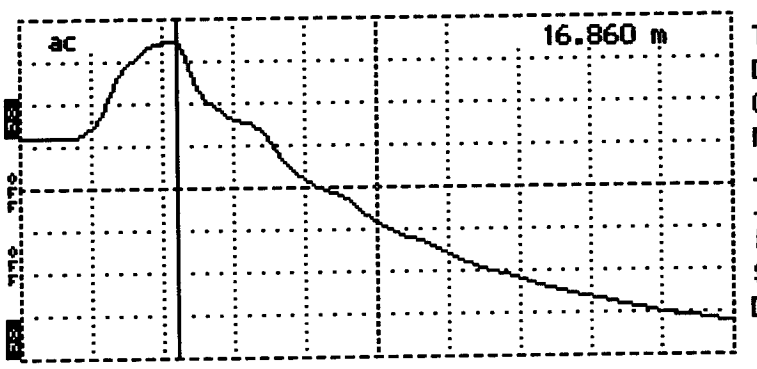
rsor ..... 16.670 m
tance/Div..... .25 m/div
rtical Scale.... 172 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 7
Notes Shorted@CP
Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted

rsor ..... 16.860 m
tance/Div..... .25 m/div
rtical Scale.... 172 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac

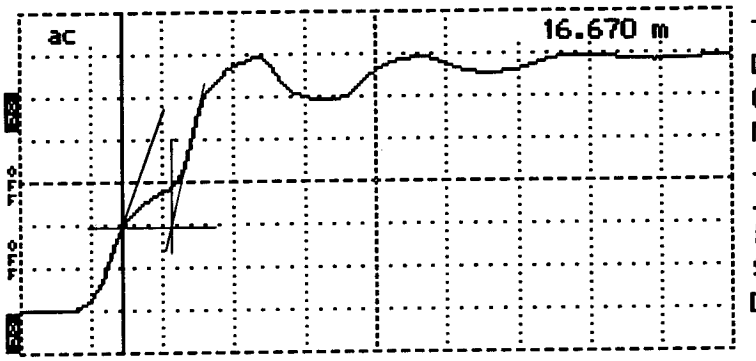


Tektronix 1502B TDR
Date 9/8/93
Cable 7
Notes Shorted@end
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

ace Number 3 - Probe in Air

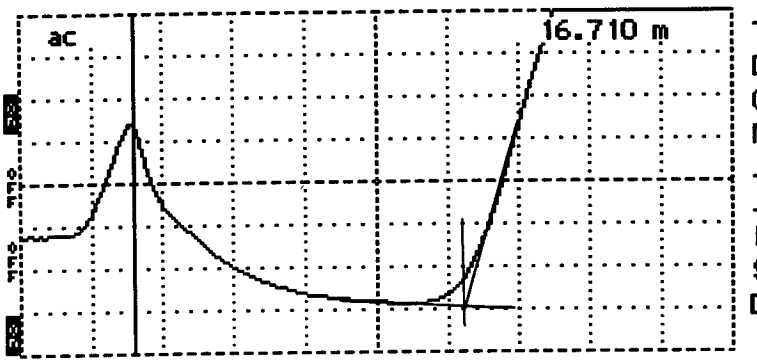
sor ..... 16.670 m
tance/Div..... .25 m/div
tical Scale.... 145 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 7
Notes In air
Input Trace
Stored Trace
Difference Trace

race Number 4 - Probe in Alcohol

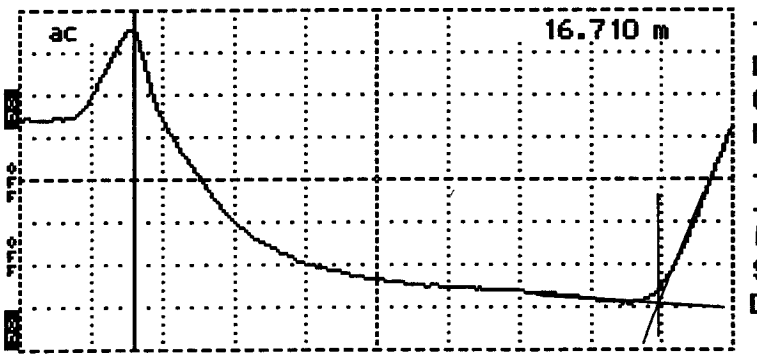
or ..... 16.710 m
ance/Div..... .25 m/div
tical Scale.... 66.7 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 7
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

race Number 5 - Probe in Water

sor ..... 16.710 m
ance/Div..... .25 m/div
ical Scale.... 72.7 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 7
Notes In H_2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

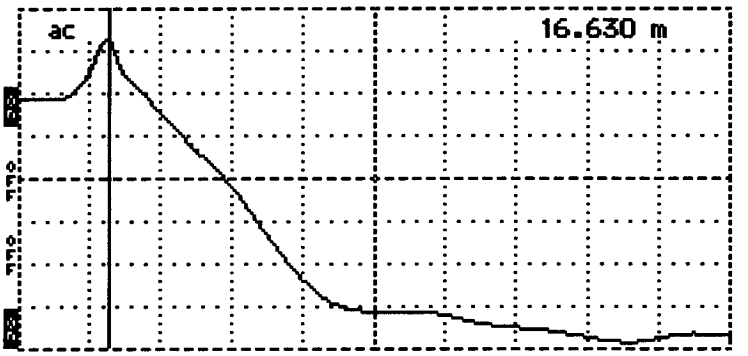
LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

Before Operation Checks - Calibration Date 9/8/93
- Probe S/N 23A08

Probe Number 8

TDR Trace 1 - Beginning Probe Shorted

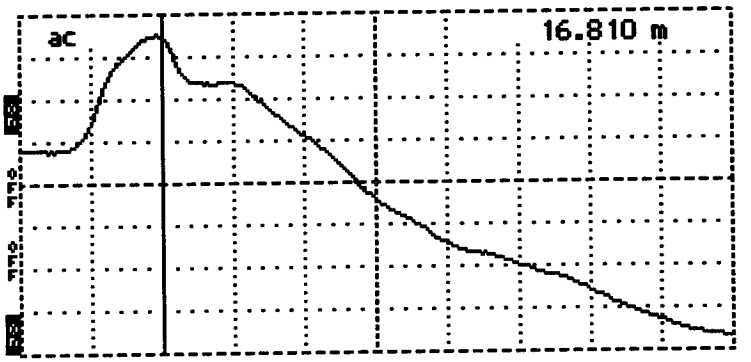
ursor ..... 16.630 m
istance/Div..... .25 m/div
ertical Scale.... 145 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 8
Notes Shorted @ CB
Input Trace
Stored Trace
Difference Trace

Trace Number 2 - Ending Probe Shorted

Cursor ..... 16.810 m
Distance/Div..... .25 m/div
Vertical Scale.... 145 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

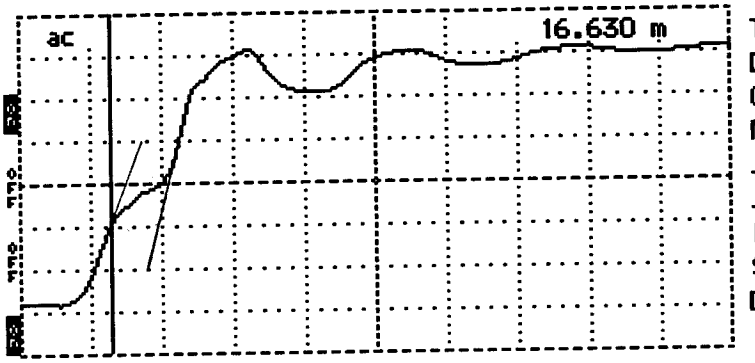


Tektronix 1502B TDR
Date 9/8/93
Cable 9
Notes Shorted @ END
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

race Number 3 - Probe in Air

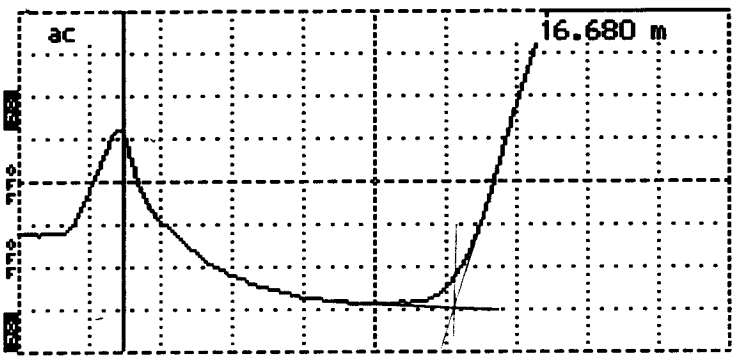
Cursor ..... 16.630 m
Distance/Div..... .25 m/div
Vertical Scale.... 145 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9/9/93
Cable 8
Notes In Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

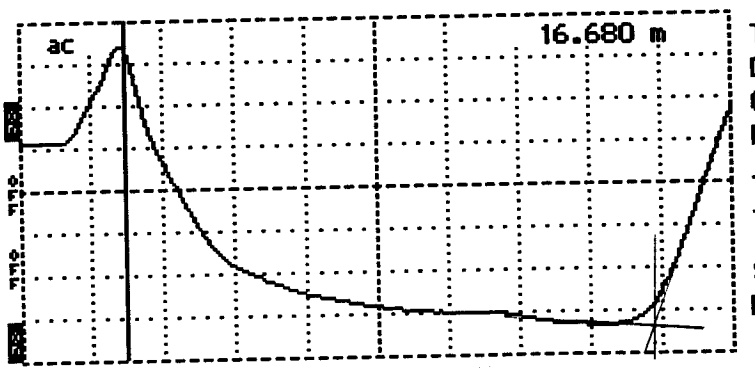
rsor ..... 16.680 m
Distance/Div..... .25 m/div
Vertical Scale.... 70.6 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 8
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

Cursor ..... 16.680 m
Distance/Div..... .25 m/div
Vertical Scale.... 70.6 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9/9/93
Cable 8
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

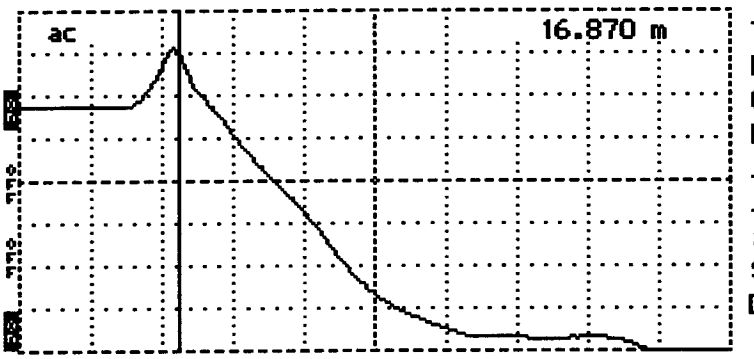
LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

efore Operation Checks
- Calibration Date 9/8/93
- Probe S/N 23A09

Probe Number 9

DR Trace 1 - Beginning Probe Shorted

Cursor ..... 16.870 m
Distance/Div..... .25 m/div
Vertical Scale.... 141 mρ/div
Vp 0.99
Noise Filter..... 1 avg
Power..... ac

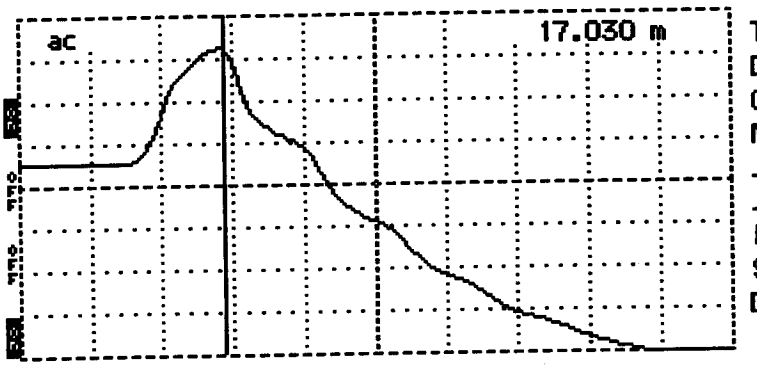


Tektronix 1502B TDR
Date 9/8/93
Cable 9
Notes Shorted@CB

Input Trace
Stored Trace
Difference Trace

race Number 2 - Ending Probe Shorted

sor ..... 17.030 m
tance/Div..... .25 m/div
tical Scale.... 145 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



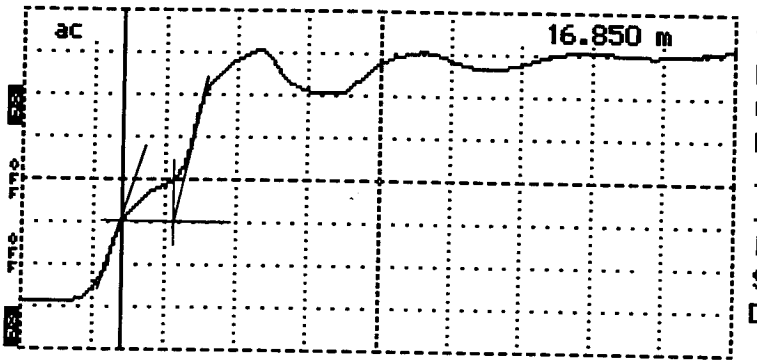
Tektronix 1502B TDR
Date 9/8/93
Cable 9
Notes Shorted@end

Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

race Number 3 - Probe in Air

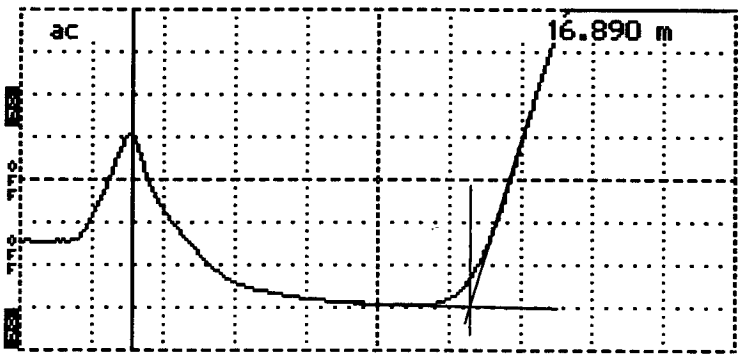
Cursor ..... 16.850 m
Distance/Div..... .25 m/div
Vertical Scale.... 145 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 9
Notes In air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

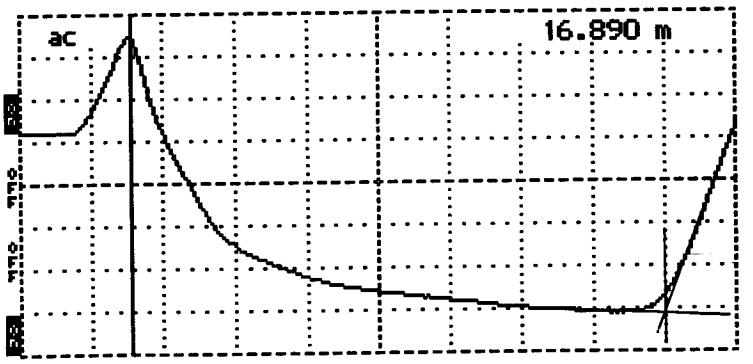
..... 16.890 m
e/Div..... .25 m/div
tical Scale.... 72.7 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 9
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

sor ..... 16.890 m
tance/Div..... .25 m/div
rtical Scale.... 72.7 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 9
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

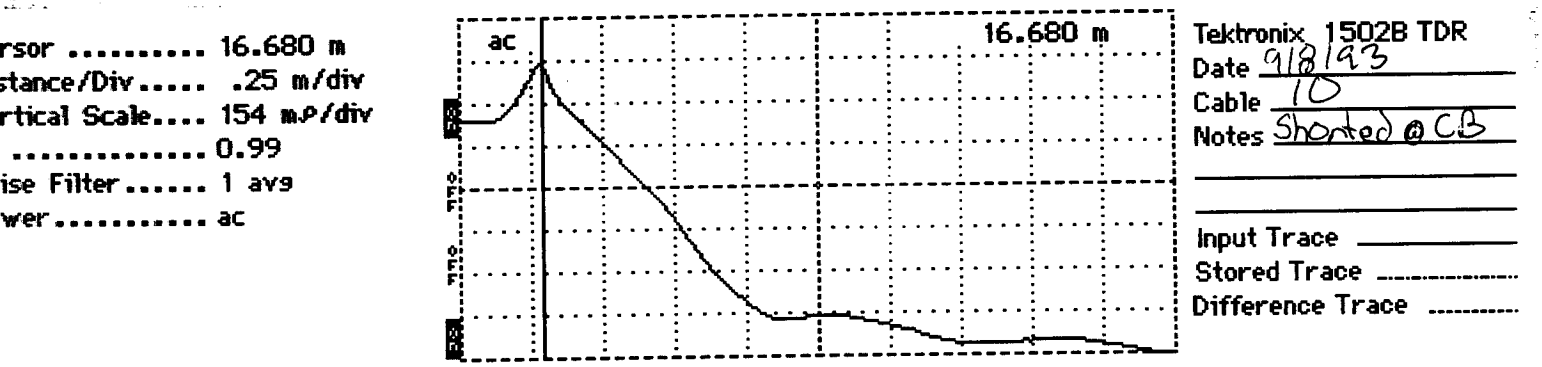
LTPP Seasonal Monitoring Study	State Code	[23]
TDR Probe Calibration	Test Section Number	[1025]

Before Operation Checks

- Calibration Date 9/8/93
- Probe S/N 23410

Probe Number 10

TDR Trace 1 - Beginning Probe Shorted



Trace Number 2 - Ending Probe Shorted

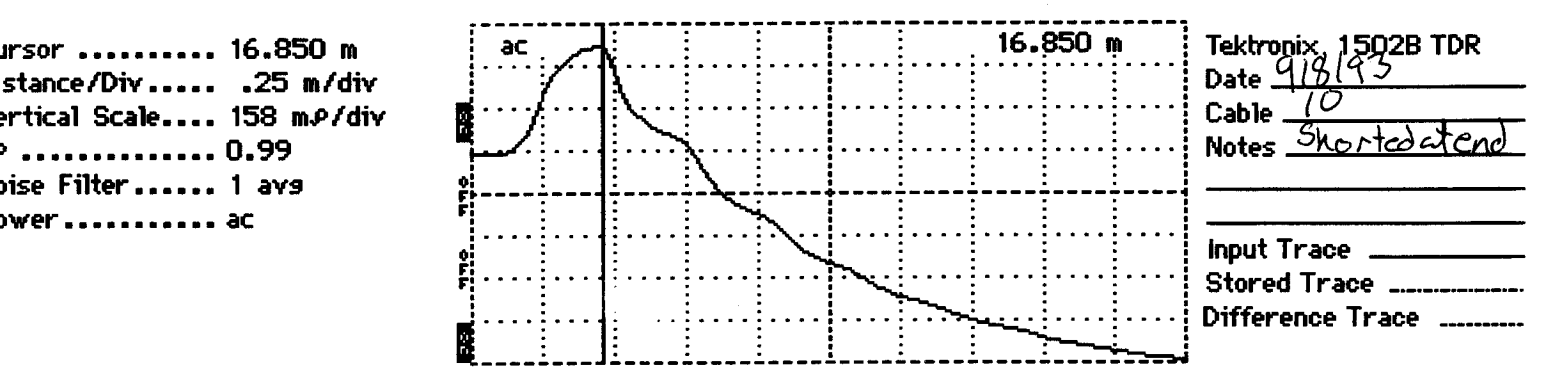
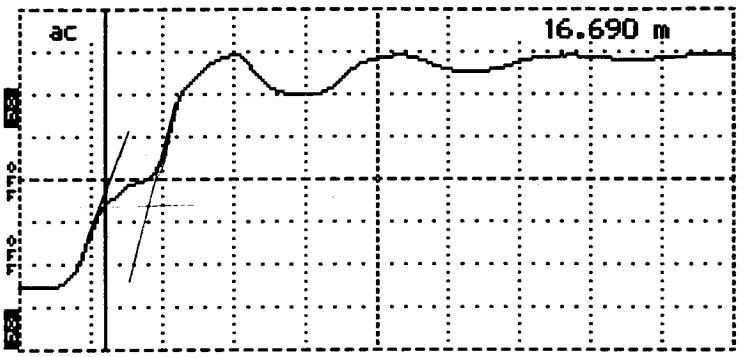


Figure B-1(cont.). TDR Traces Obtained During Calibration

Trace Number 3 - Probe in Air

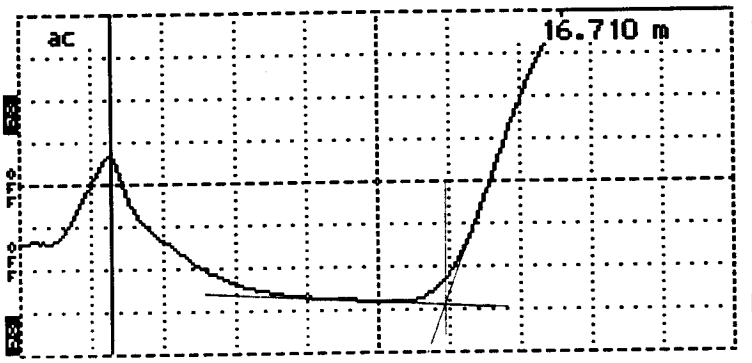
ursor ..... 16.690 m
stance/Div..... .25 m/div
rtical Scale.... 158 mρ/div
ρ 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 10
Notes In Air
Input Trace
Stored Trace
Difference Trace

Trace Number 4 - Probe in Alcohol

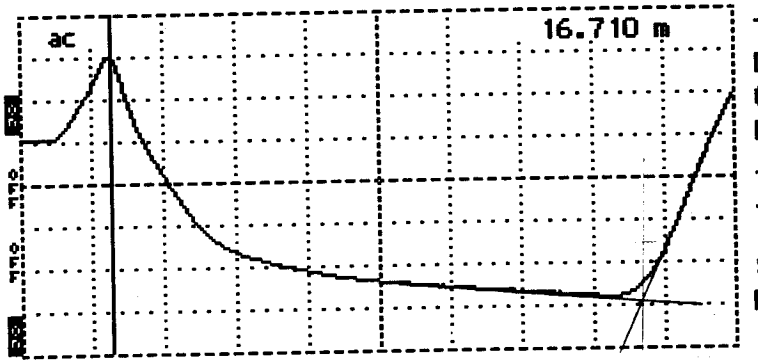
ursor ..... 16.710 m
istance/Div..... .25 m/div
ertical Scale.... 83.9 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 10
Notes In Methyl Alcohol
Input Trace
Stored Trace
Difference Trace

Trace Number 5 - Probe in Water

Cursor ..... 16.710 m
Distance/Div..... .25 m/div
Vertical Scale.... 83.9 mρ/div
Vρ 0.99
se Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9/8/93
Cable 10
Notes In H2O
Input Trace
Stored Trace
Difference Trace

Figure B-1(cont.). TDR Traces Obtained During Calibration

APPENDIX C

Supporting Instrumentation Installation Information

Appendix C contains the following supporting information:

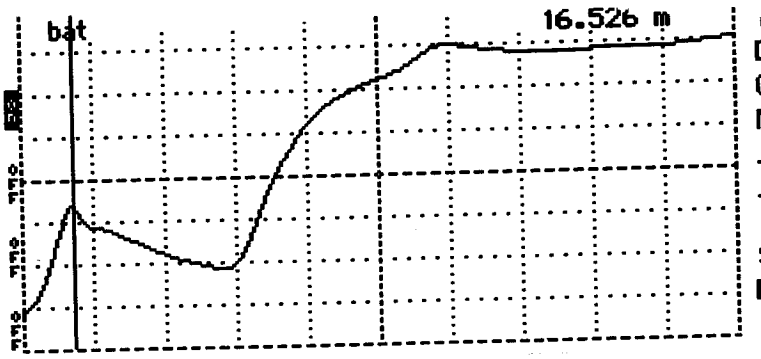
Figure C-1 TDR Traces Measured Manually During Installation

Table C-1 TDR Moisture Content During Installation

Table C-2 Field Measured Moisture Content During Installation

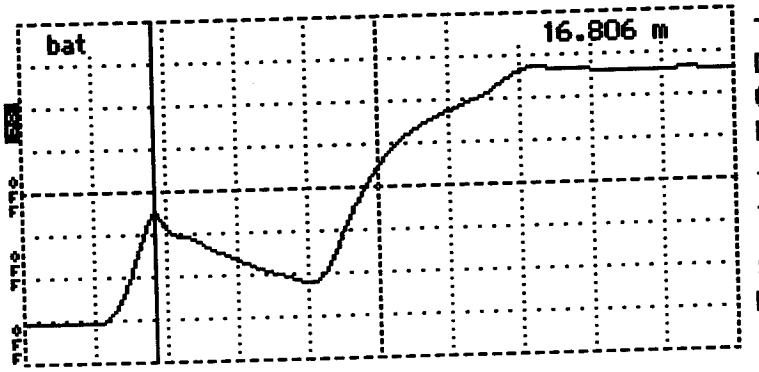
Laboratory Moisture Samples Results as Received from the State

sor ..... 16.526 m
tance/Div..... .25 m/div
tical Scale.... 83.9 mρ/div
..... 0.99
e Filter..... 1 avg
wer..... bat/low



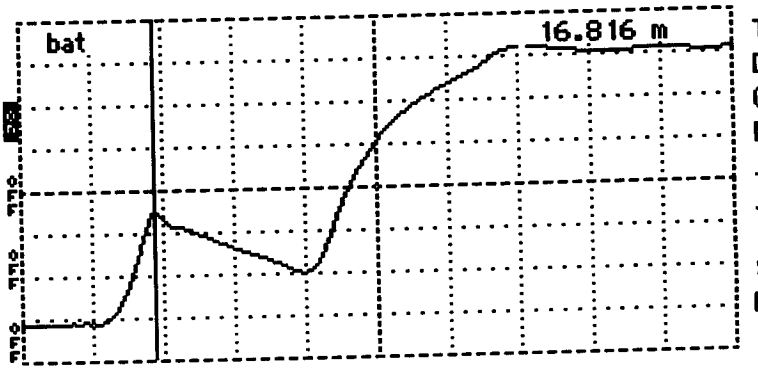
Tektronix 1502B TDR
Date 9/15/93
Cable 1
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.806 m
stance/Div..... .25 m/div
rtical Scale.... 83.9 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... bat/low



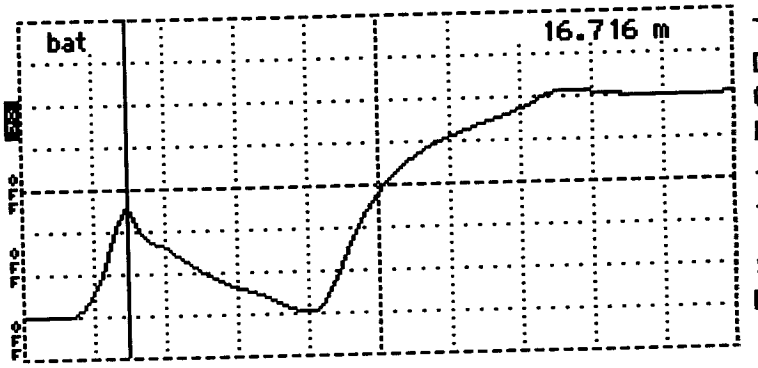
Tektronix 1502B TDR
Date 9/15/93
Cable 2
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.816 m
stance/Div..... .25 m/div
rtical Scale.... 83.9 mρ/div
..... 0.99
e Filter..... 1 avg
wer..... bat



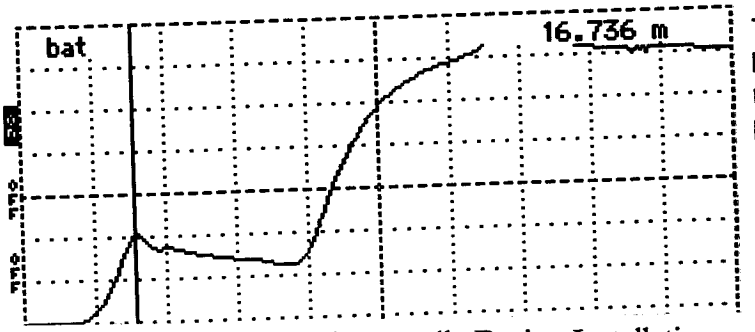
Tektronix 1502B TDR
Date 9/15/93
Cable 3
Notes
Input Trace
Stored Trace
Difference Trace

ursor ..... 16.716 m
istance/Div..... .25 m/div
ertical Scale.... 79.2 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... bat



Tektronix 1502B TDR
Date 9/15/93
Cable #4
Notes
Input Trace
Stored Trace
Difference Trace

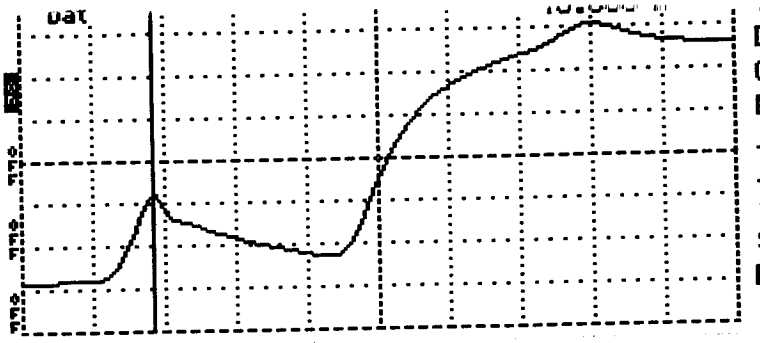
ursor ..... 16.736 m
stance/Div..... .25 m/div
ertical Scale.... 103 mρ/div
ρ 0.99
e Filter..... 1 avg
ower..... bat



Tektronix 1502B TDR
Date 9/15/93
Cable 5
Notes
Input Trace
Stored Trace
Difference Trace

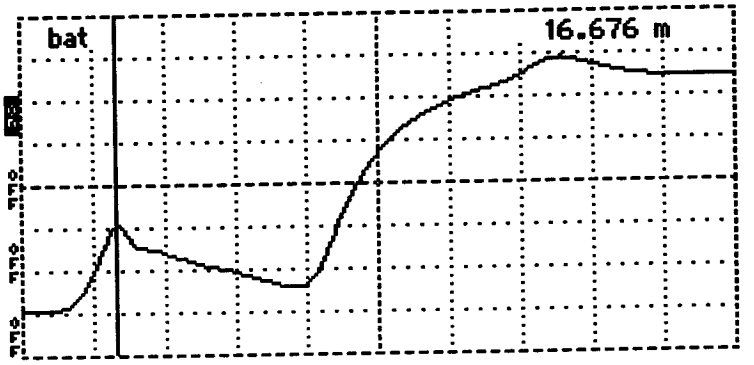
Figure C-1. TDR Traces Measured Manually During Installation

sor ..... 16.806 m
ance/Div..... .25 m/div
tical Scale.... 103 mΩ/div
..... 0.99
e Filter..... 1 avg
er..... bat



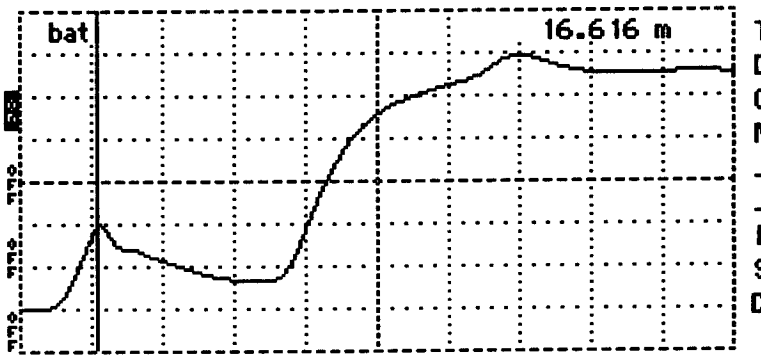
Date 9/15/93
Cable 6
Notes
Input Trace
Stored Trace
Difference Trace

sor ..... 16.676 m
tance/Div..... .25 m/div
tical Scale.... 103 mΩ/div
..... 0.99
se Filter..... 1 avg
wer..... bat



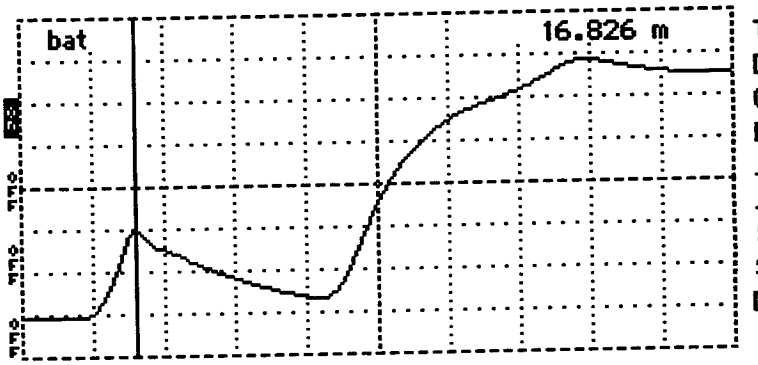
Tektronix 1502B TDR
Date 9/15/93
Cable 7
Notes
Input Trace
Stored Trace
Difference Trace

sor ..... 16.616 m
ance/Div..... .25 m/div
tical Scale.... 103 mΩ/div
..... 0.99
Filter..... 1 avg
er..... bat



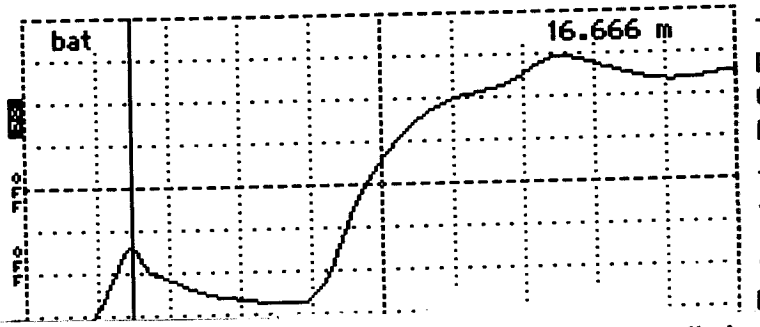
Tektronix 1502B TDR
Date 9/15/93
Cable 8
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.826 m
tance/Div..... .25 m/div
rtical Scale.... 103 mΩ/div
..... 0.99
se Filter..... 1 avg
wer..... bat



Tektronix 1502B TDR
Date 9/15/93
Cable 9
Notes
Input Trace
Stored Trace
Difference Trace

rsor ..... 16.666 m
tance/Div..... .25 m/div
rtical Scale.... 106 mΩ/div
..... 0.99
e Filter..... 1 avg
wer..... bat



Tektronix 1502B TDR
Date 9/15/93
Cable 10
Notes
Input Trace
Stored Trace
Difference Trace

Figure C-1(cont.). TDR Traces Measured Manually During Installation

Table C-1. TDR Moisture Content During Installation

TDR No.	TDR Length (m)	Dielectric Constant	Volumetric Moisture Content (%)	In-Situ Dry Density	Gravametric Moisture Content (%)
23A01	0.580	8.33	15.54	2.27	6.84
23A02	0.590	8.62	16.14	2.27	7.11
23A03	0.550	7.49	13.74	1.96	7.01
23A04	0.670	11.11	21.06	1.96	10.75
23A05	0.580	8.33	15.54	1.96	7.93
23A06	0.670	11.11	21.06	1.96	10.75
23A07	0.670	11.11	21.06	1.96	10.75
23A08	0.650	10.46	19.82	1.96	10.11
23A09	0.700	12.13	22.92	1.96	11.69
23A10	0.640	10.14	19.21	1.96	9.80

Table C-2. Field Measured Moisture Content During Installation

LTPP Seasonal Monitoring Study	State Code	[23]
In-Situ Moisture Tests	Test Section Number	[1026]

Weight (gms)	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5
Weight of Pan + Wet Soil		273.9	288.4	351.7	250.9
Weight of Pan + Dry Soil		268.3	280.7	342.1	239.2
Weight of Pan		120.9	120.3	120.9	120.3
Weight of Dry Soil		147.4	160.4	221.2	118.9
Weight of Wet Soil		153.0	168.1	230.8	130.6
Weight of Moisture		5.6	7.7	9.6	11.7
Wt of Moisture/Dry Wt x 100		3.80	4.80	4.34	9.84

Weight (gms)	Probe 6	Probe 7	Probe 8	Probe 9	Probe 10
Weight of Pan + Wet Soil	393.3	294.2	266.3	265.0	367.8
Weight of Pan + Dry Soil	369.4	279.8	254.9	252.0	344.6
Weight of Pan	120.9	120.3	120.9	120.3	120.9
Weight of Dry Soil	248.5	159.5	134.0	131.7	223.7
Weight of Wet Soil	272.4	173.9	145.4	144.7	246.9
Weight of Moisture	23.9	14.4	11.4	13.0	23.2
Wt of Moisture/Dry Wt x 100	9.62	9.03	8.51	9.87	10.37

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101426 Material : MISC. ITEMS ROADWAY SOIL #1

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. :

Sample Type : O

Sample Location :

Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

***** SIEVE ANALYSIS / T27 ***** *** Washed *** **Pass< > FAIL< >**

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 4.4 FM: Test Date: 09/18/1993

***** HYDRO / T88 *****

Dia.	% Passing

***** QUALITIES ***** **Pass < > Fail < >**

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #1 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101427 Material : MISC. ITEMS ROADWAY SOIL #2

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. : Sample Type : O

Sample Location : Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/19

***** SIEVE ANALYSIS / T27 ***** *** Washed *** **Pass< > FAIL< >**

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0	0	#4		
4"	0	0	#8		
3"	0	0	#10		
2"	0	0	#16		
1 1/2"	0	0	#20		
1"	0	0	#30		
3/4"	0	0	#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 3.9 FM: Test Date: 09/18/1993

***** HYDRO / T88 *****

Dia.	% Passing

***** QUALITIES ***** **Pass < > Fail < >**

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #2 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101428 Material : MISC. ITEMS ROADWAY SOIL #3

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. : Sample Type : O

Sample Location : Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/19

***** SIEVE ANALYSIS / T27 ***** *** Washed *** **Pass< >** **FAIL< >**

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 3.5 FM: Test Date: 09/18/1993

***** HYDRO / T88 *****

Dia.	% Passing

***** QUALITIES ***** **Pass < >** **Fail < >**

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #3 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101429 Material : MISC. ITEMS ROADWAY SOIL #4

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. : Sample Type : O

Sample Location : Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

***** SIEVE ANALYSIS / T27 ***** *** Washed *** **Pass< >** **FAIL< >**

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 4.2 FM: Test Date: 09/18/1993

***** HYDRO / T88 *****

Dia.	% Passing

***** QUALITIES ***** **Pass < >** **Fail < >**

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #4 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101430 Material : MISC. ITEMS ROADWAY SOIL #5

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. : Sample Type : O

Sample Location : Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

***** SIEVE ANALYSIS / T27 ***** *** Washed *** **Pass< >** **FAIL< >**

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.

Natural Water Content 8.7

***** HYDRO / T88 *****

Dia.	% Passing

***** QUALITIES ***** **Pass < > Fail < >**

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #5 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/21/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101431 Material : MISC. ITEMS ROADWAY SOIL #6

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. :

Sample Type : O

Sample Location :

Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

*** SIEVE ANALYSIS / T27 *** * Washed * Pass< > FAIL< >

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 7.6 FM: Test Date: 09/18/1993

*** HYDRO / T88 ***

Dia.	% Passing

*** QUALITIES *** Pass < > Fail < >

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #6 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101432 Material : MISC. ITEMS ROADWAY SOIL #7

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. :

Sample Type : O

Sample Location :

Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

*** SIEVE ANALYSIS / T27 *** * Washed * Pass< > FAIL< >

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 7.0 FM: Test Date: 09/18/1993

*** HYDRO / T88 ***

Dia.	% Passing

*** QUALITIES *** Pass < > Fail < >

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #7 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101433 Material : MISC. ITEMS ROADWAY SOIL #8

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. : Sample Type : O

Sample Location : Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

***** SIEVE ANALYSIS / T27 ***** *** Unwashed *** **Pass< > FAIL< >**

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 8.2 FM: Test Date: 09/18/1993

***** HYDRO / T88 *****

Dia.	% Passing

***** QUALITIES ***** **Pass < > Fail < >**

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #8 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101434 Material : MISC. ITEMS ROADWAY SOIL #9

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. : Sample Type : O

Sample Location : Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/19

*** SIEVE ANALYSIS / T27 *** * Washed * Pass< > FAIL< >

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 9.4 FM: Test Date: 09/18/1993

*** HYDRO / T88 ***

Dia.	% Passing

*** QUALITIES *** Pass < > Fail < >

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #9 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

STATE OF MAINE - DEPARTMENT OF TRANSPORTATION
TSD - CENTRAL LAB, BANGOR, MAINE
AGGREGATE REPORT

REF# : 101435 Material : MISC. ITEMS ROADWAY SOIL #10

Project ID: 005409.94 Town(s) : RESEARCH

Resident Engr. :

Sample Type : O

Sample Location :

Date : 09/15/1993

Original Source : -

Sampled By : C THOMPSON Received : 09/16/1993 Reported : 09/18/199

*** SIEVE ANALYSIS / T27 *** * Washed * Pass< > FAIL< >

Sieve	% Passing	Spec.	Sieve	% Passing	Spec.
6"	0.0		#4		
4"	0.0		#8		
3"	0.0		#10		
2"	0.0		#16		
1 1/2"	0.0		#20		
1"	0.0		#30		
3/4"	0.0		#40		
1/2"			#50		
3/8"			#60		
1/4"			#100		
			#200		

Water Content: 9.6 FM: Test Date: 09/18/1993

*** HYDRO / T88 ***

Dia.	% Passing

*** QUALITIES *** Pass < > Fail < >

Fracture / MDOT... :
SPGR / T84,T85.... :
LA Wear / T96..... :
Unit Weight / T19. :
Sand Equivalent / T176 :

Elongation / MDOT..... :
Absorption / T84,T85.... :
PH / MDOT..... :
Color Plate / T21..... :
Friable Particles / T112 :
Degradation / MDOT..... :

Comments:
FHWA SAMPLE #10 RESULTS TO J. DUNPHY

Reported By: Brian D. Fogg BDF
Date Reported: 09/18/1993

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

Table D-1. Data from the Onsite Datalogger During Initial Data Collection, September 16, 1993

4,259,1251,17,.1
5,259,1251,28.53,26.2,23.52,22.56,22.4
4,259,1252,17.16,2.4
5,259,1252,28.54,26.21,23.53,22.56,22.4
4,259,1253,17.38,1.3
5,259,1253,28.59,26.24,23.56,22.56,22.4
6,259,1253,-441.6,-908,-1363,-1779,-2072,-2235,-2314,-2351,-2367,-2374,-2340,-2362,-2370,-2374,-2376,-2376,-2376,-2377,-2378,-2377,-2377,-2378,-2379,-2380,-2379,-2378,-2378,-2378,-2378,-2378,-2342,-2363,-2371,-2375,-2377
4,259,1254,17.28,1.9
5,259,1254,28.63,26.28,23.57,22.57,22.43
4,259,1255,16.87,1.3
5,259,1255,28.66,26.29,23.57,22.59,22.43
1,1993,259,17.03,17.43,1253,16.7,1256,8.1,-6999,-6999,1251,-6999,1251,28.63,26.27,23.57,22.58,22.42,22.66,22.95,23.18,23.57,23.52,23.26,22.92,22.61,22.25,21.83,21.57,21.2,20.86
2,1993,259,28.73,1256,26.33,1255,23.6,1255,22.61,1255,22.43,1253,22.66,1253,22.95,1253,23.18,1253,23.57,1253,23.52,1253,23.26,1253,22.92,1253,22.64,1251,22.25,1253,21.83,125
3,21.57,1253,21.2,1253,20.86,1253
3,1993,259,28.53,1251,26.2,1251,23.52,1251,22.56,1251,22.4,1251,22.64,1251,22.95,1251,23.18,1251,23.57,1251,23.52,1251,23.26,1251,22.92,1251,22.61,1251,22.25,1251,21.83,1251,
21.57,1251,21.2,1251,20.86,1251
4,259,1256,16.73,1.1
5,259,1256,28.71,26.33,23.6,22.6,22.43
4,259,1257,16.65,1
5,259,1257,28.76,26.36,23.61,22.61,22.43
6,259,1257,-1812,-2094,-2247,-2322,-2357,-2371,-2378,-2379,-2379,-2380,-2344,-2365,-2373,-2376,-2378,-2376,-2376,-2376,-2339,-2361,-2371,-2375,-2376,-2378,-2378,-2377,-2378,-
2378,-2341,-2361,-2371,-2375,-2376,-2378,-2378
4,259,1258,16.73,.2
5,259,1258,28.8,26.38,23.62,22.62,22.43
4,259,1259,16.77,0
5,259,1259,28.84,26.4,23.65,22.64,22.43
4,259,1300,16.8,0
5,259,1300,28.88,26.43,23.66,22.64,22.44
4,259,1301,16.81,0
5,259,1301,28.92,26.45,23.67,22.66,22.45
6,259,1301,-1808,-2089,-2242,-2318,-2351,-2366,-2373,-2337,-2359,-2369,-2373,-2374,-2374,-2339,-2359,-2369,-2372,-2374,-2337,-2359,-2368,-2371,-2373,-2337,-2357,-2330,-2355,-
2366,-2371,-2374,-2374,-2374,-2374,-2373,-2372
4,259,1302,16.99,0
5,259,1302,28.96,26.48,23.7,22.66,22.46
4,259,1303,17,0
5,259,1303,28.99,26.51,23.7,22.66,22.46
1,1993,259,16.85,17.09,1304,16.62,1257,1.2,-6999,-6999,1256,-6999,1256,28.9,26.45,23.67,22.65,22.44,22.66,22.95,23.16,23.57,23.52,23.26,22.92,22.61,22.25,21.83,21.57,21.2,20.86
2,1993,259,29.01,1303,26.56,1303,23.73,1303,22.69,1303,22.46,1302,22.66,1302,22.95,1302,23.18,1256,23.57,1302,23.52,1302,23.26,1302,22.92,1302,22.61,1302,22.25,1302,21.83,13
02,21.57,1302,21.2,1302,20.86,1302
3,1993,259,28.73,1256,26.35,1256,23.6,1256,22.61,1256,22.43,1259,22.66,1259,22.95,1259,23.16,1259,23.57,1259,23.52,1259,23.26,1259,22.92,1259,22.61,1259,22.22,1256,21.83,125
9,21.57,1259,21.2,1259,20.86,1259
4,259,1304,16.99,0
5,259,1304,29.01,26.55,23.73,22.68,22.46
6,259,1305,-1841,-2107,-2250,-2318,-2350,-2365,-2371,-2375,-2339,-2361,-2369,-2373,-2338,-2359,-2368,-2373,-2373,-2373,-2374,-2374,-2374,-2375,-2374,-2373,-2374,-2373,-2373,-
2373,-2373,-2372,-2372,-2372,-2371,-2371,-2371
4,259,1305,17.31,.1
5,259,1305,29.02,26.57,23.74,22.69,22.48
4,259,1306,17.45,0
5,259,1306,29.04,26.6,23.77,22.69,22.48
4,259,1307,17.26,0
5,259,1307,29.06,26.62,23.78,22.72,22.48
4,259,1308,16.84,0
5,259,1308,29.08,26.65,23.8,22.72,22.48
6,259,1309,-1779,-2069,-2230,-2309,-2345,-2359,-2366,-2369,-2370,-2371,-2371,-2370,-2370,-2333,-2353,-2362,-2366,-2369,-2369,-2369,-2332,-2353,-2363,-2367,-2369,-2368,-2367,-
2367,-2367,-2367,-2367,-2367,-2367,-2366,-2366
4,259,1309,16.68,0
5,259,1309,29.12,26.68,23.81,22.74,22.49
4,259,1310,16.74,0
5,259,1310,29.14,26.7,23.83,22.74,22.51
4,259,1311,16.61,0
5,259,1311,29.17,26.72,23.84,22.75,22.51
1,1993,259,16.9,17.46,1305,16.51,1311,.1,-6999,-6999,1304,-6999,1304,29.11,26.66,23.81,22.73,22.49,22.66,22.95,23.16,23.56,23.52,23.26,22.92,22.61,22.24,21.83,21.57,21.2,20.86
2,1993,259,29.22,1311,26.76,1311,23.86,1310,22.77,1311,22.51,1309,22.66,1304,22.95,1304,23.16,1304,23.57,1304,23.52,1304,23.26,1304,22.92,1304,22.61,1304,22.25,1304,21.83,13
04,21.57,1304,21.2,1304,20.86,1304
3,1993,259,29.01,1304,26.56,1304,23.73,1304,22.69,1305,22.48,1308,22.66,1310,22.92,1311,23.16,1310,23.55,1310,23.52,1310,23.26,1310,22.92,1310,22.61,1310,22.22,1310,21.83,13
10,21.57,1310,21.2,1310,20.86,1310
4,259,1312,16.59,0
5,259,1312,29.2,26.75,23.86,22.77,22.51
4,259,1313,16.63,0
5,259,1313,29.23,26.77,23.88,22.77,22.52
6,259,1313,-1773,-2063,-2224,-2303,-2339,-2355,-2362,-2366,-2368,-2369,-2369,-2370,-2333,-2353,-2363,-2368,-2370,-2370,-2371,-2370,-2369,-2371,-2371,-2371,-2371,-2368,-2369,-
2370,-2370,-2370,-2370,-2370,-2370,-2333,-2353,-2361
4,259,1314,16.87,0
5,259,1314,29.26,26.79,23.88,22.79,22.53
4,259,1315,16.85,0
5,259,1315,29.28,26.81,23.9,22.79,22.53
4,259,1316,16.84,0
5,259,1316,29.32,26.83,23.92,22.82,22.53
4,259,1317,17.41,0
5,259,1317,29.34,26.86,23.93,22.82,22.56
6,259,1317,-1808,-2088,-2242,-2316,-2350,-2365,-2371,-2373,-2374,-2374,-2374,-2374,-2374,-2372,-2371,-2371,-2372,-2372,-2372,-2372,-2372,-2372,-2372,-2372,-2372,-2371,-2371,-
2371,-2371,-2371,-2371,-2370,-2333,-2352,-2361
4,259,1318,17.53,0
5,259,1318,29.37,26.89,23.96,22.83,22.56
4,259,1319,17.25,0

Table D-1(cont.). Data from the Onsite Datalogger During Initial Data Collection, September 16, 1993

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12,21.57,1312,21.2,1312,20.86,1312
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19,21.57,1319,21.2,1319,20.86,1319
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5,259,1320,29.4,26.93,23.98,22.85,22.56
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2361,-2365,-2367,-2367,-2369,-2369,-2368,-2332
4,259,1322,17.17,0
5,259,1322,29.45,26.99,24.02,22.87,22.56
4,259,1323,17.37,0
5,259,1323,29.48,27,24.04,22.87,22.58
4,259,1324,17.48,0
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4,259,1325,17.35,0
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6,259,1325,-1804,-2082,-2233,-2306,-2341,-2358,-2365,-2367,-2333,-2354,-2363,-2367,-2369,-2370,-2370,-2370,-2370,-2370,-2370,-2370,-2371,-2371,-2372,-2371,-2371,-2370,-2370,-
2369,-2369,-2369,-2370,-2333,-2354,-2362,-2366
4,259,1326,17.07,0
5,259,1326,29.58,27.09,24.09,22.91,22.6
4,259,1327,17.23,0
5,259,1327,29.61,27.09,24.11,22.92,22.61
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25,21.57,1325,21.2,1325,20.86,1325
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28,21.57,1328,21.2,1328,20.86,1328
3,1993,259,29.63,1328,27.15,1328,24.14,1328,22.95,1328,22.61,1328,22.69,1332,22.92,1334,23.1,1334,23.52,1334,23.49,1334,23.23,1334,22.9,1334,22.61,1334,22.22,1334,21.83,1334,
21.57,1334,21.2,1334,20.86,1331
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4,259,1338,17.79,0
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4,259,1339,17.78,0
5,259,1339,29.88,27.38,24.32,23.06,22.66
4,259,1340,17.59,0
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4,259,1341,17.45,0
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2357,-2321,-2341,-2350,-2354,-2356,-2357,-2357
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21.57,1337,21.17,1337,20.83,1341
4,259,1344,17.11,0
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4,259,1345,17.12,0
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Table D-1(cont.). Data from the Onsite Datalogger During Initial Data Collection, September 16, 1993

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5,259,1348,29.98,27.6,24.47,23.16,22.74
4,259,1349,16.96,0
5,259,1349,29.98,27.62,24.5,23.16,22.74
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4,259,1353,16.79,0
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6,259,1353,-1738,-2021,-2182,-2262,-2300,-2317,-2325,-2328,-2330,-2330,-2329,-2330,-2330,-2330,-2330,-2329,-2329,-2328,-2328,-2328,-2328,-2291,-2312,-2321,-2323,-2325,-2326,-2326,-2326,-2327,-2327,-2328,-2328,-2328,-2290
4,259,1354,16.76,0
5,259,1354,30.02,27.71,24.58,23.21,22.76
4,259,1355,16.77,0
5,259,1355,29.99,27.74,24.6,23.23,22.76
4,259,1356,16.88,0
5,259,1356,29.94,27.76,24.62,23.23,22.77
4,259,1357,17.18,0
5,259,1357,29.85,27.78,24.64,23.26,22.79
6,259,1357,-1718,-2007,-2173,-2256,-2295,-2313,-2320,-2287,-2309,-2319,-2325,-2325,-2325,-2325,-2325,-2324,-2325,-2288,-2307,-2317,-2320,-2322,-2323,-2324,-2325,-2325,-2323,-2323,-2323,-2286,-2306,-2315,-2318,-2320,-2321
4,259,1358,17.49,0
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4,259,1359,17.36,0
5,259,1359,29.76,27.81,24.67,23.26,22.79
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4,259,1400,17.18,0
5,259,1400,29.72,27.81,24.69,23.28,22.82
4,259,1401,17.12,0
5,259,1401,29.73,27.83,24.72,23.28,22.81
6,259,1401,-1714,-2001,-2166,-2249,-2288,-2305,-2313,-2316,-2317,-2318,-2317,-2318,-2318,-2318,-2281,-2303,-2312,-2315,-2317,-2317,-2317,-2280,-2301,-2311,-2314,-2314,-2315,-2278,-2299,-2309,-2313,-2314,-2315,-2315,-2315
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5,259,1402,29.75,27.83,24.73,23.31,22.81
4,259,1403,17.27,0
5,259,1403,29.78,27.83,24.73,23.31,22.82
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5,259,1404,29.81,27.86,24.75,23.32,22.84□

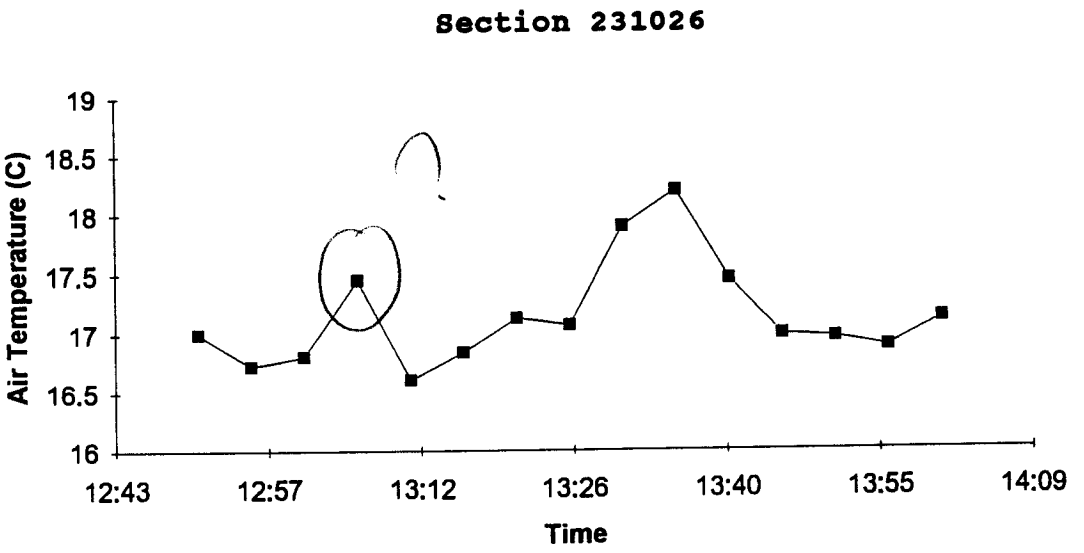

Figure D-1. Measured Air Temperature
During Initial Data Collection, September 16, 1993

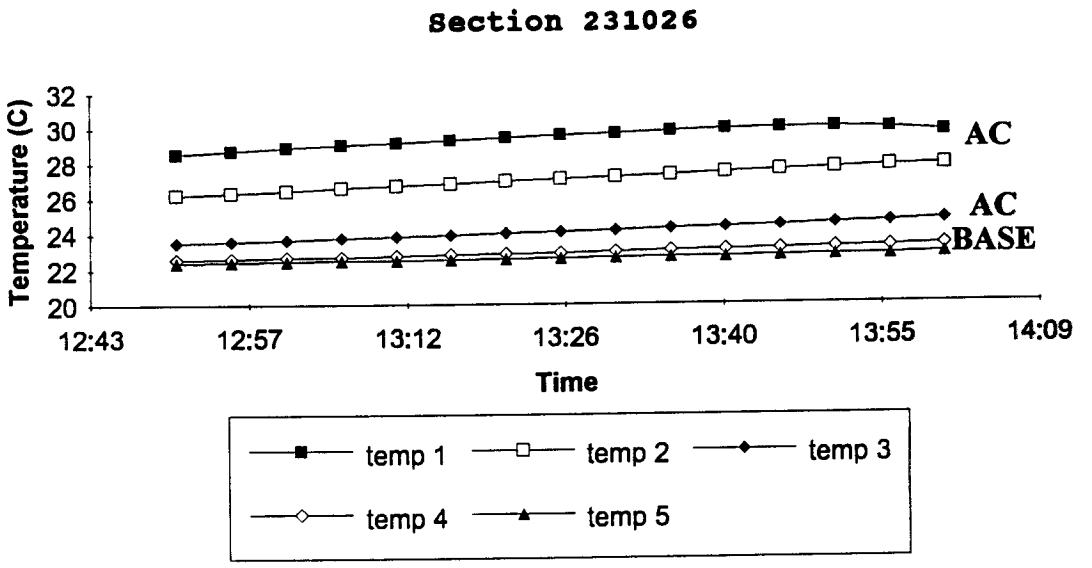

Figure D-2. Measured Subsurface Temperature for the First 5 Sensors During Initial Data Collection, September 16, 1993

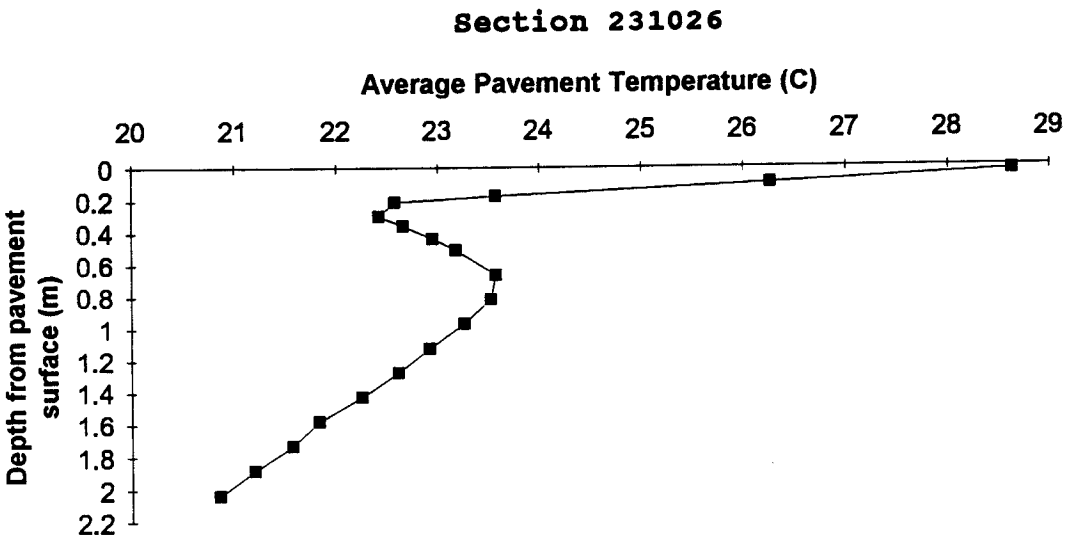

Figure D-3. Measured Subsurface Temperature for All 18 Sensors During Initial Data Collection, September 16, 1993

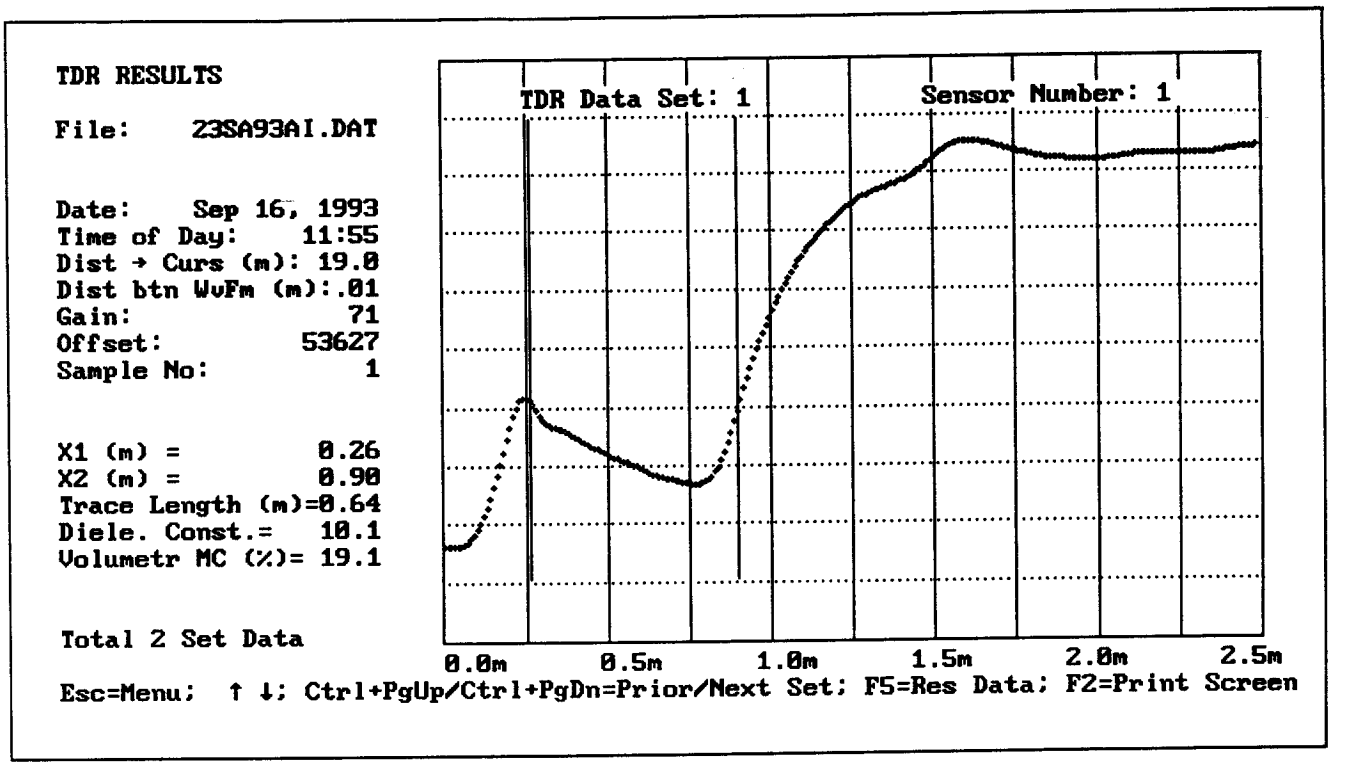

Figure D-4. Initial First Set of TDR Traces Measured with the Mobile Unit

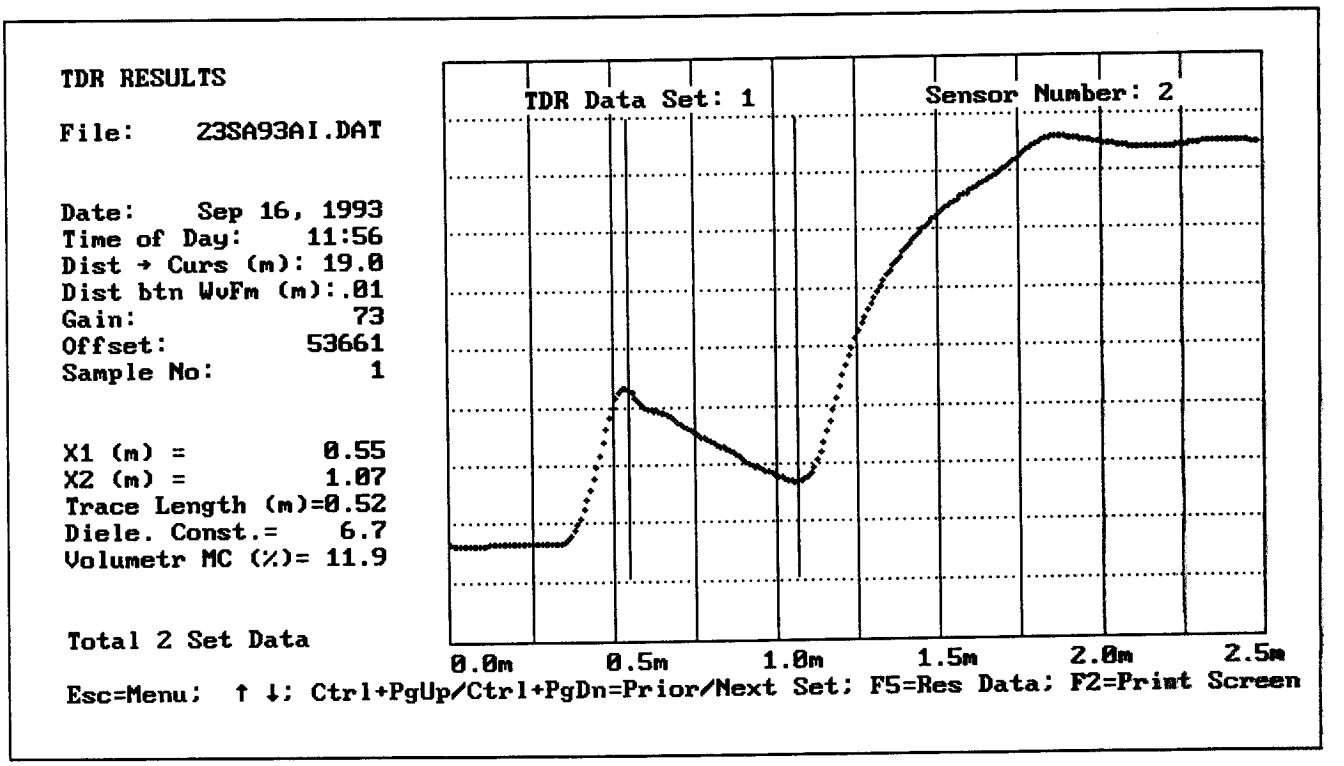

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

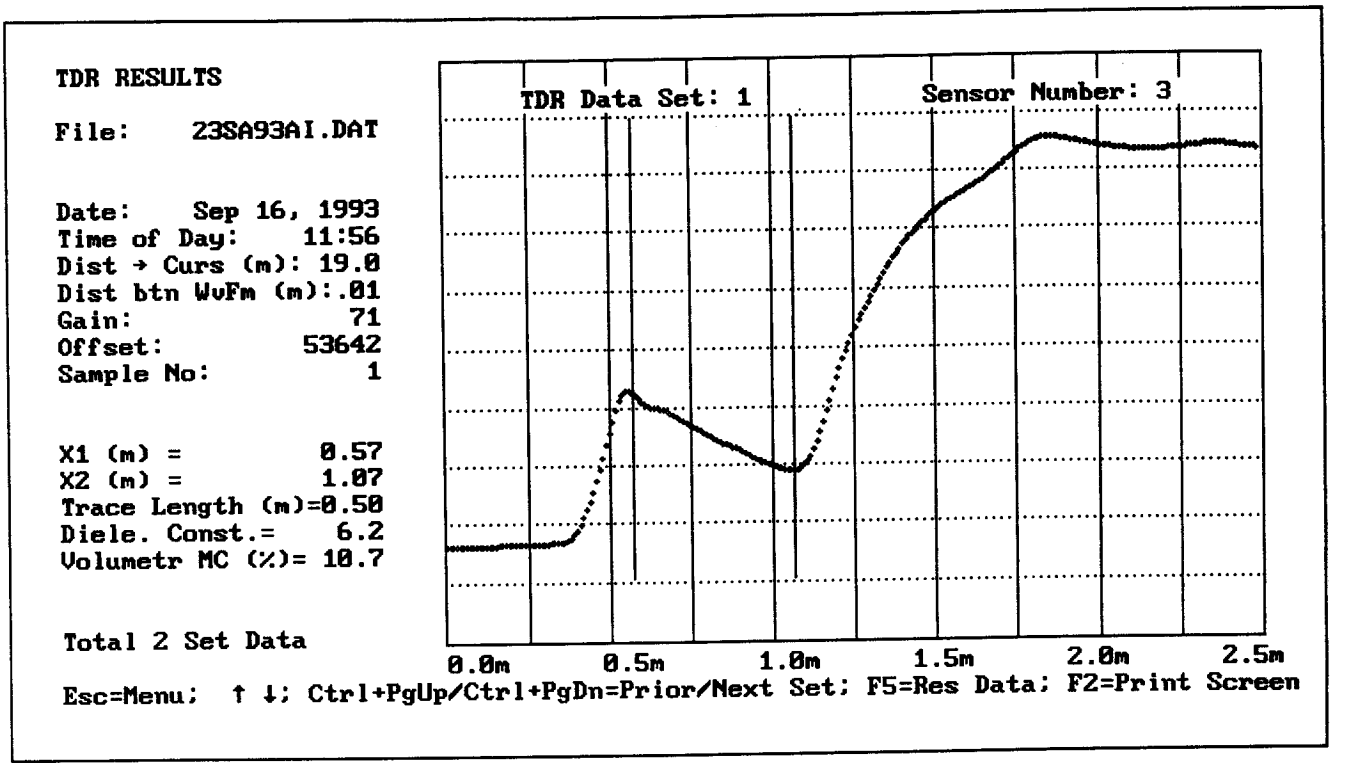

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

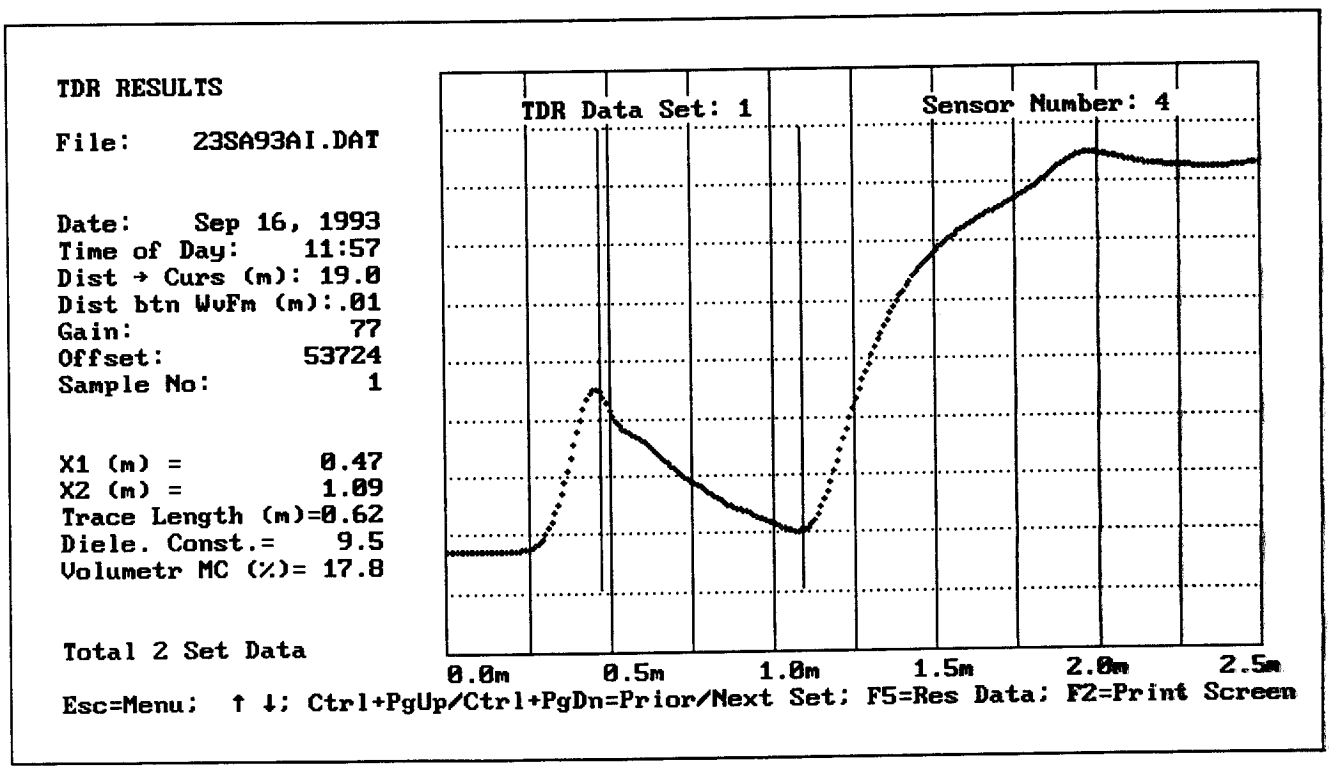

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

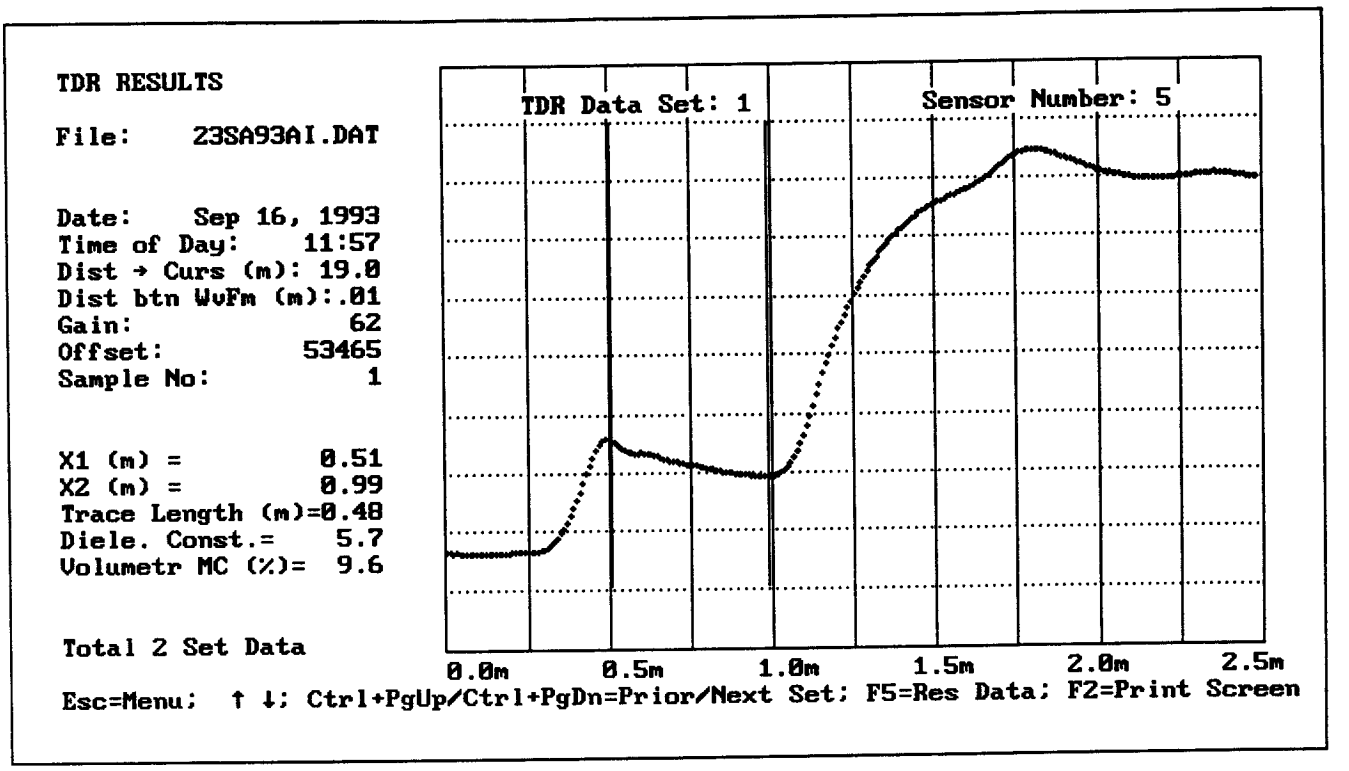

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

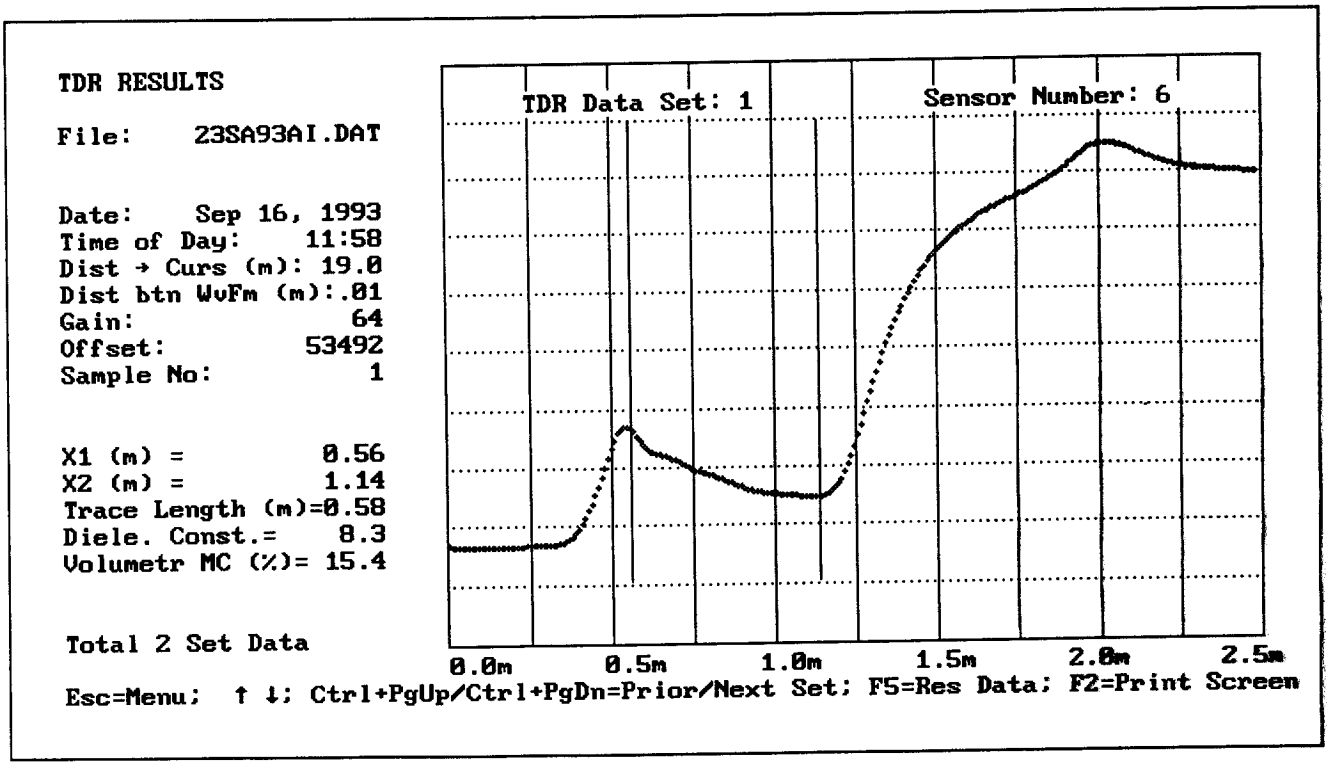

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

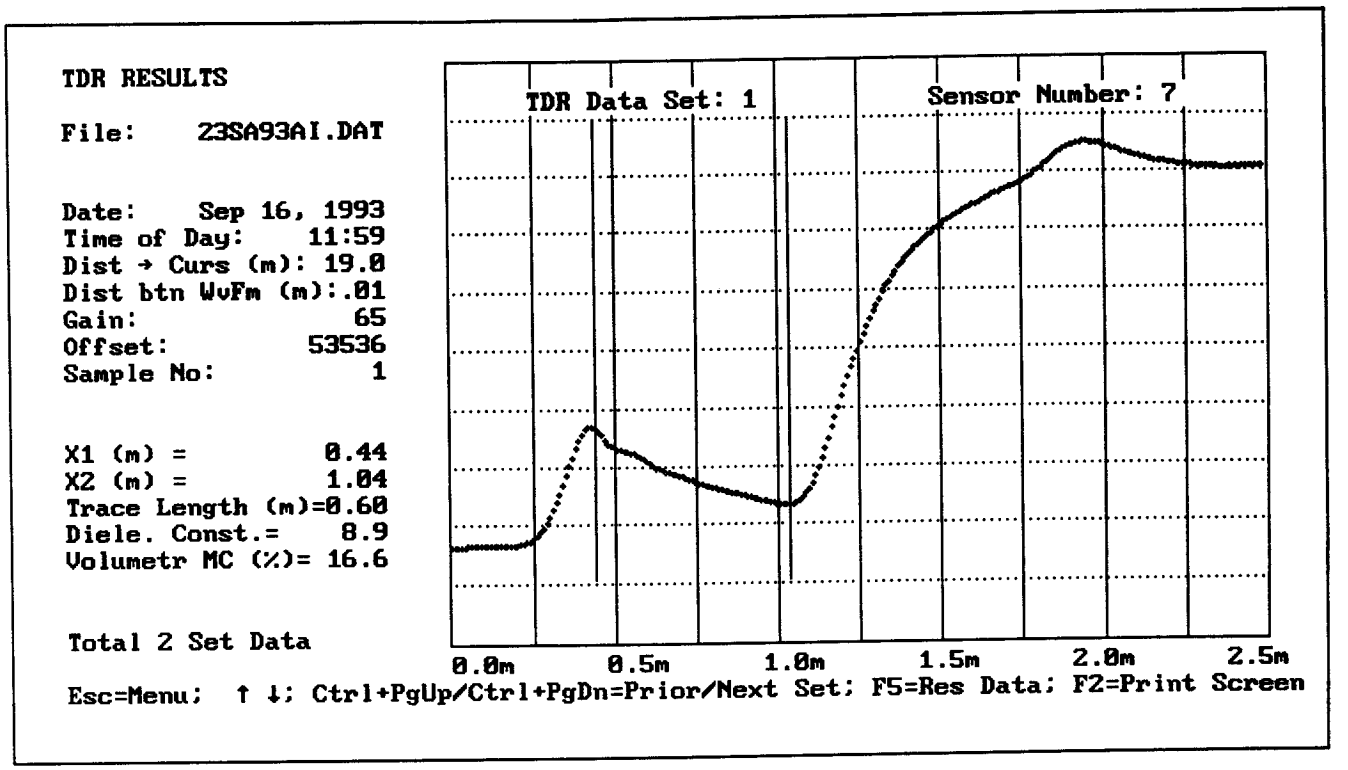

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

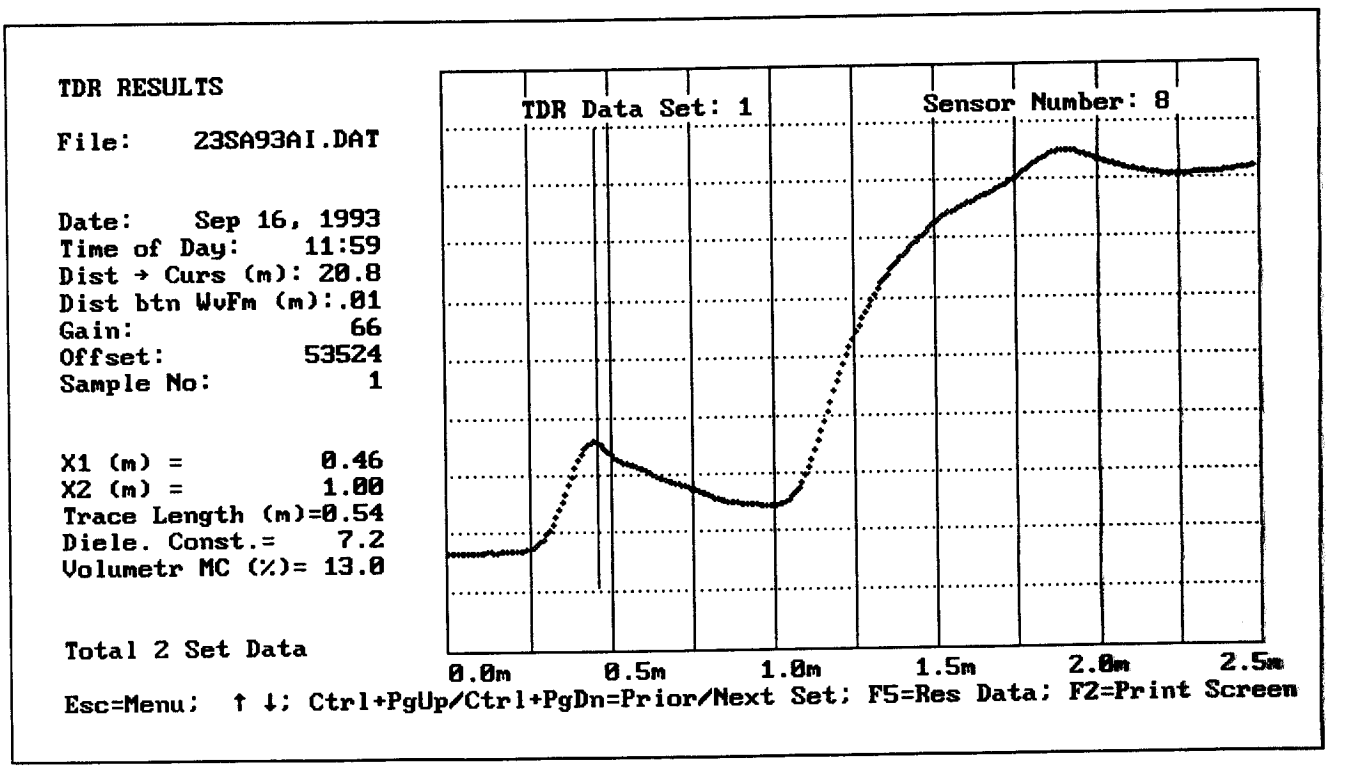

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

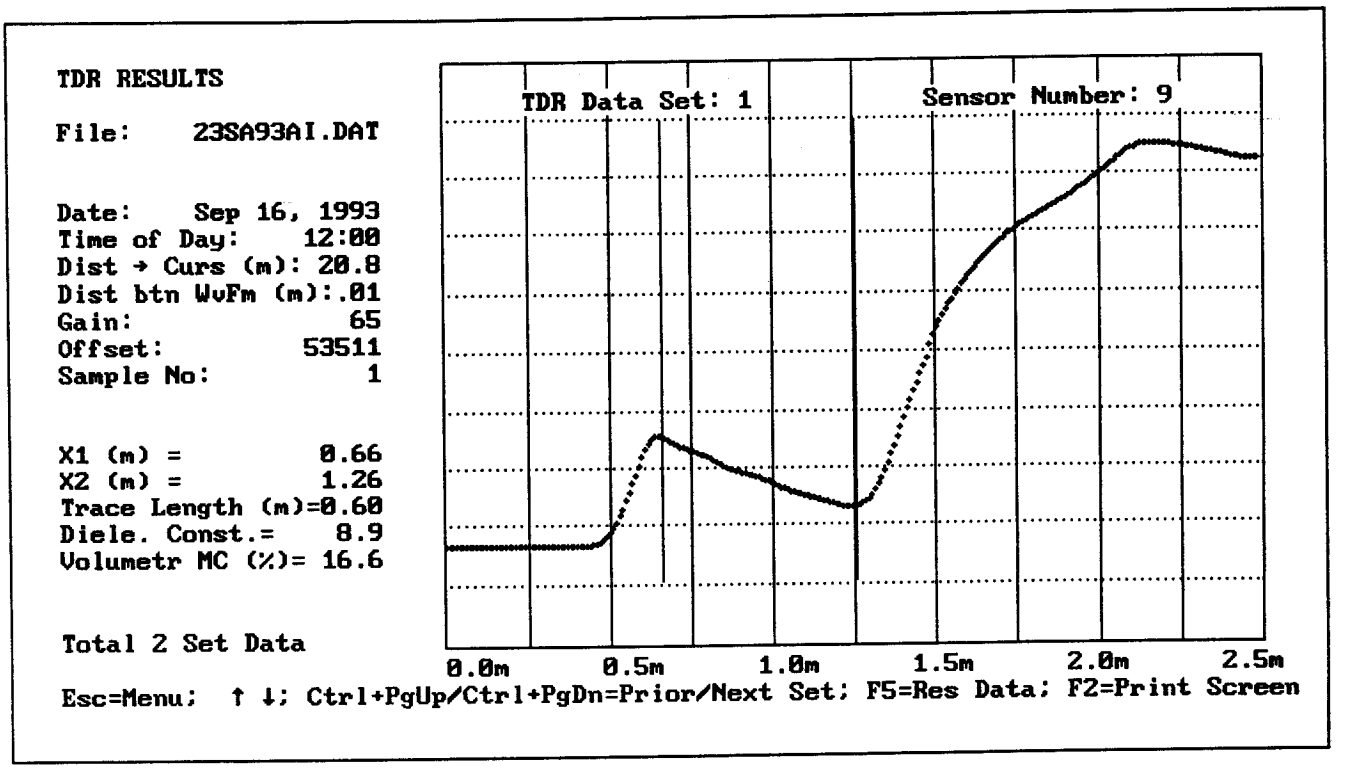

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

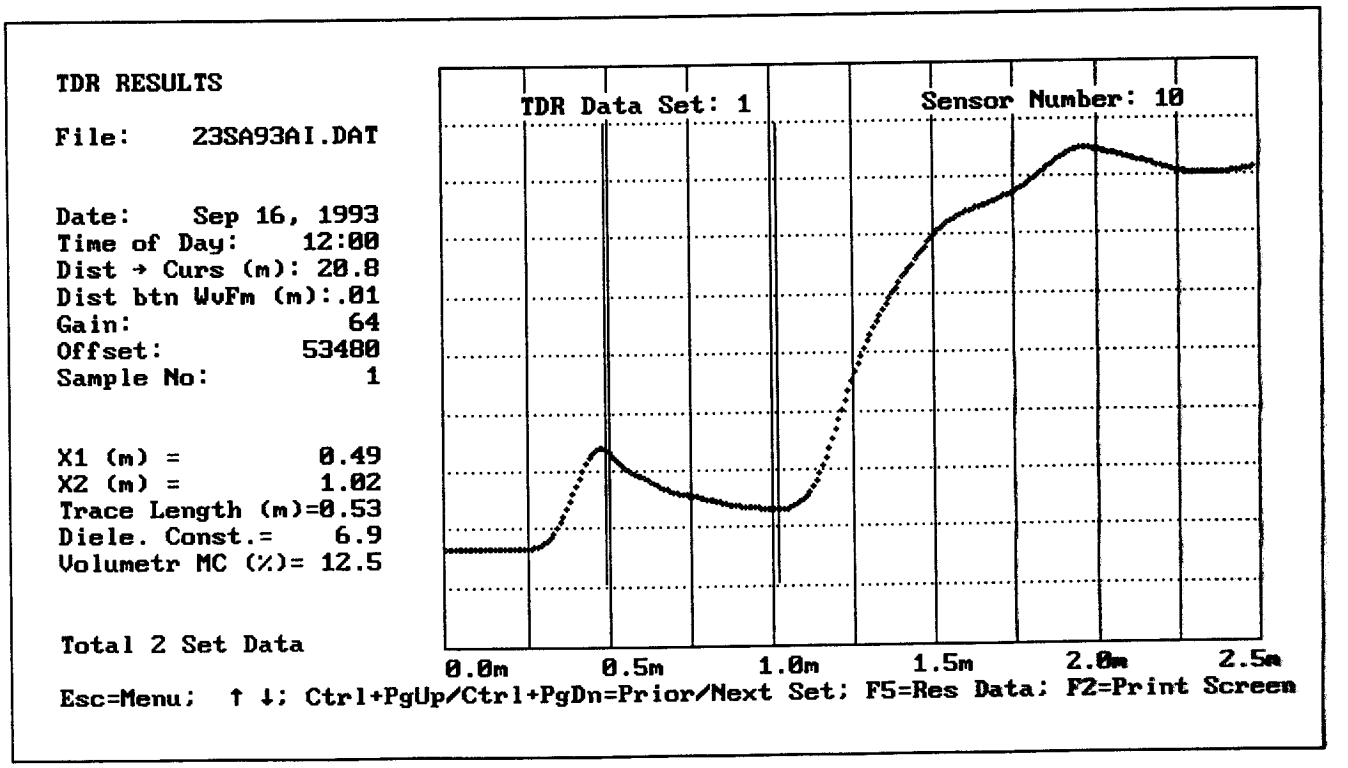

Figure D-4(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

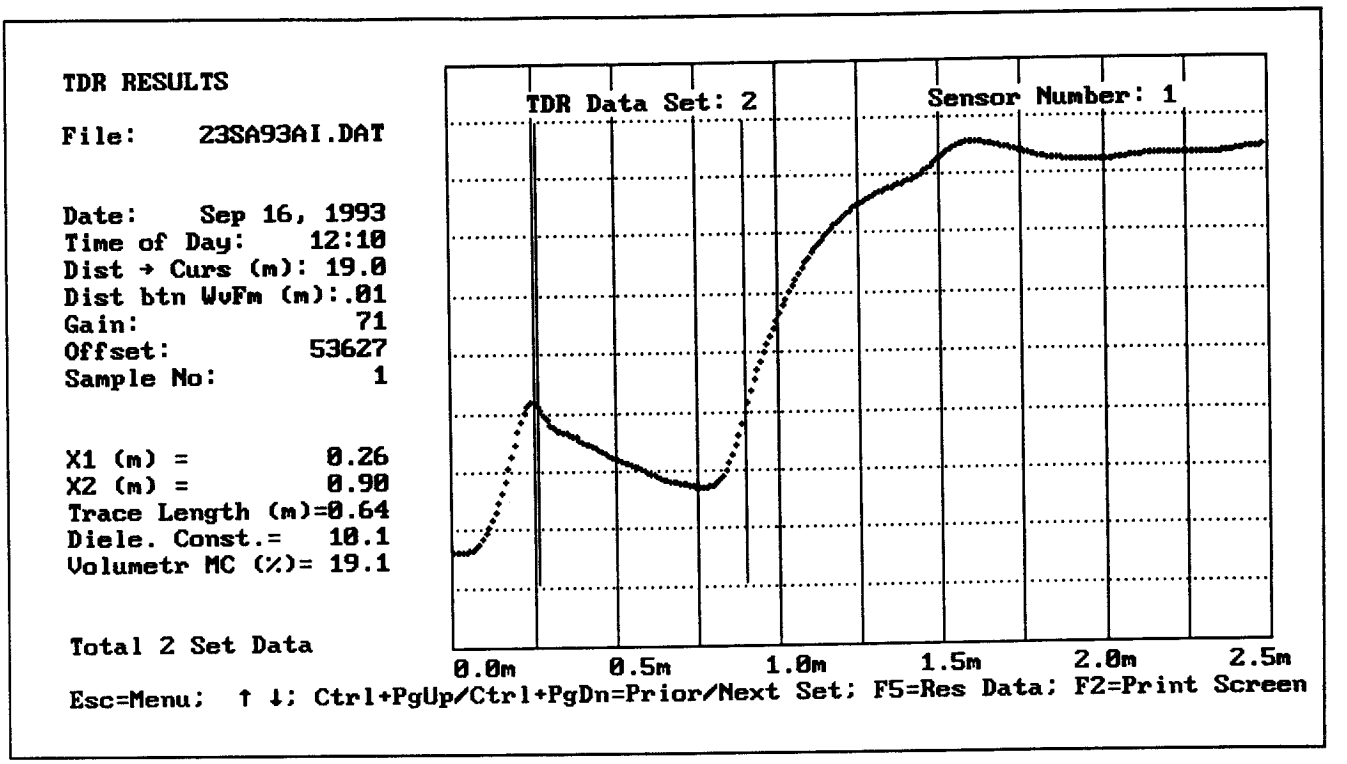

Figure D-5. Initial Second Set of TDR Traces Measured with the Mobile Unit

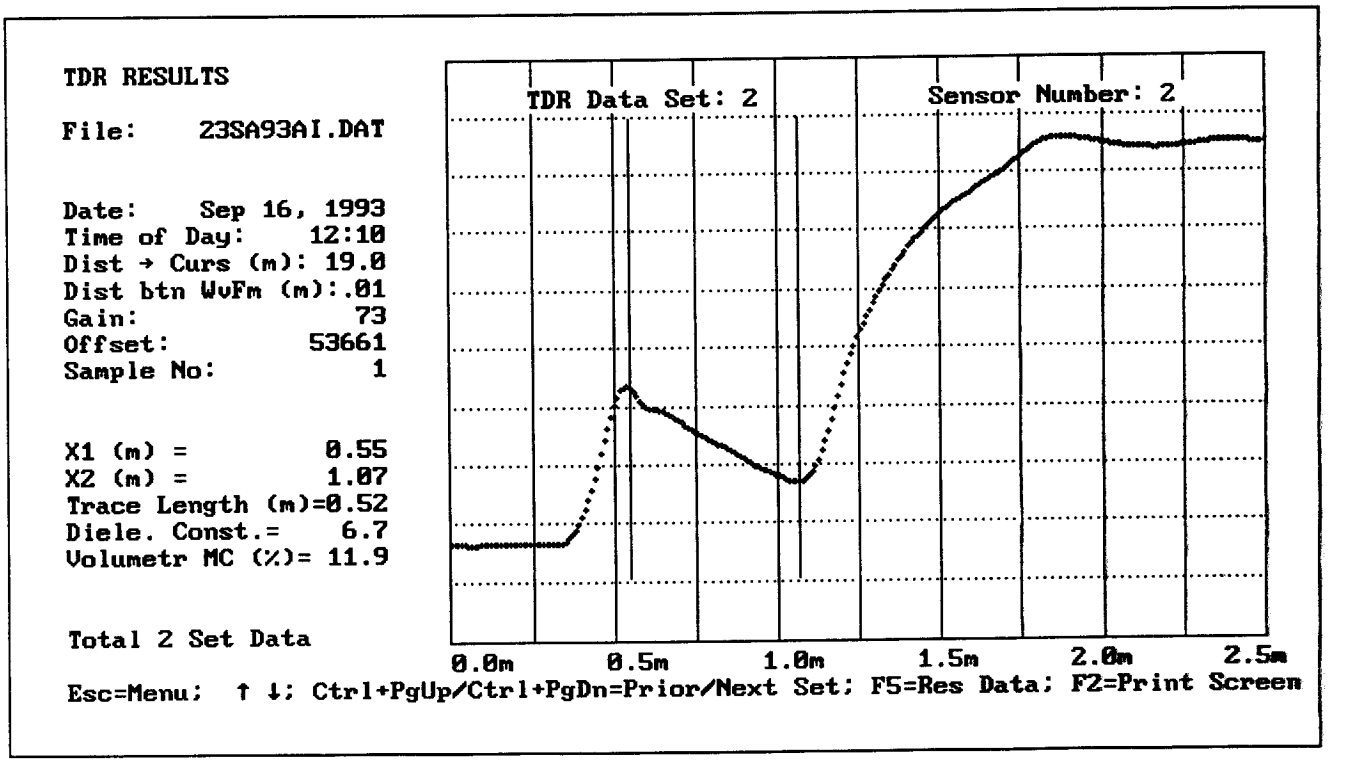

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

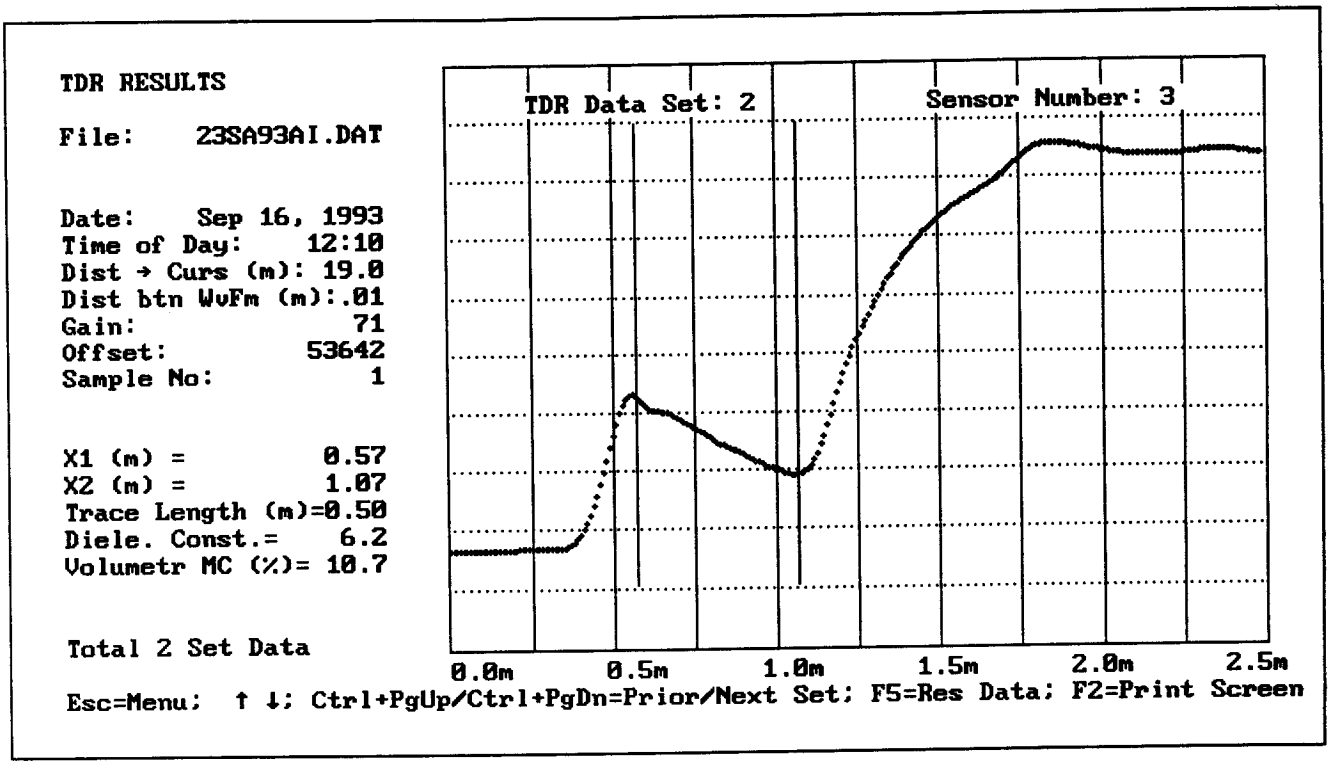

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

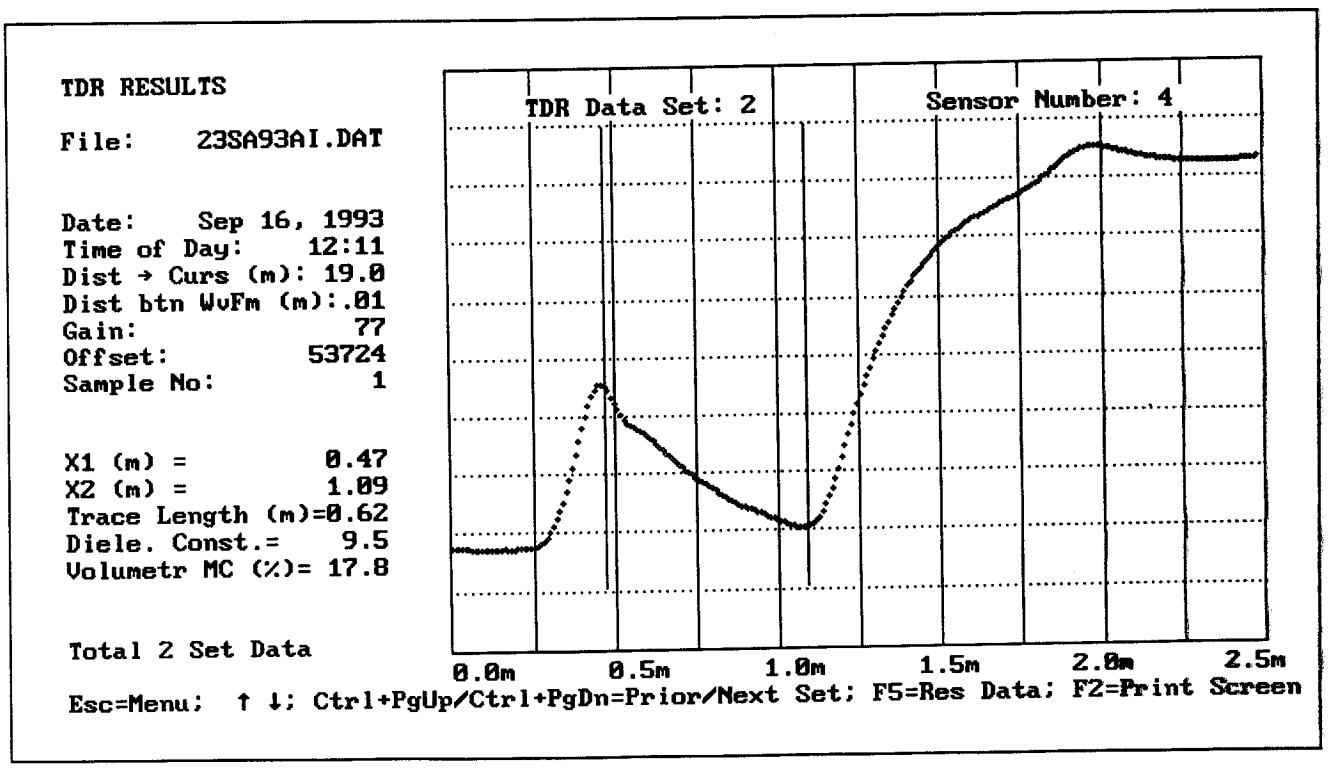

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

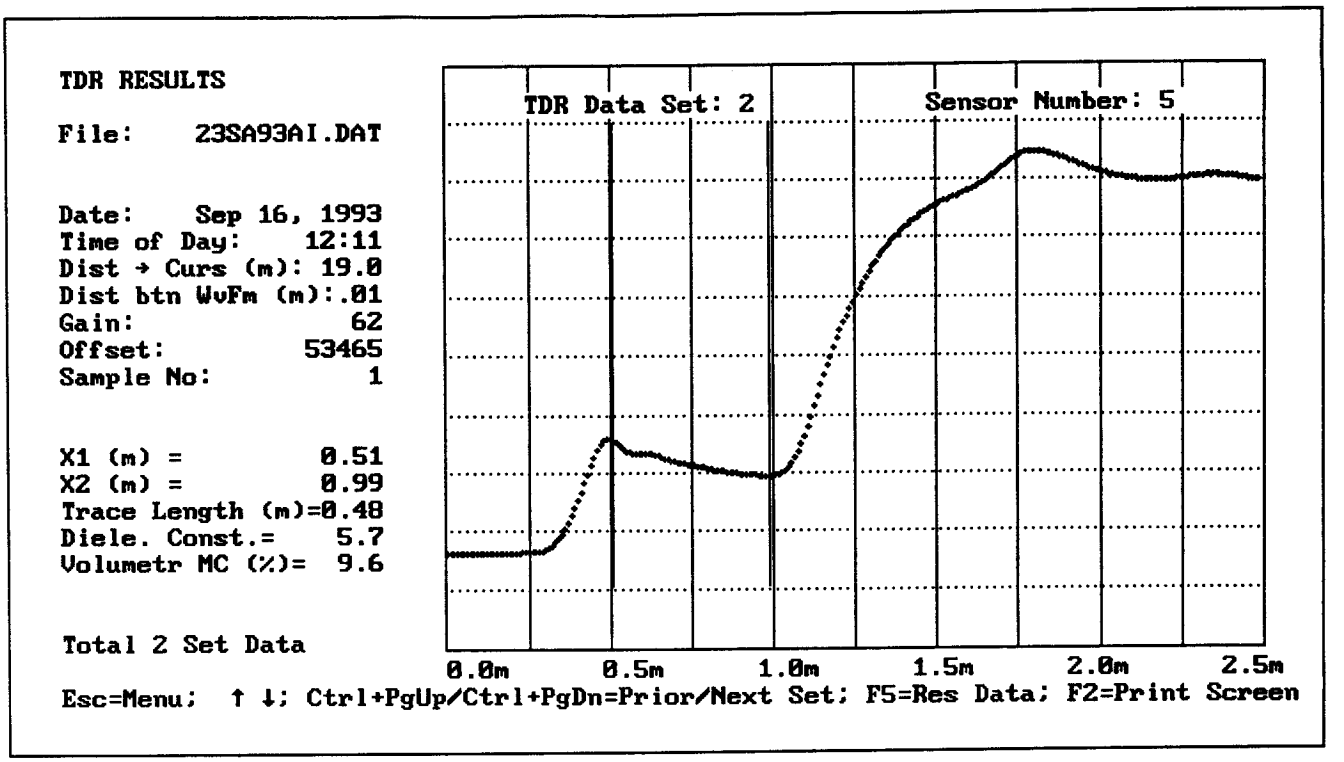

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

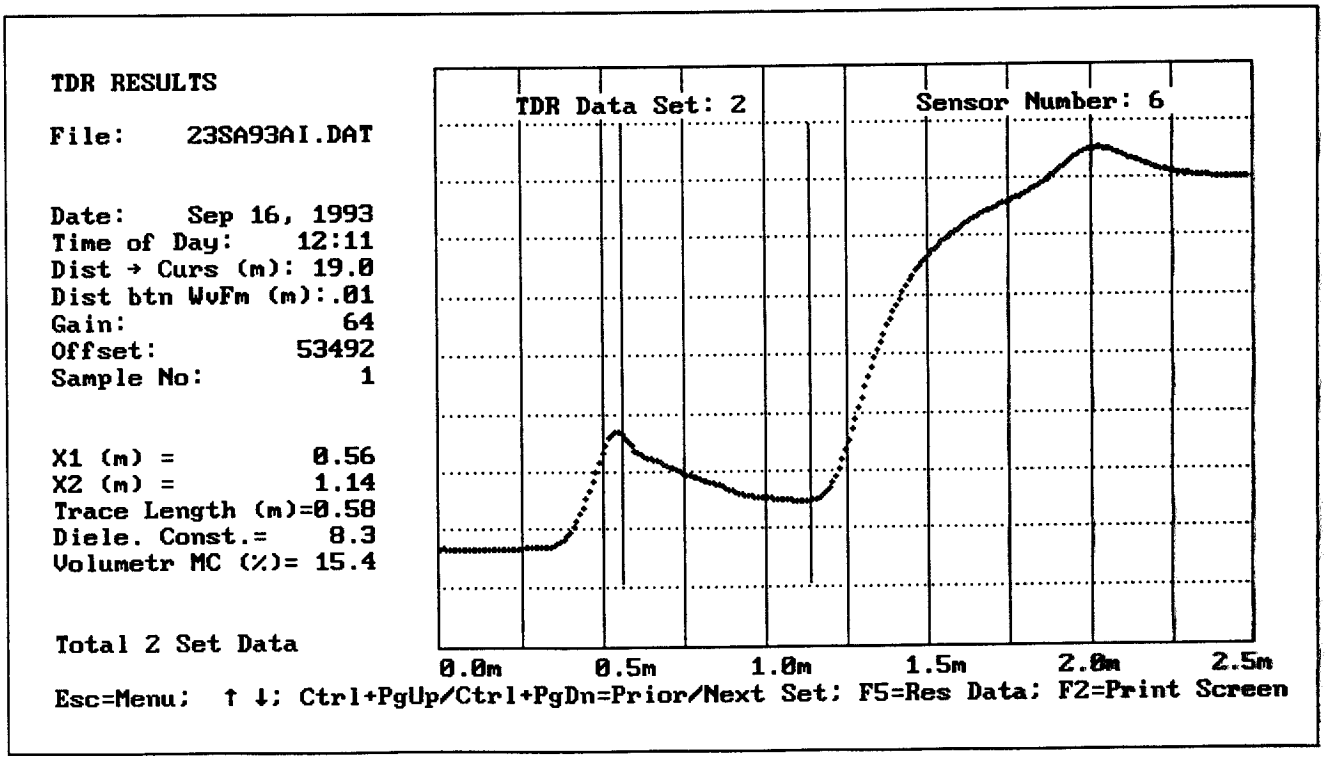

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

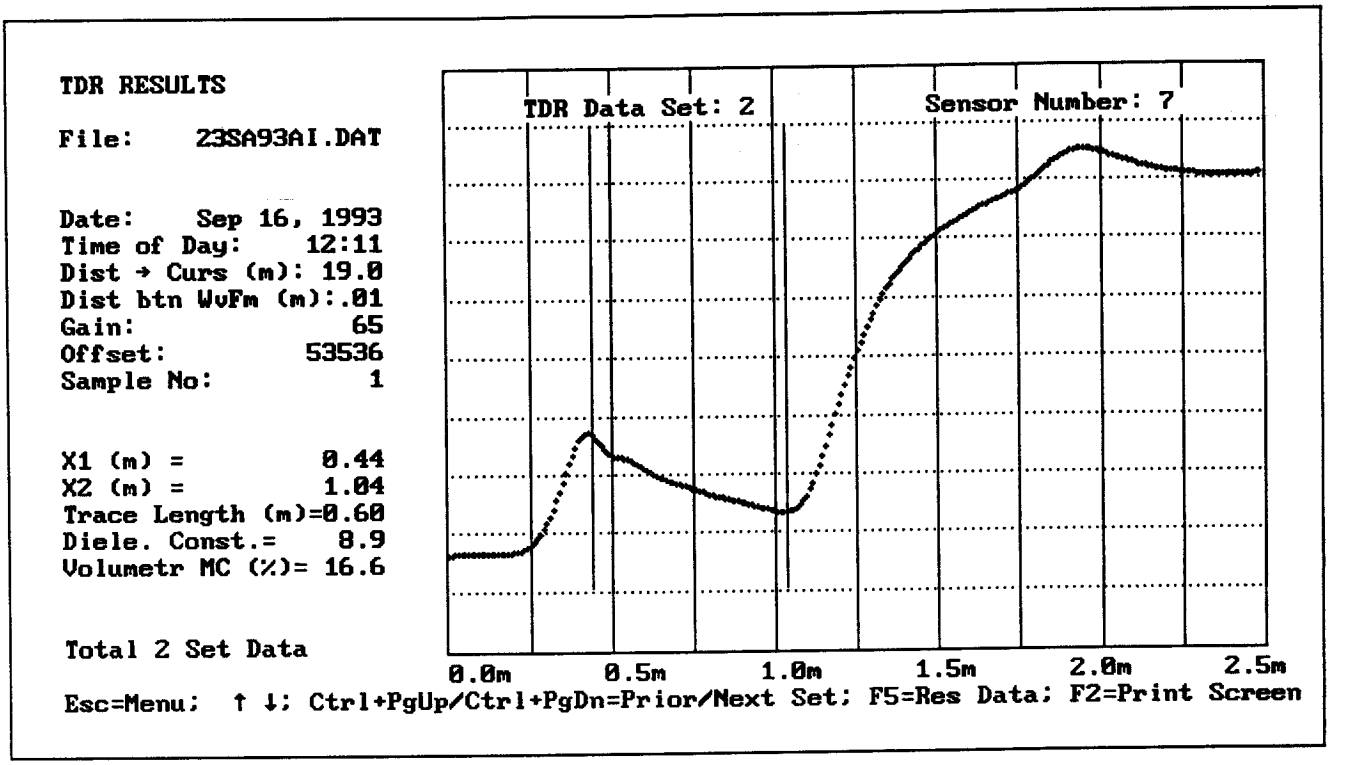

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

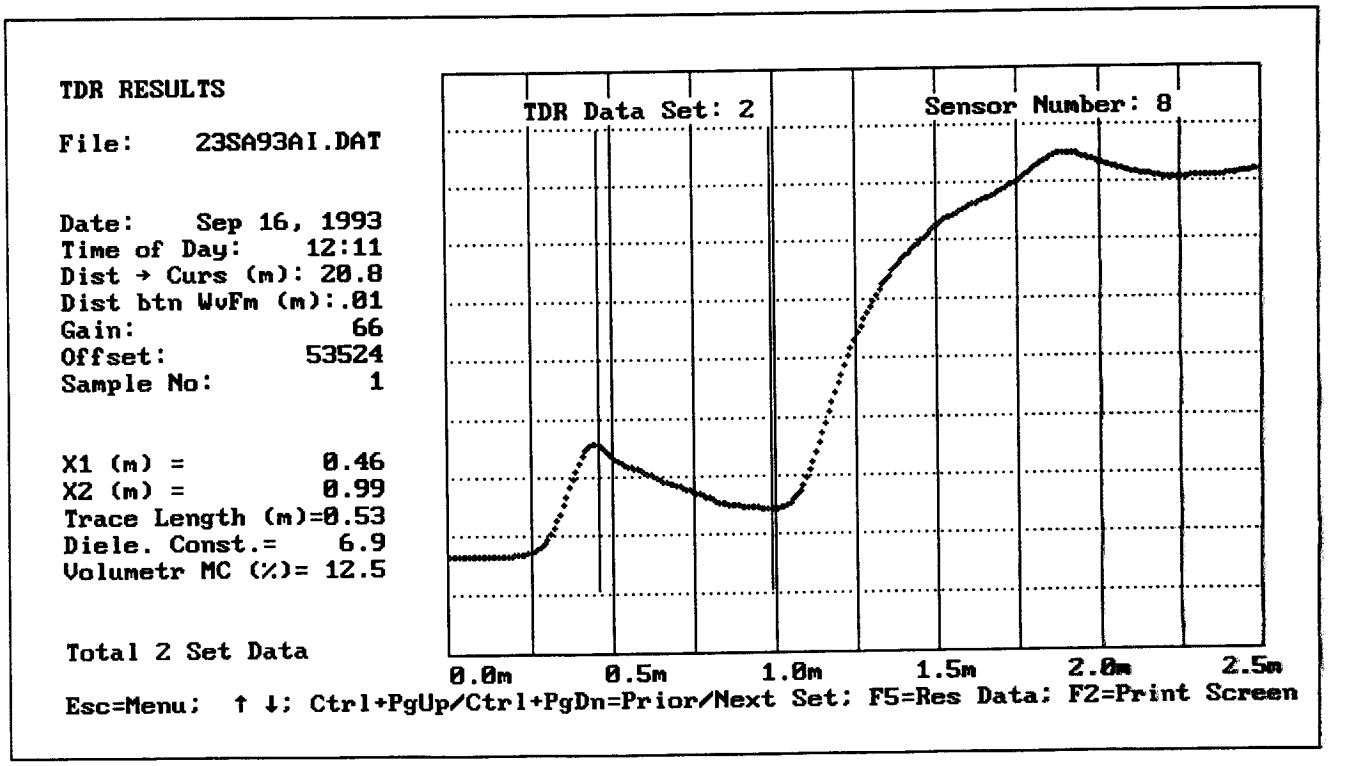

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

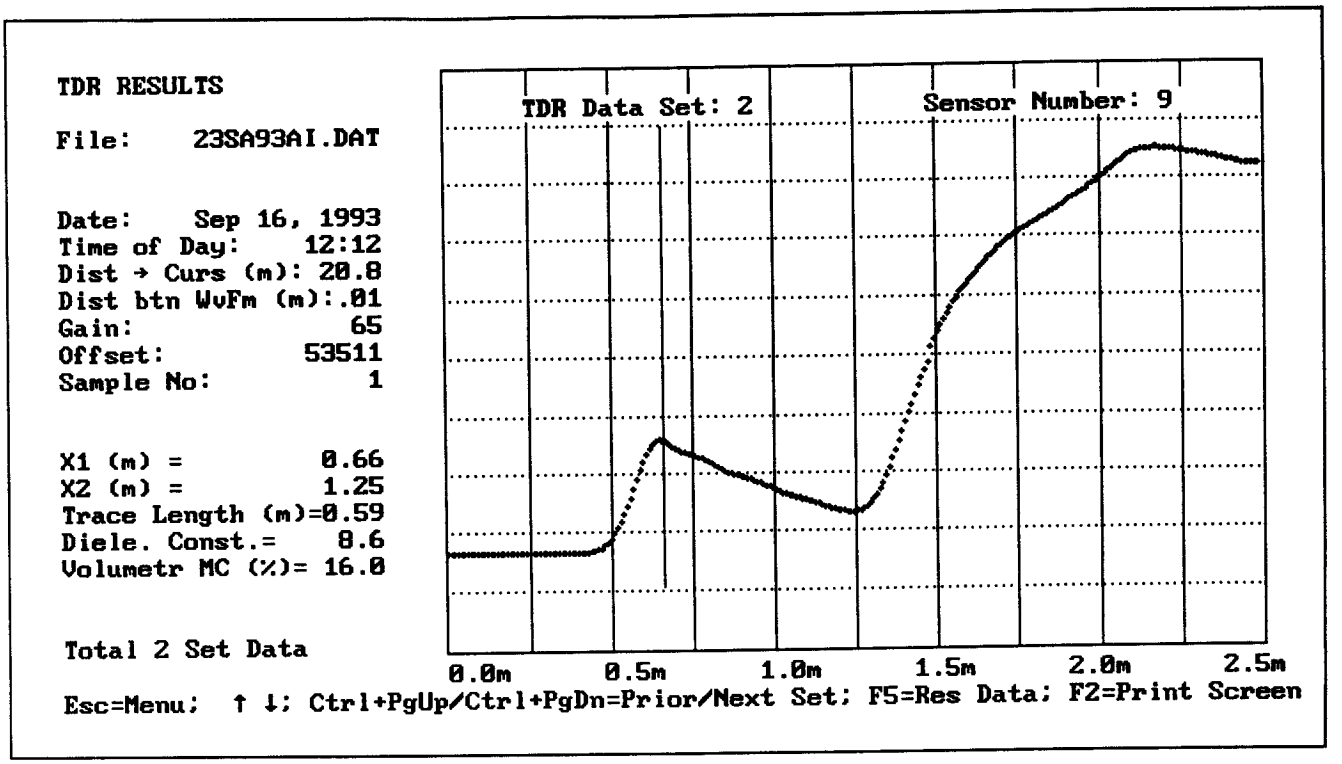

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

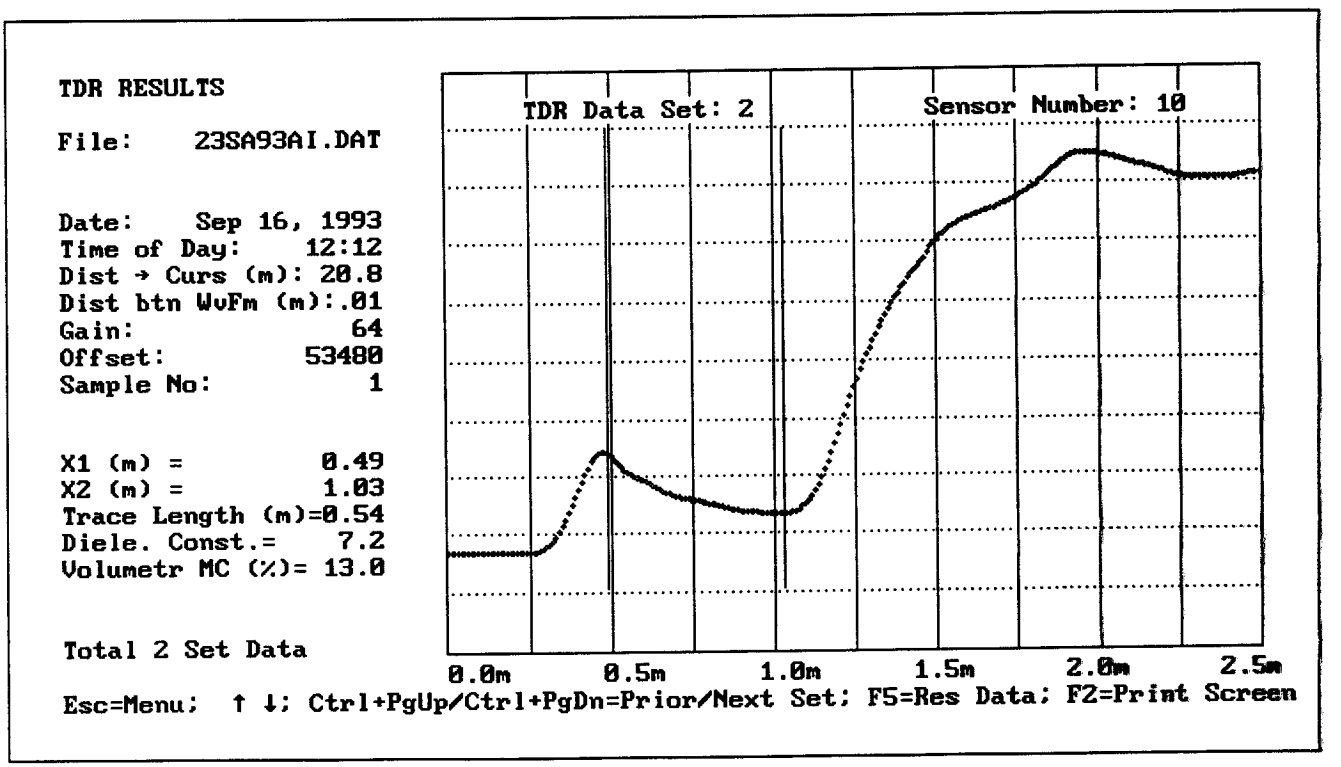

Figure D-5(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

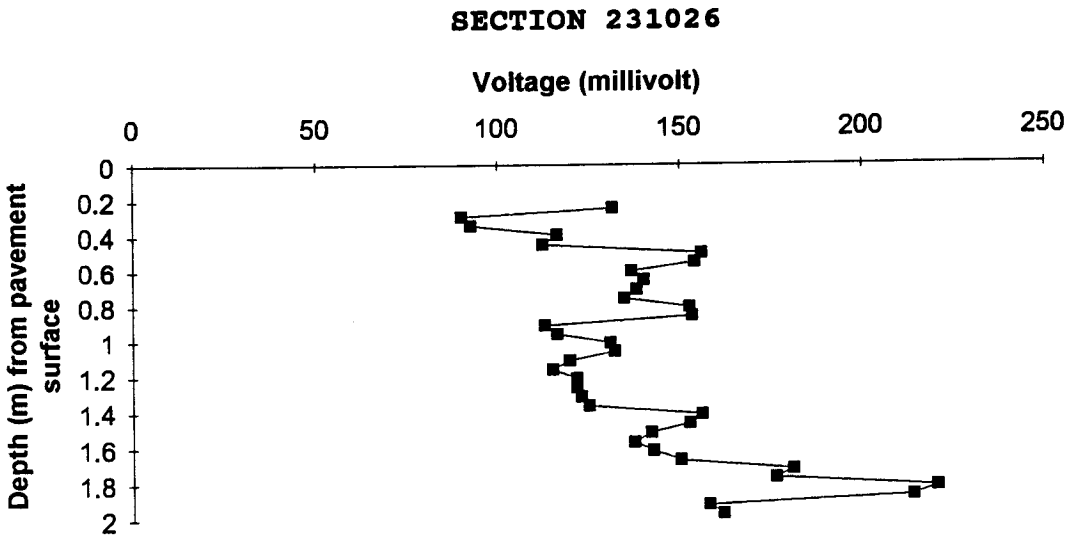

Figure D-6. Voltages Measured Using the Mobile System During Initial Data Collection, September 16, 1993

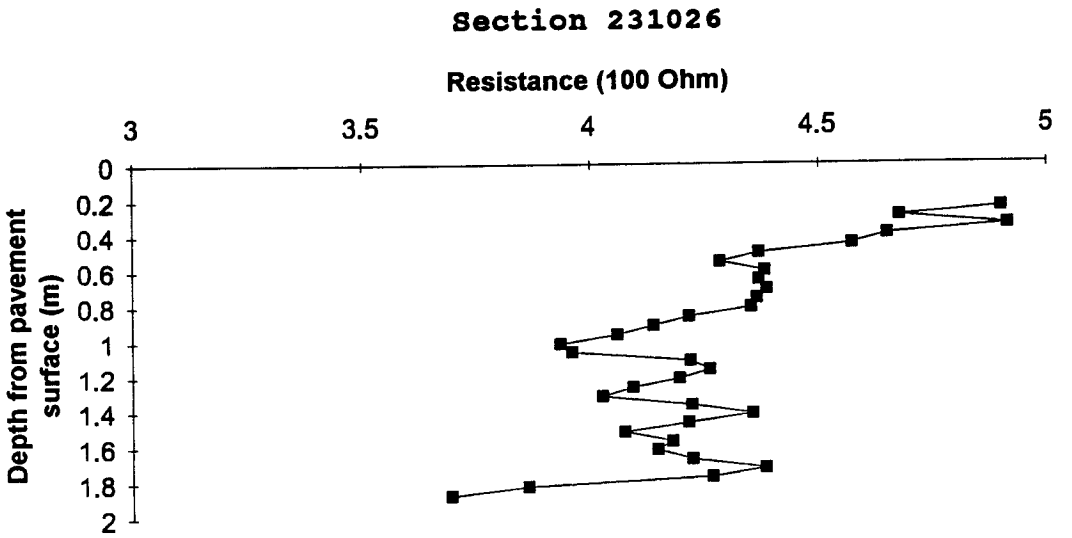

Figure D-7. Manually Collected Contact Resistance During Initial Data Collection, September 16, 1993

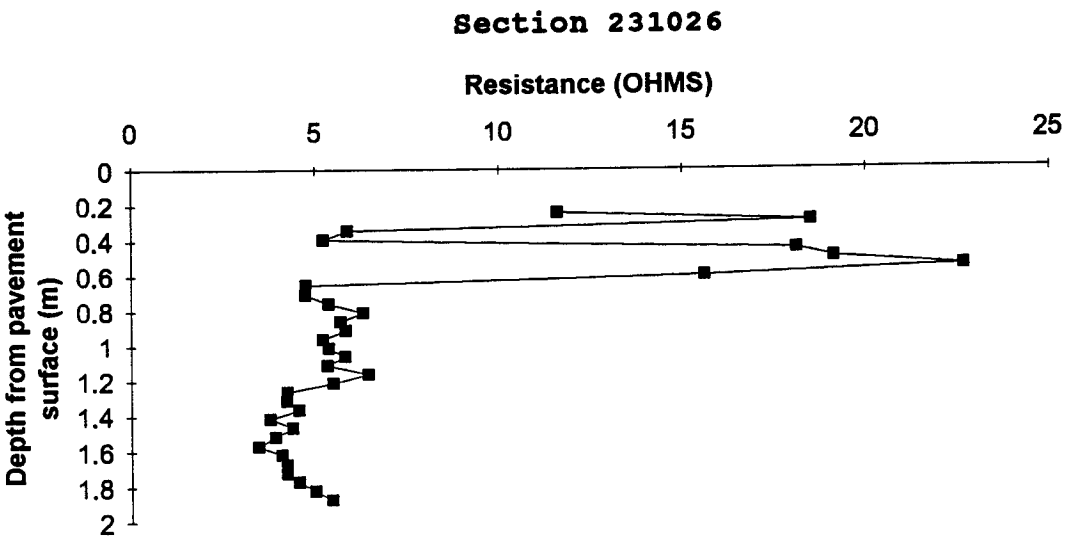

Figure D-8. Manually Collected Four Point Resistivity During Initial Data Collection, September 16, 1993

Table D-2. Contact Resistance After Installation

LTPP Seasonal Monitoring Study	State Code	[23]
Data Sheet R1		
Contact Resistance Measurements	Test Section Number	[1026]

1. Date (Month-Day-Year)	[09-16-93]
2. Time Measurements Began (Military)	[10:35]
3. Comments	After Installation * Note: Known Resistors

Test Position	Connections		Voltage (ACV)		Current (ACA)		notes
	I V	I V	Range Setting	Reading	Range Setting	Reading	
1	1	2	mV	294.5	uA	601.0	
2	3	2	mV	282.1	uA	603.0	
3	3	4	mV	296.3	uA	603.0	
4	5	4	mV	284.7	uA	612.0	
5	5	6	mV	280.4	uA	613.0	
6	7	6	mV	268.8	uA	615.0	
7	7	8	mV	263.9	uA	616.0	
8	9	8	mV	269.1	uA	614.0	
9	9	10	mV	268.3	uA	614.0	
10	11	10	mV	269.8	uA	615.0	
11	11	12	mV	269.4	uA	617.0	
12	13	12	mV	267.7	uA	615.0	
13	13	14	mV	260.6	uA	618.0	
14	15	14	mV	256.2	uA	619.0	
15	15	16	mV	251.7	uA	620.0	
16	17	16	mV	244.8	uA	622.0	
17	17	18	mV	247.2	uA	624.0	
18	19	18	mV	261.6	uA	620.0	
19	19	20	mV	263.8	uA	619.0	
20	21	20	mV	260.1	uA	620.0	
21	21	22	mV	255.0	uA	623.0	
22	23	22	mV	251.3	uA	624.0	
23	23	24	mV	262.6	uA	622.0	
24	25	24	mV	270.1	uA	620.0	
25	25	26	mV	262.2	uA	622.0	
26	27	26	mV	254.7	uA	625.0	
27	27	28	mV	260.4	uA	623.0	
28	29	28	mV	258.8	uA	624.0	
29	29	30	mV	263.1	uA	623.0	
30	31	30	mV	273.6	uA	624.0	
31	31	32	mV	266.7	uA	625.0	
32	33	32	mV	243.5	uA	630.0	
33	33	34	mV	234.0	uA	633.0	
34	35	34	mV	233.8	uA	633.0	
35	35	36	mV	257.7	uA	627.0	
36 *	37	38	mV	285.6	uA	627.0	
37 *	38	39	mV	181.6	uA	659.0	
38 *	39	40	mV	1.7	uA	837.0	

Preparer:	Michael Zawisa	Employer:	PMSL

Table D-3. Four-Point Resistivity After Installation

LTPP Seasonal Monitoring Study	State Code	[2 3]
Data Sheet R2		
Four-Point Resistivity Measurements	Test Section Number	[1 0 2 6]

1. Date (Month-Day-Year)	[09-16-93]
2. Time measurements Began (Military)	[11:05]
3. Comments	After Installation

Test Position	Connections				Voltage (ACV)		Current (ACA)		Notes
	I_1	V_1	V_2	I_2	Range Setting	Reading	Range Setting	Reading	
1	1	2	3	4	mV	7.3	uA	629	
2	2	3	4	5	mV	11.7	uA	632	
3	3	4	5	6	mV	3.7	uA	629	
4	4	5	6	7	mV	3.3	uA	631	
5	5	6	7	8	mV	11.4	uA	629	
6	6	7	8	9	mV	12.1	uA	632	
7	7	8	9	10	mV	14.4	uA	635	
8	8	9	10	11	mV	9.9	uA	634	
9	9	10	11	12	mV	3.0	uA	632	
10	10	11	12	13	mV	3.0	uA	634	
11	11	12	13	14	mV	3.4	uA	633	
12	12	13	14	15	mV	4.0	uA	635	
13	13	14	15	16	mV	3.6	uA	633	
14	14	15	16	17	mV	3.7	uA	635	
15	15	16	17	18	mV	3.3	uA	634	
16	16	17	18	19	mV	3.4	uA	634	
17	17	18	19	20	mV	3.7	uA	636	
18	18	19	20	21	mV	3.4	uA	637	
19	19	20	21	22	mV	4.1	uA	636	
20	20	21	22	23	mV	3.5	uA	637	
21	21	22	23	24	mV	2.7	uA	636	
22	22	23	24	25	mV	2.7	uA	638	
23	23	24	25	26	mV	2.9	uA	637	
24	24	25	26	27	mV	2.4	uA	637	
25	25	26	27	28	mV	2.8	uA	638	
26	26	27	28	29	mV	2.5	uA	640	
27	27	28	29	30	mV	2.2	uA	638	
28	28	29	30	31	mV	2.6	uA	637	
29	29	30	31	32	mV	2.7	uA	640	
30	30	31	32	33	mV	2.7	uA	639	
31	31	32	33	34	mV	2.9	uA	637	
32	32	33	34	35	mV	3.2	uA	639	
33	33	34	35	36	mV	3.5	uA	641	

Preparer	MZ & PZ	Employer	PMSL

Table D-4. Uniformity Survey Results Before and After Installation

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 231026	Data Collection and
Date Surveyed: September 15-September 16, 1993	Processing Summary

Section Interval (ft)	Mean Deflection Values for HT 2 (mils) Corrected								Mean Temp D1 (F)
	Sensor 1	Sensor 1 std dev	Sensor 7	Sensor 7 std dev	Subg modulus (psi)	Subg modulus std dev	Effective SN	SN std dev	
-21 to 200 **Sept.15** @ 08:21	8.84	0.47	0.84	0.18	40703	6449	5.66	0.10	80.1
-21 to 200 **Sept 16** @ 09:11	8.82	0.35	0.86	0.16	39621	5275	5.70	0.12	66.3
-21 to 200 **Sept 16** @ 11:33	9.60	0.47	0.89	0.16	39253	6491	5.48	0.15	81.9
-21 to 200 **Sept 16** @ 13:47	10.21	0.43	0.90	0.16	39263	7220	5.33	0.13	94.5

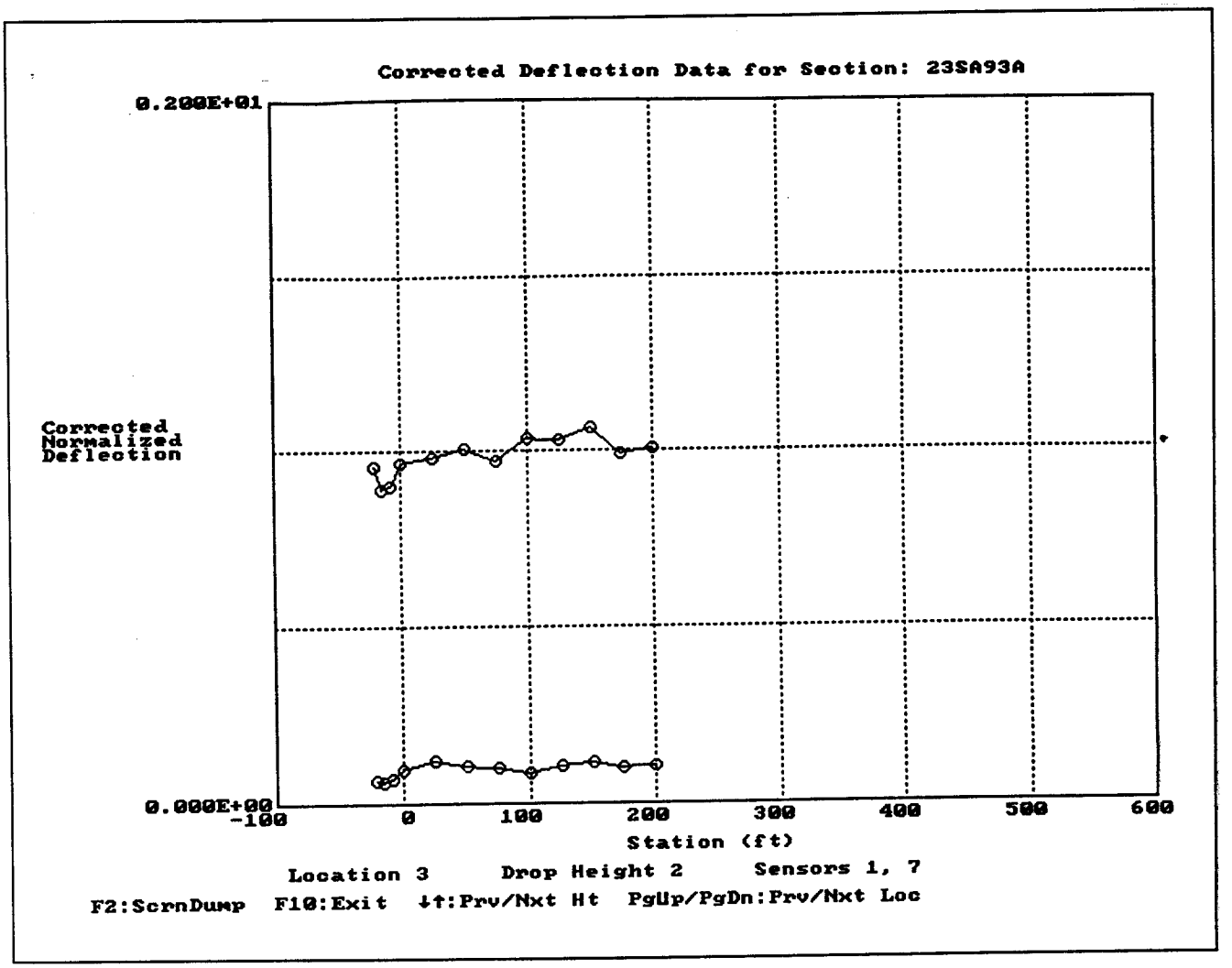

Figure D-9. Deflection Profiles from FWDCHECK
(Test Date and Time September 15, 1993 @ 08:21)

Table D-5. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time September 15, 1993 @ 08:21)

Flexible Pavement Thickness Statistics - 23SA93A - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-21	46816	5.60
	-16	52792	5.70
	-9	50501	5.75
	0	40451	5.70
	25	32164	4.85
	50	36545	4.70
	75	39275	5.70
	100	43727	5.45
	125	36906	5.60
	150	34258	5.55
	175	37668	5.70
	200	37337	5.65
Subsection 1	Overall Mean	40703	5.66
	Standard Deviation	6449	0.10
	Coeff of Variation	15.84%	1.81%

Note: No test pit data found, therefore no results exist...

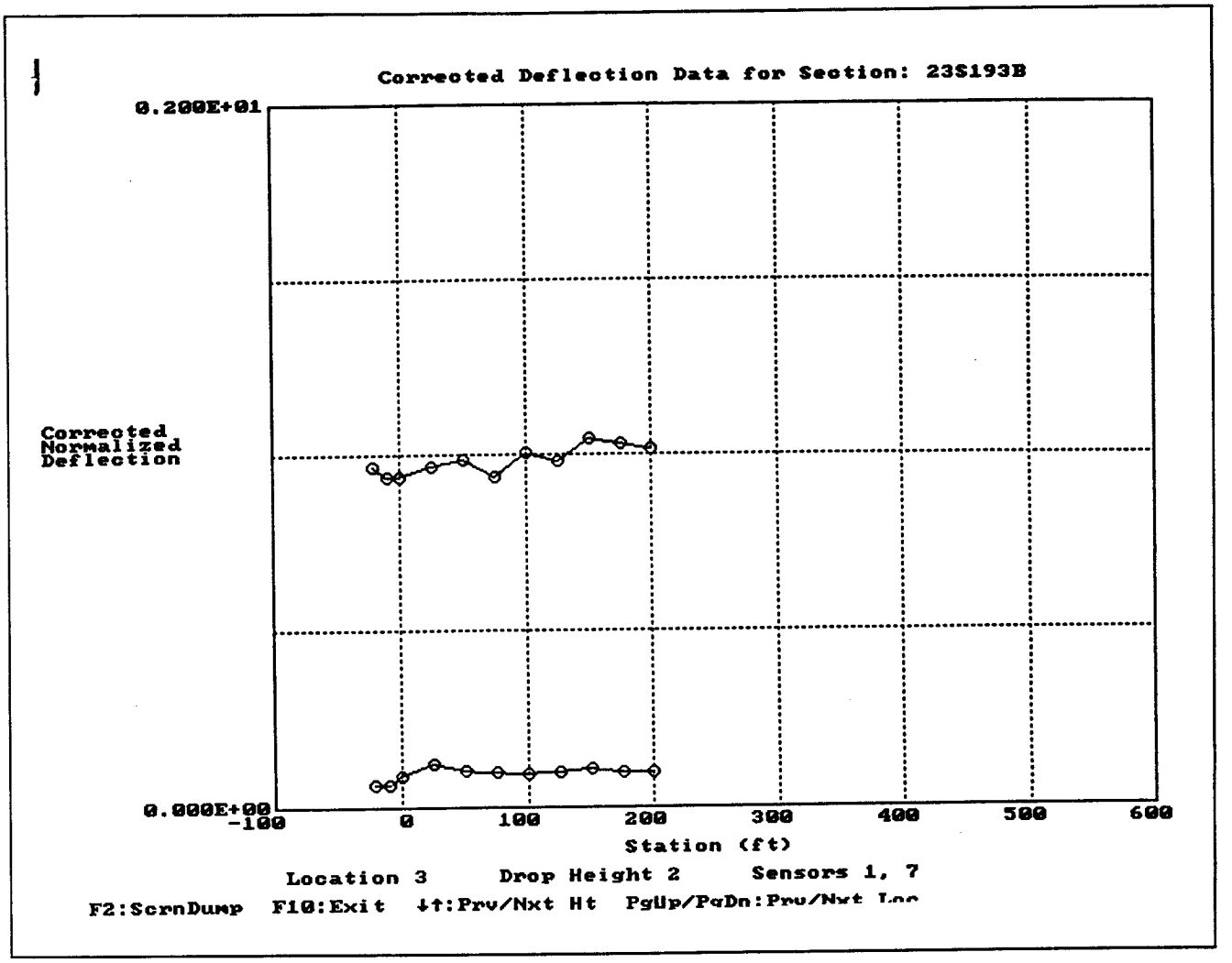

Figure D-10. Deflection Profiles from FWDCHECK
(Test Date and Time September 16, 1993 @ 09:11)

Table D-6. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time September 16, 1993 @ 09:11)

Flexible Pavement Thickness Statistics - 23S193B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-21	45147	5.65
	-9	51588	5.60
	0	41248	5.80
	25	31251	5.95
	50	37458	5.70
	75	38172	5.85
	100	40740	5.60
	125	39192	5.70
	150	35577	5.60
	175	37859	5.60
	200	37594	5.65
Subsection 1	Overall Mean	39621	5.70
	Standard Deviation	5275	0.12
	Coeff of Variation	13.31%	2.08%

Note: No test pit data found, therefore no results exist...

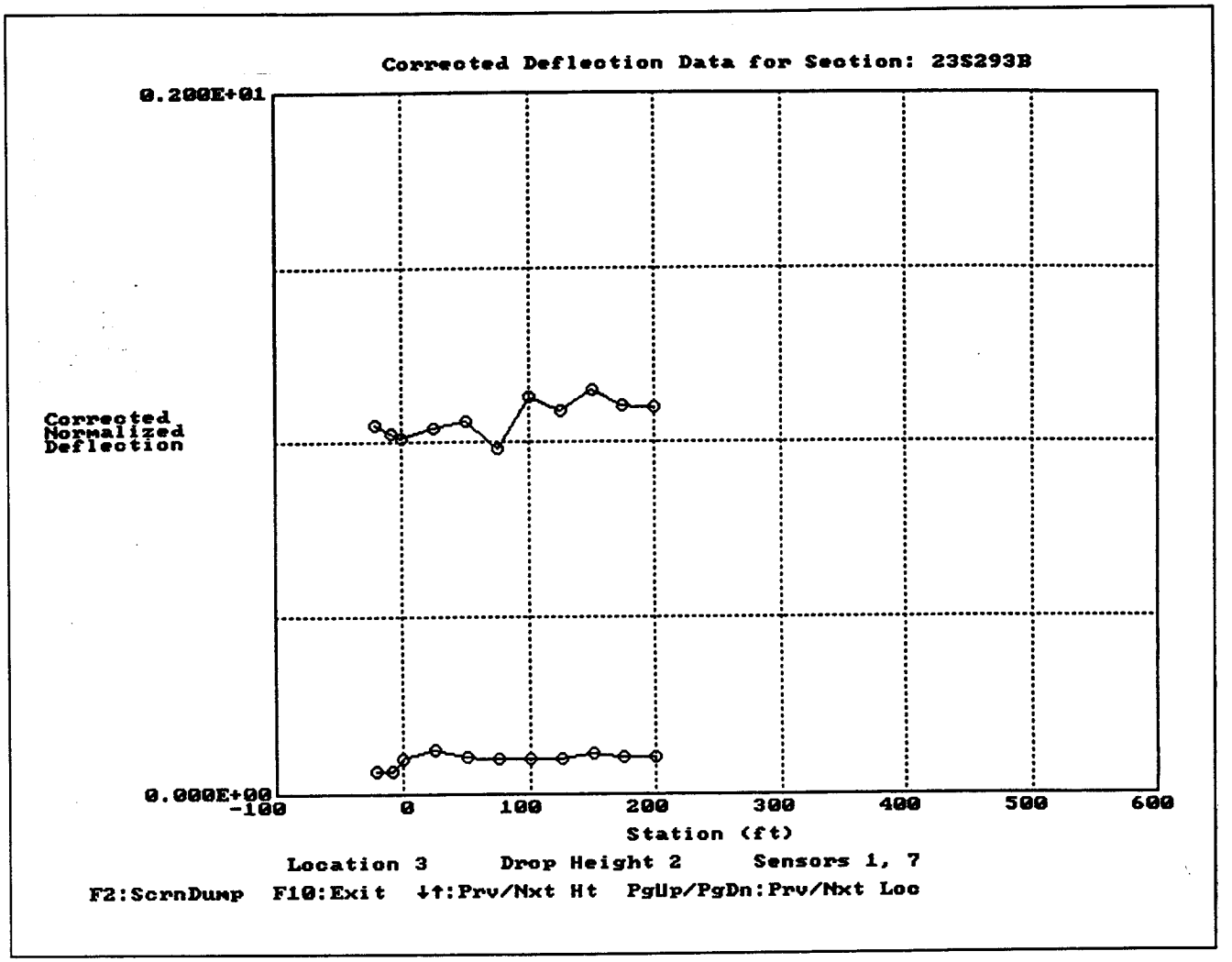

Figure D-11. Deflection Profiles from FWDCHECK
(Test Date and Time September 16, 1993 @ 11:33)

Table D-7. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time September 16, 1993 @ 11:33)

Flexible Pavement Thickness Statistics - 23S293B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-21	48212	5.35
	-9	54329	5.35
	0	38419	5.65
	25	31112	5.70
	50	35981	5.55
	75	38045	5.70
	100	38837	5.30
	125	38555	5.40
	150	34438	5.40
	175	37038	5.40
	200	36815	5.45
Subsection 1	Overall Mean	39253	5.48
	Standard Deviation	6491	0.15
	Coeff of Variation	16.54%	2.69%

Note: No test pit data found, therefore no results exist...

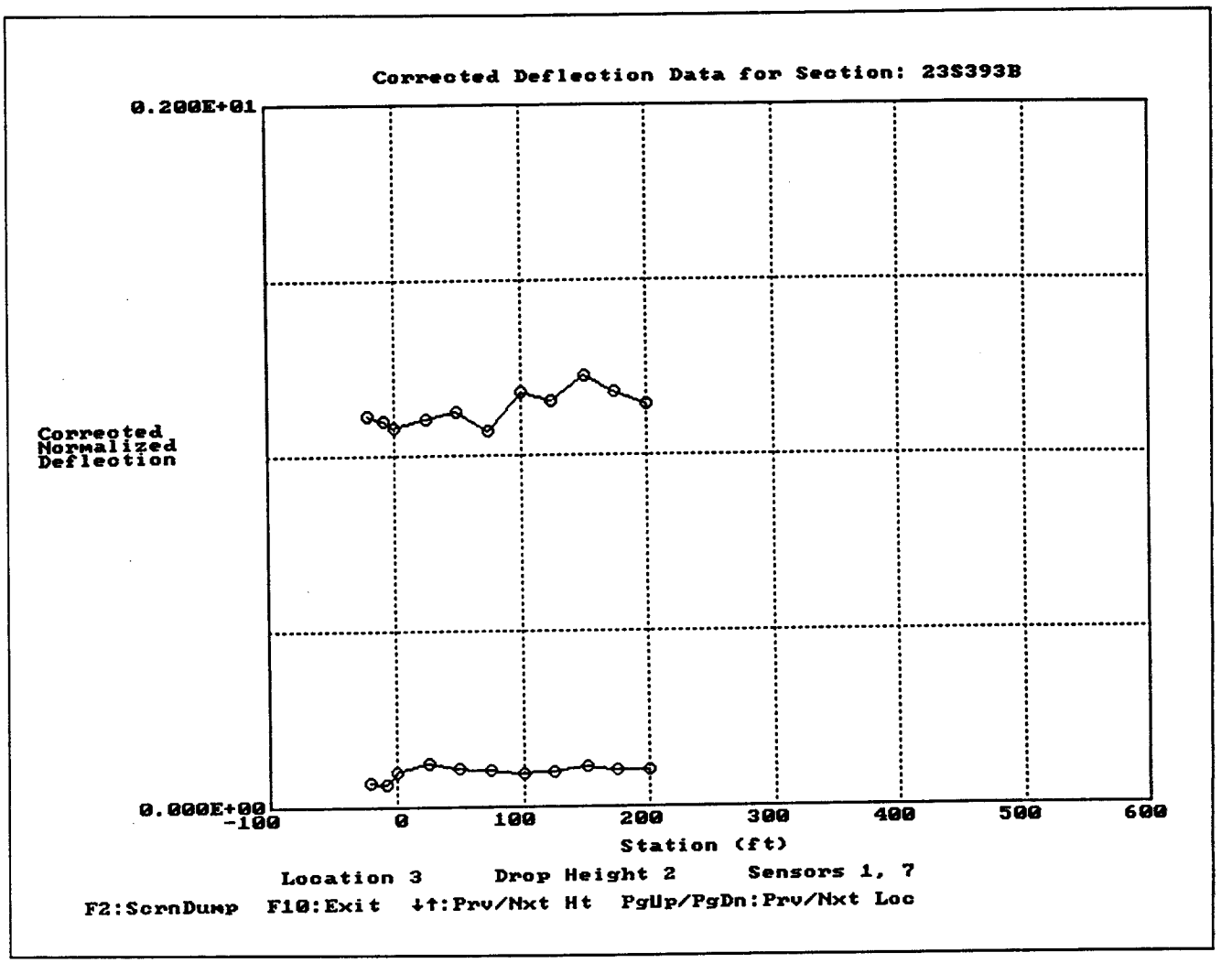

Figure D-12. Deflection Profiles from FWDCHECK
(Test Date and Time September 16, 1993 @ 13:47)

Table D-8. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time September 16, 1993 @ 13:47)

Flexible Pavement Thickness Statistics - 23S393B - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-21	50370	5.20
	-9	55470	5.15
	0	38353	5.45
	25	31208	5.55
	50	35385	5.40
	75	36688	5.50
	100	39367	5.20
	125	38767	5.30
	150	33925	5.25
	175	36389	5.25
	200	35974	5.35
Subsection 1	Overall Mean	39263	5.33
	Standard Deviation	7220	0.13
	Coeff of Variation	18.39%	2.50%

Note: No test pit data found, therefore no results exist...

Table D-9. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[23
Surface Elevation Measurements	Test Section Number	[1026

Survey Date	September 16, 1993
Surveyed By	MZ & PZ
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION		PE m offset 0.15m	OWP m offset 0.76m	ML m offset 1.83m	IWP m offset 2.69m	ILE m offset 3.30m
0-40	3+00	2.137	2.143	2.180	2.183	2.204
0-30	3+25	2.100	2.088	2.131	2.131	2.167
0-21	3+50	2.033	2.042	2.076	2.082	2.100
0-15	3+75	2.000	2.009	2.042	2.042	2.073
0-09	4+00	1.954	1.969	2.003	2.006	2.033
0+00	4+25	1.905	1.914	1.954	1.945	1.975
0+25	4+50	1.762	1.774	1.808	1.811	1.832
0+50	4+75	1.631	1.646	1.674	1.674	1.698
0+75	5+00	1.518	1.524	1.552	1.552	1.573
1+00	5+10	1.405	1.415	1.442	1.439	1.457
1+25	5+20	1.293	1.302	1.329	1.329	1.357
1+50	5+30	1.180	1.186	1.223	1.216	1.244
1+75	5+40	1.064	1.073	1.110	1.104	1.128
2+00	5+50	0.963	0.973	1.003	1.000	1.018

PE	Pavement Edge
OWP	Outer Wheel Path
ML	Mid Lane
IWP	Inner Wheel Path
ILE	Inner Lane Edge

Table D-9. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[23
Surface Elevation Measurements	Test Section Number	[1026

Survey Date	September 16, 1993
Surveyed By	MZ & PZ
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION		PE m offset 0.15m	OWP m offset 0.76m	ML m offset 1.83m	IWP m offset 2.69m	ILE m offset 3.30m
0-40	3+00	2.137	2.143	2.180	2.183	2.204
0-30	3+25	2.100	2.088	2.131	2.131	2.167
0-21	3+50	2.033	2.042	2.076	2.082	2.100
0-15	3+75	2.000	2.009	2.042	2.042	2.073
0-09	4+00	1.954	1.969	2.003	2.006	2.033
0+00	4+25	1.905	1.914	1.954	1.945	1.975
0+25	4+50	1.762	1.774	1.808	1.811	1.832
0+50	4+75	1.631	1.646	1.674	1.674	1.698
0+75	5+00	1.518	1.524	1.552	1.552	1.573
1+00	5+10	1.405	1.415	1.442	1.439	1.457
1+25	5+20	1.293	1.302	1.329	1.329	1.357
1+50	5+30	1.180	1.186	1.223	1.216	1.244
1+75	5+40	1.064	1.073	1.110	1.104	1.128
2+00	5+50	0.963	0.973	1.003	1.000	1.018

PE	Pavement Edge
OWP	Outer Wheel Path
ML	Mid Lane
IWP	Inner Wheel Path
ILE	Inner Lane Edge

APPENDIX E

Photographs

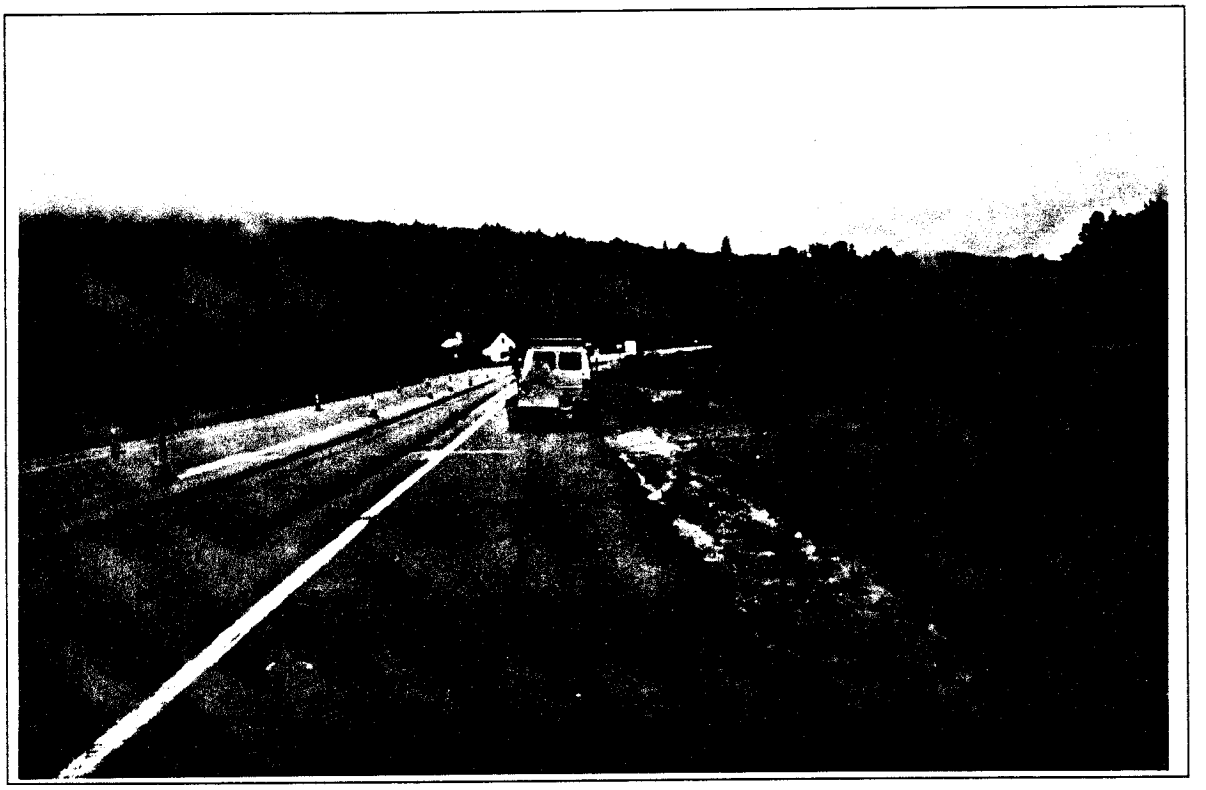

Figure E-1. Site Overview - Preliminary Visit

Figure E-2. Site Overview - Preliminary Visit

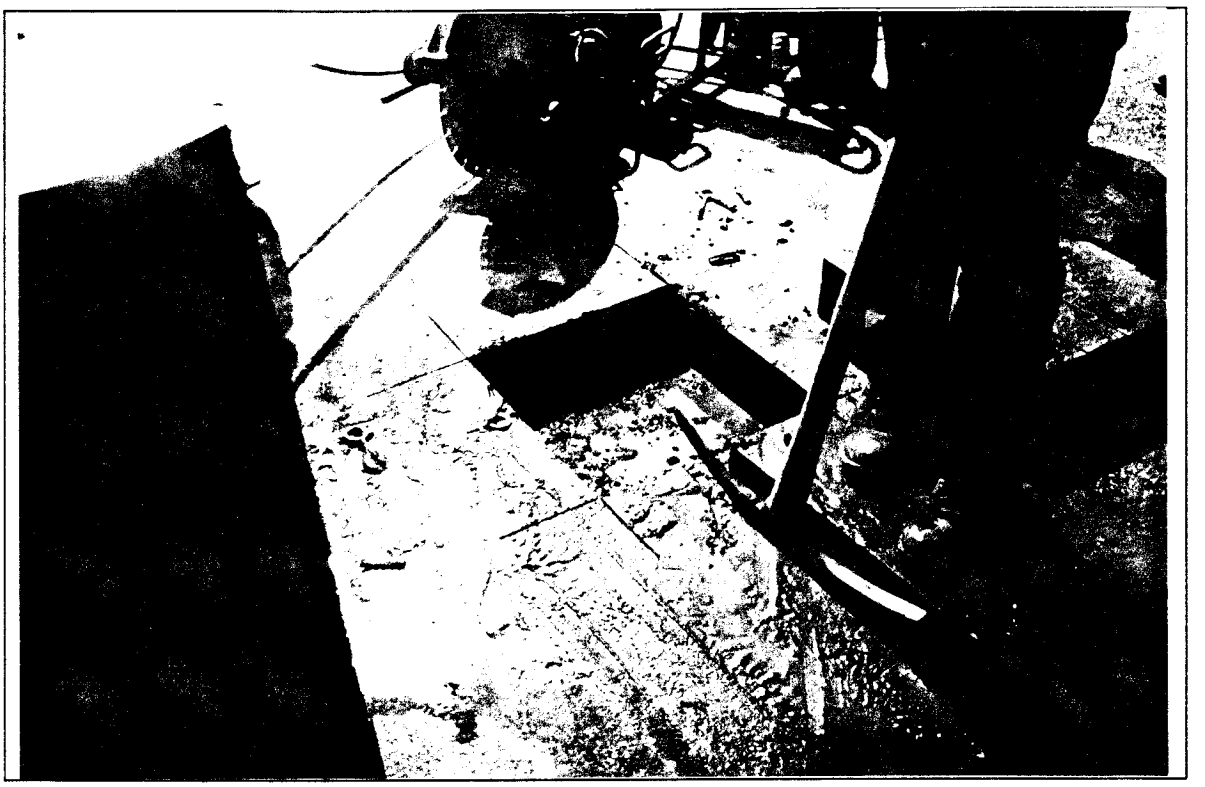

Figure E-3. Instrumentation Hole and Trench

Figure E-4. Instrumentation Hole

Figure E-5. Observation Well

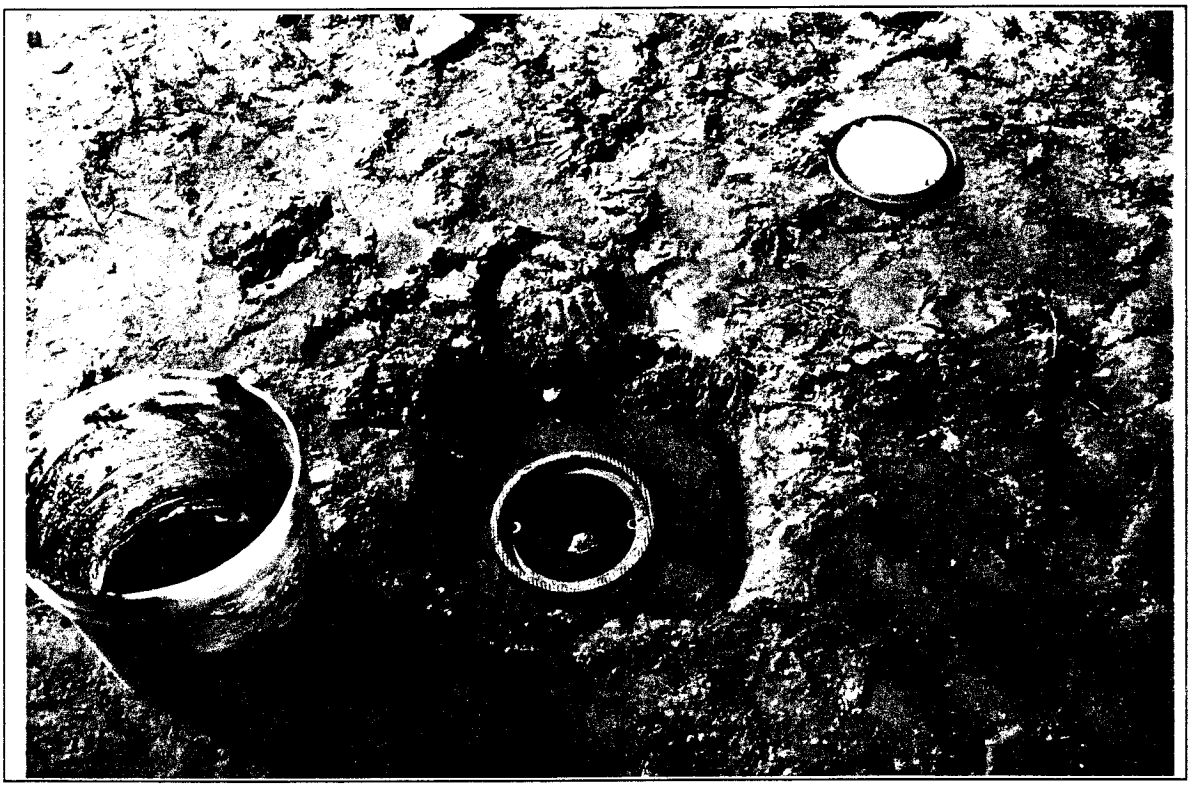

Figure E-6. Observation Well

Figure E-7. Patch Area, Two to Three Months after Installation

Figure E-8. Patch Area, Two to Three Months after Installation