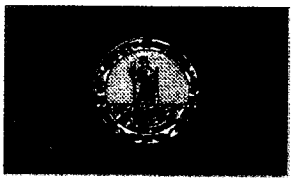

Virginia

U.S. Department
of Transportation

Federal Highway Administration

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 510113, Danville
Virginia

Report No. FHWA-TS-96-51-03

June 1996

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LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 510113, Danville, Virginia

Report No. FHWA-TS-96-51-03

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June 1996

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA-TS-96-51-03		

4. Title and Subtitle	5. Report Date
LTPP Seasonal Monitoring Program Site Installation and Initial Data Collection Section 510113, Danville, Virginia	June 1996 6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
Brandt Henderson and Dilan Singaraja	
9. Performing Organization Name and Address **Pavement Management Systems Limited** 415 Lawrence Bell Drive - Suite 3 Amherst, New York 14221	10. Work Unit No. (TRAIS) 11. Contract or Grant No. DTFH61-92-C-00007
12. Sponsoring Agency Name and Address **Federal Highway Administration** LTPP-Division, HNR-40 Turner-Fairbanks Highway Research Center 6300 Georgetown Pike McLean, Virginia 22101	13. Type of Report and Period Covered 14. Sponsoring Agency Code

15. Supplementary Notes

The report is a cooperative effort between Virginia Department of Transportation (VDOT) Transportation Research Council, Long Term Pavement Performance (LTPP) Division Federal Highway Administration, and Pavement Management Systems Limited (PMSL) LTPP North Atlantic Region Coordination Office (NARCO).

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 Specific Pavement Study (SPS-1) section 510113 on Route 265 near Danville, Virginia. This asphalt concrete surface pavement test section was instrumented on October 24, 1995. The instrumentation installed included time domain reflectometry probes for moisture content, thermistor probes for temperature, tipping bucket rain gauge, piezometer to monitor the ground water table, and an on-site datalogger. Initial data collection was performed on October 25, 1995 which consisted of deflection measurements with a Falling Weight Deflectometer, elevation, temperature, TDR, and water table measurements. Longitudinal profile data is collected with the LTPP profiler during scheduled visits to the site. 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, LTPP profiler, Time Domain Reflectometry, Thermistor, Piezometer.	

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price

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SEASONAL INSTRUMENTATION STUDY
INSTRUMENTATION INSTALLATION
VIRGINIA SECTION 510113

I. Introduction

The installation of the LTPP instrumentation on seasonal site 510113 near Danville, Virginia was performed on October 23 - October 26, 1995. The test section is a SPS-1 experiment, located on Southbound Route 265 approximately 4.1 kilometers South of S.R. 695. A map indicating the location detail of the site is presented in Figure A-1 of Appendix A. The highway consists of one 3.7 m wide lane in each direction, with a 3.7 m wide paved outside shoulder and an asphalt curb at the outside shoulder edge. A guard rail exists along the asphalt curb. Transportation plans are to make the current Northbound and Southbound lanes into Southbound traffic lanes.

This road was constructed during the summer months of 1995 and has not been opened to traffic yet. The site history data available for this site is minimal because it is a new road. There is no FWD history, profile history, distress rating, traffic data, and weather data specific to this site. Information regarding material types and depths were extracted from construction records. Cores taken at the time of installation were used to determine thicknesses. No laboratory data was available when this report was being prepared.

The pavement, which is built on an elevated fill area, consists of 100 mm of asphalt concrete on a 200 mm dense graded aggregate base. The subgrade predominantly consists of sandy silt with some clay and gravel. The top 150 mm of the subgrade is cement treated. The design depths for the entire SPS-1 project are presented in Figure A-2 of Appendix A. Pavement structure information taken from the SPS material drilling logs are presented in Figure A-3. Properties determined from field tests and logs are shown in Table 1. The uniformity survey results are summarized 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 and resides in cell 4 (thin AC on fine subgrade) of the Seasonal Monitoring Program. Below is a summary from the LTPP climate database based on ten years of data:

- Freezing Index (C-Days) 67
- Precipitation (mm) 1143
- No. of Freeze/Thaw Cycles 86
- Days Above 32°C 48
- Days Below 0°C 83
- Wet Days 117

The climatic data listed above was taken from site 512004, since there was no climatic data available for site 510113. Site 512004 is approximately 5 kilometers West of 510113, and is the closest LTPP site that could be used for climatic data. This portion of State Road 265 provides a bypass and access route on the East side of Danville taking traffic from S.R. 29 to the intersection at S.R. 58. S.R. 265, South of S.R. 58, goes to Greensboro, North Carolina.

An International Road Dynamics (IRD) Weigh In Motion (WIM) has been installed 243 meters before the most Northerly site 510114. This WIM is to provide continuos volume, weight, and vehicle classification. In addition to the seasonal monitoring program climatic data, an Automated Weather Station (AWS), is also installed at this location. This weather station will be used to collect air temperature, relative humidity, solar radiation, wind speed/direction and rainfall for the SPS-1 test sections.

Installation of the instrumentation was a cooperative effort between Commonwealth of Virginia Department of Transportation (VDOT), Federal Highway Administration (FHWA) Long Term Pavement Performance (LTPP) Division, and Pavement Management Systems Limited (PMSL) LTPP North Atlantic Region Coordination Office (NARCO) staff. The main contractor for this SPS project was W.C. English. The following personnel participated in the instrumentation installation:

Buddy Wood	VDOT-Research Council
George Wise	VDOT-Lynchburg Materials
Ken J. Jenning	VDOT-Lynchburg, Materials
Dave Woolley	VDOT-Lynchburg, Materials
N. B. Walton	VDOT-Lynchburg, Materials
Tim Karnes	VDOT-Chatham Residency
Tyler Meadows	VDOT-Chatham Residency
A. W. Moore	VDOT-Chatham Residency
Henry Yeatts	VDOT-Chatham Residency
Scott Comstock	PMSL NARCO
Tim Comstock	PMSL NARCO
Brandt Henderson	PMSL NARCO
Randy Plett	PMSL NARCO
Dilan Singaraja	PMSL NARCO

Table 1. Material Properties

Description	Surface	Base	Treated Subgrade	Subgrade
Material (Code)	Dense Graded HMAC (01)	Soil Aggregate Mixture (308)	Cement Treated Soil (333)	Sandy Silty Clay with Gravel (137)
Thickness (mm)	100	200	150	
In-Situ Density (kg/m^3)	2095	2065	1521	
In-Situ Moisture Content (%)		4.3	24.5	

* Note: Laboratory data had not been received during the preparation of this report.

II. Instrumentation Installation

Site Inspection and Meeting with Highway Agency

A preliminary planning meeting was held at the Lynchburg district office in Lynchburg, Virginia on September 21, 1995. The attendees at the meeting were:

• Dale Grigg	VDOT Materials
• Randy Hamilton	VDOT Chatham Res.
• A. L. Simpson	VDOT
• Buddy Wood	VDOT - Research Council
• Basel Abukhater	PMSL - NARCO
• Brandt Henderson	PMSL - NARCO
• Bill Phang	PMSL - NARCO

A presentation on the installation of seasonal monitoring instrumentation and monitoring requirements was provided by Bill Phang and Brandt Henderson of Pavement Management Systems. Reasons for picking this site for the seasonal monitoring program were discussed along with the details and the frequency of scheduled testing. Brandt Henderson then gave a more detailed description of roles and responsibilities of the agencies and the personnel involved with the installation. The list of materials required by VDOT was presented. Correspondence regarding the installation are presented in Appendix B.

A pre-installation meeting was arranged and conducted on October 20, 1995 at the VDOT district office in Lynchburg. Final details of the installation were discussed with VDOT members. A 305 mm thin walled core barrel was loaned to the VDOT Materials group for coring the instrument hole. FWD testing to pick the most uniform end for the installation, was conducted on October 21, 1995. The 0+00 end was picked because it was much more uniform than the 5+00 end. The presence of a culvert beneath the road at the 5+00 end most likely resulted in the non-uniform readings. Arrangements were made to meet on site at 0800 hours on Monday October 23, 1995.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air, pavement, and subsurface temperatures, precipitation, subsurface moisture content, and water table. An equipment cabinet was installed to hold the datalogger, battery pack, and all electrical connections for the instrumentation. The equipment cabinet installation and wiring of the panel was completed on October 25, 1995. The equipment installed are shown in Table 2.

Table 2. Equipment Installed

Equipment	Quantity	Serial Number
Instrumentation Hole		
MRC Thermistor Probe	1	51AT
CRREL Resistivity Probe	N/A	N/A
TDR Probes	10	51A01-51A10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16579
Campbell Scientific PS12 Power Supply	1	5386
Weather Station		
TE525MM Tipping Bucket Rain Gage	1	12076
Campbell Scientific 107-L Air Temperature Probe	1	51AAT
Observation Well/Bench Mark	1	N/A

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 473 ml 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 473 ml of water, the tipping bucket should measure 100 tips $\pm$ 3 tips. The results were 99 tips, which was within 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 hot water. In order for the probes to pass this check, the temperatures for each probe needed to 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 respectively, therefore the probes were considered to be functioning correctly. The results from the calibration of the air temperature and the thermistor probes along with the spacing between the thermistors are presented in Appendix B.

The TDR probes used at this site were manufactured by Campbell Scientific. These probes were of the FHWA three prong design. The 6 mm stainless steel probes are 203 mm in length, mounted to a printed circuit board encased in a 15 mm epoxy coating with burial type coaxial cable used to transmit signals between the Mobile unit and the TDR probe. This probe is more rugged than the FHWA probe but it is more difficult to maneuver around the instrument hole because it is bulkier.

The function of the TDR probes was 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 tests 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 during the pre-installation meeting on the afternoon of October 20, 1995. The installation was confirmed for 0800 hours on October 23, 1995. This site was installed in conjunction with site 510114 because of the close proximity of both sites. Traffic control was not required because the section was not open to the public. During the data collection period the traffic control is scheduled to provided by the VDOT Chatham Residency. The pavement surface drilling and augering of the piezometer and instrumentation hole were done by agency equipment and drilling crew. The sawing of the trench was done by VDOT Chatham Residency personnel. The installation of the measurement equipment, the observation piezometer, weather station pole, and cabinet was performed by PMSL staff. Assistance was provided by VDOT local district personnel. The original schedule was altered slightly because the pavement saw was not operational.

The instrumentation was installed on the North end of SPS 510113, in the Southbound lane of Route 265, approximately 4.1 km South of the S.R. 695 in Danville, Virginia. 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 75 mm flexible conduit and buried in a trench running from the instrument hole to the equipment cabinet. The cabinet was located on the road embankment adjacent to the shoulder, 5.84 m from the centre of the instrumentation hole. The weather pole was installed 0.25 m behind the equipment cabinet. The guardrail, at the edge of the shoulder, was removed for the duration of the installation, after which it was re-installed. 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 0.5 m from the edge of the paved shoulder to a depth of 4.27 m. Shale or water was not encountered during the drilling. The PVC access cover was seated firmly in concrete at the completion of the piezometer installation.

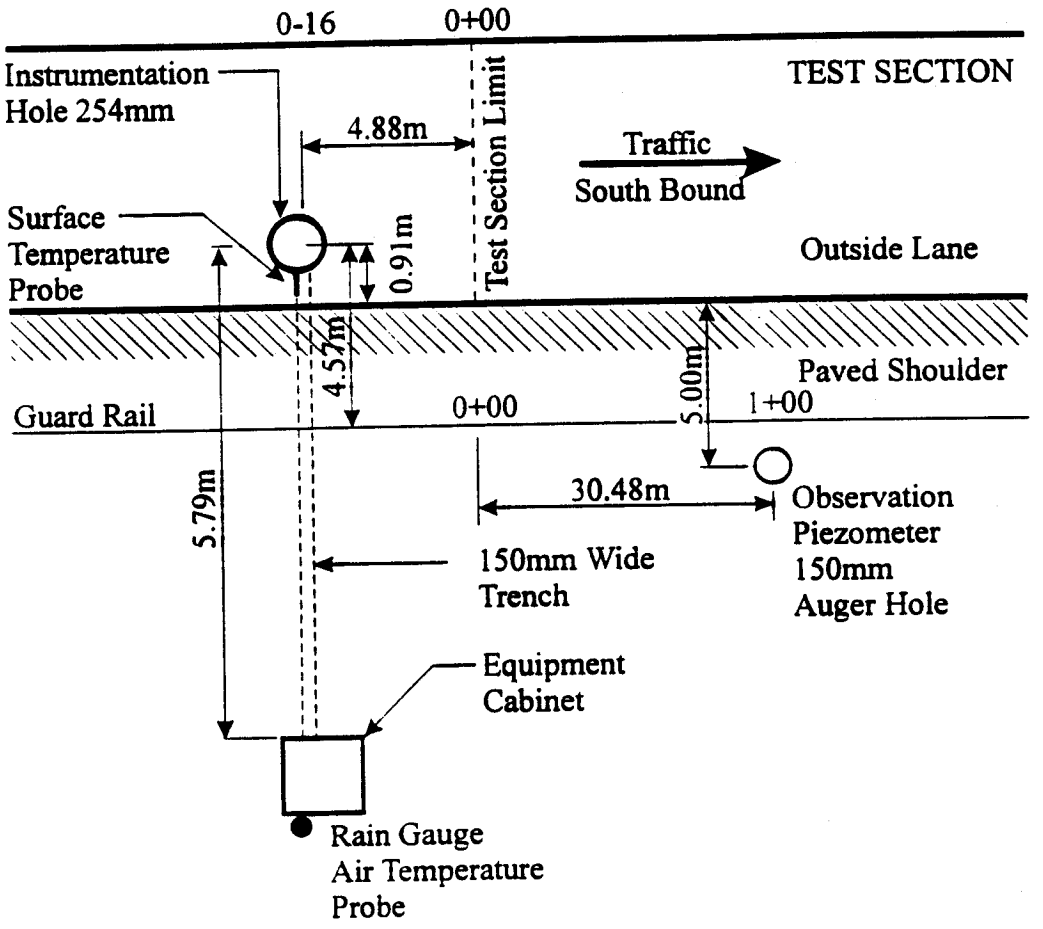
A core hole was drilled in the pavement surface, located in the outside wheel path 0.91 m from the edge of the travel lane at station 0-16, using a 305 mm thin wall diamond core barrel mounted to a heavy duty trailer drilling unit. A 150 mm wide by 225 mm deep

trench was saw cut between the core hole and the edge of the pavement using a heavy duty pavement sawing machine. The asphalt concrete portion of the trench was removed with picks and shovels.

The instrumentation hole was excavated using a 254 mm hollow stem auger with the hollow end blocked so that material mixing did not occur. Care was taken to ensure that the excavated material was stored in the order that it was removed. A standard proctor test of the subgrade soil was conducted in the field. The sandy silt yielded a dry density of 1360 kg/m^3 (as shown in Table C-3. of Appendix C). The drilling was stopped approximately 2.0 m below the surface of the pavement. The findings from the excavation of the instrumentation hole at station 0-16 are presented in Figure 2. All the material excavated from the instrument hole was placed and hand compacted in the order of removal with the TDR probes, and the thermistor probe placed at the specified locations. The 150 mm layer of soil cement was reconstituted by pulverizing the existing material and blending in 2 - 3% cement with water. This material was tampered back into the location it was retrieved from. During the placement of TDR probe number 1, the larger stones were picked out of the soil, so as to attain maximum soil contact with the probes. Once the probe was surrounded by soil the stones were placed above it. The location and elevation information of the instrumentation is presented in figure 2. Samples of the material placed around the TDR probes were retrieved for the field determination of the gravimetric moisture. The accuracy of the VDOT field procedure for determining moisture was such that no laboratory testing was required.

The pole for the rain gauge and air temperature probe were installed as per manual guidelines. The equipment cabinet installation and the wiring of the panel was completed on October 25, 1995.

To check for breakage of the TDR probes during installation, each probe was connected to the cable tester and it's wave form monitored during compaction of the material around it. The TDR traces are included in Appendix C. Spikes in the wave forms are the result of inverter noise. The TDR battery was low, which required using AC power for the TDR data collection. The cables coming from the TDR probes were staggered along the perimeter of the instrument hole to avoid water migrating along a bundle of cables. The top TDR probe was placed with the cabling and the printed circuit board facing downward so as to avoid contact with the asphalt pavement. The top of the thermistor probe was 0.121 m below the pavement surface. The cables from all instrumentation installed converged at the opening of the flexible conduit pipe which was placed about 50 mm from the edge of the core hole. The cables were then tie wrapped and passed through a 75 mm flexible conduit to the equipment cabinet. The ends of a conduit were plugged with a mastic pipe sealant.



- Height of Air Temperature Probe: 3.18m
- Height of Tipping Bucket Rain Gauge: 3.20m
- Depth of Piezometer: 4.27m

Figure 1. Location of Seasonal Monitoring Instrumentation Installed at SPS 510113

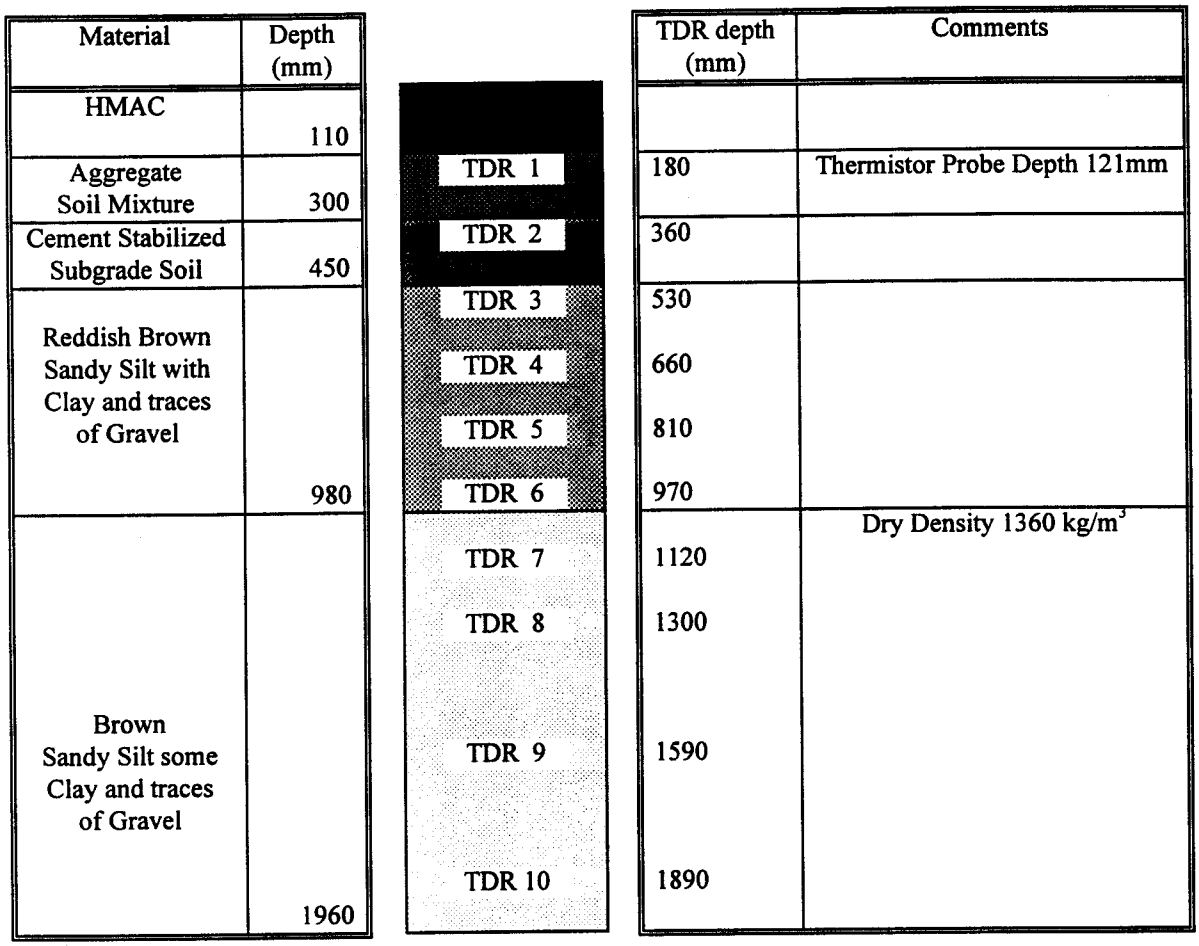


Figure 2. Profile of Pavement Structure and Probe Depths, Station 0-16

Tables 3, and 4 present the installed depths of the TDR probes, and thermistor sensors respectively. Table 5 gives TDR, and field measured moisture content collected during the installation. A comparison of the moisture content from the TDR traces, and the field determination indicate some discrepancies. The installation of the TDR probes and retrieving moisture samples, took place during the dusk to dark hours of the day. Although care was taken in trying to match the moisture samples with the soil placed around the corresponding TDR probe it is possible that there weren't exact matches. The moisture added to the soil cement mixture might have also added to some of the variability. It should be noted that the calculation of moisture is dependent on the calibration inputs to the TDR model. Differences of moisture content in the range of 1 to 2% are not uncommon.

Table 3. Installed Depths of TDR Sensors

Sensor #	Depth from Pavement Surface (m)	Layer
51A01	0.180	Base
51A02	0.360	Treated Subgrade
51A03	0.530	Subgrade
51A04	0.660	
51A05	0.810	
51A06	0.970	
51A07	1.120	
51A08	1.300	
51A09	1.590	
51A10	1.890	

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	0.054	
	3	0.083	
2	4	0.137	This unit was installed below the AC layer into the subgrade.
	5	0.214	
	6	0.291	
	7	0.367	
	8	0.442	
	9	0.598	
	10	0.747	
	11	0.897	
	12	1.049	
	13	1.203	
	14	1.355	
	15	1.504	
	16	1.654	
	17	1.811	
	18	1.960	

Table 5. TDR, and Field Moisture Content During Installation

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt)*	Field Moisture Content (by wt)*
51A01	0.180	Base	7.76	4.1
51A02	0.360	Treat. Subgrade	30.85	25.0
51A03	0.530	Subgrade	25.23	36.0
51A04	0.660		29.09	**
51A05	0.810		29.09	**
51A06	0.970		25.23	41.9
51A07	1.120		20.99	18.2
51A08	1.300		20.99	19.0
51A09	1.590		16.54	15.0
51A10	1.890		14.28	15.4

* Note: Raw data given in Appendix C

** Note: No field moisture tests conducted.

Site Repair and Cleanup

The instrumentation hole and trench were repaired by placing and compacting hot mix asphalt concrete. The VDOT personnel filled and compacted the hot-mix on October 25, 1995. Soil cover of at least 50 mm was maintained over the conduit for the extent of the paved trench. The road base material removed from the trench was used to bring it up to grade. The chunks of asphalt removed from the pavement were cleared by the VDOT personnel on October 25, 1995. The sharp drop off at the location of the weather station and the equipment cabinet necessitated the construction of a platform such that field operators could easily access the air temperature probe and the tipping bucket with a ladder. This platform was constructed by bonding loose boulders with Portland cement concrete mix and applying an asphalt leveling coarse.

The wiring panel in the equipment cabinet was installed on October 25, 1995. All equipment checks and initial data collection was completed by October 26, 1995.

Patch/Repair Area Assessment

All indications until the site visit on January 24, 1996, were that the instrument hole and trench were in very good condition. Pictures of the instrument hole are presented in Appendix E.

III. Initial Data Collection

Initial data collection on the site and checks on functioning of installed equipment were conducted on October 26, 1995. This consisted of examination of the data collected over the day by the onsite datalogger, data collection and check of the mobile CR10 datalogger, check of the tipping bucket, deflection testing, and elevation survey. A sample of the data collected by the onsite datalogger is presented in Appendix D (Table D-1).

Air Temperature, Subsurface Temperature, Rain-fall Data

The air temperature, pavement subsurface temperature profile, and rainfall data, collected on October 26 by the CR10 datalogger, were examined. The thermistors first sensor was yielding incorrect temperatures on the first day of data collection. This was most likely a result of the placement of hot mix asphalt concrete in the instrument hole and trench area on that day. It was noticed that, since the first day it has been functioning correctly. This probe was sent to the manufacturer twice prior to the installation because of a problem with MRC #1. It's function will be monitored closely. Other than the thermistor sensor number 1, all other equipment and the datalogger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. The plots of the temperature profiles are presented in Appendix D (figures D-1 and D-2).

The tipping bucket rain gauge was checked by determining the number of tips recorded from 473 ml of water discharged into the gauge over a 1 hour time period. The rain gauge was found to be operating properly.

TDR Measurements

TDR data was 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 2.2 of the MOBILE program was used to collect and record the TDR wave form traced for each sensor.

Figure D-3 shows the initial TDR 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. The trace for TDR #2 does not have a defined reflection point for the end of the probe. This probe is placed in the soil cement.

Deflection Measurement Data

Deflection measurements followed procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The analysis results from the FWDCHECK program from the day of installation and the

following day are presented in Appendix D. Since then FWD testing has been conducted once every month. It should be noted that this site contains variable subgrade soil conditions.

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). As a result of the delay in lane painting, profile data was gathered only once on April 24, 1996 (IRI of 61.35 inches/mile).

Elevation Surveys

One set of the surface elevation survey was performed following the guidelines. The elevation at the top of the piezometer pipe was assumed to be 1.000 meters. The survey was conducted on October 25, 1995 and the results are presented in Appendix D. Since then elevation surveys have been performed on January 24, February 21, and April 24, 1996.

Water Depth

There was no water encountered during the drilling process and there has not been any water in the piezometer pipe since the installation. The last site visit was on May 15, 1996 and the piezometer was dry then.

IV. Summary

The installation of the seasonal monitoring instrumentation at the SPS site 510113 near Danville, VA was completed on October 25, 1995. A check of the equipment and initial data collection was completed on October 26, 1995. The instrumentation, permanently installed at the site, were:

- Time domain reflectometer probes for moisture measurements,
- Thermistor probes for pavement and soil gradient temperature measurements,
- Air temperature, thermistor probe, and tipping bucket rain gauge to record local climatic conditions, and
- Combination piezometer (well) and bench mark to determine changes in water level and pavement elevations.

The pavement gradient temperature and local climatic data are to have continuous data collection stored in an on-site datalogger. The moisture measurement is 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 Southbound Route 265, 4.1 km South of the S.R. 695. The site is located in a predominantly fill area. The road embankment on the West side, slopes steeply downward toward a creek. The pavement consists of one 3.7 m wide lane in each direction with a 3.7 m paved shoulder that ends at an asphalt curb. Guardrails have been installed along the curb. Future transportation plans combine the present Northbound and Southbound lanes as Southbound traffic lanes. The pavement structure consists of 100 mm of asphalt concrete over 200 mm dense graded aggregate base which lies on 150 mm of cement treated subgrade. The subgrade material consists of sandy silts with clay and gravel.

A WIM installed just North of S.R. 695 will provide continuos traffic data for this section. It is expected the WIM will be operational prior to the section being opened to traffic.

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 the installation and the following day indicated that all instrumentation were functioning properly. Thermistor sensor number one yielded erroneous readings on October 25, 1995 which was the day that hot mix asphalt was used to fill the instrument hole and the trench. The air temperature and gradient temperatures measured in the pavement surface compared favourably with the hand held Omega temperature gauge. The temperature profile for the pavement soils appeared reasonable with no outlying sensors except for sensor number one as mentioned above. A check of the tipping bucket indicated it was functioning correctly with tips corresponding to the amount of water supplied.

Moisture content of the soil was determined by TDR method, and field moisture determination at time of installation by soil drying. There were slight differences between the moisture content determined by the TDR method and gravimetric moisture content determined in the field.

The installation generally proceeded as expected with only a few minor problems. The removal/replacement of the material from the instrumentation hole was successful, with the hot-mix being well compacted and level with the existing pavement surface at completion.

The soil cement was reconstituted with 2 - 3% cement prior to the placement. The TDR probe #2 that was placed in the soil cement, did not have a well defined reflection point for the end of the probe. It was still possible to interpret the trace from this probe.

Environmental data will be collected by an Automated Weather Station (AWS) located at the North end of the SPS-1 project.

The ongoing monitoring of this section is progressing fairly well.

APPENDIX A

Test Section Background Information

Appendix A contains the following supporting information:

Figure A-1	Site Location Map
Figure A-2	SPS-1 Design Schematic
Figure A-3	Profile of Pavement Structure
Table A-1	Uniformity Survey Results
Figure A-4	Deflection Profiles from FWDCHECK (Test Date October 21, 1995)
Table A-2	Subgrade Modulus and Structural Number from FWDCHECK (Test Date October 21, 1995)

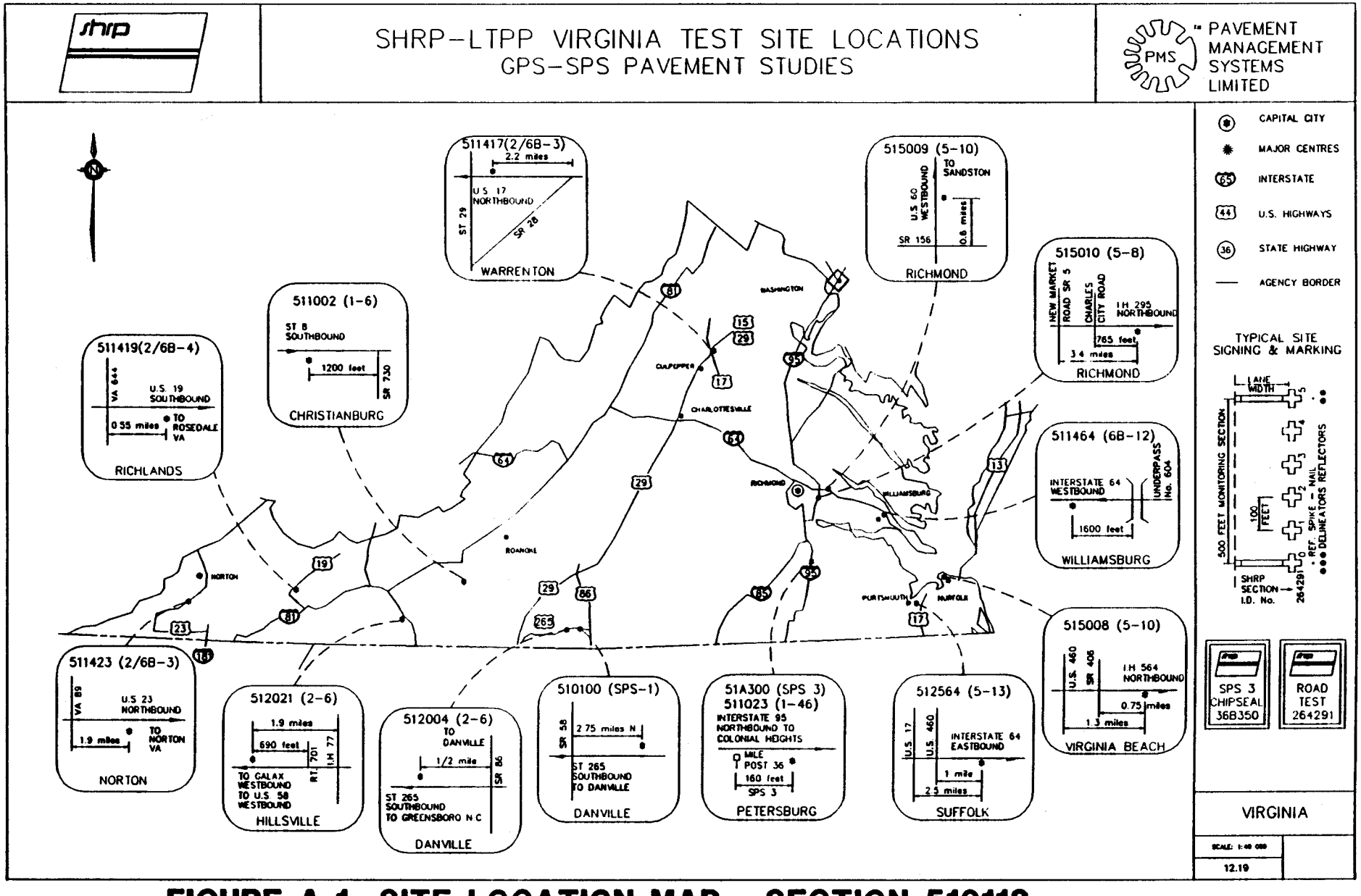
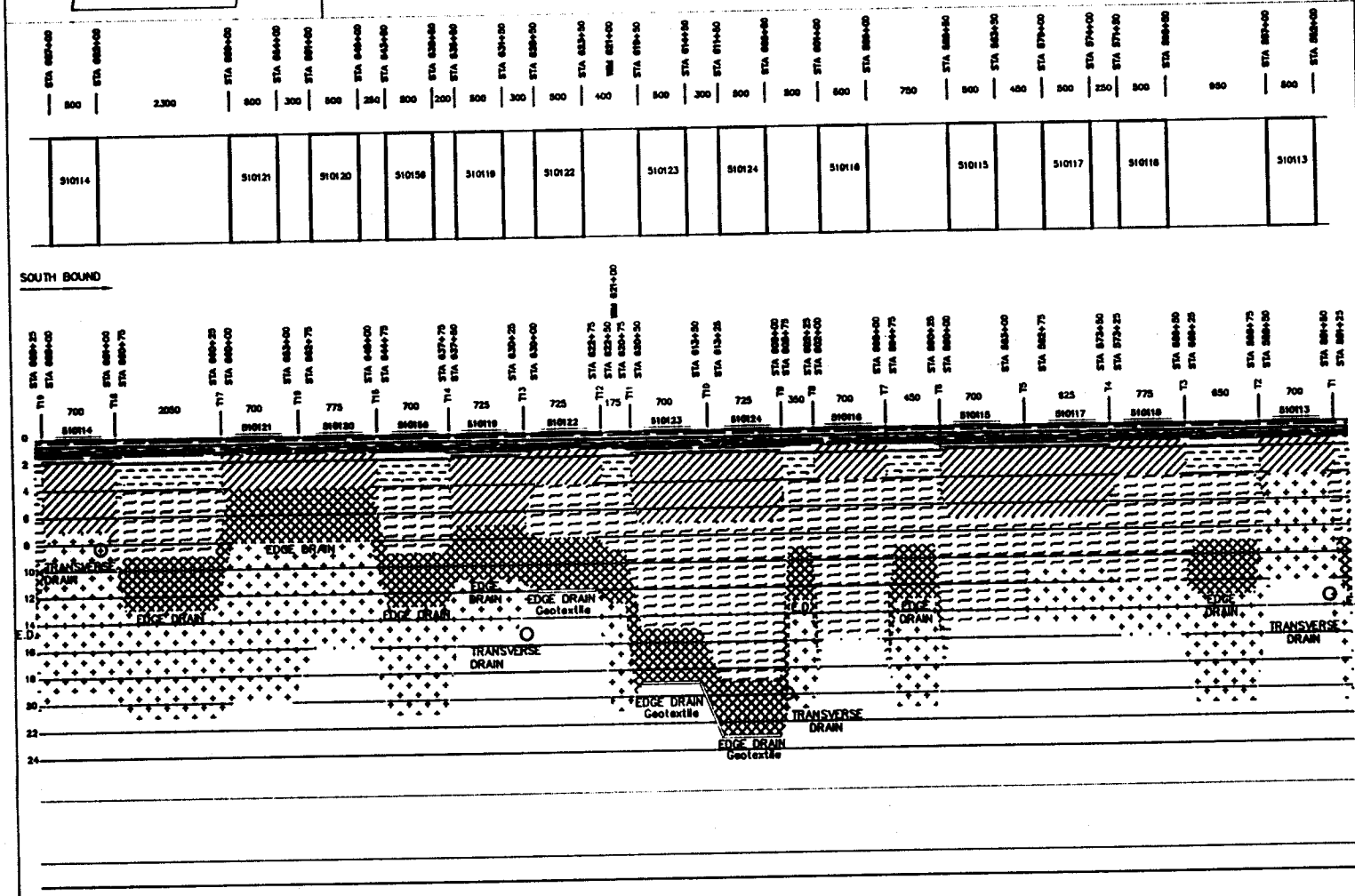


FIGURE A-1 SITE LOCATION MAP - SECTION 510113

FHWA-LTPP SPS-1 VIRGINIA DESIGN SCHEMATIC

STRUCTURE FACTORS FOR FLEXIBLE PAVEMENTS

PAVEMENT MANAGEMENT SYSTEMS LIMITED



LEGEND

SM-2B	-ASPHALT CONCRETE WEARING COURSE MIX	PROJECT LAYER CODE J
IM-1A	-ASPHALT CONCRETE INTERMEDIATE COURSE MIX	PROJECT LAYER CODE H
IM-1B	-ASPHALT CONCRETE INTERMEDIATE COURSE MIX	PROJECT LAYER CODE G
BM-3	-ASPHALT CONCRETE BASE COURSE MIX	PROJECT LAYER CODE F
PATB	-PERMEABLE ASPHALT TREATED BASE	PROJECT LAYER CODE E
DGAB	-DENSE GRADED AGGREGATE BASE	PROJECT LAYER CODE D
CSAB	-CEMENT STABILIZED AGGREGATE BASE	PROJECT LAYER CODE K

TRANSITION 1-19 ARE 25' LONG
A V.DOT STRUCTURE IS PLANNED FOR SEGMENTS BETWEEN TRANSITIONS:
T2 AND T3, - 650'
T6 AND T7, - 450'
T8 AND T9, - 350'
T11 AND T12, - 175'
T17 AND T18, - 2050'

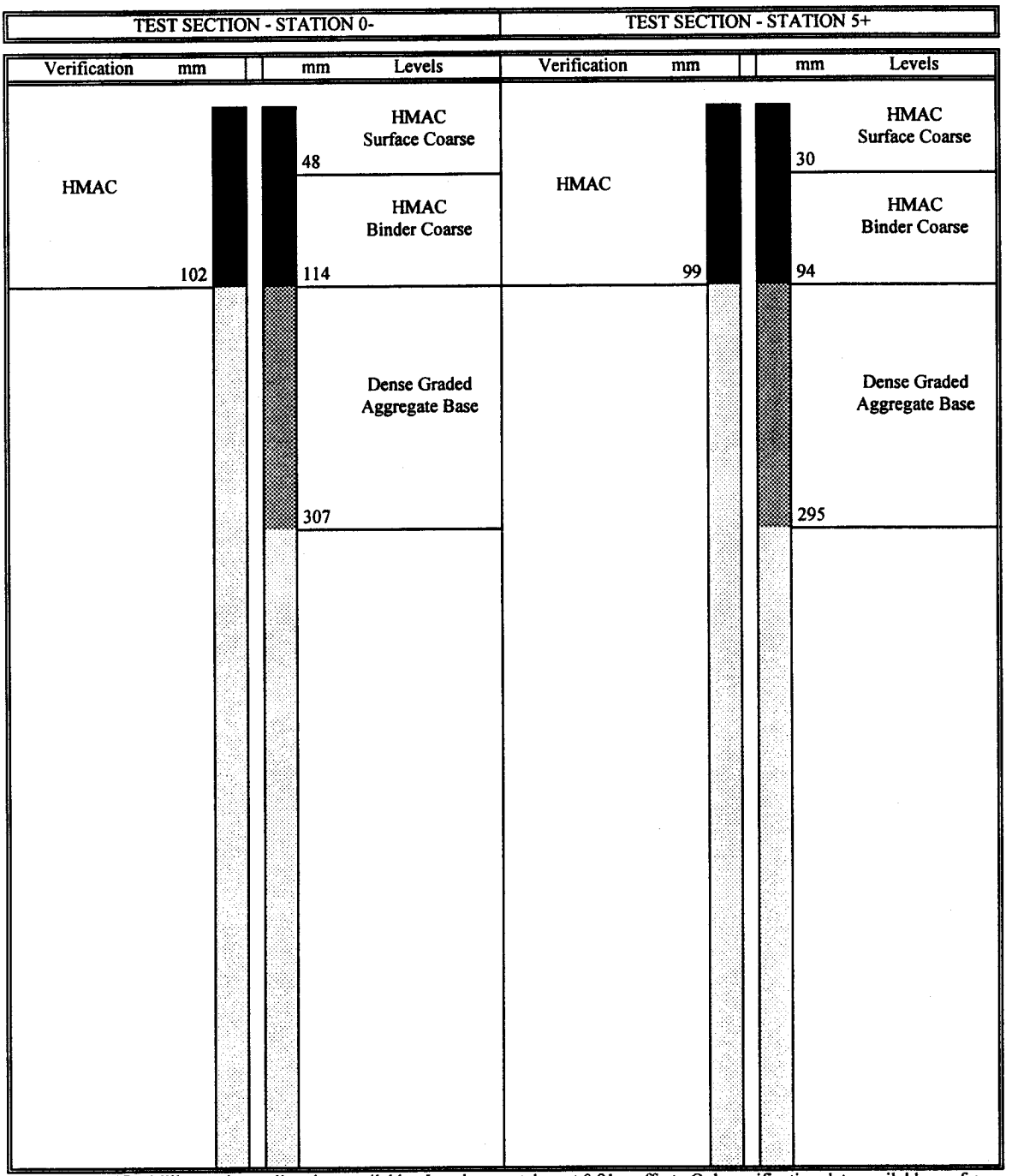
SPS-1
VIRGINIA DOT SPS-1
RTE. 265 SBL, DANVILLE

PLOTTED ARE 10/00

SPS-1-1A

SHRP SPS-1 TEST SECTIONS ONLY. DRAWING NOT INTENDED TO BE USED FOR CONSTRUCTION PURPOSES

FIGURE A-2. SPS-1 DESIGN SCHEMATIC



* No site specific drilling and sampling data available. Levels were taken at 0.91m offset. Only verification data available are from the AC cores taken

Figure A-3. Profile of Pavement Structure

Table A-1. Uniformity Survey Results

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 510113	Data Collection and
Date Surveyed: October 21, 1995	Processing Summary

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 - 250	19.47	1.50	1.77	0.29	14251	2641	3.56	0.13
250 - 600	17.76	9.07	1.98	0.66	14536	9920	4.72	1.56

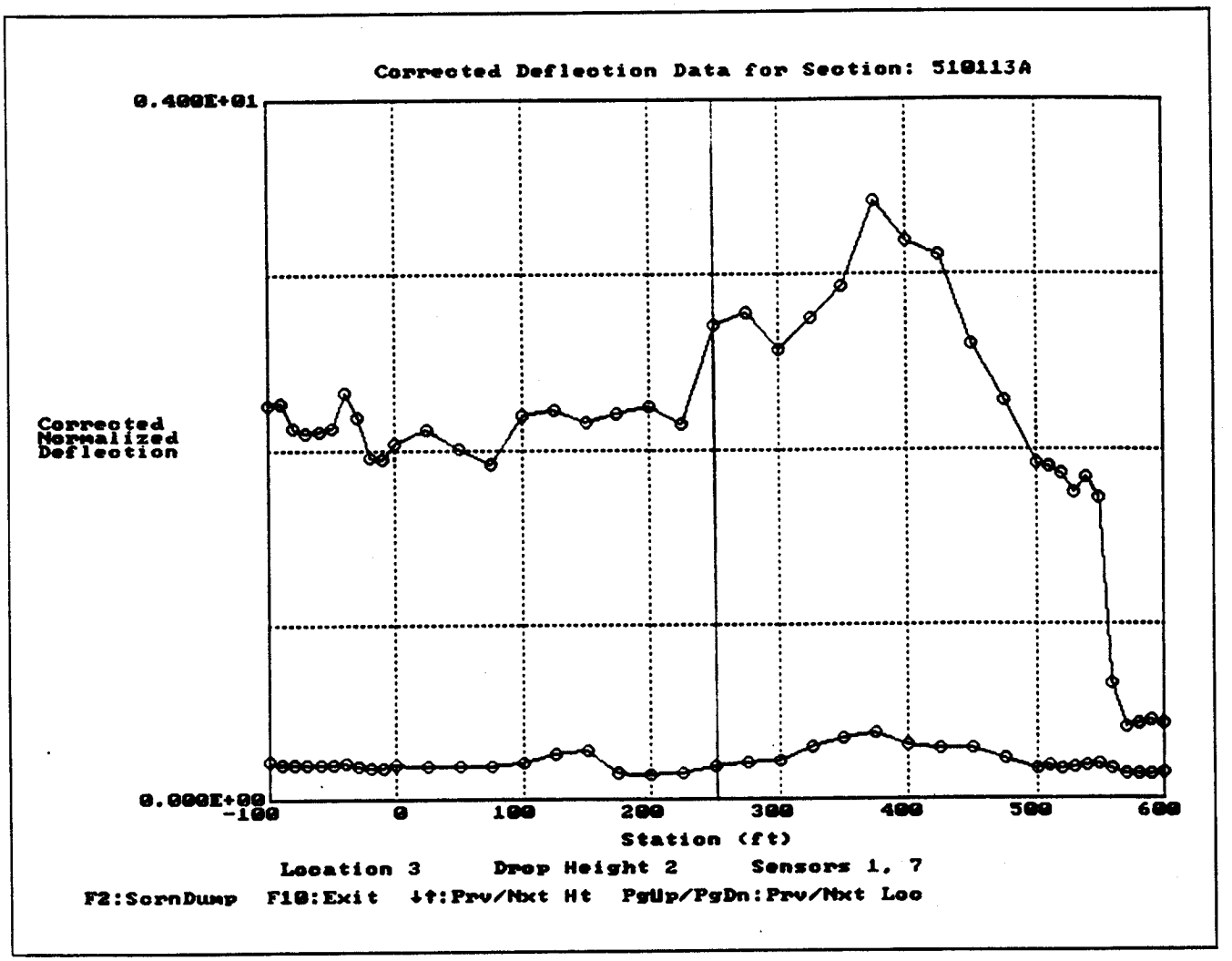


Figure A-4. Deflection Profile from FWDCHECK
(Test Date October 21, 1995)

Table A-2. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date October 21, 1995)

Flexible Pavement Thickness Statistics - 510113A - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-100	16273	3.35
	-90	14315	3.45
	-80	15753	3.45
	-70	15947	3.50
	-60	18118	3.40
	-50	17718	3.40
	-40	13653	3.40
	-30	13509	3.55
	-20	15914	3.65
	-10	15330	3.70
	0	12897	3.75
	25	13833	3.60
	50	17109	3.55
	75	16800	3.65
	100	11105	3.70
	125	10842	3.70
	150	12094	3.65
	175	10914	3.70
	200	12221	3.60
	225	16581	3.40
	250	8341	3.55
2	275	7039	3.65
	300	7010	3.85
	325	5677	3.95
	350	4445	4.15
	375	3781	3.95
	400	4494	3.80
	425	4269	4.00
	450	5340	4.20
	475	8257	3.95
	500	15990	3.65
	510	15752	3.65
	520	15786	3.70
	530	17903	3.70
	540	14904	3.75
	550	13582	4.00
	560	25115	6.10
	570	31046	7.80
	580	30391	7.65
	590	30507	7.30
	600	29441	7.60
Subsection 1	Overall Mean	14251	3.56
	Standard Deviation	2641	0.13
	Coeff of Variation	18.53%	3.54%
Subsection 2	Overall Mean	14536	4.72
	Standard Deviation	9920	1.56
	Coeff of Variation	68.24%	33.11%

APPENDIX B

Supporting Site Visit and Installed Instrument Information

Appendix B contains the following supporting information:

Correspondence from the Site Inspection and the 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. TDR Probes Calibration

Figure B-1. TDR Traces Obtained During Calibration

FAX TRANSMITTAL

Date: October 12, 1995

To: Dale Grigg **Fax No.:** (804) 947-2190

Sender: Brandt Henderson BH **Project No.:** 5-045-11-25

File No.:

Reference: Seasonal Site Installation Includes cover sheet plus 4 pages

☑ Original will follow by mail

MESSAGE:

To follow up your letter dated September 25, 1995, please find enclosed diagrams detailing the site plan view and projected instrument placement for Seasonal sites 510113 and 510114. The installation is scheduled for Monday October 23, 1995 and Tuesday October 24 respectively. We would like to have a pre-installation meeting at the Lynchburg office on Friday October 20, 1995, at 2:00 p.m. to discuss the final details regarding the installation. Our 12" core barrel will be with us at this time. We will contact you to confirm this meeting.

The uniformity survey will be conducted on Saturday October 21, 1995 by the FHWA FWD unit. The location for the installation will be finalised after the uniformity test. The relative location of the piezometer, instrumentation hole, equipment cabinet and instrument weather pole are identified in the attached plan view diagram. Utility clearances will be required at these locations. If there are any problems with clearances we can review and adjust the locations as part of the pre-installation meeting.

Your letter dated September 25, 1995, indicates that preparation for the installation are progressing well.

As verification of the field moisture we are requesting that the agency provide laboratory moisture values for soil samples taken at each TDR installation location. There will be 10 samples at each site for a total of 20. Proctor tests will be conducted on 1 to 2 samples from each instrument hole utilising VADOT equipment.

The Pavement Management Systems employees coming for this installation are:

Scott Comstock	Instrumentation Technician
Tim Comstock	Installation Technician
Brandt Henderson	Team Leader
Randy Plett	FWD Operator
Dilan Singaraja	Engineering Assistant

If you have not received a complete message, please call sender at:

Pavement Management Systems Limited

415 Lawrence Bell Drive, Unit 3, AMHERST, New York 14221 Ph: (716) 632-0804, Fax: (716) 632-4308

FAX TRANSMITTAL

I plan to be there on Friday October 20, 1995 with the instrumentation and the installation equipment. Randy Plett will arrive later in the day with the FHWA FWD to commence with the uniformity testing on October 21, 1995. Along with the seasonal instrumentation we will be bringing a complete weather station set-up minus the UT3 base which was forwarded to you on October 03, 1995.

If you have any questions or need further information do not hesitate to call.

We look forward to seeing you and your co-workers on October 23.

Copies: Thomas Freeman, (w/o attachments)
Aramis Lopez, (w/o attachments)
Bill Phang, (w/o attachments)
Ivan Peznik, (w/o attachments)

If you have not received a complete message, please call sender at:

Pavement Management Systems Limited

415 Lawrence Bell Drive, Unit 3, AMHERST, New York 14221 Ph: (716) 632-0804, Fax: (716) 632-1908

FILE # D-171

COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
P.O. Box 11649
LYNCHBURG, 24506-1649

VID R. GEHR
OMMISSIONER

W. T. RAMEY, P.E.
DISTRICT ADMINISTRATOR

September 25, 1995

Mr. W. A. Phang, D. Eng.
Program Manager, FHWA-LTPP
Pavement Management Systems
415 Lawrence Bell Drive
Unit #3
Amherst, NY 14221

Re: VA DOT SPS-1

Project 6265-071-F02,P403
Pittsylvania County

Dear Mr. Phang:

With regard to our meeting on September 21, 1995 concerning the installation of seasonal monitoring instrumentation at two sites on the above captioned project, the following were determined:

Seasonal sites will be installed at SPS-1 Sections 510113 and 510114, within 25 L.F. of either end of each section. Deflection tests will be performed with the FHWA FWD in order to determine the uniformity of each respective section, and based on these findings the site locations will be selected. VDOT will proceed with the preparation of each potential seasonal site (2 per section) such that the necessary equipment cabinet and mast can be installed adjacent to the roadway shoulder, either behind the ditchline or behind the guardrail. The actual installation of the seasonal sites will take place the week of October 23-27. VDOT will provide an asphalt concrete core drill and a soil auger drill. PMS will provide a 12" diameter core barrel to be fitted onto VDOT's asphalt drill. VDOT will provide a 10" diameter soil auger capable of augering up to 7' deep. VDOT will also provide a proctor kit including a stove to be used for determining the density and moisture content of soil. VDOT will also furnish a pavement saw capable of cutting to a minimum depth of 7". In addition to the foregoing equipment, VDOT will also furnish the following materials:

1 bag of clean sand
1 bucket (5 gal.) of bentonite
2 - 80 lb. bags of sackrete concrete mix
2 - 24" long pieces of either 6" I.D. or 8" I.D. Sch. 40 pvc pipe with 2 threaded cap adapters and caps

It is understood that each seasonal site installation will take approximately one day. It is also understood that work will not take place during periods of wet weather.

In addition to the seasonal sites, during the week of October 23-27 VDOT will also drill the remaining cores from the SPS-1 sites. VDOT will provide hot mix to patch the core holes. VDOT also intends to have the site for the weather station prepared by that same time such that installation of the tower and associated equipment can be facilitated.

Deflection tests will be run on the SPS-1 sections the last week in November by both VDOT's and the FHWA's FWD's. Provided the test data between the two units correlates, VDOT will perform subsequent periodic deflection testing. VDOT will be responsible for all traffic control for all subsequent testing of the SPS-1 sections once the project has been opened to traffic.

If there are any items I have overlooked, please let me know. I will keep you advised of any developments concerning the items discussed herein.

Very truly yours,

D. H. Grigg, Jr.
District Materials Engineer

DHG/bw

Cy: Mr. R. L. Hamilton
Mr. R. J. Gibson
Mr. D. L. Woolley
Mr. T. N. Karnes
Mr. G. W. Wise, Jr.
Mr. N. B. Walton, Jr.
Mr. T. E. Freeman
Mr. L. I. Pettigrew, III
Mr. B. C. Pierce
Mr. A. L. Simpson

FAX TRANSMITTAL

		Date:	September 8, 1995
To:	Thomas E. Freeman	**Fax No.:**	(804) 293-1990
Sender:	Brandt Henderson	**Project No.:**	5-045-11-25
	Bill Phang	**File No.:**	16.03
Reference:	Seasonal SPS 510113 & 510114 Installation Planning Meeting	Includes cover sheet plus page	
		☐ Original will follow by mail	

MESSAGE:

Dear Mr. Freeman,

We would like to conduct the Installation Planning Meeting on Thursday September 21, 1995 at your offices. Arrangements for the installation such as the dates, traffic control, coring and auguring equipment, supplies, and personnel have to be made. We will be sending you further detail on the site information, instrumentation layout, installation scheduling, installation team, and supplies needed as the information becomes available to us.

We will contact you to confirm the date and time of the meeting. We would appreciate it if those attending the meeting are notified once the date and time have been fixed. Thank you for your cooperation.

If you have not received a complete message, please call sender at:

Pavement Management Systems Limited

415 Lawrence Bell Drive, Unit 3, AMHERST, New York 14221 Ph: (716) 632-0804, Fax: (716) 632-4808

VIRGINIA DEPARTMENT OF TRANSPORTATION
DAVID R. GEHR, COMMISSIONER
TRANSPORTATION RESEARCH COUNCIL
GARY R. ALLEN, PH.D., DIRECTOR

VTRC
TRANSPORTATION RESEARCH COUNCIL

FILE # 13.19-1

COMMONWEALTH of VIRGINIA

TRANSPORTATION RESEARCH COUNCIL
530 EDGEMONT ROAD
CHARLOTTESVILLE, VA 22903

UNIVERSITY OF VIRGINIA
JOHN T. CASTEEN, PRESIDENT
DEPARTMENT OF CIVIL ENGINEERING
FURMAN W. BARTON, CHAIRMAN

File No. 11-10-3

April 3, 1995

Mr. Brandt Henderson
Manager, Field and Data Operations
Pavement Management Services Limited
415 Lawrence Bell Drive
Unit #3
Amherst, New York 14221

Subject: Seasonal Site at the SPS-1 Project
Route 265 Danville Bypass

Dear Mr. Henderson:

I have discussed with my associates the possibility of including a seasonal site in our SPS-1 project, and we have decided that we can support this effort. We appreciate the limitations in the number of available candidates in the wet-freeze areas with fine subgrade soils, and therefore recognize the value to the LTPP program of including such a site in this project.

We understand that VDOT will be responsible for installing a piezometer (6-in. diameter hole to a depth of 15 ft) for water table depth monitoring. Additionally, we will provide a cover for the observation hole as well as bentonite and filter sand to be used as backfill material. We will also provide coring and auguring equipment to accomodate your installation of the instrumentation. VDOT will be responsible for sawing a trench through the pavement from the observation hole to the pavement edge for placement of equipment cables. We will provide traffic control to enable you to collect seasonal monitoring data. We understand that this will require the closing of one lane for a period of one day approximately once per month.

TELEPHONE (804) 293-1900 ———— FAX (804) 293-1990

VDOT is ready to move forward with the inclusion of a seasonal site at your direction. We expect to begin construction of the SPS-1 project during the first part of May, so we look forward in the near future to your input with regard to scheduling this work.

Very truly yours,

Thomas E. Freeman

Thomas E. Freeman, P.E.
Senior Research Scientist

TEF/tef

cc: Mr. J.S. Hodge
Dr. G.R. Allen
Mr. W.T. McKeel
Mr. R.J. Gibson
Mr. D.H. Grigg, Jr.
Mr. T.A. Wiles, IV
Mr. G.W. Maupin

PAVEMENT
MANAGEMENT
SYSTEMS

January 9, 1995
50451010-13.19.1

Mr. Thomas E. Freeman
Virginia Transportation Research Council
530 Edgemont Road
Charlottesville, Virginia 22903

Dear Mr. Freeman:

The LTPP program is preparing to recruit the second round of seasonal site nominations. In accordance with your previous discussions with Dennis Morian and Basel Abukhater of our staff, it was indicated that there may be interest in including a seasonal site at the SPS-1 project. We are very interested in including a seasonal site from this project, as we are limited in the number of candidates available in the wet-freeze and no-freeze areas with fine subgrade soils. In particular we would be interested in either site 500113 or 500114.

For your information we have enclosed a "Seasonal Monitoring Program Guideline" as well as a sample of one of our existing installation reports.

Page III-24 of the "Seasonal Monitoring Program Guidelines" provides a list of the data collection activities with the level of effort required. Data is collected monthly with the exception in a wet-freeze environment, this is increased to bi-weekly during the thaw period, for a total of 14 site visits during the annual cycle. This will be the frequency of traffic control needed. A minimum of 2 cycles over a 3 year period is required for the core experiment, with the objective of obtaining up to 5 cycles over the life of the program.

In general, the seasonal instrumentation consists of moisture, temperature, water table depth, and frost depth measurements beneath the pavement. Along with this are climatic measurements of air temperature and precipitation. Pages II-27-28 of the Guidelines" indicate areas of responsibility for the FHWA, RCOC, and agency.

General items required of the agency for installation are a drill rig with the capability to drill 6" diameter hole to a 15' depth for installation of a piezometer. In addition, the cover for the observation hole, bentonite, and filter sand to fill the hole are to be provided by the agency. The agency is also to provide coring and auguring equipment for holes 10" to 12" in diameter up to a maximum depth of 7'. In addition, a concrete pavement saw must be provided to cut a trench from the observation hole to the pavement edge. This trench will carry the instrumentation cabling to the equipment cabinet adjacent to the roadway.

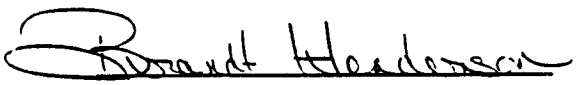
415 LAWRENCE BELL DRIVE
UNIT #3
AMHERST, N.Y. 14221
TEL. (716) 632-0804
FAX (716) 632-4808

The agency will also be responsible for traffic control for collecting the monthly data. This will require a lane closure approximately 300' in length at the instrument hole, for essentially one day each month.

The addition of the seasonal monitoring data, at different geographical locations promises to significantly enhance the LTPP database, and increase the potential analysis of the data.

Thank you for your consideration of supporting a seasonal data site.

Yours Sincerely,



Brandt Henderson
Manager, Field and Data Operations
Pavement Management Systems Limited

BH/tf

enclosure

C.C. I.J. Pecnik, RE, w/o enclosure
W.A. Phang, NARO, w/o enclosure

Table B-1. Air Temperature Thermistor Calibration

LTPP Seasonal Monitoring Study	State Code	[51]
Air Temperature Thermistor Calibration	Test Section Number	[0113]

Before Operation Checks	Calibration Date (dd-mm-yy)	12-10-95
	Probe S/N	51AAT
	Operator	SC

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
22.35	21.25	25.22	22.2	754	0.215	915	49.4	1210	y

Probe Accepted	S.C.	(Initials)

Table B-2. MRC Probe Calibration

LTPP Seasonal Monitoring Study	State Code	[51]
MRC Probe Calibration	Test Section Number	[0113]

Before Operation Checks	Calibration Date (dd-mm-yy)	12-10-95
	Probe S/N	51AT
	Operator	SC

	Mobile Datalogger (24 hour)			Water Room Temp Time 754	Ice Bath 0 °C (+/- 1 °C) Time 915	Hot Water 50 °C (+/-) Time 1210	ok
No.	Mean	Min.	Max.	Reading	Reading	Reading	y/n
1	22.31	20.92	25.19	22.2	2.35	49.4	y
2	22.26	21.33	24.24	22.2	-6.34	48.6	y
3	22.17	20.72	25.29	21.9	0.63	47.4	y
4	22.17	21.30	26.15	22.1	2.79	49.0	y
5	22.22	21.33	27.48	22.1	-0.04	48.3	y
6	22.14	21.34	27.07	22.0	0.92	48.3	y
7	22.26	21.40	28.36	22.1	1.84	47.4	y
8	22.27	21.40	29.56	22.1	-0.41	47.2	y
9	22.44	21.38	30.62	22.2	0.41	47.7	y
10	22.23	21.33	29.56	22.0	1.60	48.6	y
11	22.36	21.44	31.26	22.1	1.06	48.7	y
12	22.30	21.39	31.28	22.0	0.19	49.5	y
13	22.23	21.41	30.16	22.0	1.38	49.1	y
14	22.14	21.35	29.96	21.9	-0.37	49.1	y
15	22.16	21.28	29.66	21.9	0.00	49.3	y
16	22.27	21.35	30.21	21.9	1.60	47.5	y
17	22.34	21.43	31.22	21.9	0.55	48.0	y
18	22.23	21.30	28.84	21.8	-0.22	48.4	y

Probe Accepted:	S.C.	(Initials)
Probe Length:	1.851	(meters)

Thermistor distance from top of probe: (meters)									
4	0.016	7	0.246	10	0.626	13	1.082	16	1.533
5	0.093	8	0.321	11	0.776	14	1.234	17	1.690
6	0.170	9	0.477	12	0.928	15	1.383	18	1.839

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

Unit	Channel No.	Distance from Top of Unit(m)	Remarks
1	1	0.025	0.3302 m long by 6.35 mm stainless steel probe installed in the AC layer.
	2	0.177	
	3	0.327	
2	4	0.016	1.851 m long by 25.4 mm PVC tube installed in the base and subgrade.
	5	0.093	
	6	0.170	
	7	0.246	
	8	0.321	
	9	0.477	
	10	0.626	
	11	0.776	
	12	0.928	
	13	1.082	
	14	1.234	
	15	1.383	
	16	1.533	
	17	1.690	
	18	1.839	

Table B-4. TDR Probes Calibration

LTPP Seasonal Monitoring Study	State Code	[51]
TDR Probes	Test Section Number	[0113]

Before Operation Checks	AL/SC	Initial	Calibration Date (dd-mm-yy)	12-10-95
			Seasonal Site	51SA

No.	Probe (S/N)	Resistance (ohms)		Probe Shorted		Air	Alcohol	Water
		Core	Shield	Begin Length	End Length *	Begin Length	Begin Length	Begin Length
1	51A01	.5	.5	15.11	15.25	15.11	15.10	15.10
2	51A02	.2	.3	14.94	15.13	14.94	14.93	14.93
3	51A03	.4	.4	15.24	15.42	15.24	15.23	15.24
4	51A04	.3	.3	15.09	15.27	15.09	15.09	15.09
5	51A05	.4	.3	15.18	15.34	15.18	15.17	15.16
6	51A06	.1	.2	15.21	15.38	15.21	15.19	15.20
7	51A07	.2	.2	15.28	15.44	15.28	15.26	15.27
8	51A08	.5	.4	15.25	15.44	15.25	15.24	15.25
9	51A09	.5	.5	15.13	15.29	15.13	15.12	15.12
10	51A10	.1	.6	15.12	15.30	15.12	15.10	15.11

NOTE: Record lengths from TDR

Calculation of Dielectric Constant

Probe Length 0.203 m

V_p Setting 0.99 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	0.20	0.97	y	0.97	22.8	y	1.78	76.9	y
2	0.19	0.88	y	0.98	23.3	y	1.79	77.8	y
3	0.18	0.79	y	0.98	23.3	y	1.76	75.2	y
4	0.18	0.79	y	0.97	22.8	y	1.77	76.0	y
5	0.20	0.97	y	0.97	22.8	y	1.79	77.8	y
6	0.20	0.97	y	0.98	23.3	y	1.76	75.2	y
7	0.20	0.97	y	0.97	22.8	y	1.76	75.2	y
8	0.19	0.88	y	0.95	21.9	y	1.77	76.0	y
9	0.20	0.97	y	0.97	22.8	y	1.80	78.6	y
10	0.18	0.79	y	0.96	22.4	y	1.75	74.3	y

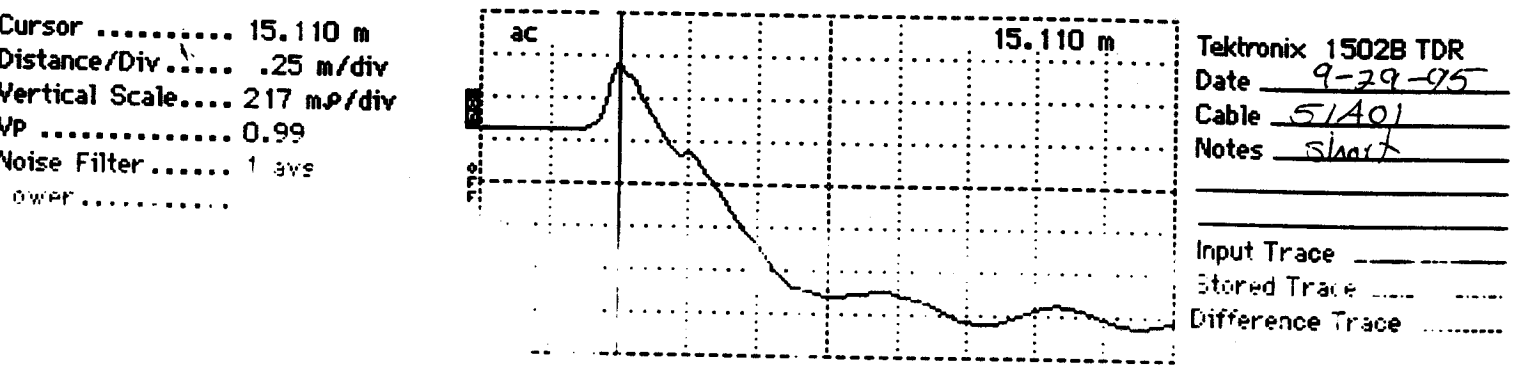
* Note: Some end lengths are incorrect

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A01 **Date (dd/mm/yy):** 29/09/95

Probe Number 01

Trace 1 - Probe Shorted at Start



Trace 2 - Probe Shorted at End

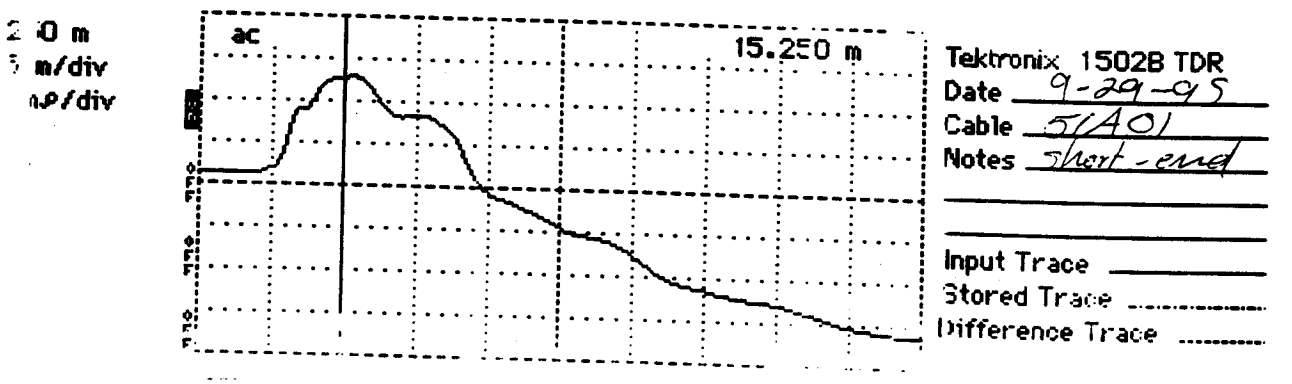


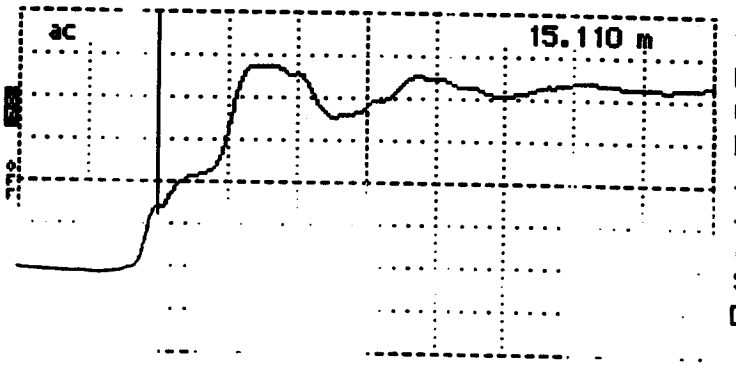
Figure B-1. TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Number 01

Trace 3 - Probe in Air

Cursor ..... 15.110 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

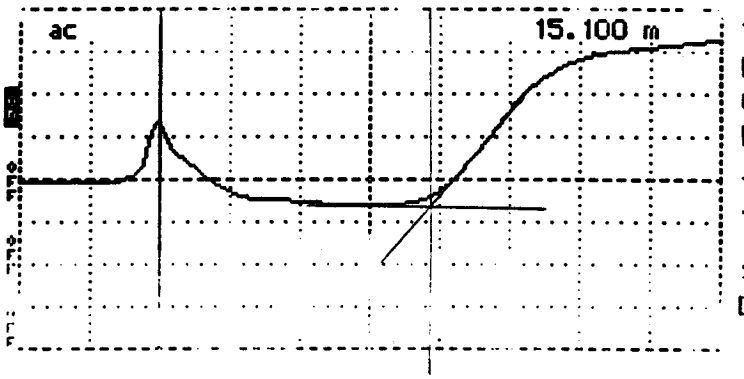


Tektronix 1502B TDR
Date 9-29-95
Cable 5140
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

ursor ..... 15.100 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac

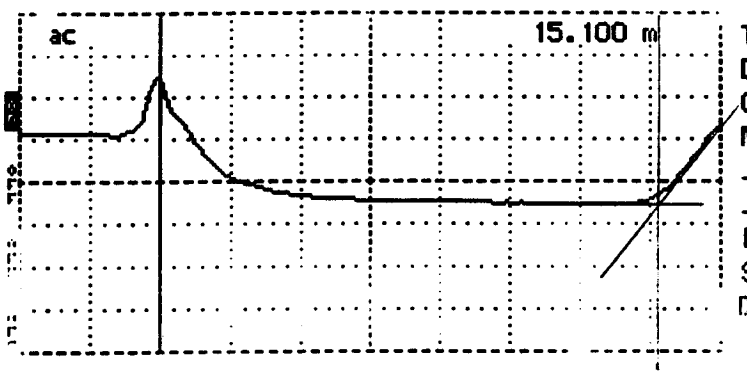


Tektronix 1502B TDR
Date 9-29-95
Cable 5140
Notes alcohol 56.3

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor ..... 15.100 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 5140
Notes water 23.8

Input Trace
Stored Trace
Difference Trace

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

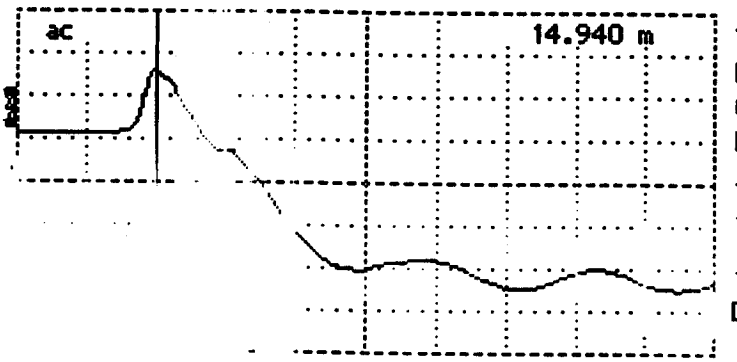
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [ST] LTPP Section ID: [0113]

Probe Serial Number: S1A02 **Date (dd/mm/yy):** 29/09/95

Probe Number 02

Trace 1 - Probe Shorted at Start

. ..... 14.940 m
ce/Div ..... .25 m/div
cal Scale.... 217 mρ/div
. .. . 0.99
.. . avg

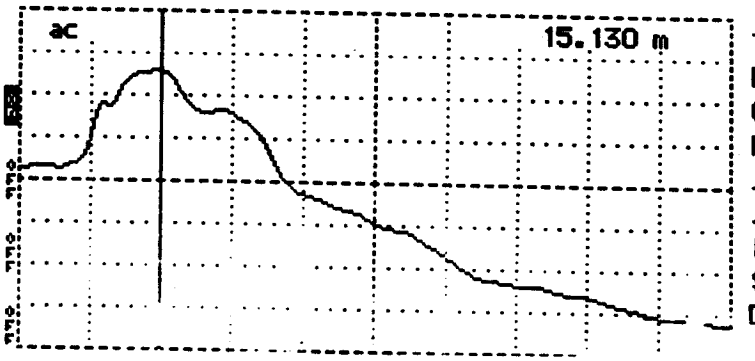


Tektronix 1502B TDR
Date 9-29-95
Cable S1A02
Notes short
- trace not stable

Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

Cursor ..... 15.130 m
Distance/Div..... .25 m/div
Vertical Scale.... 211 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power ..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable S1A02
Notes short - er

Input Trace
Stored Trace
Difference Tr...

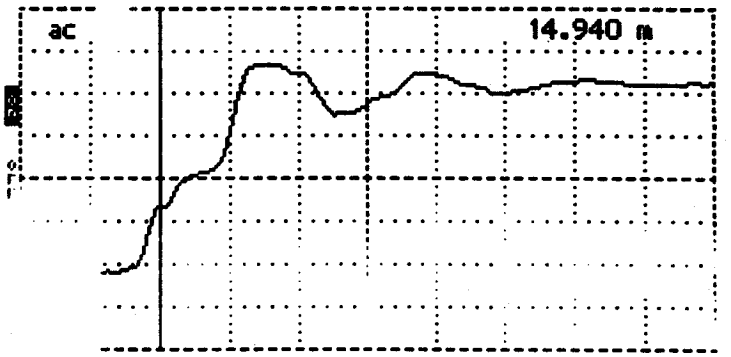
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Number 52

Trace 3 - Probe in Air

ursor ..... 14.940 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac

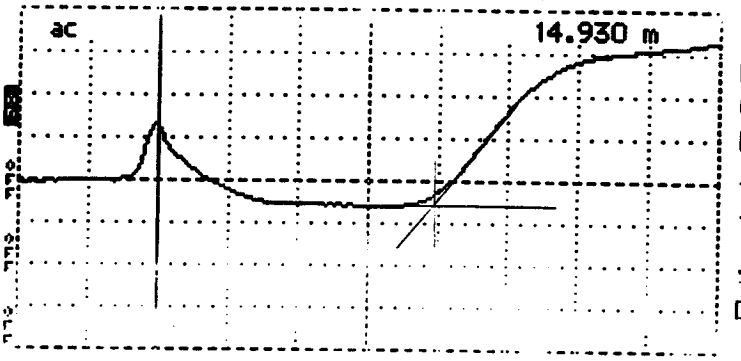


Tektronix 1502B TDR
Date 9-29-95
Cable 51A02
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

ursor ..... 14.930 m
stance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac

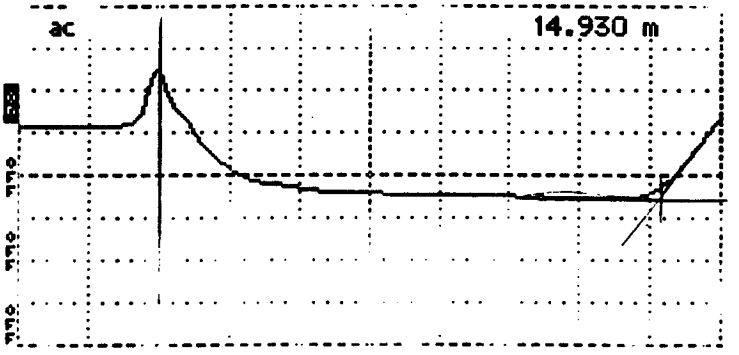


Tektronix 1502B TDR
Date 9-29-95
Cable 51A02
Notes alcohol 58.4

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

ur or ..... 14.930 m
stance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A02
Notes water 23.7

Input Trace
Stored Trace
Difference Trace

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

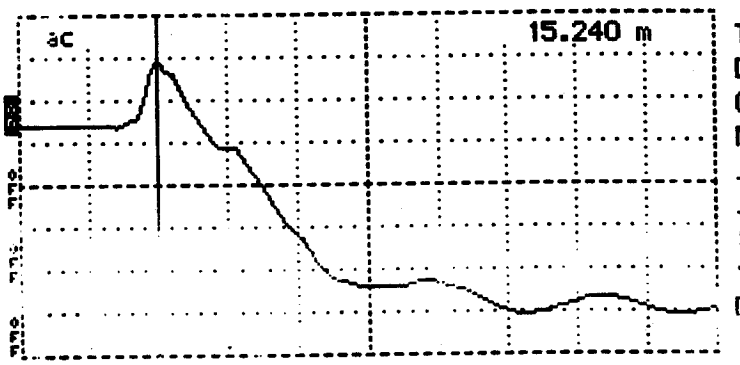
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A03 **Date (dd/mm/yy):** 29/09/95

Probe Number 03

Trace 1 - Probe Shorted at Start

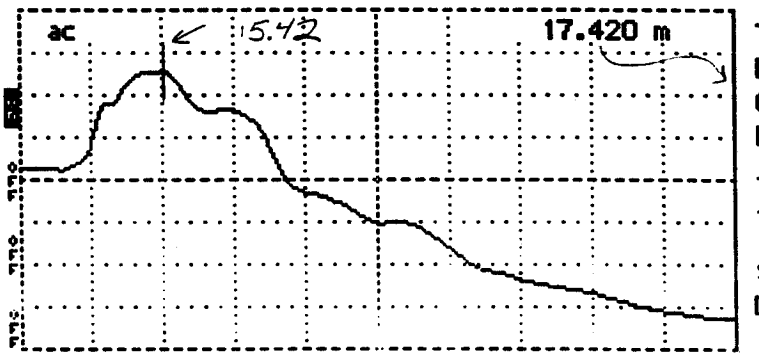
... 15.240 m
...5 m/div
...211 mρ/div
...0.99



Tektronix 1502B TDR
Date 9-29-95
Cable 51A03
Notes short
Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

or ..... 17.420 m
ance/Div..... .25 m/div
ical Scale.... 211 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A03
Notes short-end
Input Trace
Stored Trace
Difference Trace

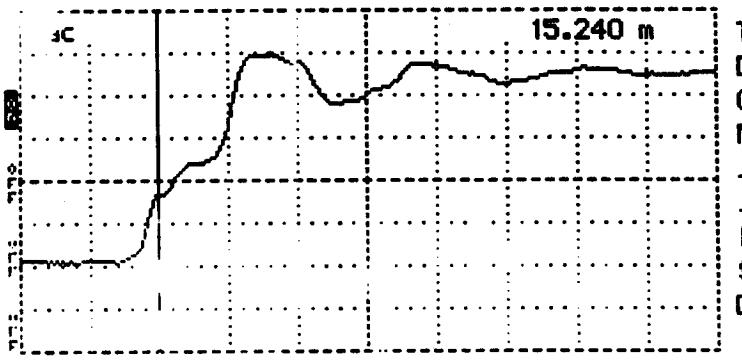
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Number 53

Trace 3 - Probe in Air

Cursor .... 5.240 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

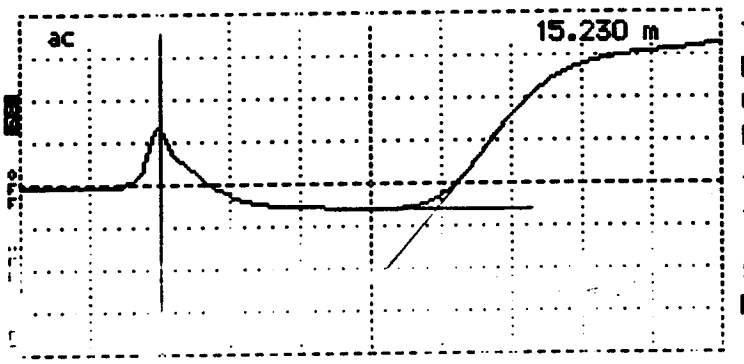


Tektronix 1502B TDR
Date 9-29-95
Cable 51A03
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

rsor ..... 15.230 m
stance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

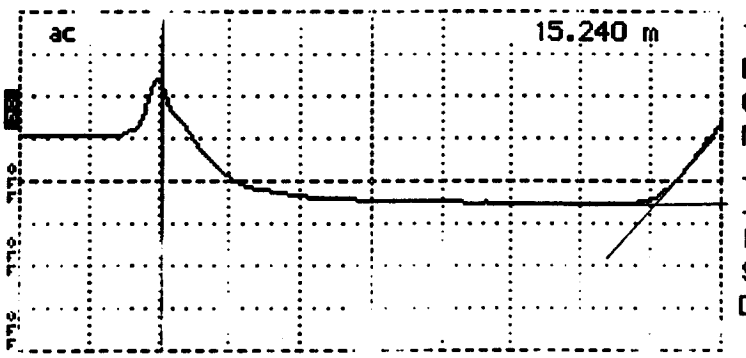


Tektronix 1502B TDR
Date 9-29-95
Cable 51A03
Notes alcohol 26.5

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

ursor ..... 15.240 m
stance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
..... 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A03
Notes water 23.6

Input Trace
Stored Trace
Difference Trace

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

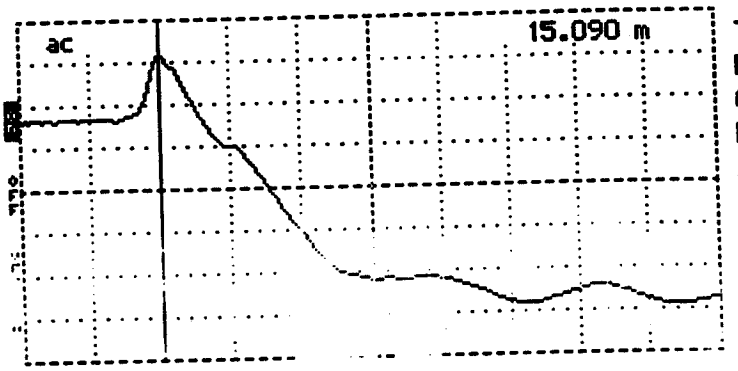
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A04 **Date (dd/mm/yy):** 29/09/95

Probe Number 04

Trace 1 - Probe Shorted at Start

or ..... 15.090 m
ance/Div..... .25 m/div
ical Scale.... 217 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac

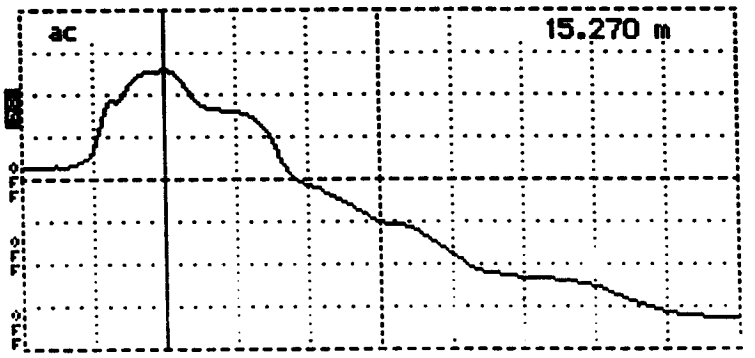


Tektronix 1502B TDR
Date 9-29-95
Cable 51A04
Notes Short

Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

rsor ..... 15.270 m
rtance/Div..... .25 m/div
rtical Scale.... 211 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A04
Notes short-end

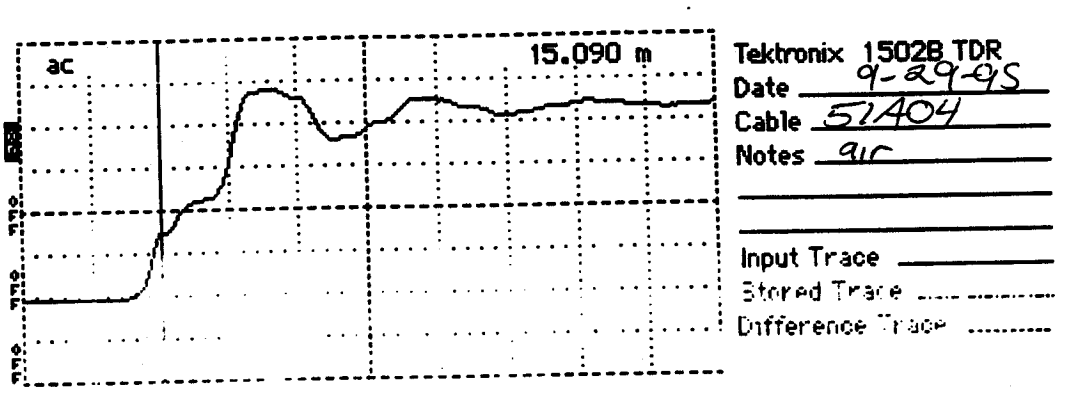
Input Trace
Stored Trace
Difference Trace

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

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

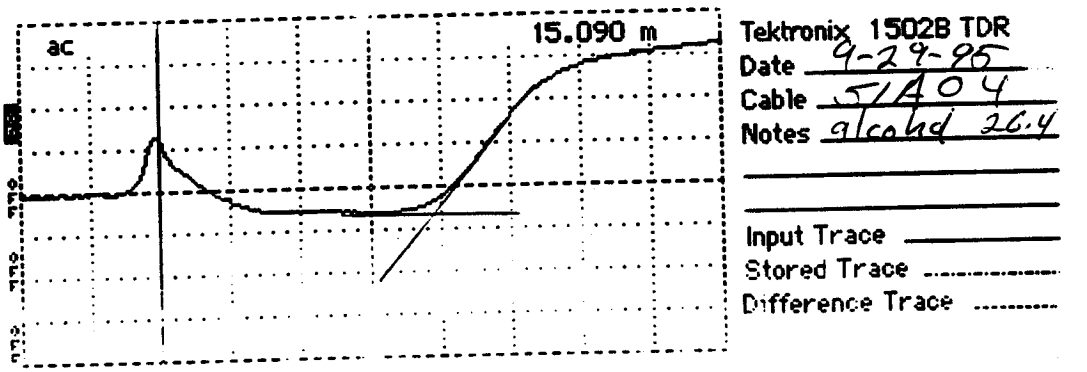
Probe Number 04

Trace 3 - Probe in Air



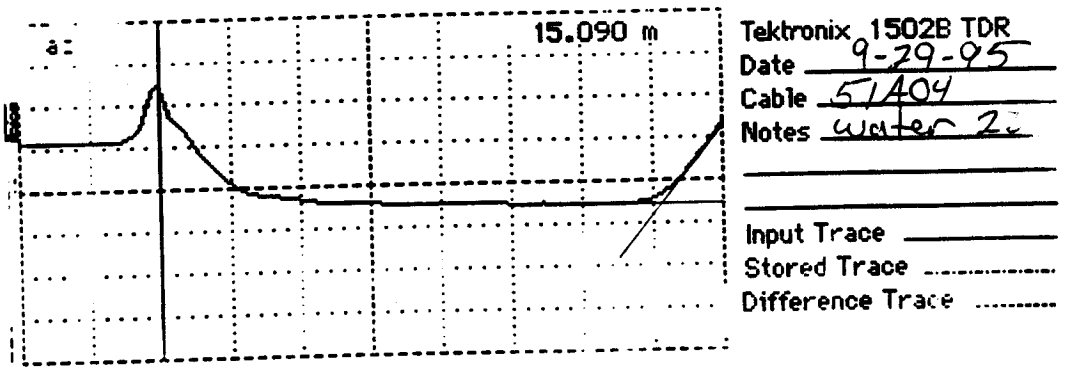
ursor ..... 15.090 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac

Trace 4 - Probe in Alcohol



rsor ..... 15.090 m
stance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

Trace 5 - Probe in Water



Cursor ..... 15.090 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

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

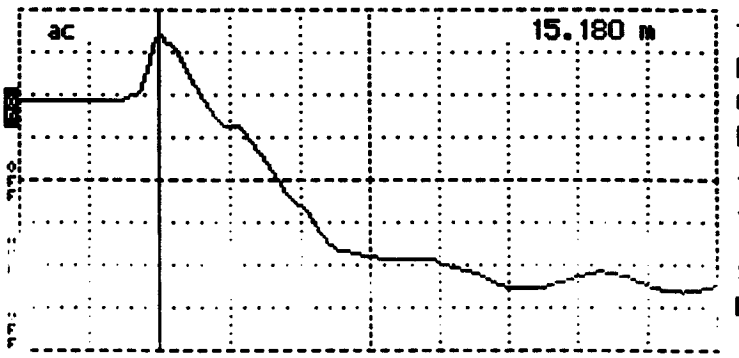
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A05 **Date (dd/mm/yy):** 29/09/95

Probe Number 05

Trace 1 - Probe Shorted at Start

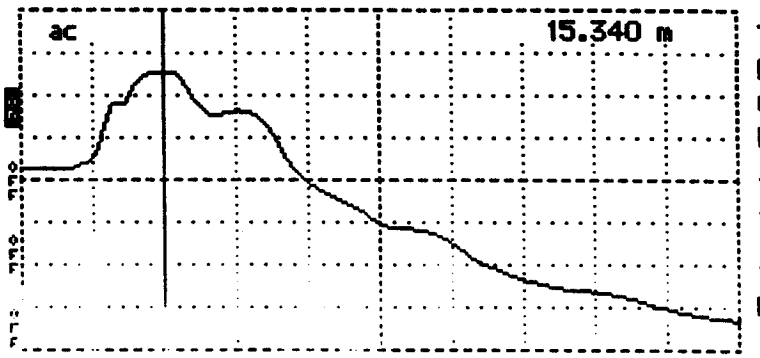
ursor ..... 15.180 m
istance/Div .... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
loise Filter..... 1 avg
ower..... .... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A05
Notes Short
Input Trace
Stor Trace
Diff n e Trace

Trace 2 - Probe Shorted at End

rsor ..... 15.340 m
stance/Div..... .25 m/div
rtical Scale.... 211 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A05
Notes short end
Input Trace
Stored Trace
Difference Trace

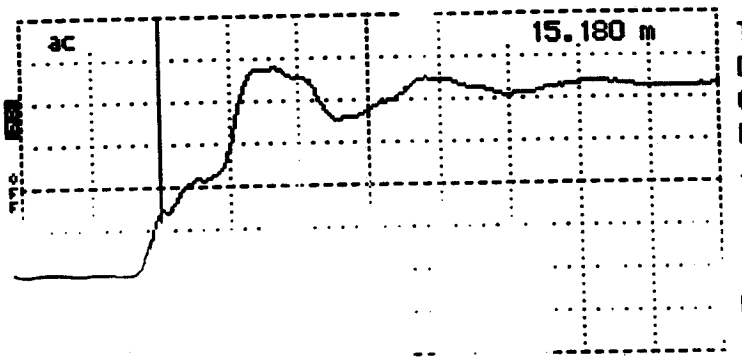
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Number 05

Trace 3 - Probe in Air

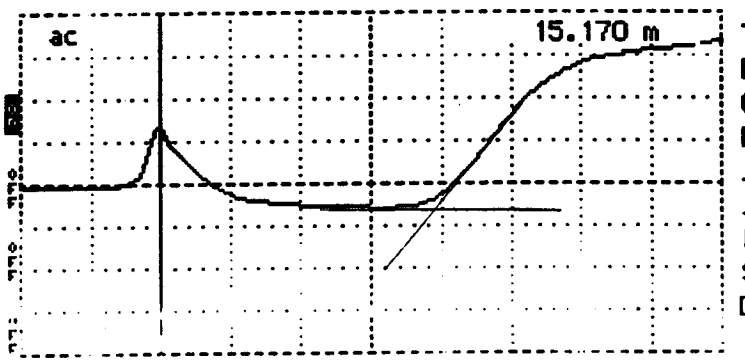
Cursor ..... 15.180 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter ..... 1 avg
Power.. .... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A05
Notes air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

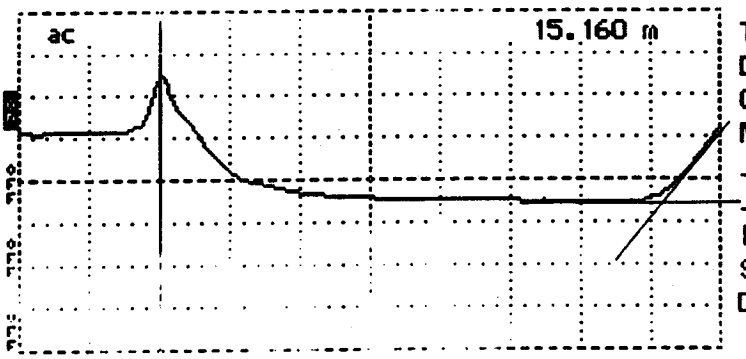
Cursor ..... 15.170 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A05
Notes alcohol 26.
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

sor ..... 15.160 m
ance/Div..... .25 m/div
tical Scale.... 217 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A05
Notes water
Input Trace
Stored Trace
Difference Trace

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

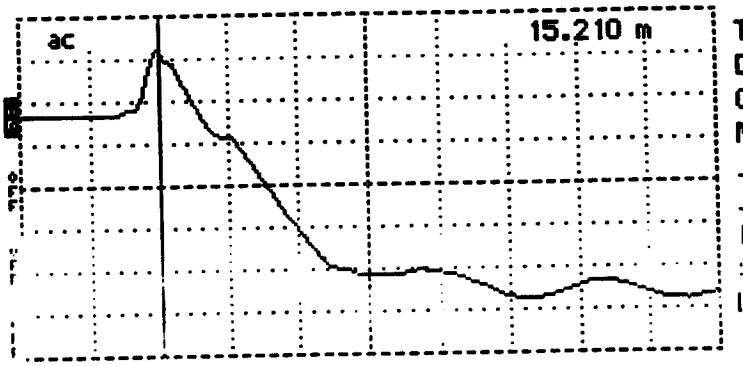
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A06 **Date (dd/mm/yy):** 29/09/95

Probe Number 06

Trace 1 - Probe Shorted at Start

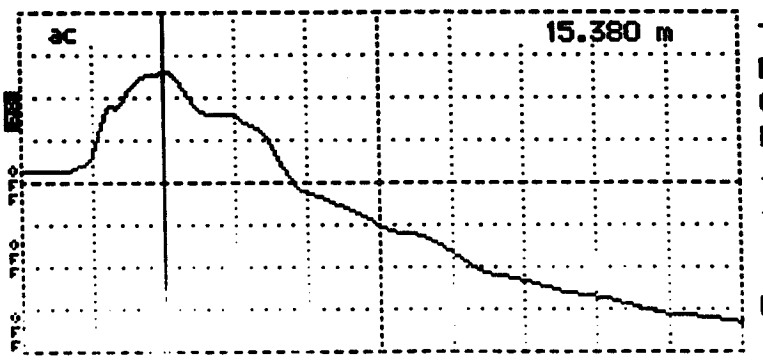
sor ..... 15.210 m
ance/Div.... .25 m/div
tical Scale.... 217 mρ/div
..... 0.99
se Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A06
Notes Short
Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

sor ..... 15.380 m
tance/Div..... .25 m/div
tical Scale.... 211 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A06
Notes Short end
Input Trace
Stored Trace
Difference Trace

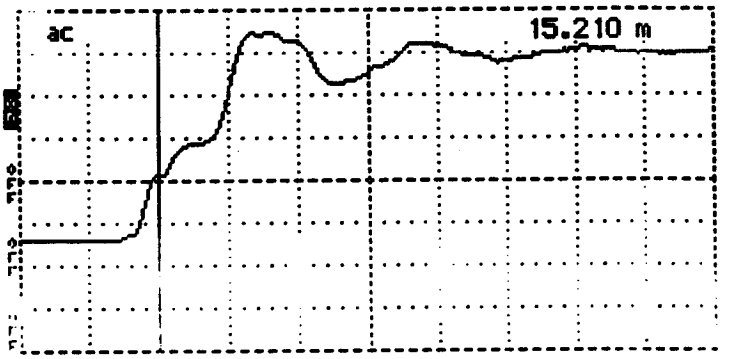
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [SL] LTPP Section ID: [0113]

Probe Number 6

Trace 3 - Probe in Air

rsor ..... 15.210 m
tance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac

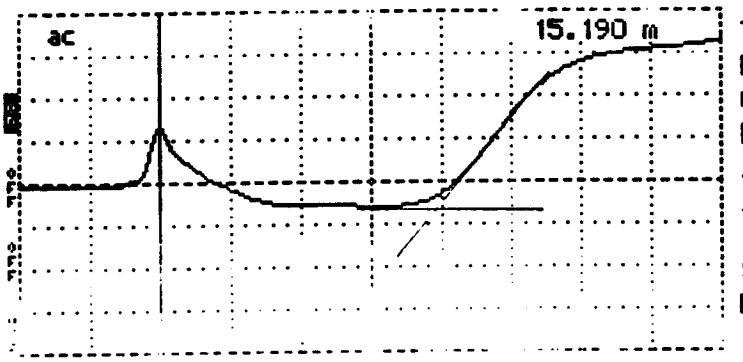


Tektronix 1502B TDR
Date 9-29-95
Cable 51A06
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

ursor ..... 15.190 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac

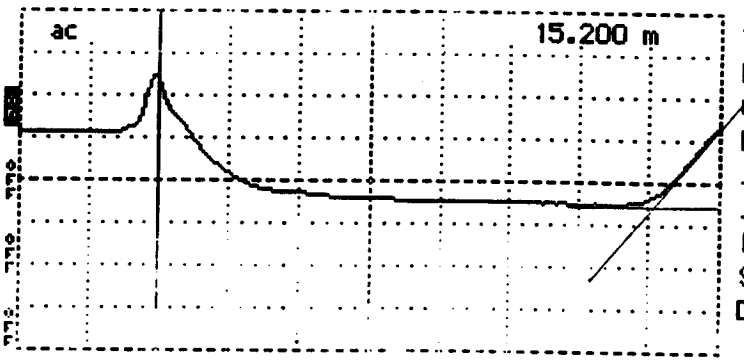


Tektronix 1502B TDR
Date 9-29-95
Cable 51A06
Notes alcohol 26.5

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

ur.. ..... 15.200 m
stan.e/Div..... .25 m/div
ertical Scale.... 217 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A06
Notes water 24.0°

Input Trace
Stored Trace
Difference Trace

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

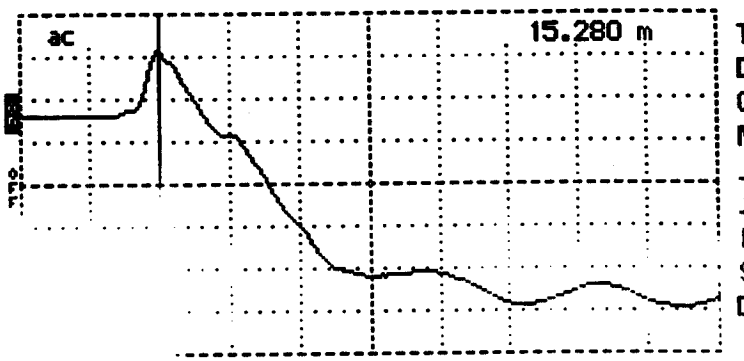
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A07 **Date (dd/mm/yy):** 29/09/95

Probe Number 07

Trace 1 - Probe Shorted at Start

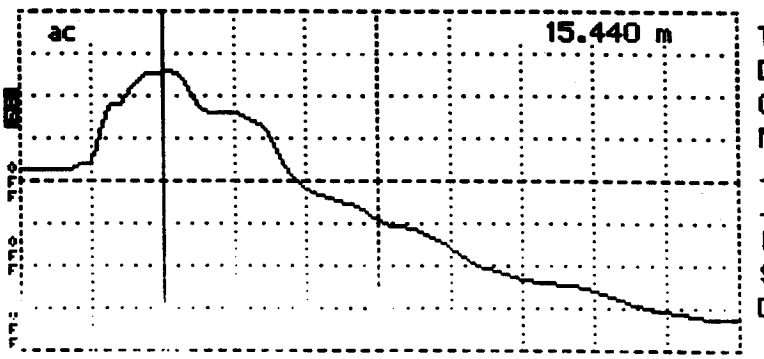
rsor ..... 15.280 m
tance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix
Date 9
Cable 5
Notes 4
Input Trac
Stor d Tr
Diffe ence

Trace 2 - Probe Shorted at End

rsor ..... 15.440 m
tance/Div..... .25 m/div
rtical Scale.... 211 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A07
Notes short end
Input Trace
Stored Trace
Difference Trace

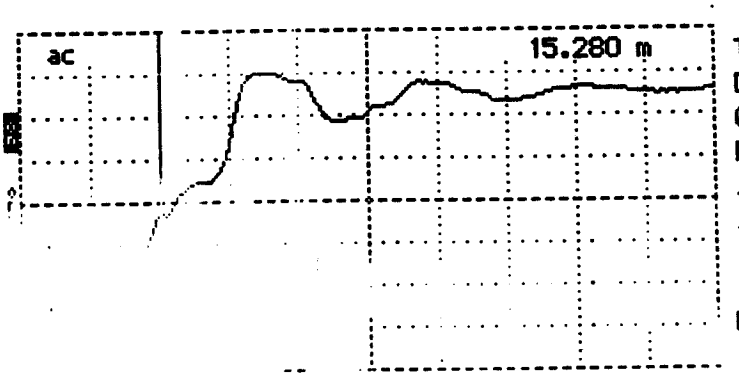
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [21] LTPP Section ID: [0113]

Probe Number 07

Trace 3 - Probe in Air

ursor ..... 15.280 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
P 0.99
oise Filter..... 1 avg
ower..... ac

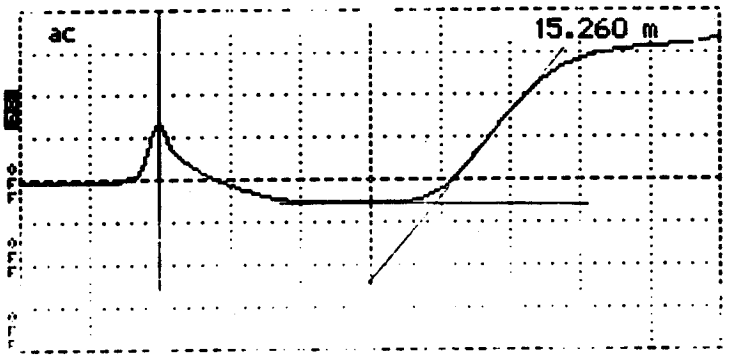


Tektronix 1502B TDR
Date 9-29-95
Cable 51A07
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor ..... 15.260 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac

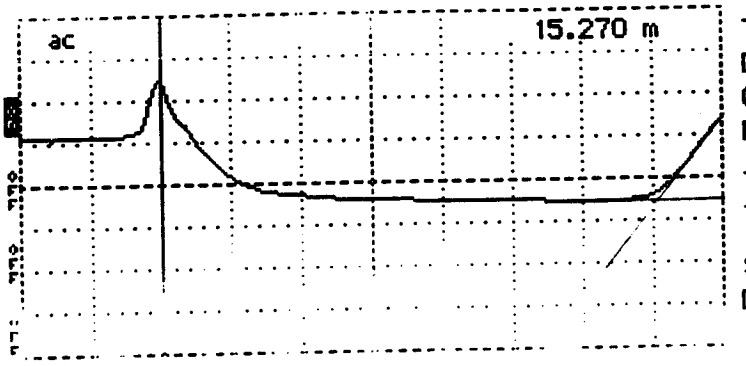


Tektronix 1502B TDR
Date 9-29-95
Cable 51A07
Notes alcohol 26.4

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

ırsor ..... 15.270 m
stance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A07
Notes water 24.0°

Input Trace
Stored Trace
Difference Trace

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

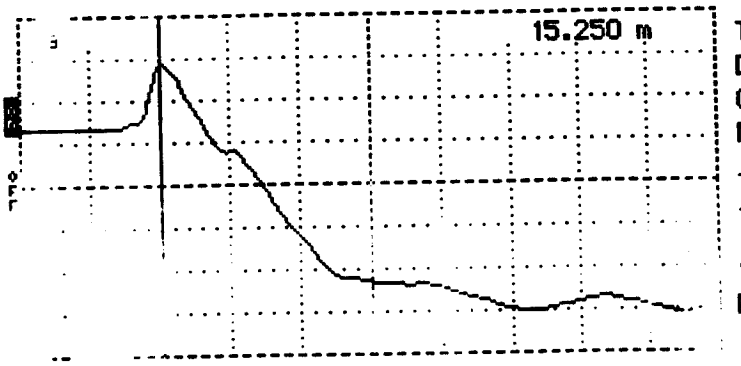
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [52] LTPP Section ID: [0113]

Probe Serial Number: 51A08 **Date (dd/mm/yy):** 29/09/95

Probe Number 08

Trace 1 - Probe Shorted at Start

. .... 5.250 m
tance/Div. ... .25 m/div
tical Scale.... 217 mρ/div
.... 0.99
se Filter. avg
ver.....

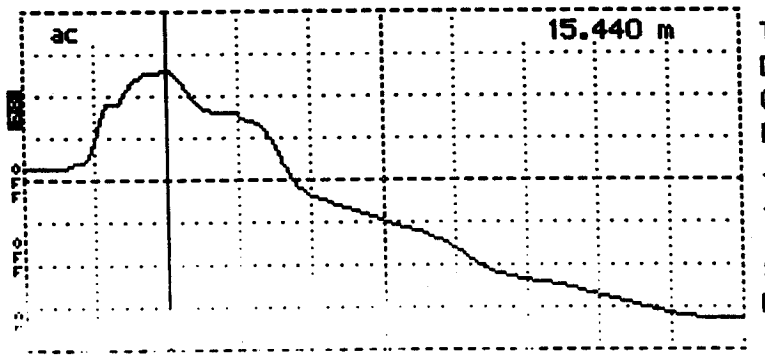


Tektronix 1502B TDR
Date 9-29-95
Cable 51A08
Notes short

Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

or ..... 15.440 m
ance/Div..... .25 m/div
ical Scale.... 211 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A08
Notes short end

Input Trace
Stored Trace
Difference Trace

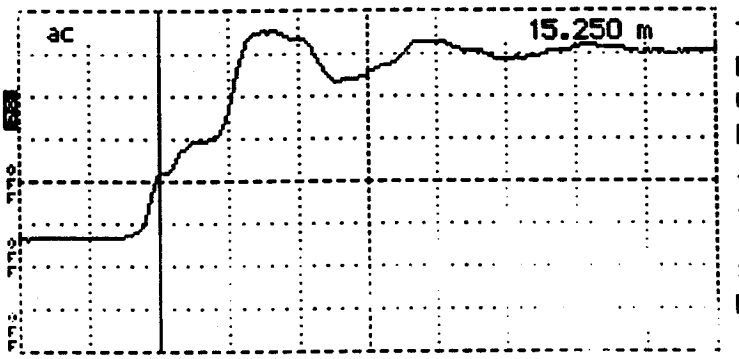
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Number 08

Trace 3 - Probe in Air

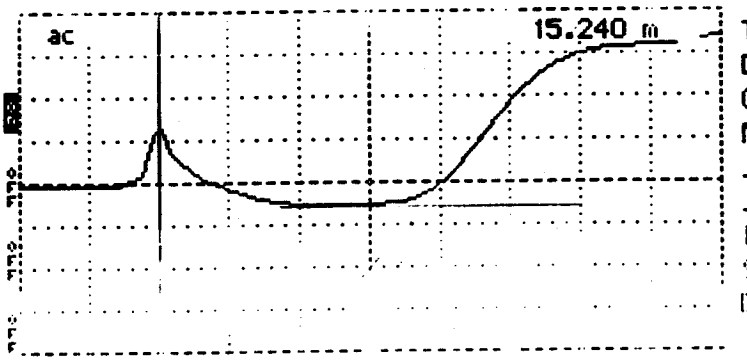
or ..... 15.250 m
nce/Div..... .25 m/div
cal Scale... 217 mρ/div
..... 0.99
Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A08
Notes air
Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

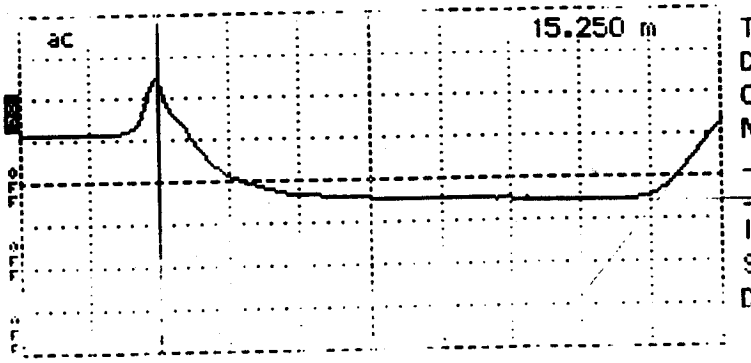
sor ..... 15.240 m
ance/Div..... .25 m/div
tical Scale.... 217 mρ/div
..... 0.99
se Filter..... 1 avg
ver..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A08
Notes alcohol 26.5
Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

rsor ..... 15.250 m
stance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A08
Notes water 24.1°
Input Trace
Stored Trace
Difference Trace

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

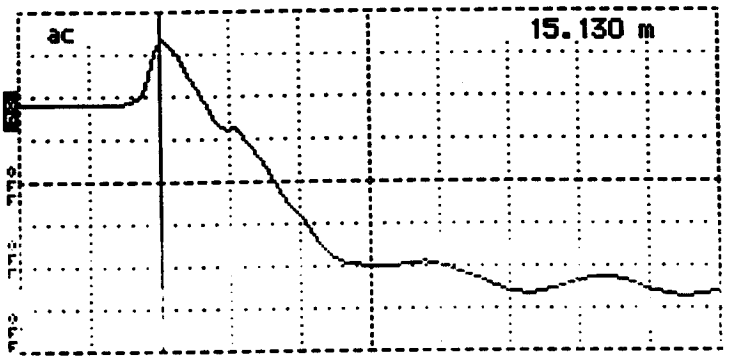
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51A09 **Date (dd/mm/yy):** 29/09/95

Probe Number 51

Trace 1 - Probe Shorted at Start

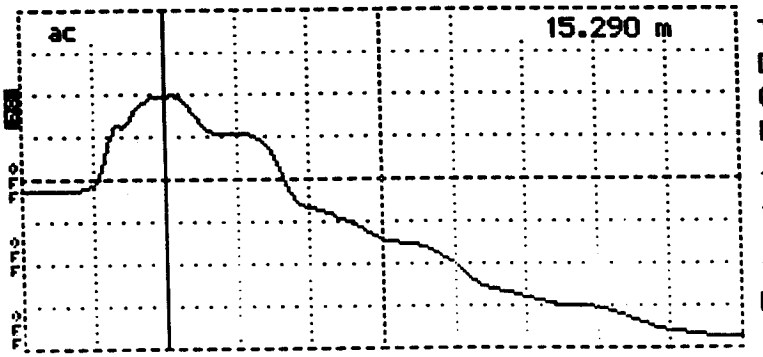
or ..... 15.1 0 m
nce/Div..... .25 m/div
ical Scale.... 217 mρ/div
..... 0.99
Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A09
Notes short
Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

or ..... 15.290 m
ance/Div..... .25 m/div
ical Scale.... 217 mρ/div
..... 0.99
e Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A09
Notes short end
Input Trace
Stored Trace
Difference Trace

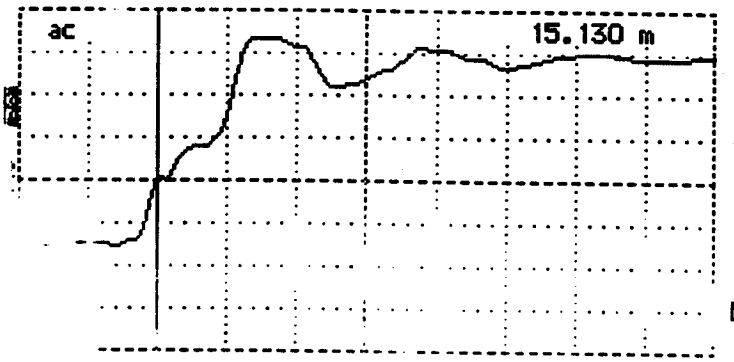
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0 1 3]

Probe Number 91

Trace 3 - Probe in Air

ursor 5. 30
istance/Div..... .25 m/
ertical Scale.... 217 m
P 0.99
ise Filter..... 1 avg
...

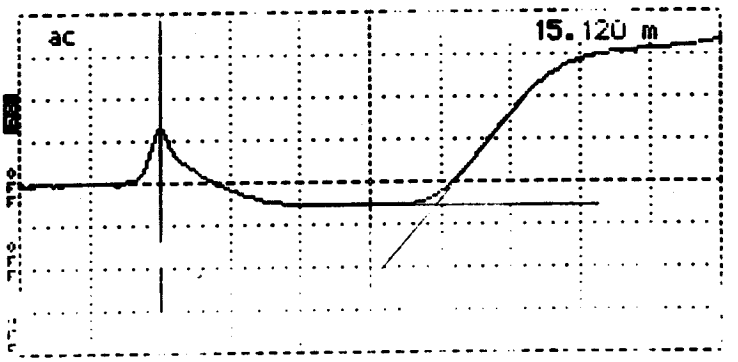


Tektronix 1502B TDR
Date 9-29-95
Cable 51A09
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

rsor ..... 15.120 m
stance/Div..... .25 m/div
rtical Scale.... 217 m/div
..... 0.99
ise Filter..... 1 avg
wer..... ac

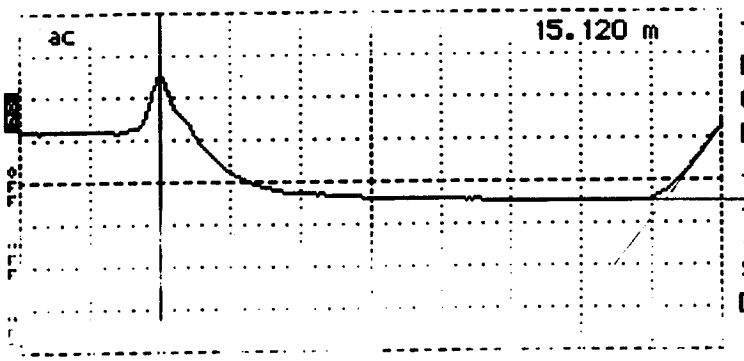


Tektronix 1502B TDR
Date 9-29-95
Cable 51A09
Notes alcohol 26.5

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

sor ..... 15.120 m
ance/Div..... .25 m/div
tical Scale.... 217 m/div
..... 0.99
se Filter..... 1 avg
er..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A09
Notes water 24.3

Input Trace
Stored Trace
Difference Trace

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

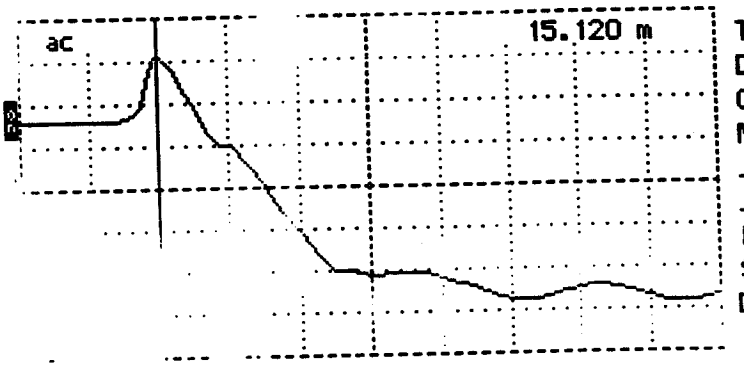
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Serial Number: 51810 **Date (dd/mm/yy):** 29/09/95

Probe Number 10

Trace 1 - Probe Shorted at Start

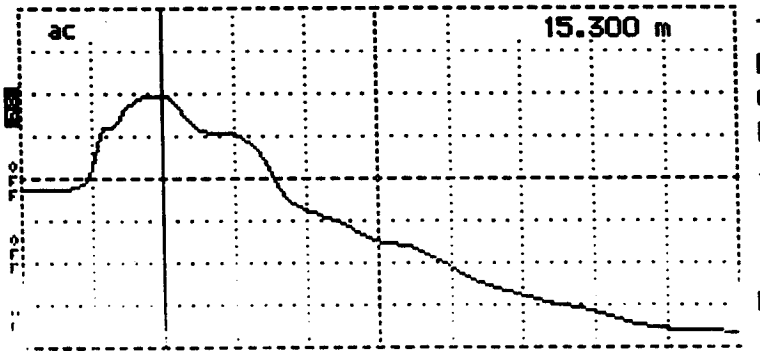
Cursor ..... 15.120 m
Distance/Div..... .25 m/div
Vertical Scale.... 217 mρ/div
VP 0.99
Noise Filter..... 1 avg
Power .....



Tektronix 1502B TDR
Date 9-29-95
Cable 51A10
Notes short
Input Trace
Stored Trace
Difference Trace

Trace 2 - Probe Shorted at End

rsor ..... 15.300 m
stance/Div..... .25 m/div
rtical Scale.... 217 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A10
Notes short end
Input Trace
Stored Trace
Difference Trace

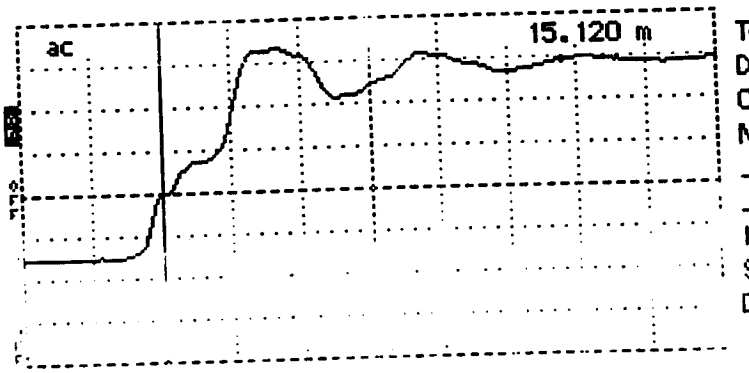
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [51] LTPP Section ID: [0113]

Probe Number 10

Trace 3 - Probe in Air

r .. .. 15.120 m
ance/Div..... .25 m/div
ical Scale... 217 mρ/div
..... 0.99
e Filter..... 1 avg
er... ..... ac

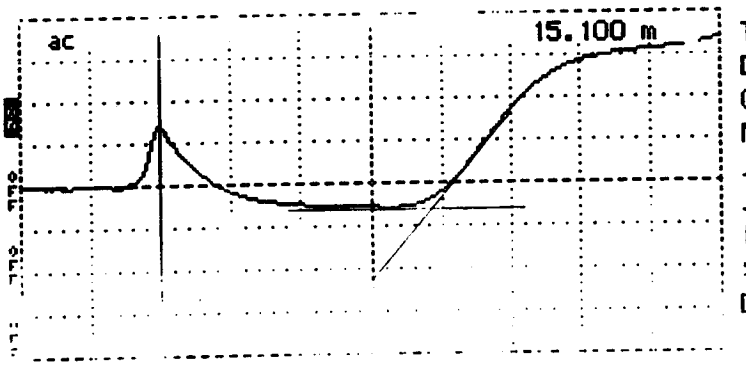


Tektronix 1502B TDR
Date 9-29-95
Cable 51A10
Notes air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

ursor ..... 15.100 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac

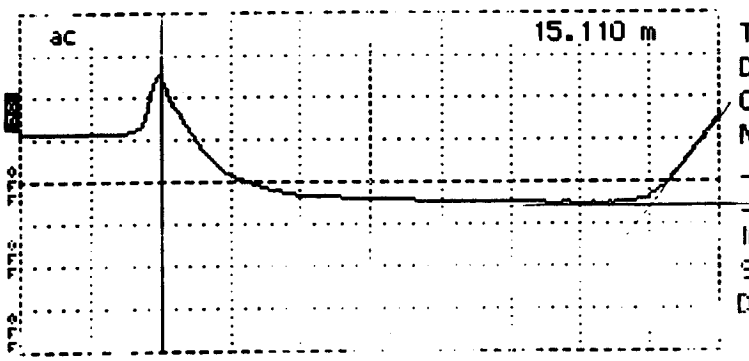


Tektronix 1502B TDR
Date 9-29-95
Cable 51A10
Notes alcohol 26.5

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

ursor ..... 15.110 m
istance/Div..... .25 m/div
ertical Scale.... 217 mρ/div
ρ 0.99
oise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date 9-29-95
Cable 51A10
Notes water 23.4

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:

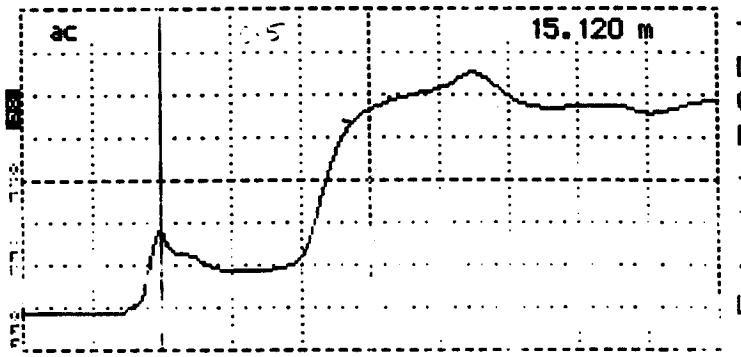
Figure C-1 TDR Traces Measured Manually During Installation

Table C-1 TDR Moisture Content

Table C-2 Field Measured Moisture Content

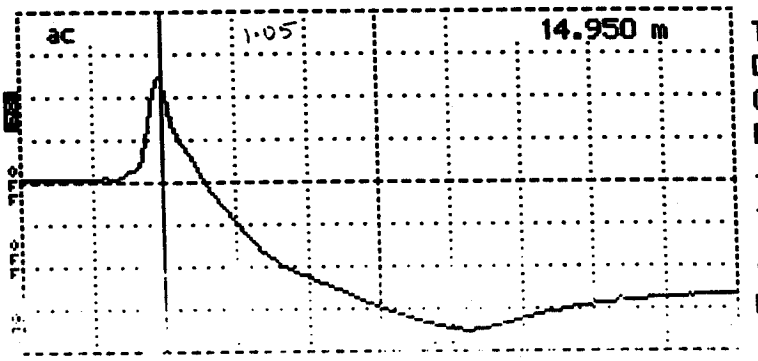
Table C-3 Field Measured Dry Density

Cursor ..... 15.120 m
Distance/Div..... .25 m/div
Vertical Scale.... 163 mΩ/div
VP 0.99
Noise Filter..... 1 avg
Power..... ac



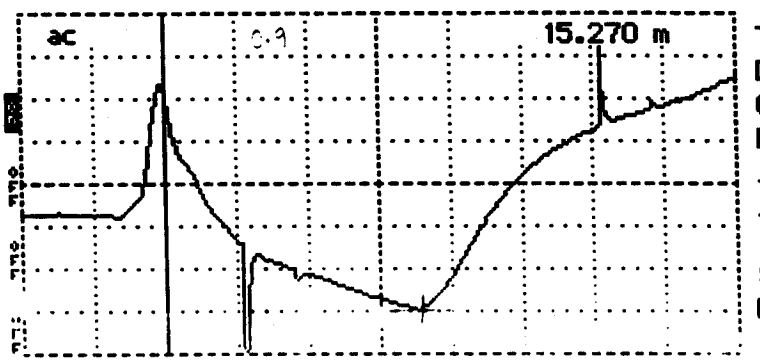
Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #1 After Conv
Notes 510113
Input Trace
Stored Trace
Difference Trace

rsor ..... 14.950 m
stance/Div..... .25 m/div
rtical Scale.... 126 mΩ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



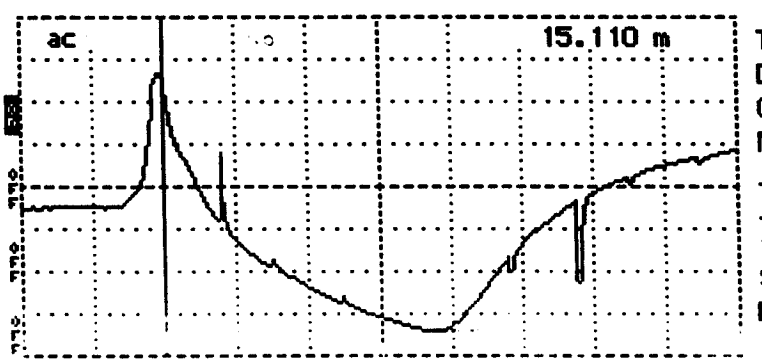
Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #2 After Conv
Notes 510113
Input Trace
Stored Trace
Difference Trace

ursor ..... 15.270 m
stance/Div..... .25 m/div
rtical Scale.... 96.9 mΩ/div
..... 0.99
oise Filter..... 1 avg
ower..... ac



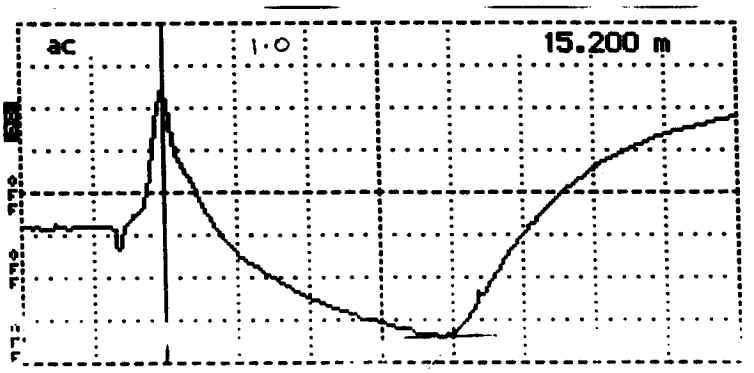
Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #3 After Conv
Notes 510113
Input Trace
Stored Trace
Difference Trace

rsor ..... 15.110 m
stance/Div..... .25 m/div
rtical Scale.... 96.9 mΩ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #4 After Conv
Notes 510113
Input Trace
Stored Trace
Difference Trace

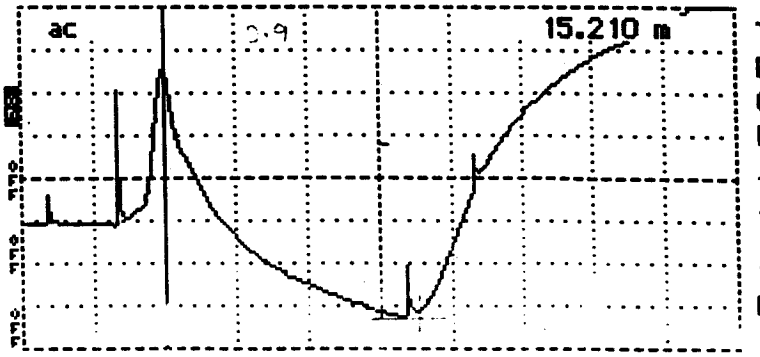
ursor ..... 15.200 m
istance/Div..... .25 m/div
ertical Scale.... 96.9 mΩ/div
P 0.99
loise Filter..... 1 avg
ower..... ac



Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #5 After Conv
Notes 510113
Input Trace
Stored Trace
Difference Trace

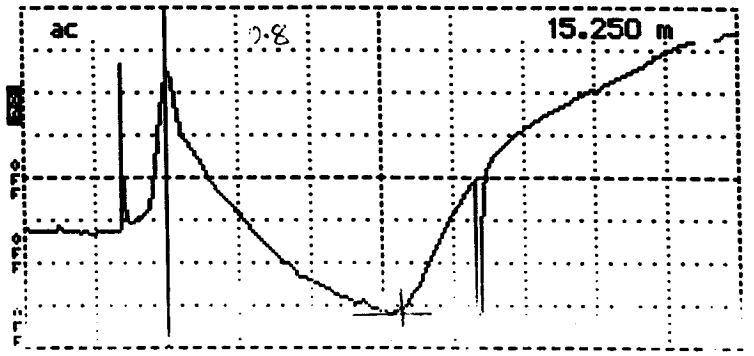
Figure C-1. TDR Traces Measured Manually During Installation

sor ..... 15.210 m
tance/Div..... .25 m/div
rtical Scale.... 81.6 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



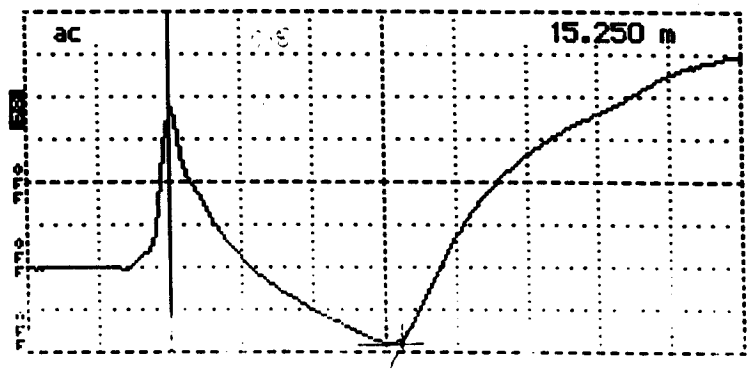
Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #6 after Comp
Notes 510113
Input Trace
Stored Trace
Difference Trace

rsor ..... 15.250 m
tance/Div..... .25 m/div
rtical Scale.... 81.6 mρ/div
..... 0.99
se Filter..... 1 avg
wer..... ac



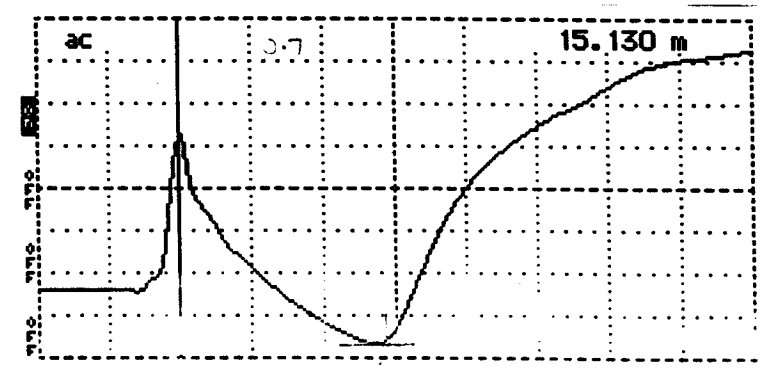
Tektronix 1502B TDR
Date Oct. 24, 1995
Cable #7 after Comp
Notes 510113
Input Trace
Stored Trace
Difference Trace

rsor ..... 15.250 m
stance/Div..... .25 m/div
rtical Scale.... 81.6 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



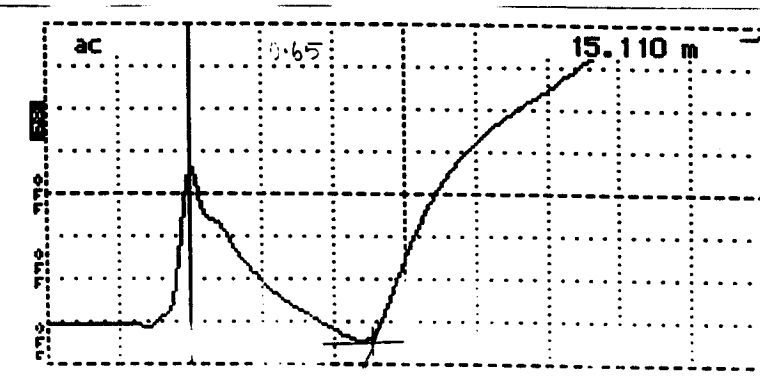
Tektronix 1502B TDR
Date Oct. 24, 95
Cable #8 after Comp.
Notes 510113
Input Trace
Stored Trace
Difference Trace

rsor ..... 15.130 m
stance/Div..... .25 m/div
rtical Scale.... 81.6 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date Oct. 24, 95
Cable #9 after Comp
Notes 510113
Input Trace
Stored Trace
Difference Trace

rsor ..... 15.110 m
stance/Div..... .25 m/div
rtical Scale.... 81.6 mρ/div
..... 0.99
ise Filter..... 1 avg
wer..... ac



Tektronix 1502B TDR
Date Oct. 24, 95
Cable #10 after Co
Notes 510113
Input Trace
Stored Trace
Difference Trace

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

Table C-1. TDR Moisture Content

TDR No.	Depth (m)	TDR Length (m)	Dielectric Constant (ε)	Volumetric Moisture Content (%)	In-Situ Dry Density (kg/m³)	Gravimetric Moisture Content (%)
51A01	0.180	0.50	6.07	10.55	1360	7.76
51A02	0.360	1.05	26.75	41.95	1360	30.85
51A03	0.530	0.90	19.66	34.31	1360	25.23
51A04	0.660	1.00	24.27	39.56	1360	29.09
51A05	0.810	1.00	24.27	39.56	1360	29.09
51A06	0.970	0.90	19.66	34.31	1360	25.23
51A07	1.120	0.80	15.53	28.55	1360	20.99
51A08	1.300	0.80	15.53	28.55	1360	20.99
51A09	1.590	0.70	11.89	22.49	1360	16.54
51A10	1.890	0.65	10.25	19.42	1360	14.28

Table C-2. Field Measured Moisture Content

LTPP Seasonal Monitoring Study	State Code	[51]
In-Situ Moisture Tests	Test Section Number	[0113]

Weight (gm)	Probe 1	Probe 2	Probe 3	Probe 4*	Probe 5*
Weight of Pan + Wet Soil	476.3	308.4	281.2		
Weight of Pan + Dry Soil	462.7	272.2	240.4		
Weight of Pan	127.0	127.0	127.0		
Weight of Dry Soil	335.7	145.2	113.4		
Weight of Wet Soil	349.3	181.4	154.2		
Weight of Moisture	13.6	36.3	40.8		
Wt of Moisture/Dry Wt x 100	4.1	25.0	36.0		

Weight (gm)	Probe 6	Probe 7	Probe 8	Probe 9	Probe 10
Weight of Pan + Wet Soil	326.6	303.9	440.0	335.7	467.2
Weight of Pan + Dry Soil	267.6	276.7	390.1	308.4	421.8
Weight of Pan	127.0	127.0	127.0	127.0	127.0
Weight of Dry Soil	140.6	149.7	263.1	181.4	294.8
Weight of Wet Soil	199.6	176.9	313.0	208.7	340.2
Weight of Moisture	59.0	27.2	49.9	27.2	45.4
Wt of Moisture/Dry Wt x 100	41.9	18.2	19.0	15.0	15.4

Prepared by:	N.B.W.	Employer:	VDOT
Date (dd/mm/yy):	24/10/95		

* Note: No samples were taken for TDR's #4 and #5.

Table C-3. Field Measured Dry Density

LTPP Seasonal Monitoring Program Data Sheet SMP-I07 Representative Dry Density	Agency Code [51] LTPP Section ID [0113]

Depth of Representative Sample (from pavement surface): 1.00 m

Dry Density Determination:

a.	Tare Weight of Empty Mold:	2014 g	(4.44 lb)
b.	Weight of Mold and Compacted Soil:	3692 g	(8.14 lb)
c.	Weight of Compacted Soil (b-a):	1678 g	(3.70 lb)
d.	Unit Weight of Compacted Soil = (c/943.0) =		1.78 g/cm^3
	= [c/(1/30)] =		(111.0 lb/ft^3)
e.	Dry Density of Compacted Soil = [d/(1+r/100)] =		1.36 g/cm^3
			(79.9 lb/ft^3)

Moisture Content Determination:

m	Tare Weight of Pan:	g
n.	Weight of Pan and Moisture Sample:	g
o.	Weight of Pan and Dry Sample:	g
p.	Weight of Moisture (n -o):	g
q.	Weight of Dry Sample (o - m):	g
r.	Moisture Content by Weight = [(p/q)*100] =	30.9 %

Prepared by:	N.B.W.	Employer:	VDOT
Date (dd/mm/yy):	24/10/95		

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

Table D-1. Sample Data from the Onsite Datalogger During Initial Data Collection, October 26, 1995

5,1995,299,100,12.53,4.417,0
6,1995,299,100,13.62,15.6,17.53,20.96,22.34
5,1995,299,200,12.52,4.11,0
6,1995,299,200,12.89,14.8,16.66,20.08,21.6
5,1995,299,300,12.52,3.6,0
6,1995,299,300,12.28,14.1,15.88,19.28,20.91
5,1995,299,400,12.52,3.318,0
6,1995,299,400,11.74,13.49,15.21,18.57,20.27
5,1995,299,500,12.52,4.174,0
6,1995,299,500,11.39,13.01,14.63,17.92,19.67
5,1995,299,600,12.52,4.011,0
6,1995,299,600,11.14,12.67,14.19,17.35,19.12
5,1995,299,700,12.52,3.667,0
6,1995,299,700,10.89,12.34,13.79,16.85,18.63
5,1995,299,800,12.52,4.465,0
6,1995,299,800,11.3,12.37,13.57,16.42,18.17
5,1995,299,900,12.48,7.03,8.1
6,1995,299,900,12.77,13.31,14,16.18,17.79
5,1995,299,1000,12.5,9.07,1.9
6,1995,299,1000,14.57,14.62,14.89,16.27,17.57
5,1995,299,1100,12.52,11.12,0
6,1995,299,1100,17.25,16.68,16.37,16.71,17.55
5,1995,299,1200,12.53,11.59,0
6,1995,299,1200,18.77,18.04,17.51,17.21,17.68
5,1995,299,1300,12.53,13.1,0
6,1995,299,1300,22.33,20.48,19.24,17.97,18
5,1995,299,1400,12.54,15.14,0
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Section 510113

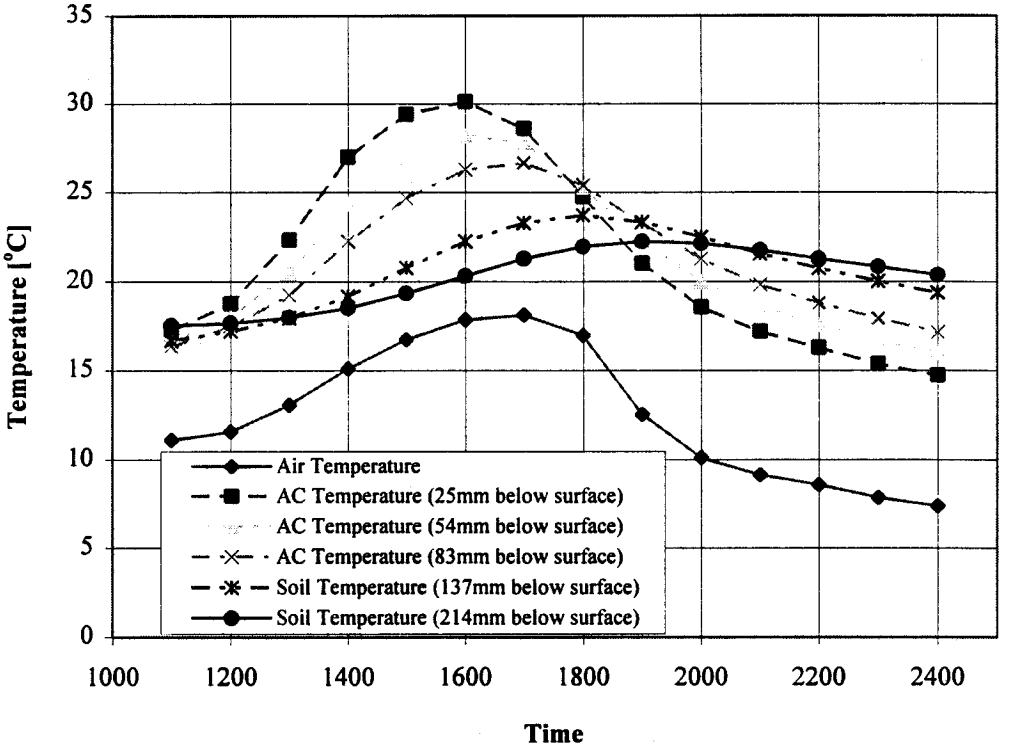

Figure D-1. Air Temperature and First Five Sub-Surface Temperatures From Initial Data Collection, October 26, 1995

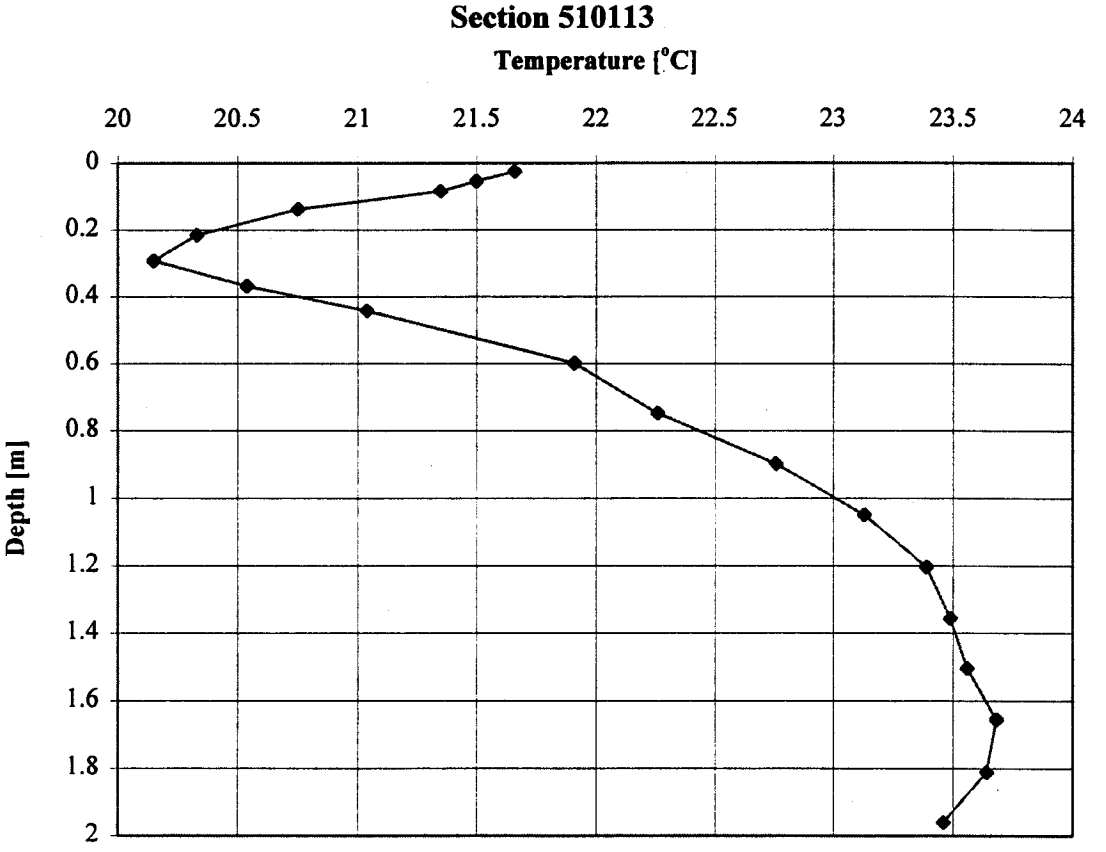

Figure D-2. Average Subsurface Temperature for all 18 Sensors
From Initial Data Collection, October 26, 1995

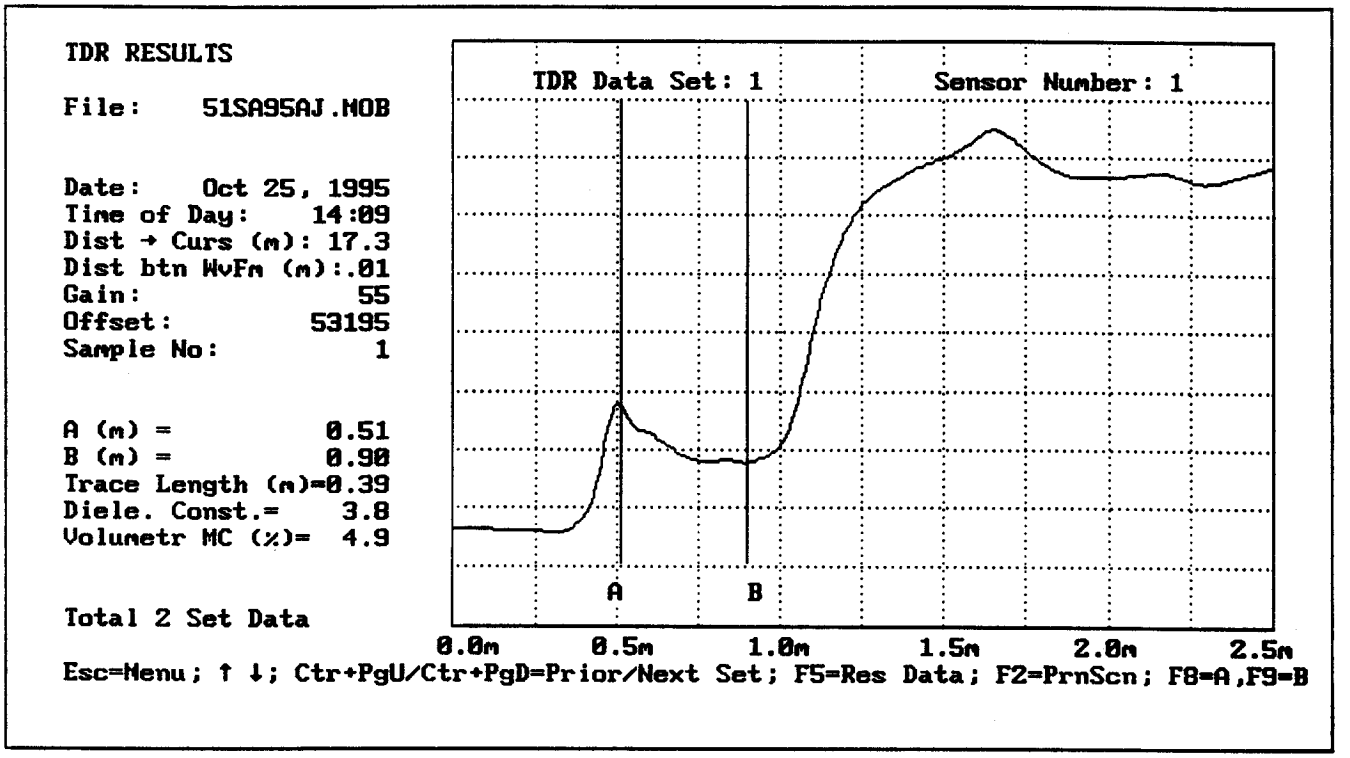

Figure D-3. Initial First Set of TDR Traces Measured with the Mobile Unit

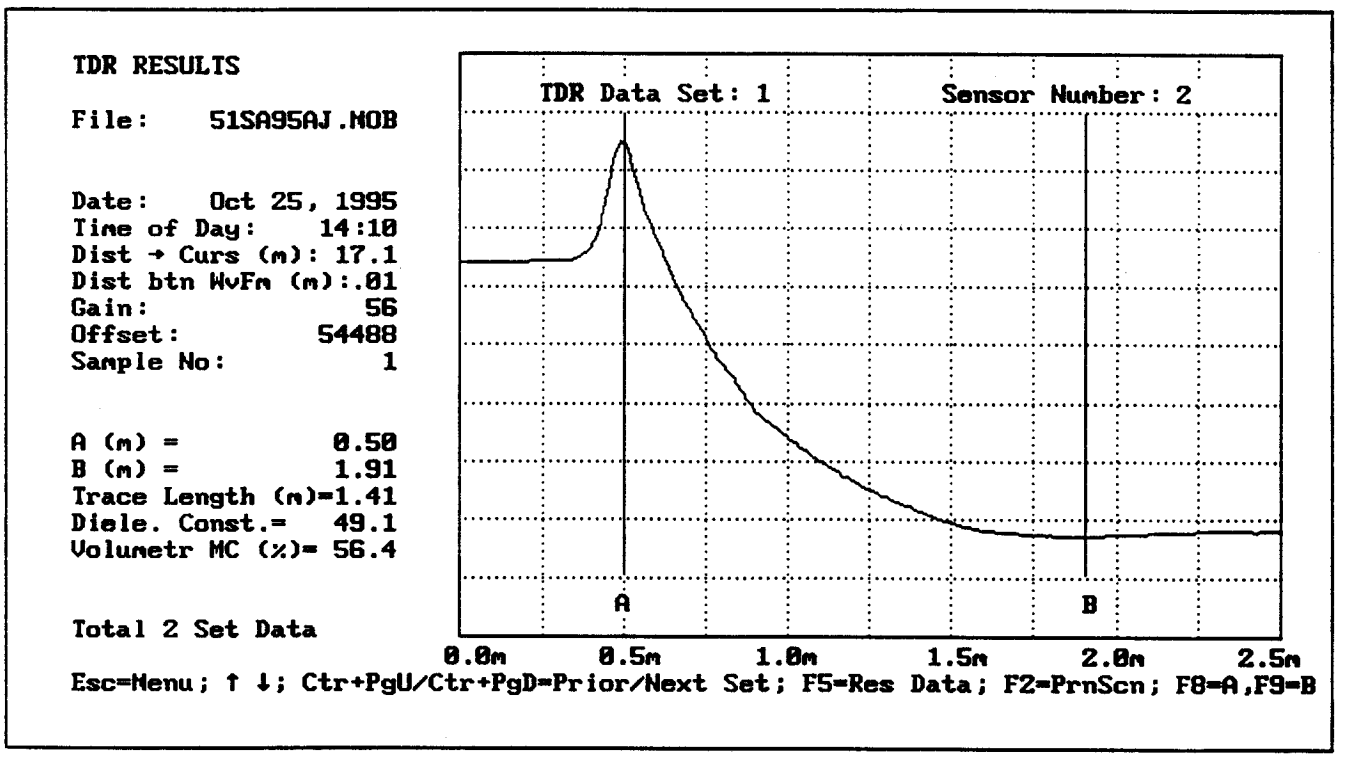

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

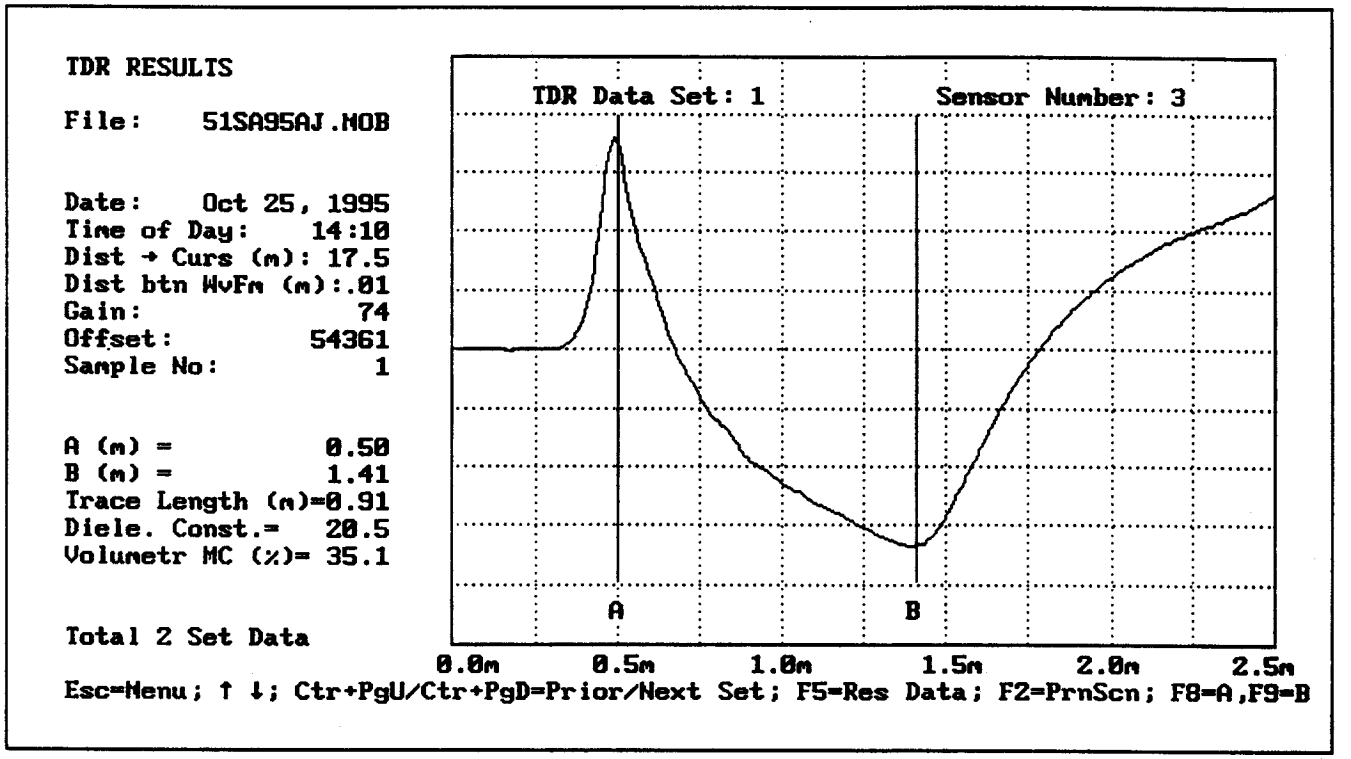

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

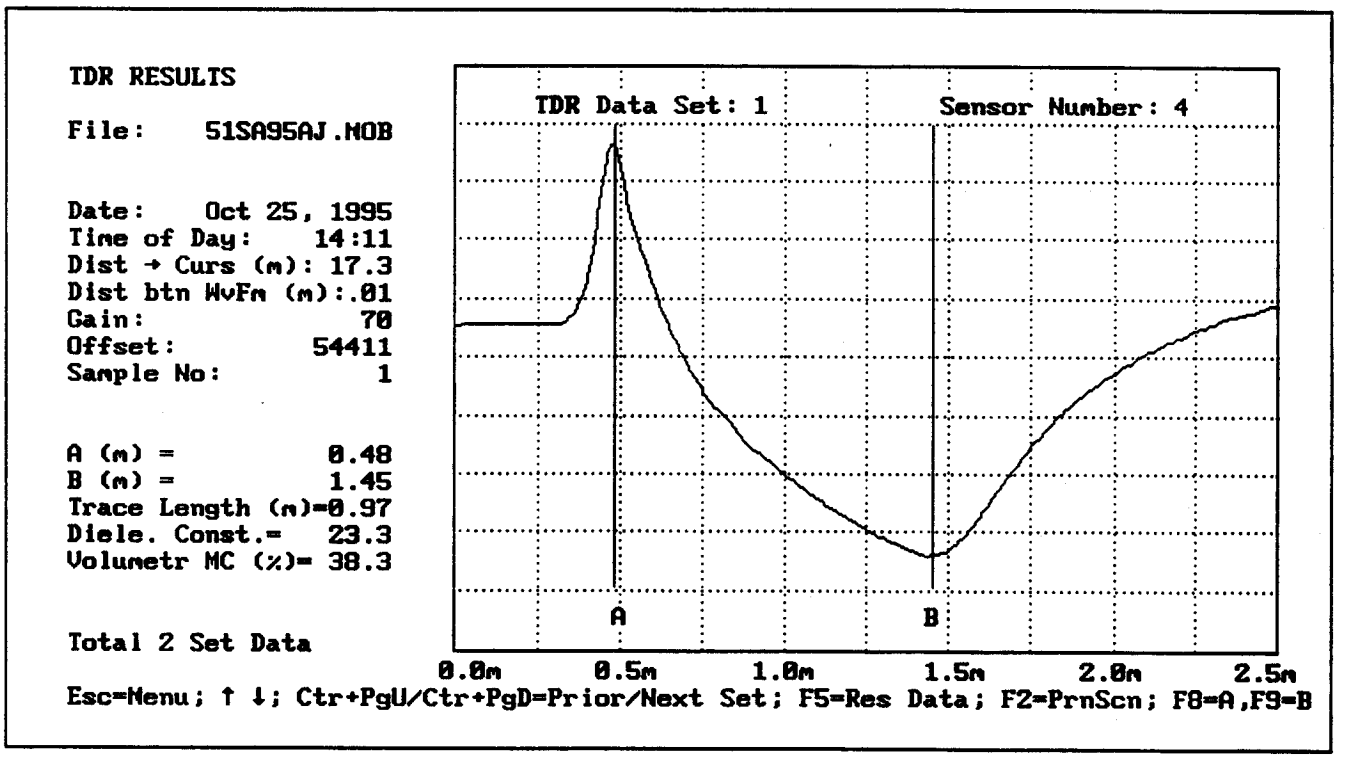

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

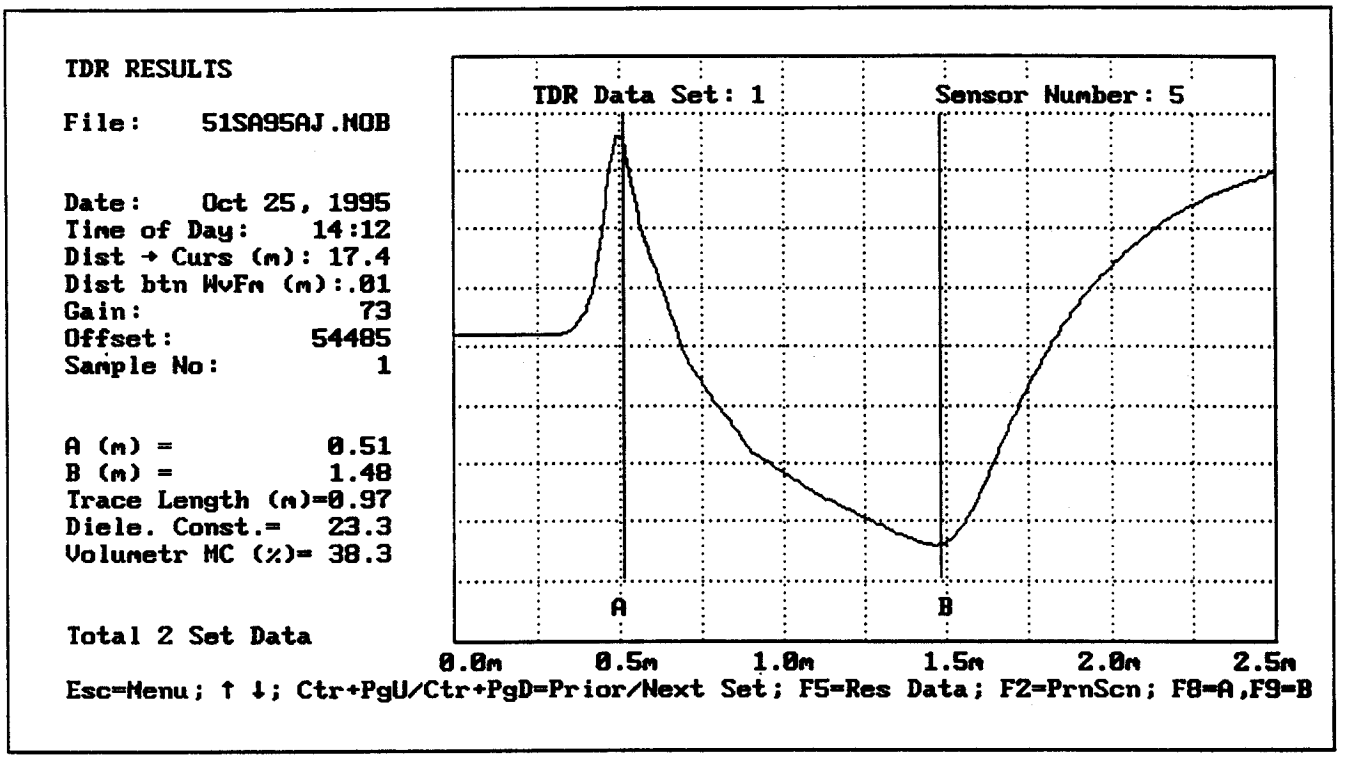

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

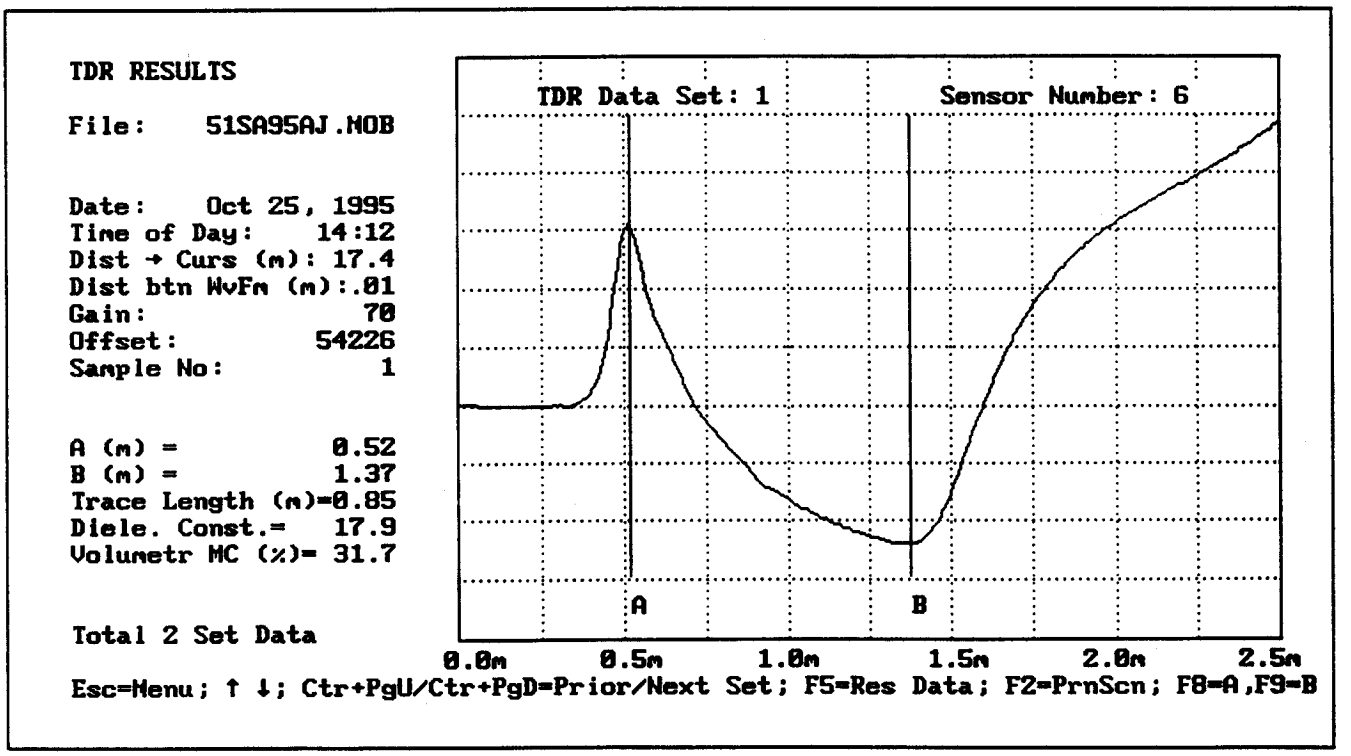

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

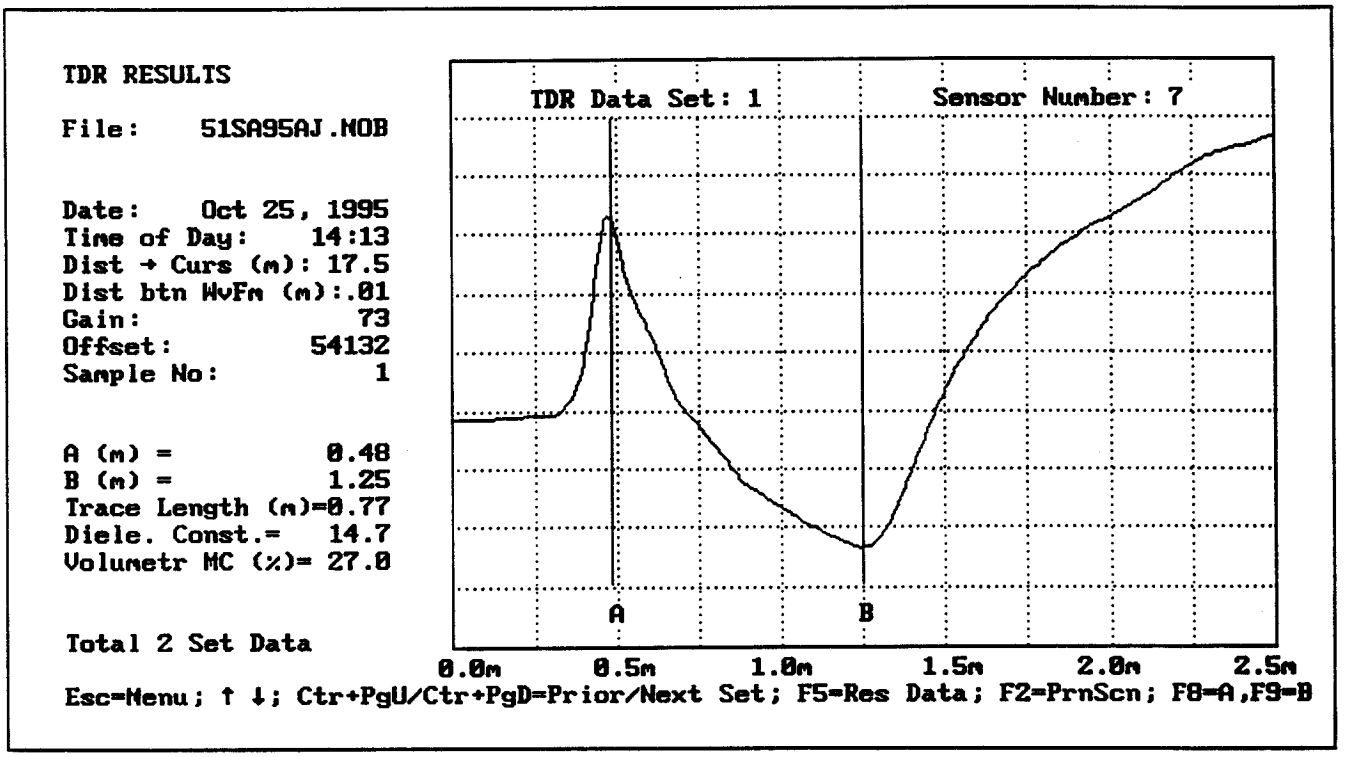

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

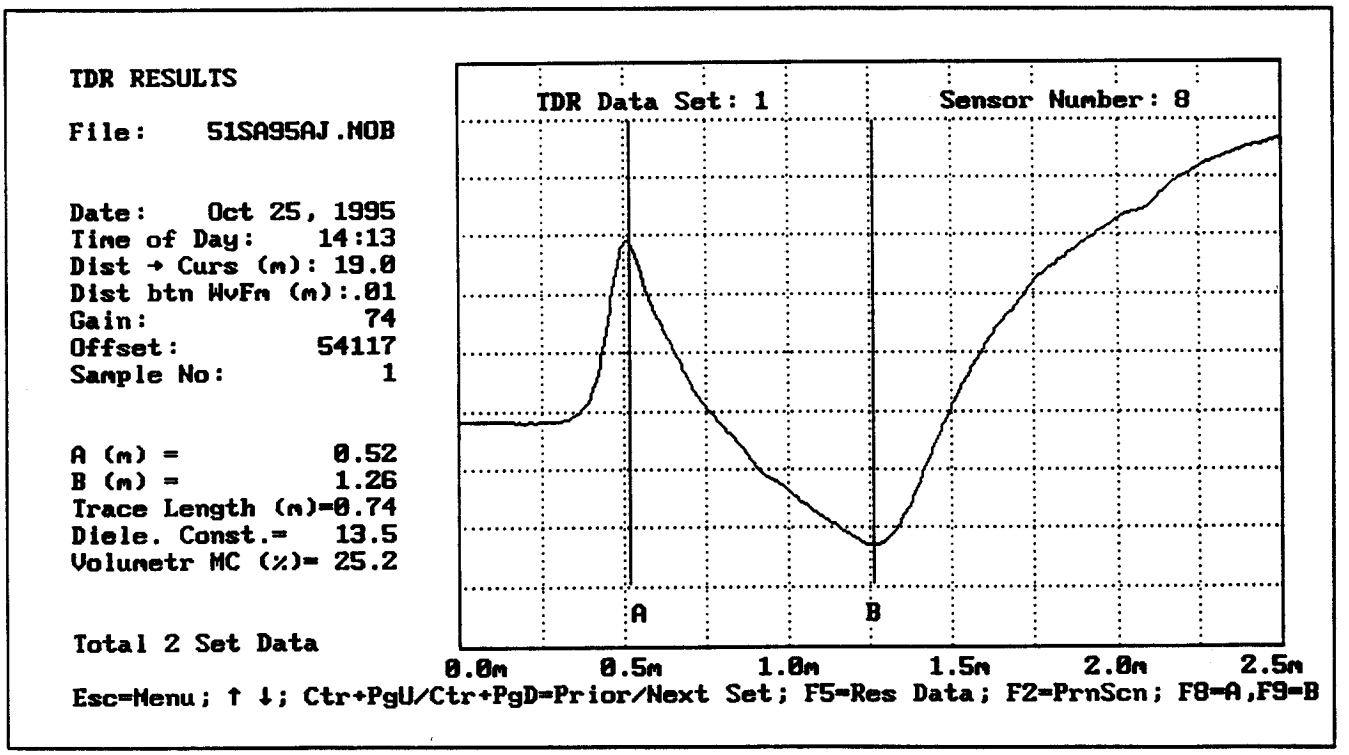

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

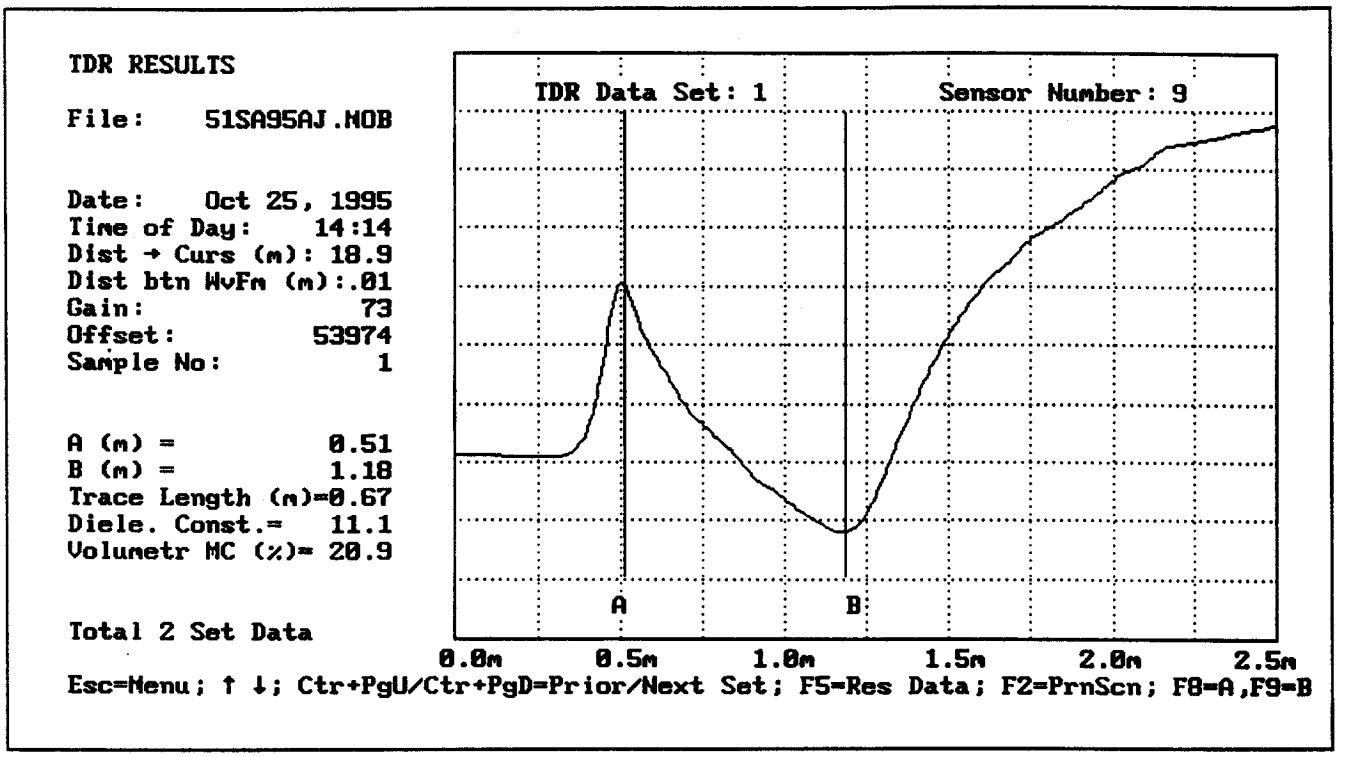

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

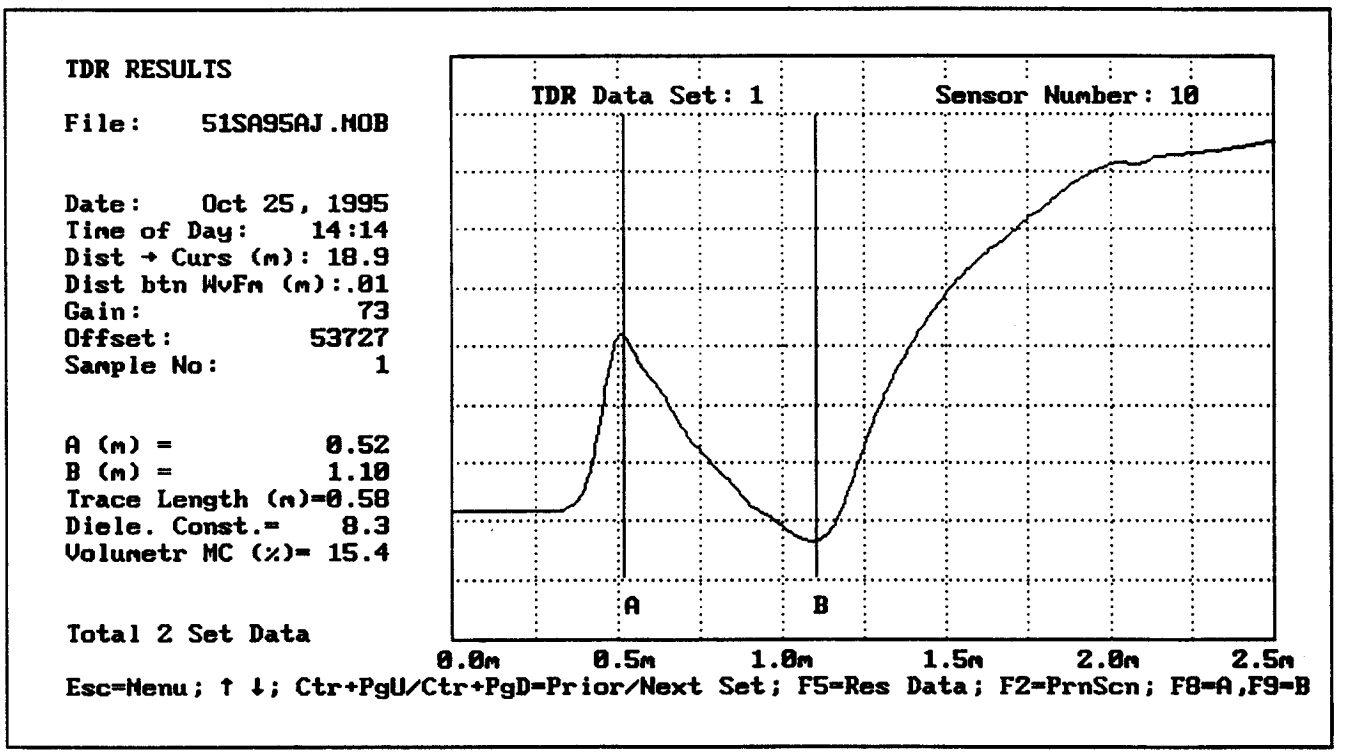

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

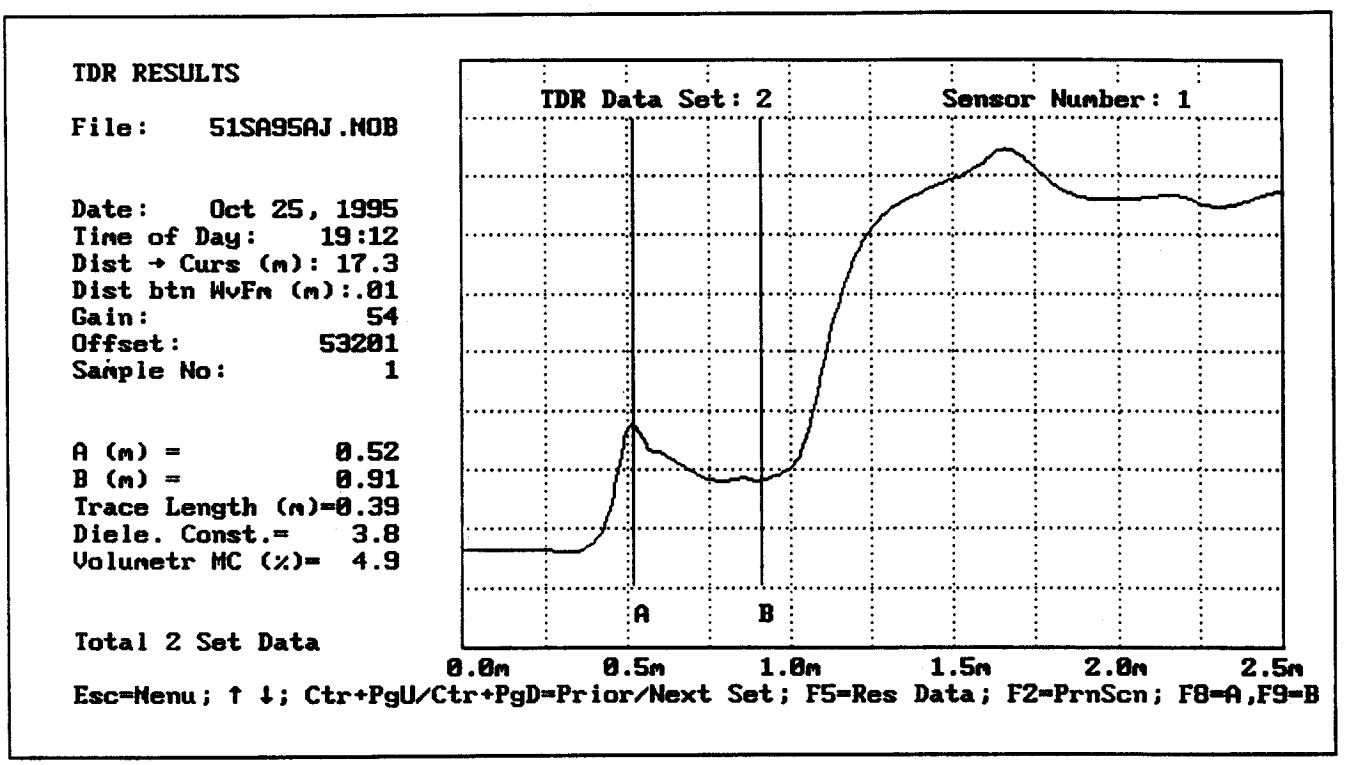

Figure D-3. Initial Second Set of TDR Traces Measured with the Mobile Unit

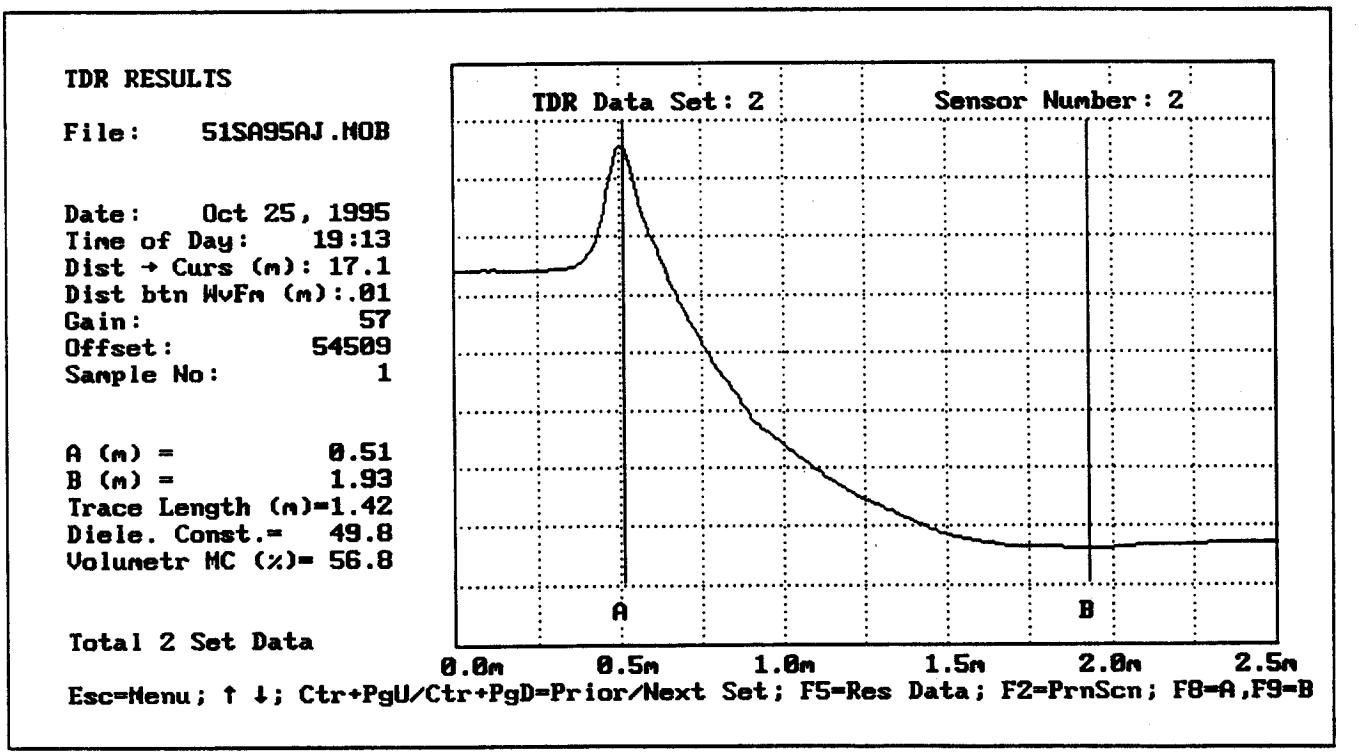

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

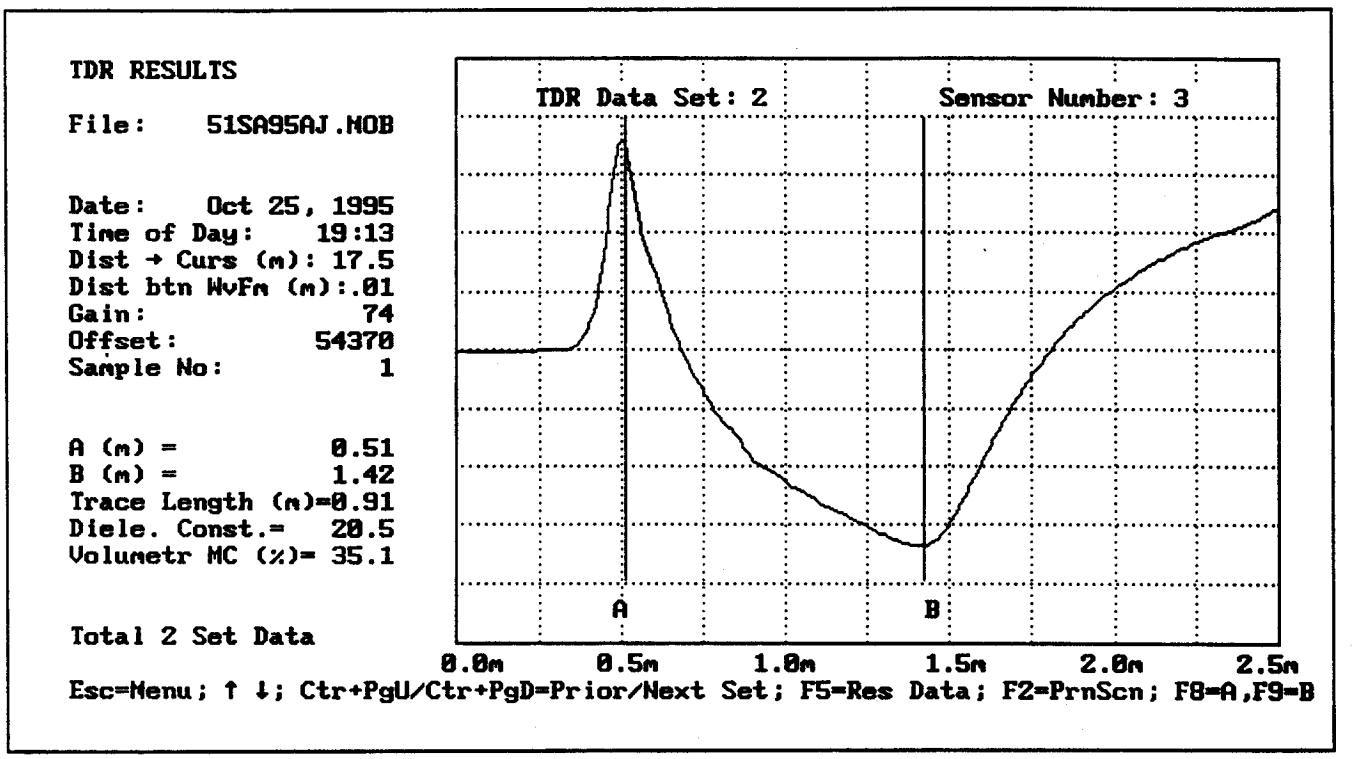

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

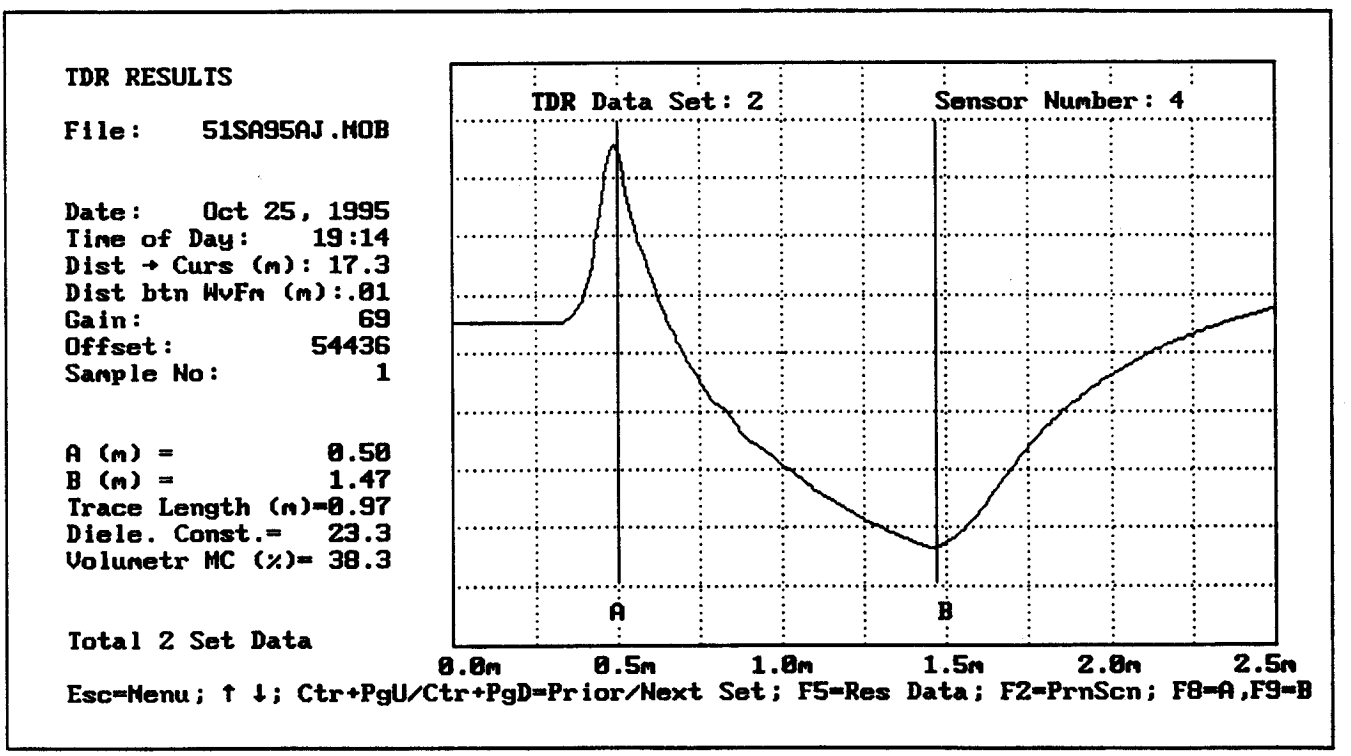

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

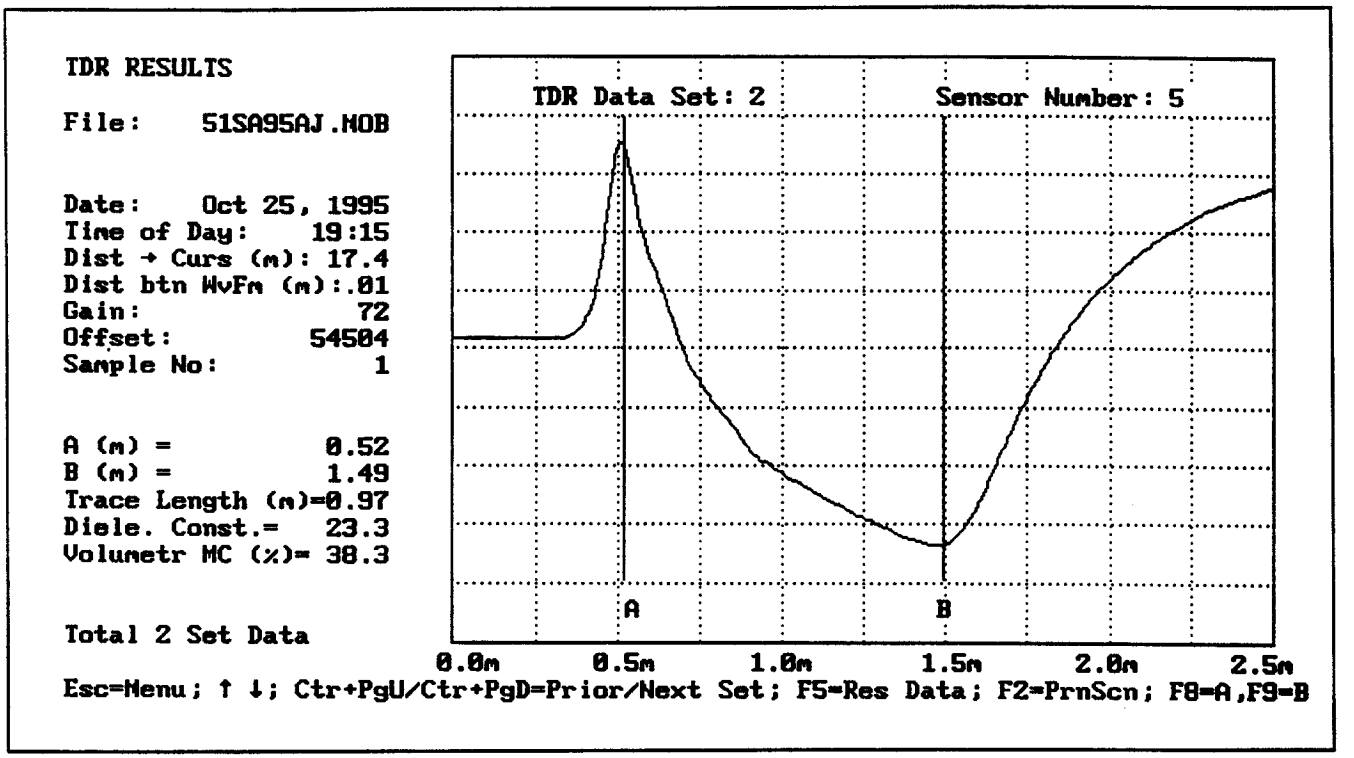

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

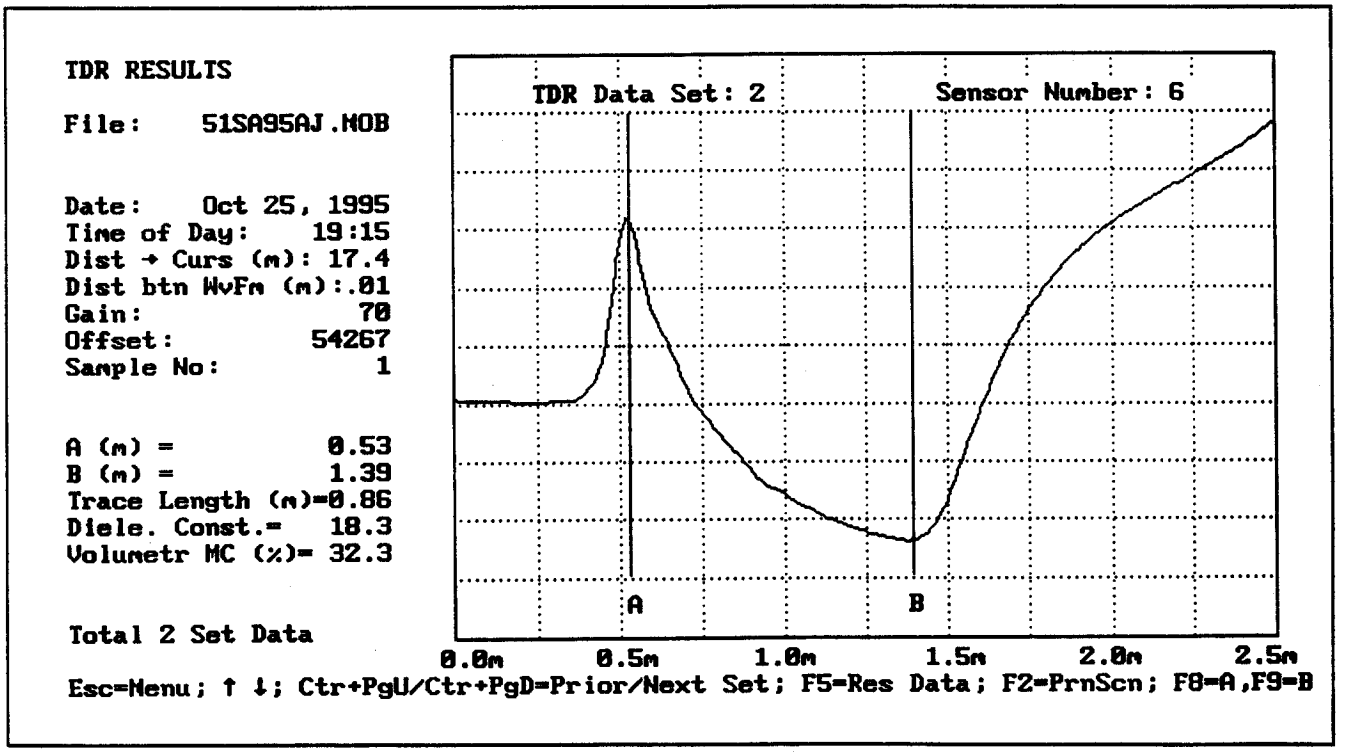

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

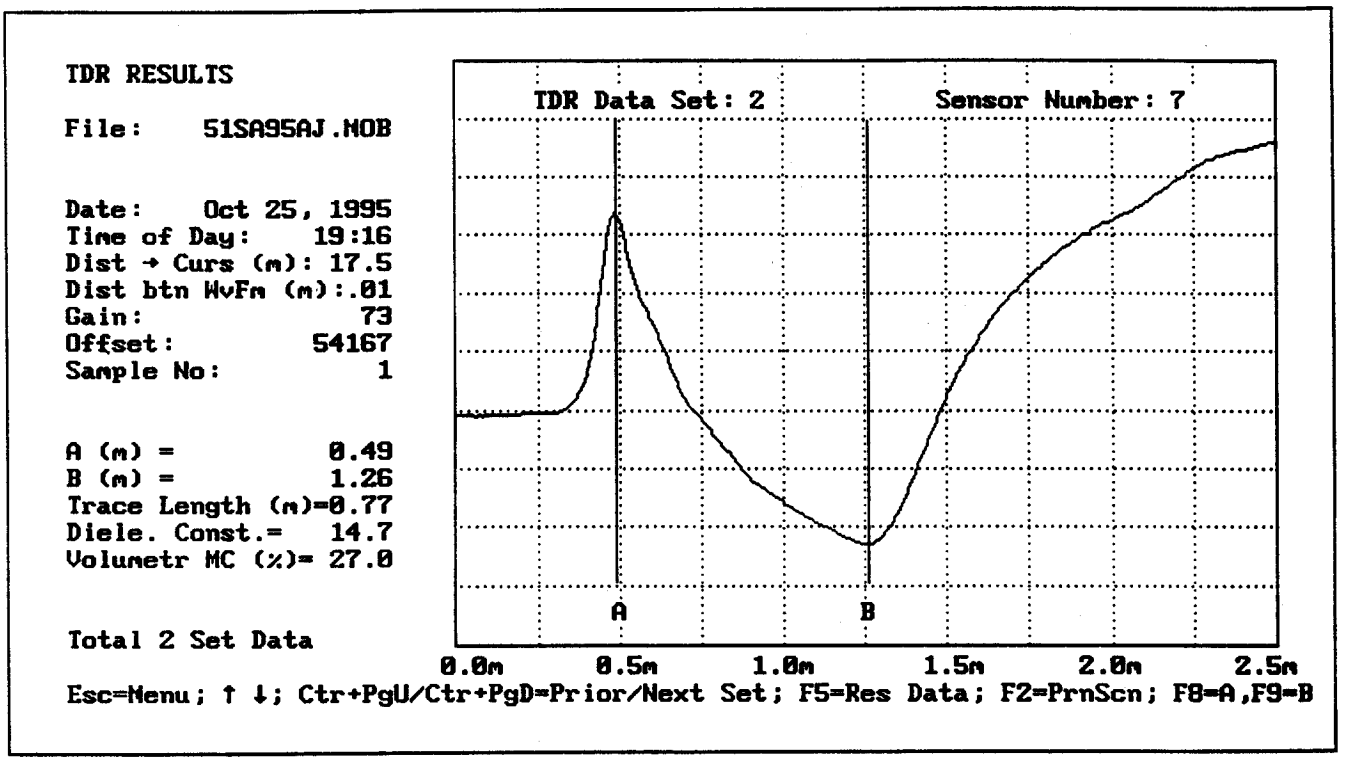

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

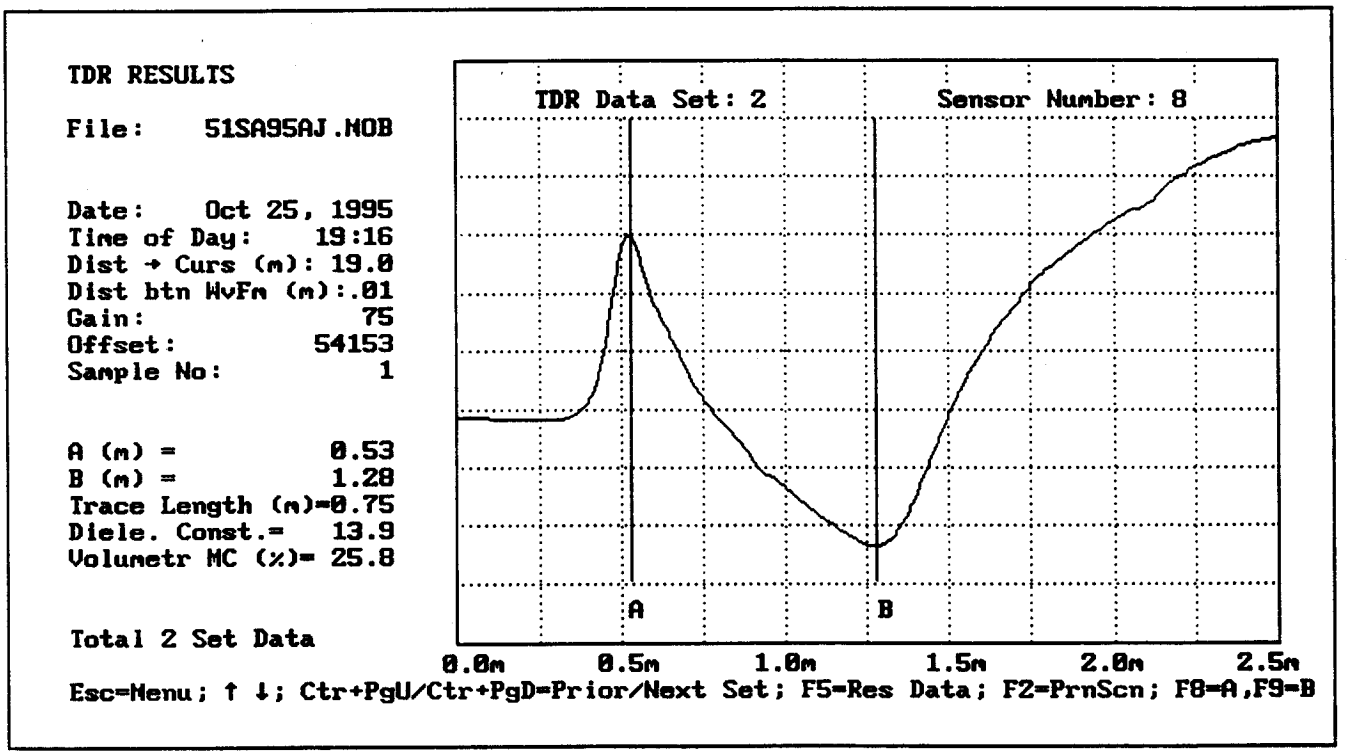

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

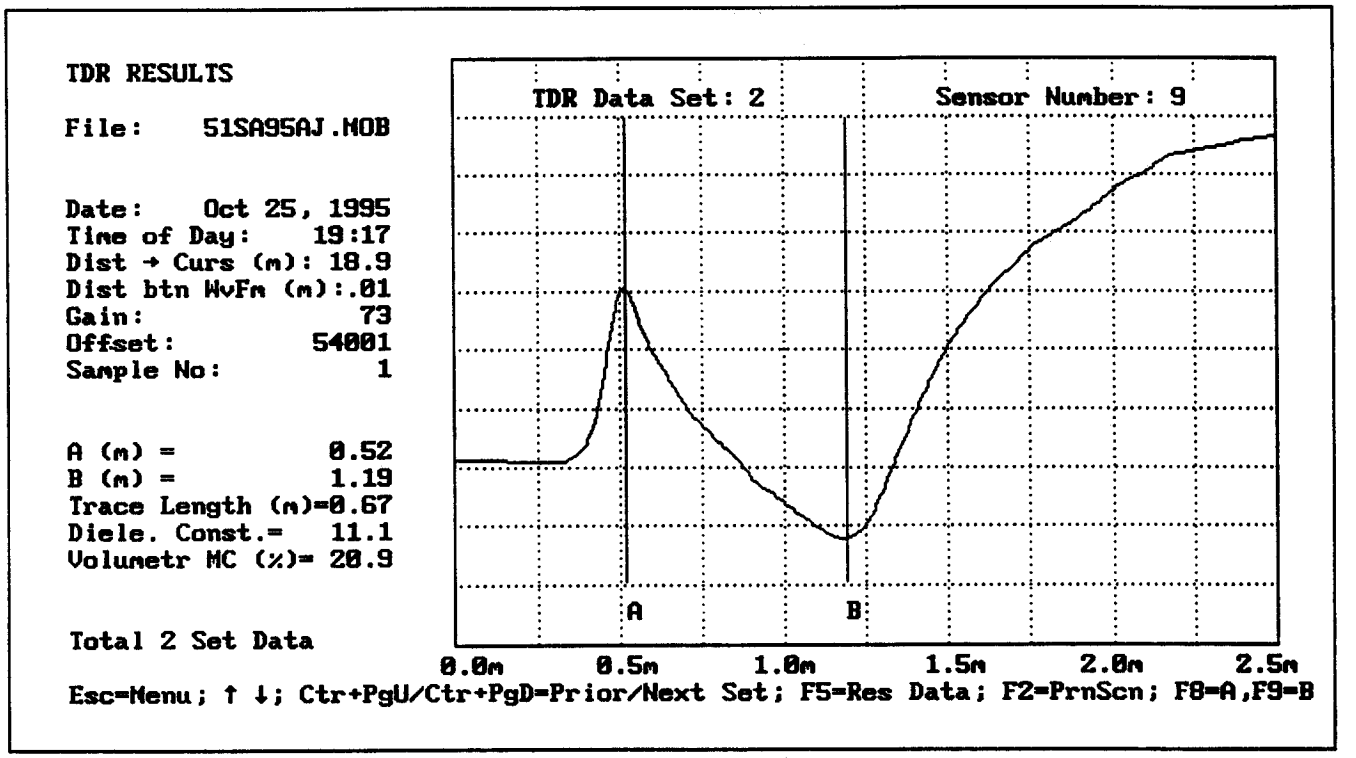

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

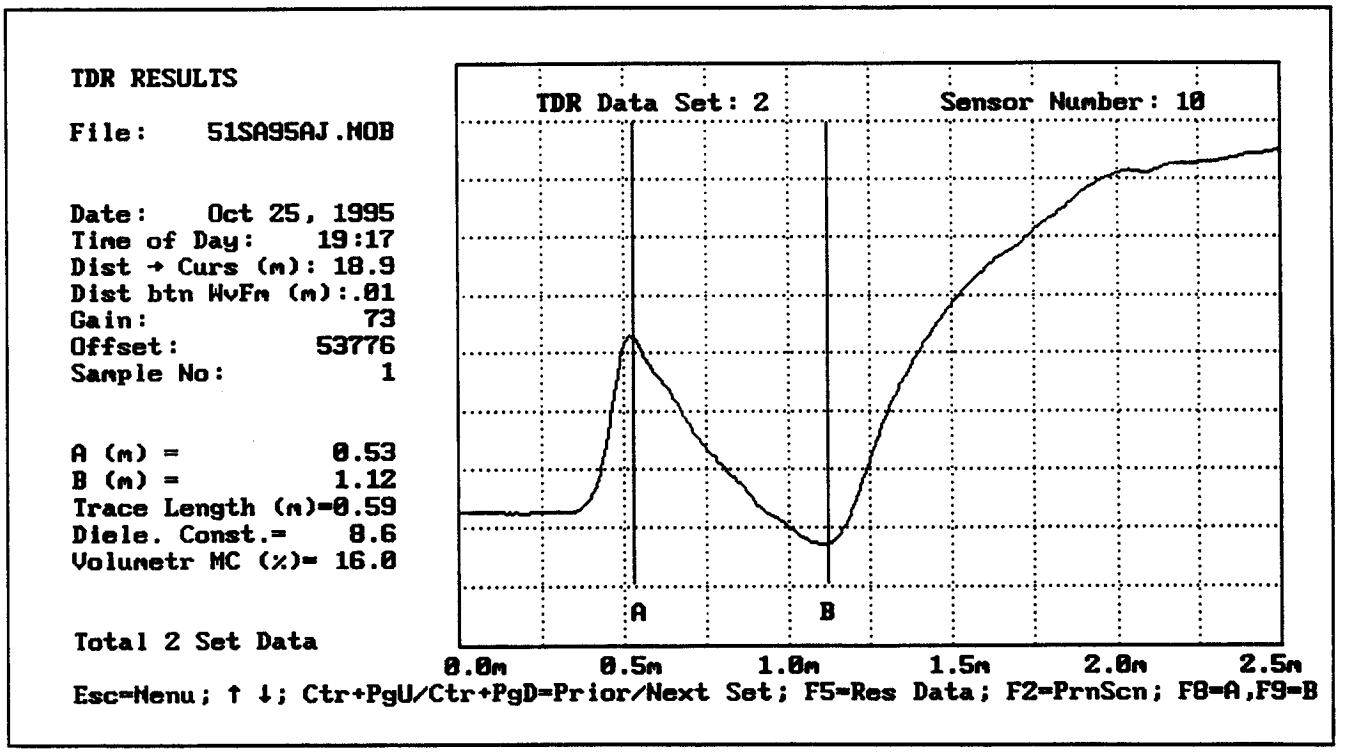

Figure D-3(cont.). Initial Second Set of TDR Traces Measured with the Mobile Unit

Table D-2. Uniformity Survey Results Before and After Installation

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 510113	Data Collection and
Date Surveyed: October 24 - October 25, 1995	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	
-27 to 200 **October 24** @ 0810	18.21	1.24	1.77	0.38	12198	1816	3.82	0.10	56.6
-22 to 200 **October 25** @ 1552	22.39	2.07	1.85	0.41	15146	2995	3.24	0.11	96.5
-22 to 200 **October 25** @1722	22.18	1.66	1.84	0.39	14408	2858	3.30	0.10	86.2

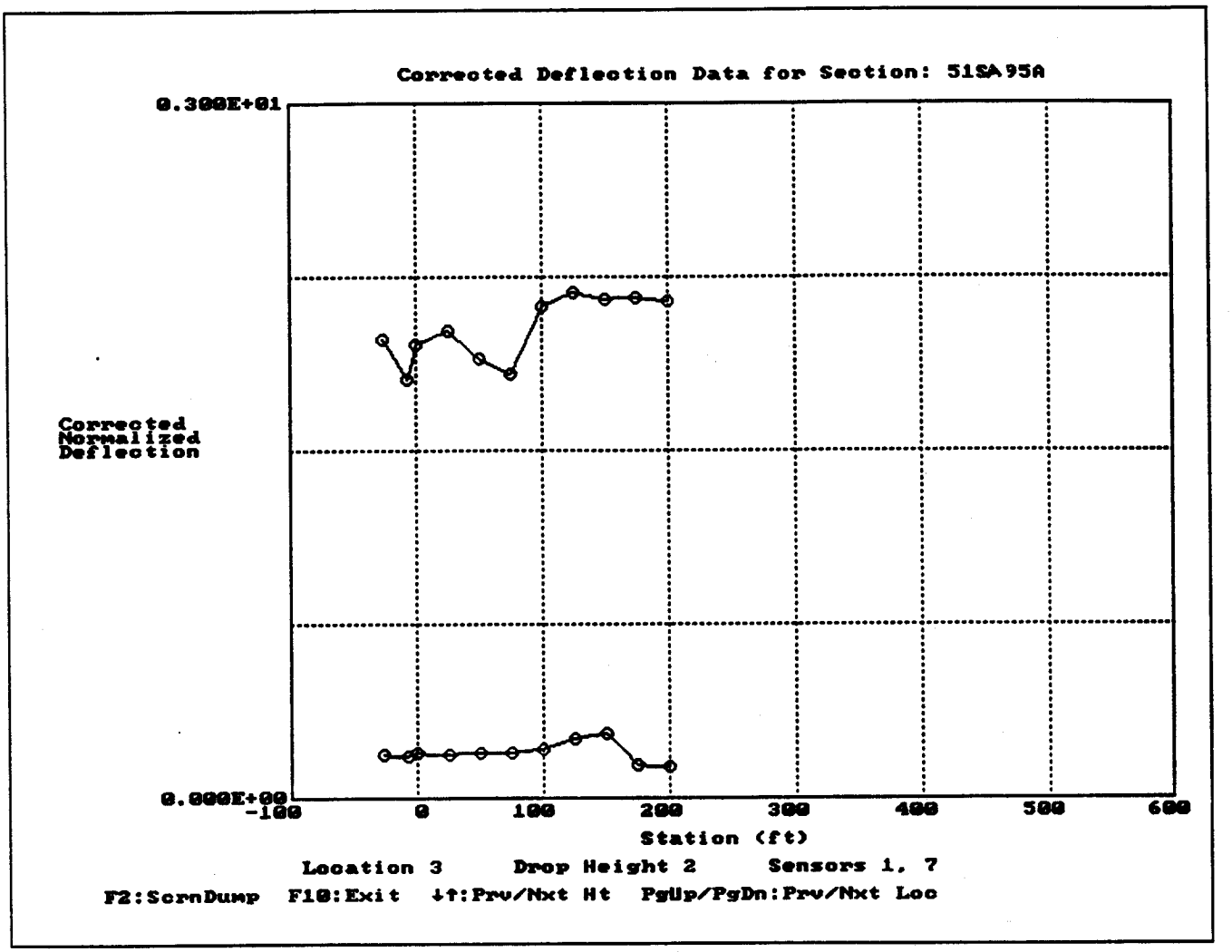

Figure D-4. Deflection Profiles from FWDCHECK
(Test Date and Time October 24, 1995 @ 0810)

Table D-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 24, 1995 @ 0810)

Flexible Pavement Thickness Statistics - 51SA95A - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-27	11631	3.90
	-7	12958	4.00
	0	11706	3.90
	25	12630	3.75
	50	15600	3.70
	75	15110	3.80
	100	10222	3.90
	125	10206	3.80
	150	12034	3.70
	175	10332	3.85
	200	11752	3.70
Subsection 1	Overall Mean	12198	3.82
	Standard Deviation	1816	0.10
	Coeff of Variation	14.88%	2.64%

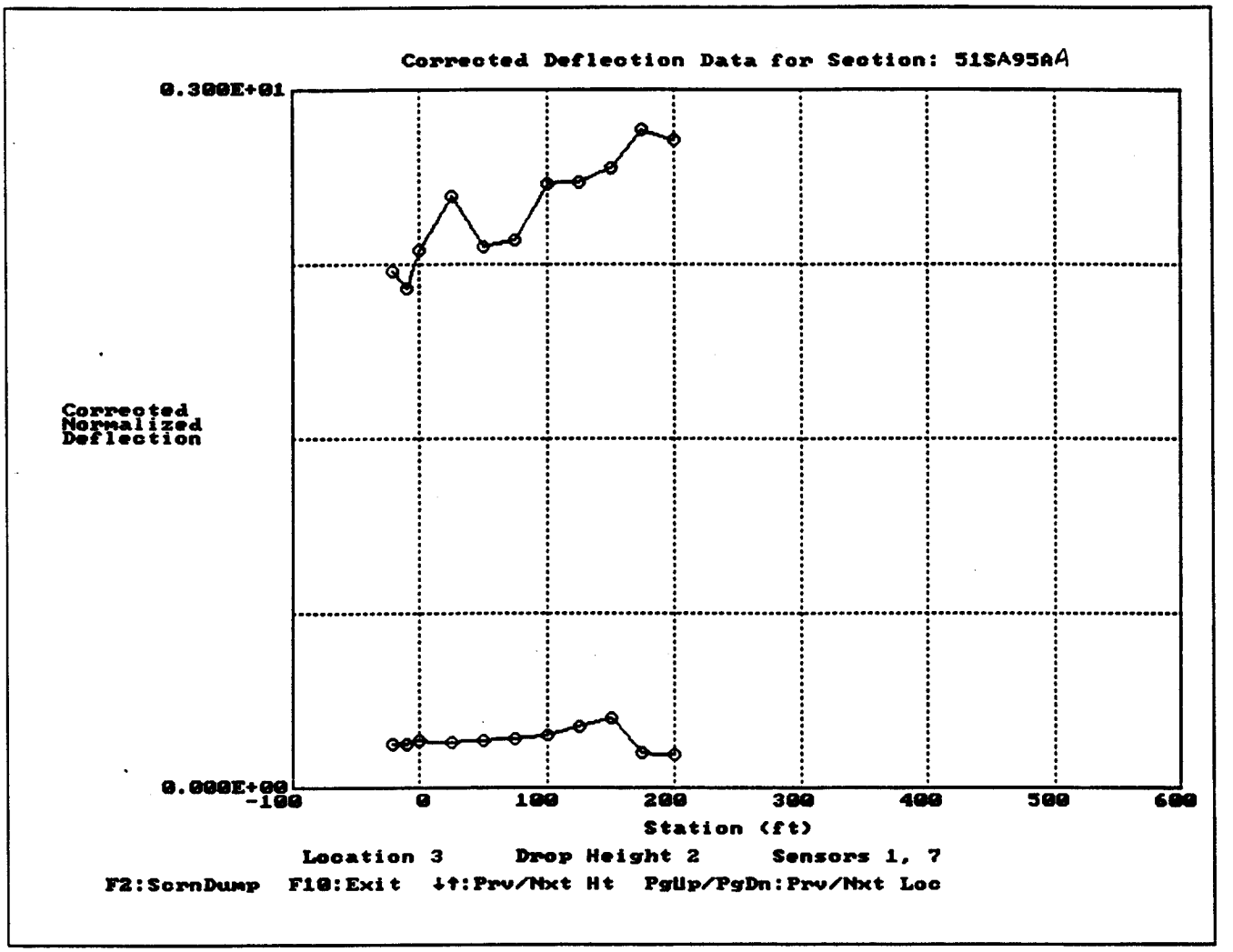

Figure D-5. Deflection Profiles from FWDCHECK
(Test Date and Time October 25, 1995 @ 1552)

Table D-4. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 25, 1995 @ 1552)

Flexible Pavement Thickness Statistics - 51SA95AA - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-22	17367	3.30
	-10	16651	3.40
	0	14264	3.40
	25	15603	3.15
	50	20436	3.15
	75	19181	3.15
	100	12270	3.30
	125	11837	3.30
	150	12863	3.20
	175	11620	3.20
	200	14511	3.05
Subsection 1	Overall Mean	15146	3.24
	Standard Deviation	2995	0.11
	Coeff of Variation	19.78%	3.46%

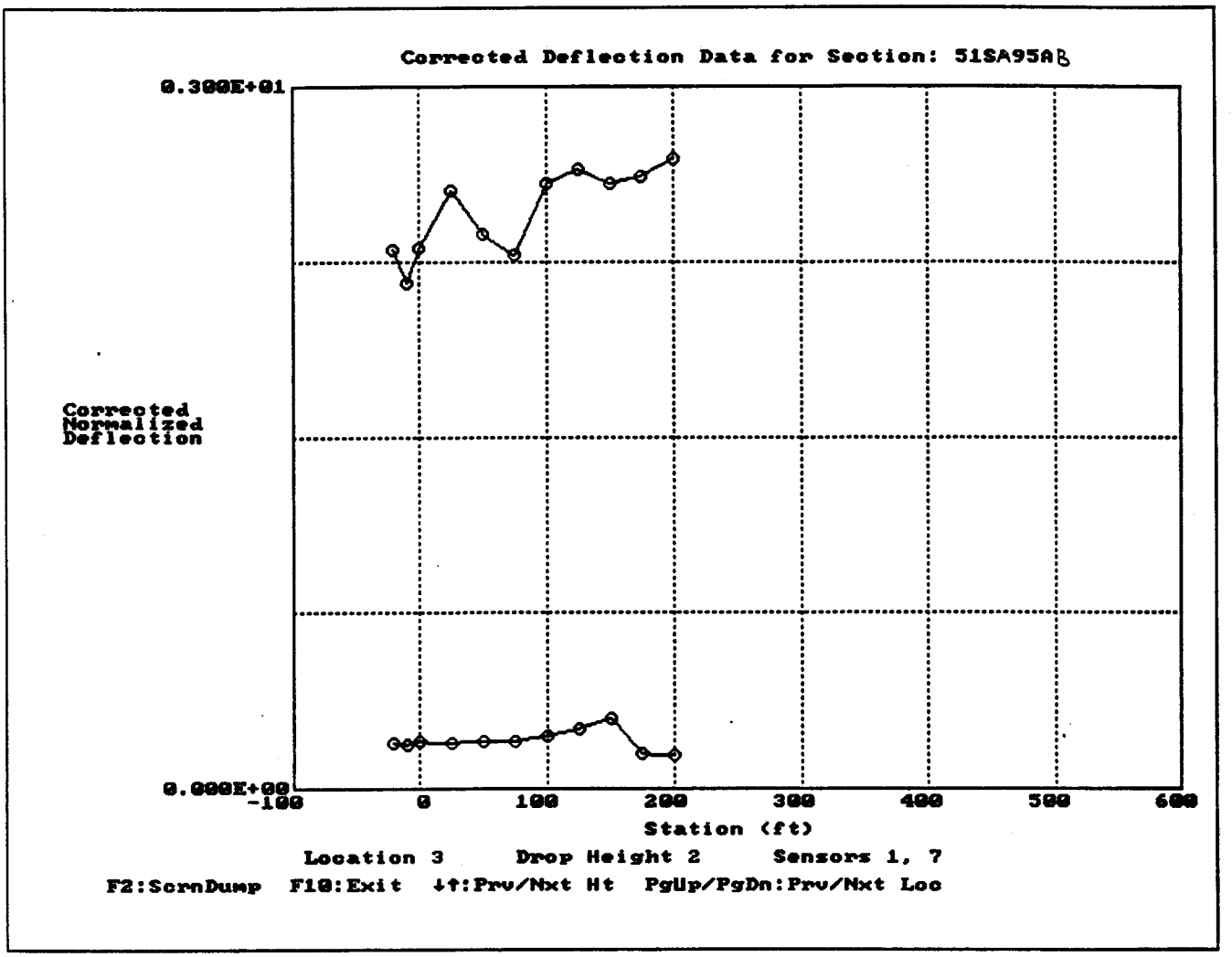

Figure D-6. Deflection Profiles from FWDCHECK
(Test Date and Time October 25, 1995 @ 1722)

Table D-5. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time October 25, 1995 @ 1722)

Flexible Pavement Thickness Statistics - 51SA95AB - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-22	16562	3.30
	-10	15593	3.45
	0	14026	3.40
	25	14598	3.20
	50	19436	3.15
	75	18434	3.25
	100	11537	3.35
	125	10980	3.35
	150	12533	3.30
	175	11311	3.35
	200	13482	3.15
Subsection 1	Overall Mean	14408	3.30
	Standard Deviation	2858	0.10
	Coeff of Variation	19.83%	2.99%

Table D-6. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[51]
Surface Elevation Measurements	Test Section Number	[0113]

Survey Date	October 25, 1995
Surveyed By	DS/RP
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION	PE m offset 0.30m	OWP m offset 0.91m	ML m offset 1.83m	IWP m offset 2.74m	ILE m offset 3.35m
0-22	2.1250	2.1300	2.1325	2.1400	2.1450
0-16	2.0950	2.1025	2.1075	2.1125	2.1125
0-10	2.0600	2.0650	2.0700	2.0750	2.0825
0+00	1.9075	2.0025	2.0125	2.0200	2.0250
0+25	1.8475	1.8550	1.8650	1.8775	1.8825
0+50	1.7050	1.7050	1.7225	1.7325	1.7375
0+75	1.5450	1.5625	1.5800	1.5925	1.5950
1+00	1.3975	1.4150	1.4375	1.4525	1.4625
1+25	1.2600	1.2725	1.2925	1.3075	1.3175
1+50	1.1200	1.1325	1.1450	1.1600	1.1650
1+75	0.9750	0.9825	0.9950	1.0075	1.0175
2+00	0.8350	0.8425	0.8600	0.8750	0.8850

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

APPENDIX E

Photographs

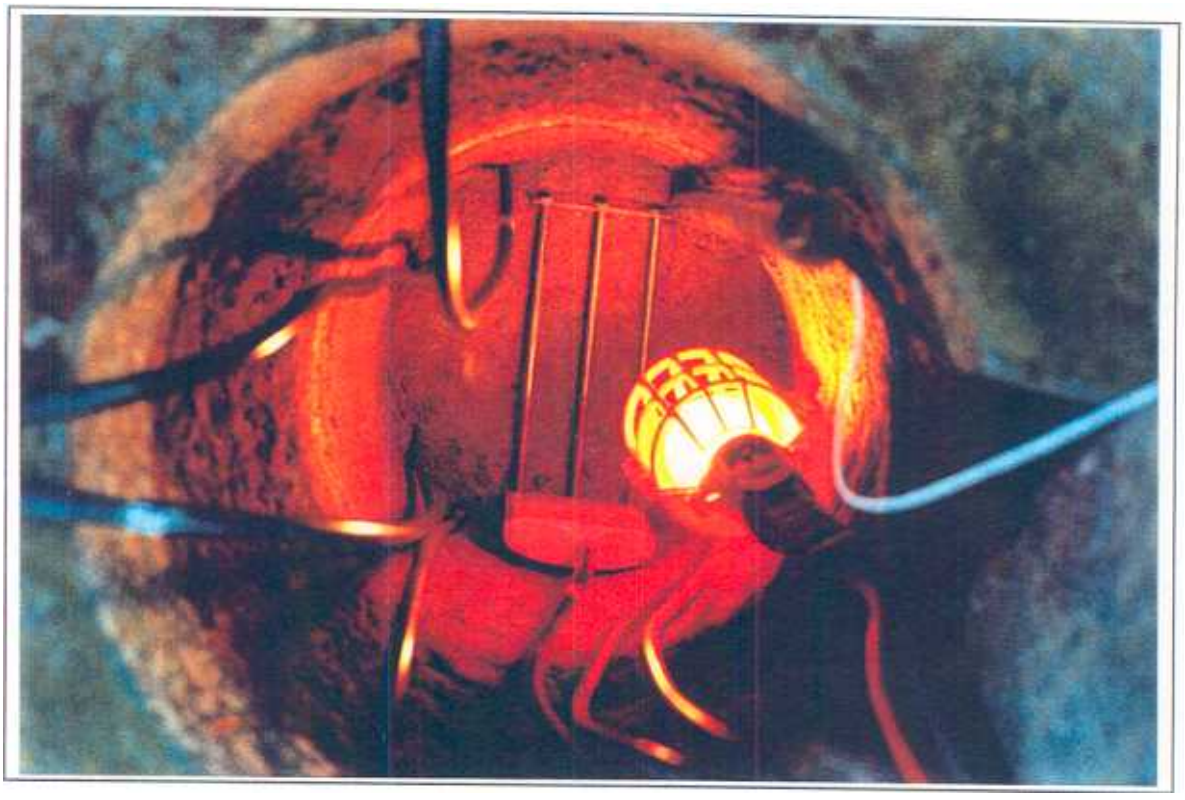

Figure E- Compacting Instrumen Hol at TDR #4 Locatio

Equipm C nd W th ac West

Figure E-3. Instrument Hole and Trench Area After Completion - Facing West

Figure E-4. Equipment Cabinet and Weather Station - Facing North

Figure E-5. Piezometer Access Location

Figure E-6. Mobile Data Collection Set-Up

Figure E-7. Close-up of Instrument Hole After Paint Striping - December 20, 1995