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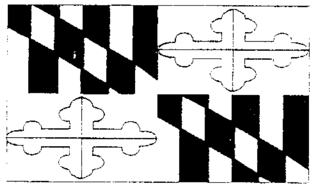

Maryland

LTPP Seasonal Monitoring Program

Site Installation and Initial
Data Collection
Section 241634, Ocean City
Maryland

Report No. FHWA-TS-96-24-01

June 1996

Notice

LTPP Seasonal Monitoring Program

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15. Supplementary Notes

The report is a cooperative effort between Maryland State Highway Administration (MDSHA), Long Term Pavement Performance (LTPP) Division of Federal Highway Administration (FHWA), 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 General Pavement Study (GPS) section 241634 on ST 90 near Ocean City, Maryland. This asphalt concrete surface pavement test section was instrumented on May 11, 1995. The instrumentation installed included time domain reflectometry probes for moisture content, thermistor probes for temperature, resistivity probe for frost depth, tipping bucket rain gauge, piezometer to monitor the ground water table, and an on-site data logger. Initial data collection was performed on May 12, 1995 which consisted of deflection measurements with a Falling Weight Deflectometer, elevation, temperature, frost depth, TDR, and water table measurements. Longitudinal profile data is collected during scheduled visits with the LTPP profiler. 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 Instrumentation, Monitoring, Survey, FWD, LTPP profiler, Time Domain Reflectometry, Thermistor, Piezometer, Electrical Resistance, Electrical Resistivity.		18. Distribution Statement	
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I. Introduction

The installation of the LTPP instrumentation, on seasonal site 241634, near Ocean City, Maryland was performed on May 11 - May 12, 1995. The test section is a GPS-2 experiment, located on Eastbound Route 90, approximately 1.0 kilometers East of US 50. The highway consists of one 3.7 m wide lane in each direction with a 3.0 m wide paved outside shoulder. The centre line of the road contains indented stripes to keep the traffic in the specified lanes in this primary access route to the Ocean City beaches.

The pavement structure, which elevates the roadway in a wet, low lying plain, consists of 95 mm of asphalt concrete on 120 mm of sand asphalt treated base and 355 mm of fine grained soil. The subgrade consists of fine sands and silts. The depth to rock below road surface is more than 7.5 m. Pavement structure information from the GPS material drilling logs is presented in Appendix A, Figure A-2. Properties determined from the laboratory material tests are shown in Table 1.

Table A-1 in Appendix A summarizes the distress, IRI values from the LTPP profiler longitudinal profile measurements, and Falling Weight Deflectometer deflection values as monitored since 1989. 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 12 (thick AC on fine subgrade) of the Seasonal Monitoring Program. Salt is used for ice control at this location. Below is a summary from the LTPP climate database based on eleven years of data:

• Freezing Index (C-Days)	88
• Precipitation (mm)	1118
• No. of Freeze/Thaw Cycles	76
• Days Above 32°C	16
• Days Below 0°C	77
• Wet Days	136

The estimated annual average daily traffic (AADT) in 1989 was 3000 in the GPS lane. Approximately 6% of the traffic in the GPS lane consisted of trucks. The estimate of annual ESALS in the GPS lane using vehicle ESALS is 64000. The annual average daily traffic obtained from 306 days of ATR counts in 1994 is 3472 in the GPS lane. Installation of WIM equipment is expected to occur in 1996.

Installation of the instrumentation was a cooperative effort between Maryland State Highway Administration (MDSHA), Federal Highway Administration Long Term Pavement Performance Division, and Pavement Management Systems Limited (PMSL) LTPP North Atlantic Region Coordination Office staff. The following personnel participated in the instrumentation installation:

Al Blazucki	MDSHA/SHRP Coordinator
Lynwood Clarke	MDSHA-Geotechnical
Timothy Durman	MDSHA-Geotechnical
Bruce Mielke	MDSHA-Geotechnical
Donald Schlaich	MDSHA-Geotechnical
George Wilson	MDSHA-Geotechnical
Roy Brewington	Maintenance - Snowhill
Ellwood Collins	Maintenance - Snowhill
Bill Farlow	Maintenance - Snowhill
Bobby Hart	Maintenance - Snowhill
Mike Mariner	Maintenance - Snowhill
Brandt Henderson	Pavement Management Systems (NARCO)
Alfred Lip	Pavement Management Systems (NARCO)
Douglas Marshall	Pavement Management Systems (NARCO)
James Orzulak	Pavement Management Systems (NARCO)
Dilan Singaraja	Pavement Management Systems (NARCO)

Table 1. Material Properties

Description	Surface	Treated Base	Base	Subgrade
Material (Code)	Dense Graded HMAC (01)	Sand Asphalt (320)	Fine Grained Soil (309)	Silt (141)
Thickness (mm)	95	120	355	
Lab Max Dry Density (kg/m^3)			2050	1633
Lab Opt Moisture Content (%)			8	12
In-situ Wet Density (kg/m^3) *			2194	1877
In-situ Dry Density (kg/m^3) *			2005	1680
In-situ Moisture Content (%) *			9.4	11.7
Bulk Specific Gravity	2.35			
Max Specific Gravity	2.40			
Liquid Limit			0	0
Plastic Limit			0	0
Plasticity Index			NP	NP
% Passing # 200			98.9	99.0

* Note: Test pit @ station 5+62

II. Instrumentation Installation

Site Inspection and Meeting with Highway Agency

A FWD uniformity survey was done on April 04, 1995 by Douglas Marshall (NARCO). Tests were performed within the LTPP section limits and for 30.5 m on either side of the section. The results of this survey indicated the 5+00 end to be most uniform.

A preliminary planning meeting was held at the Materials and Research Division in Brooklandville, Maryland on April 12, 1995. The attendees at the meeting were:

• Al Blazucki	SHA/SHRP Coordinator
• Ray Dotterweich	OMR - Asst. Deputy Chief Engineer
• Neal Drexel	Pavement Inspection
• Gil Rushton	Field Technologist
• Donald Schlaich	Geotechnical Explorations
• Gopal Shah	Pavement Testing
• Lou Wagner	Structural and Pavement Inspection
• George H. Wilson	Geotechnical Explorations
• Gene Cofiell	D-1 Traffic
• A. L. Larson	D-1 R.M.E.
• James R. Wright	D-1 ADE Maintenance
• Bill Phang	Pavement Management Systems, NARCO
• Brandt Henderson	Pavement Management Systems, NARCO

A presentation on the installation of seasonal monitoring instrumentation and requirements was provided by Bill Phang and Brandt Henderson of Pavement Management Systems. Plans for the installation on May 10 and May 11, 1995 including the tasks to be covered by all parties involved were discussed. MDSHA's plans for widening and reconstructing highway 90 were discussed to determine if they would conflict with the LTPP plans. It was determined that the LTPP sites would probably not be reconstructed until the year 1998. Correspondence from the site inspection and planning meeting are in Appendix B.

The site was visited on April 26, 1995 by Brandt Henderson (NARCO) and George Wilson (MDSHA) to select the location for instrumentation installation and mark the site for utility clearance. The site was marked with paint and stakes to identify the clearance locations. In addition, the site was reviewed for potential installation problems as the water table is very high in this area.

A pre-installation meeting was held at the Snowhill maintenance facility on May 09, 1995. The plans for the installation and long term monitoring at the site were discussed with Alfred Larson and Sidney Wooten. Concerns were raised that any testing between

Memorial day and Labour day had to be completed by 0830 hours. Arrangements were made to meet on site at 0800 hours with traffic control to be in place by 0830 hours. Rain was forecasted for the day of installation. Arrangements were made to contact the maintenance yard by 0530 hours if the installation needed to be postponed because of rain.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air, pavement and subsurface temperature, subsurface moisture content, frost depth, precipitation, and water table. An equipment cabinet was installed to hold the datalogger, battery pack, and all electrical connections from the instrumentation. A list of the equipment installed is shown in Table 2.

Table 2. Equipment Installed

Equipment	Quantity	Serial Number
Instrumentation Hole		
MRC Thermistor Probe	1	24AT
CRREL Resistivity Probe	1	24AR
TDR Probes	10	24A01-24A10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16587
Campbell Scientific PS12 Power Supply	1	5648
Weather Station		
TE525MM Tipping Bucket Rain Gage	1	12066-693
Campbell Scientific 107-L Air Temperature Probe	1	24AAT
Observation Well/Bench Mark	1	N/A

Equipment Check/Calibration

Prior to the 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 showed 98 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 should correspond to the water temperature. The check indicated that the air temperature and thermistor probes were working properly. A second check was done where the air temperature and thermistor probes were connected to the datalogger and run, in air, for 24 hours. The minimum, maximum, and mean temperature for each sensor was 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 of the air temperature and thermistor probes calibration along with the spacing between the thermistors are presented in Appendix B.

The wiring of the resistivity probe was checked using continuity measurements between each electrode and the corresponding pins on the connector. The distance between each electrode was measured and recorded as shown in Table B-4 in Appendix B. Contact resistance measurements were performed with the probe immersed in a salt water bath. The results of these measurements have been misplaced, thus they are not included in this report. The initial data collected indicates that the probe is functioning correctly. Due to defects in the manufacturing, clear silicon sealant was used to cover exposed wires to the electrodes. The checks on the resistivity probe indicated all electrodes were functioning properly.

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

Equipment Installation

The installation planned for May 10, 1995 was cancelled because of heavy rain and fog at the site. Arrangements were made to reschedule all activities for 0830 hours on May 11, 1995. Traffic control for the installation and monitoring was provided by Maryland State Highway Administration district 1 maintenance facility in Snowhill. The pavement surface drilling and augering of the piezometer and instrumentation hole were done by agency equipment and drilling crew under the supervision of George Wilson, MDSHA Geotechnical division. The sawing of the trench and cut for the pavement surface temperature probe was supervised by Roy Brewington of MDSHA Maintenance division. The installation of the measurement equipment, the observation piezometer, weather station pole, and cabinet was performed by PMSL staff. Assistance was provided by MDSHA's Al Blazucki, special projects, materials and testing group and the local district personnel.

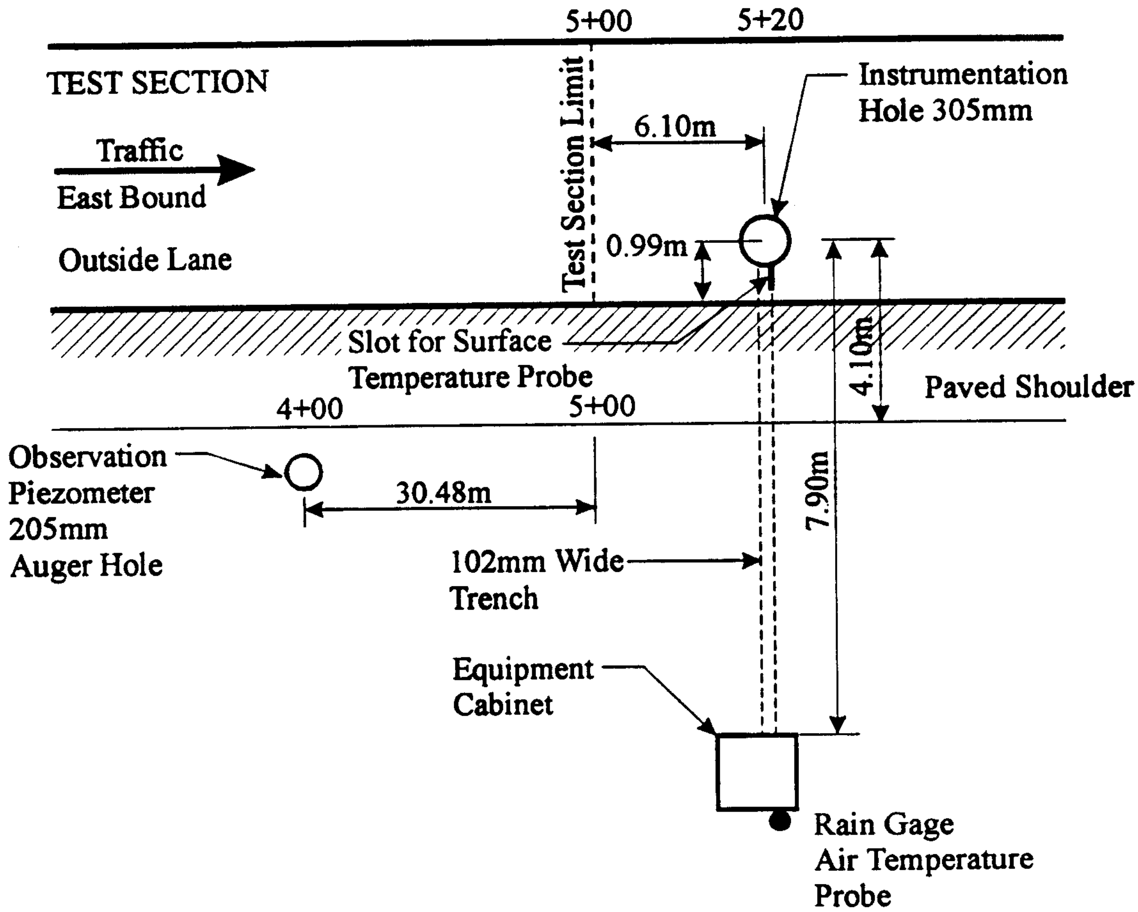
The instrumentation was installed on the East end of GPS 241634, in the Eastbound lane of route 90, 1.0 km East of the junction with route 50 near Ocean City, Maryland. The combination bench mark/piezometer was placed in the shoulder at station 4+00. The in-pavement instrumentation was installed in the outer wheel path at station 5+20. The cabling from the instrumentation was placed in a 51 mm flexible conduit and buried in a trench running from the instrument hole to an equipment cabinet installed on the slope of the roadway embankment, 7.9 m from the instrumentation hole. To support the cabinet, excess bentonite clay and crushed gravel were spread around the cabinet base. The weather pole was installed immediately behind the equipment cabinet. Figure 1 provides the location and distances for the various instrumentation and equipment installed.

The installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". The combination piezometer/bench mark was installed close to the edge of the paved shoulder to a depth of 4.6 m. A 205 mm flight auger was used for drilling the hole. The high water table and the liquid like nature of the soil caused the hole to collapse as the augers were withdrawn from the hole. Hollow stem augers were then used to hold the soil in place once the desired depth was reached and the piezometer was placed through the center of the augers. The piezometer's base plate was replaced with a cap such that the installation could be done with the augers in place.

A core hole was drilled in the pavement surface, located in the outside wheel path, 0.99 m from the edge of the travel lane at station 5+20, using a 305 mm thin wall diamond core barrel, attached to the truck mounted drilling unit. A 102 mm wide by 220 mm deep saw cut was done between the core hole and the edge of the pavement, using a heavy duty pavement sawing machine. The remainder of the material from the trench was removed with a trencher and shovels.

A 305 mm flight hollow stem auger was used to drill the instrumentation hole. Material was removed in 0.3 to 0.4 m lifts. Care was taken to ensure that the material was stored in the order of excavation. The material removed was stored in buckets with distinct layers separated. The road base consisted of sand. Some roots were found in the fine sand layer below the base. At approximately 1.4 m, water started seeping into the hole. The augering was conducted past the design depth of the hole to determine if the type of material changed. The findings from the drilling are presented in Figure 2. It is likely that the rainy conditions that prevailed in the area a day prior to the installation had caused water to permeate into the sand layer. The relatively impermeable layer of silt and possibly clay below this sand layer most likely held the water in the sand layer. Drilling through this layer released much of the water into the hole. A wet vacuum and sponges were used to remove as much moisture as was possible. Compaction of the bottom layers was made considerably more difficult due to the presence of the wet soil conditions. It was not possible to consolidate the sandy soil to it's initial state at the depths of TDR probes 9 and 10. Some material from the bottom layer was retained in order to match the depths of the distinct layers during replacement of the hole. The compaction was much more efficient once the wet soils were passed.

Samples of the material placed around each TDR probe were retrieved and a field moisture determination was conducted at the site with sample material retained for laboratory moisture determination by the MDSHA Materials and Research Laboratory. Two Standard Proctor tests were conducted in the field to determine the density of the soils. The density of the sand layers near the top were 1790 kg/m^3 and the bottom sandy silt layers were 1900 kg/m^3. The equipment cabinet and pole for the rain gauge and air temperature probe was installed as per manual guidelines with the following two exceptions, first the cabinet was installed on the inside ledge of the ditch and a crushed granular fill was used to support the cabinet and provide a platform for access, and second the pole for the rain gauge and air temperature probe was installed to a depth of 0.66 m supported in the granular base for the cabinet. The excavation of the trench proceeded fairly smoothly as the material was generally a clean sand without cobbles or boulders. The wiring of the instrumentation to the equipment cabinet was completed on the same day as the installation.



- Height of Air Temperature Probe: 2.96m
- Height of Tipping Bucket Rain Gauge: 2.98m
- Depth of Piezometer: 4.27m

Figure 1. Location of Seasonal Monitoring Instrumentation Installed at GPS 241634

Material	Depth (mm)	Probe	TDR depth (mm)	Comments
HMAC	211			Average core depth 211 mm
Light brown Sand w/ small stones	457	TDR 1	368	Resistivity probe depth 254 mm Thermistor probe depth 254 mm
Light brown fine Sand	1117	TDR 2	514	Dry Density 1790 kg/m^3
		TDR 3	660	
		TDR 4	813	
		TDR 5	990	
		TDR 6	1118	
Grey fine Sand	1574	TDR 7	1295	Dry Density 1900 kg/m^3
		TDR 8	1422	
Grey Silt trace of Sand	1828	TDR 9	1727	
Firm grey Silt trace of Clay	2362	TDR 10	2184	

Figure 2. Profile of Pavement Structure and Probe Depths from Surface, Station 5+20

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. The TDR probes were placed such that the cables coming out of them were evenly spaced around the perimeter of the hole to avoid water migrating along a bundle of cables. The thermistor and resistivity probes were installed at opposite sides of the instrumentation hole 0.254 m below the pavement surface. The cables were kept spaced as best as possible until they converged at the opening of the flexible conduit pipe, placed about 50 mm from the edge of the core hole. The cables were then tie wrapped and passed through the conduit to the equipment cabinet. The ends of the conduit were plugged with a mastic pipe sealant.

Tables 3, 4, and 5 present the installed depths of the TDR probes, thermistor sensors, and the resistivity probe respectively. Table 6 gives TDR, field, and laboratory measured moisture content during installation. Moisture content measurements were not conducted for the soils around probe numbers 8, 9, and 10, due to the water saturated condition of the samples. A comparison of the moisture content from the TDR traces, field, and laboratory determination indicate some discrepancies. The field and laboratory moisture contents generally compare more favourably. Given the method under which the material was sampled and the variability in the material, the results can be considered reasonable. 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
24A01	0.368	Base
24A02	0.514	Subgrade
24A03	0.660	
24A04	0.813	
24A05	0.990	
24A06	1.118	
24A07	1.295	
24A08	1.422	
24A09	1.727	
24A10	2.184	

Table 4. Installed Location of MRC Thermistor Sensors

Unit	Channel Number	Depth from Pavement Surface (m)	Remarks
1	1	0.035	This unit was installed in the AC layer.
	2	0.110	
	3	0.185	
2	4	0.274	This unit was installed below the AC layer into the subgrade.
	5	0.348	
	6	0.424	
	7	0.501	
	8	0.576	
	9	0.727	
	10	0.879	
	11	1.034	
	12	1.186	
	13	1.324	
	14	1.490	
	15	1.642	
	16	1.794	
	17	1.948	
	18	2.098	

Table 5. Location of Electrodes of the Resistivity Probe

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
36	1	0.288
35	2	0.336
34	3	0.386
33	4	0.436
32	5	0.489
31	6	0.524
30	7	0.589
29	8	0.639
28	9	0.689
27	10	0.739
26	11	0.790
25	12	0.843
24	13	0.894
23	14	0.934
22	15	0.994
21	16	1.045
20	17	1.097
19	18	1.147
18	19	1.197
17	20	1.249
16	21	1.300
15	22	1.351
14	23	1.401
13	24	1.452
12	25	1.502
11	26	1.553
10	27	1.603
9	28	1.656
8	29	1.706
7	30	1.758
6	31	1.808
5	32	1.859
4	33	1.908
3	34	1.959
2	35	2.010
1	36	2.060

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

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt)*	Field Moisture Content (by wt)*	Lab Moisture Content (by wt)*
24A01	0.368	Base	6.1%	7.4%	6.9%
24A02	0.514	Subgrade	11.1%	7.8%	7.5%
24A03	0.660		7.7%	5.9%	6.0%
24A04	0.813		16.2%	13.8%	13.5%
24A05	0.990		17.9%	13.5%	14.3%
24A06	1.118		18.3%	20.3%	19.8%
24A07	1.295		19.7%	23.7%	22.0%
24A08	1.422		22.3%	**	**
24A09	1.727		22.3%	**	**
24A10	2.184		21.1%	**	**

* Note: Raw data given in Appendix C
** Note: No field or lab moisture for probes #8, 9, and 10

Site Repair and Cleanup

The instrumentation hole was repaired by reinstalling the 305 mm core. Some juggling was required to get the core level with the existing pavement surface. Once the core was leveled it was removed from the hole and the bottom 100 mm was heavily covered with a two part epoxy (PC-7) and reset into the hole forcing the epoxy against the side and up along the wall of the hole. The weight of the state dump truck, which slowly moved back and forth over the core, was used to firmly seat the core into the hole.

The trench for the cabling from the instrumentation hole to the edge of pavement was leveled with the native sand material to the existing bottom of the paved layer and a cold mix was compacted to the level of the existing surface. The remainder of the trench was filled with native material and compacted, followed by a cleanup of loose material from the paved area. Traffic control was removed at 1800 hours and the lane reopened to traffic. During the next day the instrument hole and edge of the trench were sealed using Corning self-leveling 888 crack sealing compound. Removal of the asphalt trench material and other disposable items were handled by the MDSHA Snowhill maintenance crew.

Patch/Repair Area Assessment

The site has been visited at least once a month since the installation, except for the months of June and August, 1995. The trench area had settled slightly. There exists very slight transverse and longitudinal cracking in the instrument hole area. Overall the site is in good condition.

III. Initial Data Collection

The second day's activities included wiring the instrumentation to the datalogger, initial data collection on the site, and checks on the functioning of installed equipment. This consisted of examination of the data collected over the day by the onsite datalogger, data collection with the mobile datalogger, deflection testing, water table measurements, manual resistivity measurements, and an elevation survey. The onsite datalogger was downloaded on the morning of May 13, 1995, before leaving the area. The initial 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 May 13 by the CR10 datalogger, were examined. The equipment and datalogger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. 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. Only the second set of TDR traces are shown in the appendix because the first set of traces were used to fine tune the starting locations of the traces. The figures indicate that the multiplexers of the mobile system and TDR sensors were working properly, although TDR sensor number 8 may indicate some moisture in the connector or the coaxial lead. Since the installation, all traces of probe number 8 have been good.

Resistance Measurement Data

Resistance data was collected in two modes, automated and manual. The MOBILE data acquisition system automatically performs two point contact resistance measurements and stores the values in terms of millivolts between adjacent electrodes. Figure D-4 shows pavement depth versus measured voltage produced by the MOBILE system. The second and third readings were erroneous, thus they have been omitted from the plot.

Manual contact resistance and resistivity measurements were performed using a Simpson Model 420d function generator, a Fluke Voltmeter, a Fluke Ammeter, and a FHWA switching box. The measured contact resistance and four-point resistivity data are plotted in Figure D-5 and Figure D-6 respectively. Table D-2 and D-3 in Appendix D shows the raw data for the 2-point and the 4-point resistance respectively.

The general trend of the automated resistance voltage, manual contact resistance, and the four-point resistivity collected are similar. The data appears to be consistent with what could be expected for the materials and conditions at the site.

Deflection Measurement Data

Deflection measurements followed procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines". Data collected on the installation day was affected by equipment problems. Time constraints did not permit fixing these problems. The analysis results from the FWDCHECK program from May 11, 1995 are presented in Appendix D. Since then, FWD data has been collected on July 06, September 19, December 13, 1995, January 17, February 14, February 28, March 13, April 17, and May 08, 1996.

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). The first survey was performed on November 06, 1995, the second on February 24, 1996, and the third on April 17, 1996.

Elevation Surveys

A surface elevation survey of the site was performed following the guidelines. It was assumed that the elevation at the top of the piezometer pipe was 1.000 meters. The survey was conducted on May 12, 1995 and the results are presented in Appendix D. Since then, five more sets of the surface elevation surveys have been performed, the first on July 06, 1995, then on October 19, 1995, January 17, 1996, February 14, 1996, and April 17, 1996.

Water Depth

The water level on May 12, 1995 was approximately 1.46 m below the top of the piezometer. The water table has been monitored during every visit to the site since. The lowest recorded water table of 3.36 m was on December 13, 1995 and the highest value of 0.65 m was recorded on February 14, 1996. The water table at this site is highly variable because of the very permeable sand and silt soils. We have observed fluctuations of 0.45 m within six hours.

IV. Summary

The installation of the seasonal monitoring instrumentation at the GPS site 241634 near Ocean City, MD was completed on May 11, 1995. The installation was initially scheduled for May 10, 1995, but it was rescheduled because of the rain. A check of the equipment and initial data collection was completed on May 13, 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,
- Resistivity probe for frost depth 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 and the frost depth are to be collected during each site visit (14 times per year) using a mobile datalogger system. The water level, electrical resistivity, and elevation data are to be collected manually during site visits.

The test section is on Eastbound route 90, 1.0 km East of US 50. The site is located in a flat low lying area. Farmers fields start at the road right of way on both sides of the road. The pavement resides in a slightly elevated platform and consists of one 3.7 m wide lane in each direction with a 3.0 m wide paved outside shoulder. There was some water present at the bottom of the ditch on the side of the road. The pavement structure consists of 211 mm of asphalt concrete over fine sand base. This resides on layers of fine sand and silts over a firm silt/clay foundation.

All instrumentation was checked prior to installation at the PMSL facility in Amherst, NY. These initial checks indicated that the instrumentation was within specifications, as required for the seasonal monitoring program. Operational checks during installation and the following day indicated that all instrumentation was functioning properly. The 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. A check of the tipping bucket indicated it was functioning correctly with tips corresponding to amount of water supplied.

Moisture content of the soil was determined by TDR method, field moisture determination at time of installation by soil drying, and laboratory results provided by MDSHA Materials and Research Unit. The moisture content determined by the TDR, and from soil samples taken in the field generally compared favourably.

The installation proceeded as expected with only a few minor problems. The installation was completed and the section was opened to traffic by 1800 hours. The combination piezometer/bench mark installation was altered slightly to counter the collapsing of the soil soon after drilling the hole. The removal/replacement of the material from the instrumentation hole was complicated by the presence of water in the hole. The bottom layer of the instrument hole was not compacted as firmly as the top layers because of the presence of the excess moisture. This resulted in material having to be discarded to match the profile depths during the replacement of the soil. The stiff sand layers near the top of the instrument hole should provide adequate stability to the pavement and the instrumentation. We will monitor this location to identify any settling.

Subsequent to the installation it was identified that rehabilitation may occur at this site earlier than expected. At this time there are no definitive plans as to when this site may be rehabilitated.

The ongoing monitoring of this section is progressing fairly well. For the peak season test periods traffic control is provided between 5:00 and 8:30 a.m. This has enabled us to collect at least one cycle of FWD tests.

APPENDIX A

Test Section Background Information

Appendix A contains the following supporting information:

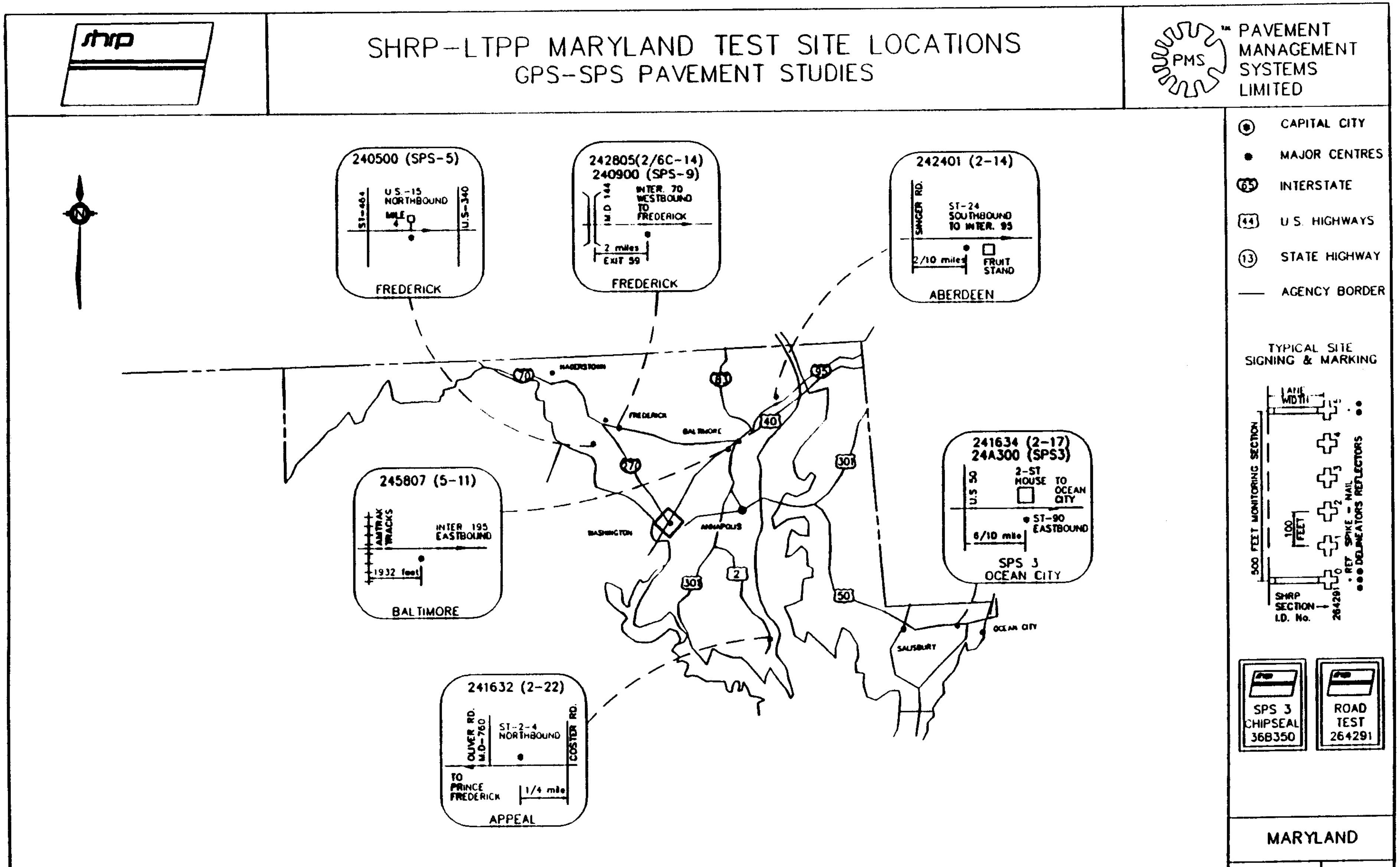


FIGURE A-1 SITE LOCATION MAP - SECTION 241634

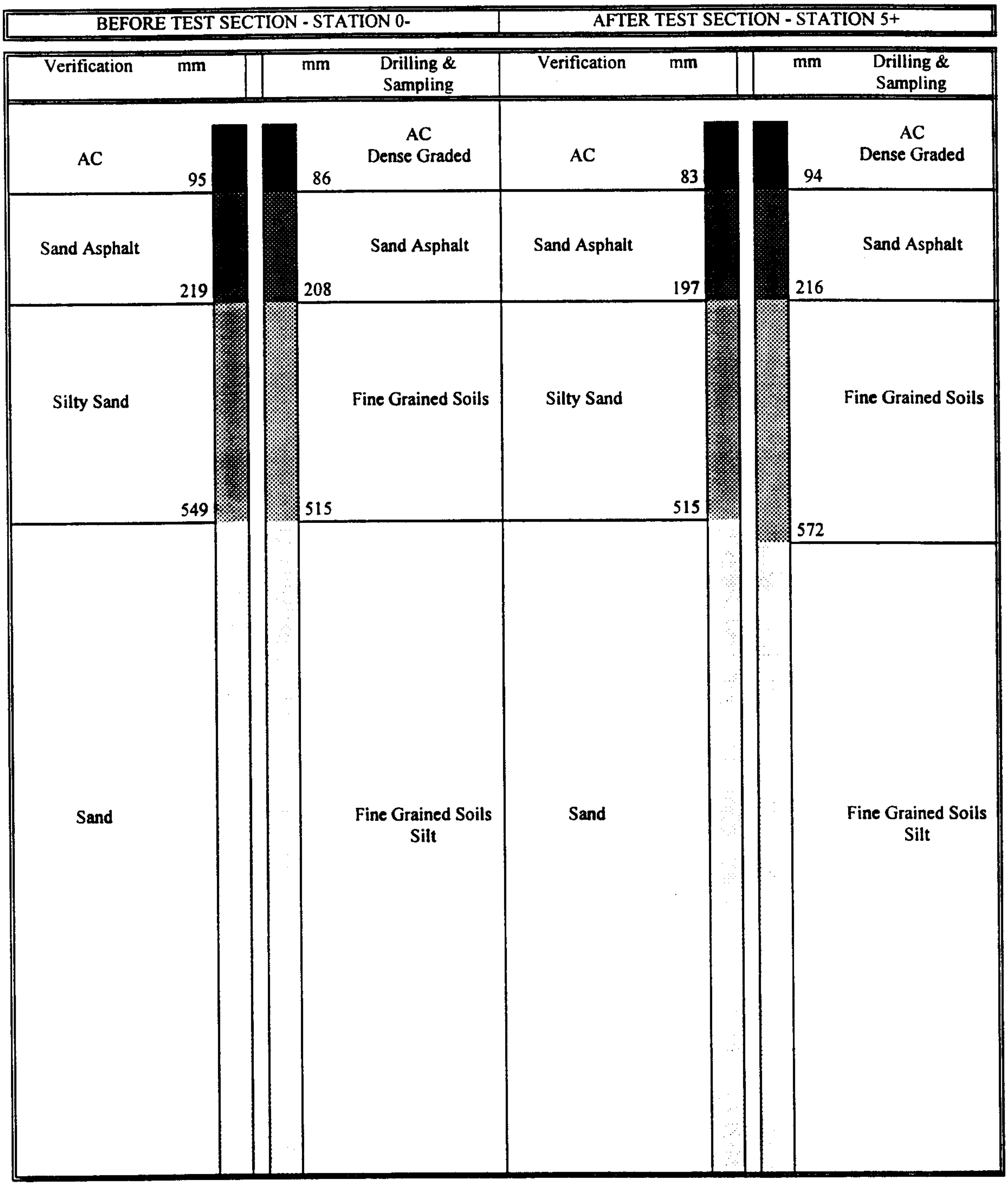


Figure A-2. Profile of Pavement Structure

Table A-1. Site Performance Summary

Distress and Profile Summary		
Distress Summary September 20, 1995	Profile Summary	
	Date (dd-mm-yy)	IRI (in/mi)
Low Sev. Long. Crack.(wheel path)- 11m	26-03-90	60.41
Low Sev. Long. Crack.(non-w.path)-162.9m	05-12-90	62.59
Low Sev. Trans. Crack.- 112 Cracks (16.2m)	19-06-91	64.65
Low Sev. Fatigue Cracking - 67.2 m^2	25-06-92	65.10
	15-06-93	59.15
	18-06-94	59.57
	06-10-95	58.23

Falling Weight Deflectometer Data Summary

Date	Mean Value for Drop HT 2 (mils)					
	Sensor 1	Sensor 1 std. dev.	Sensor 7	Sensor 7 std. dev.	Mean Temp D1 (F)	Min/Max TempD1(F)
26-04-89	11.10	0.84	1.35	0.06	76	67/88
16-04-90	9.84	0.61	1.48	0.08	58	51/66
02-12-93	7.96	0.41	1.32	0.06	51	44/58

	Effective SN	SN std dev	Subgrade Modulus (psi)	Modulus std dev (psi)	Test Pit Mod. (psi)	
					1	2
26-04-89	4.99	0.17	26655	1053	27053	26262
16-04-90	5.29	0.10	25331	638		
	5.09	0.17	22470	1011		
02-12-93	5.63	0.11	27564	533		
	5.51	0.20	25983	717		

Note: FWD subsection boundary at 210 ft for 16-04-90 test and at 335 ft for 02-12-93 as entered into RIMS.

Table A-2. Uniformity Survey Results

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 241634	Data Collection and
Date Surveyed: April 04, 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	10.09	1.25	1.31	0.06	26994	1304	5.17	0.27
250 - 600	10.12	0.60	1.38	0.04	25946	933	5.19	0.15

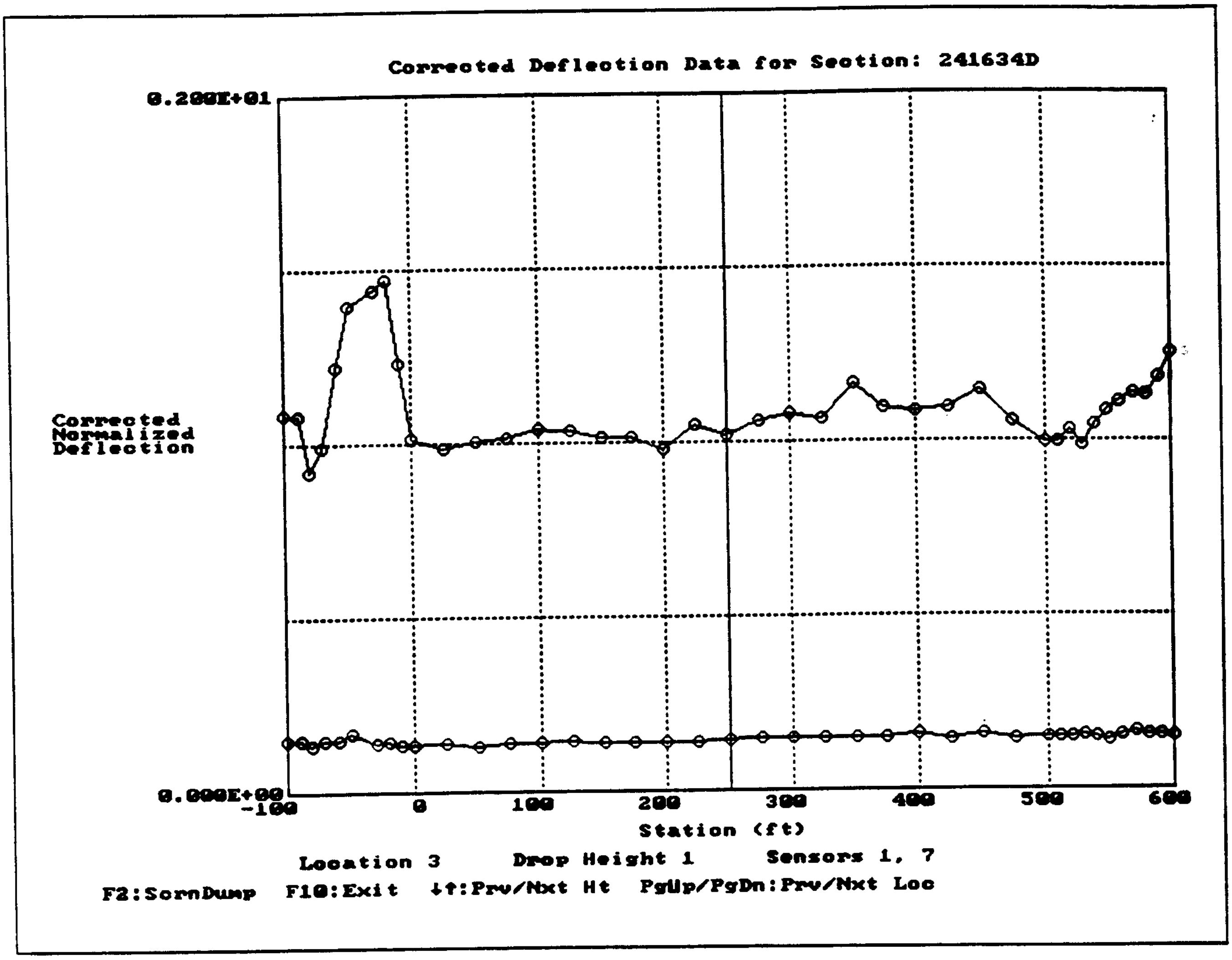


Figure A-3. Deflection Profile from FWDCHECK
(Test Date April 04, 1995)

Table A-3. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date April 04, 1995)

Flexible Pavement Thickness Statistics - 241634DA - Drop Height 2			
Subsection	Station	Subgrade Modulus	Effective SN
1	-100	26057	5.20
	-89	26524	5.15
	-80	27526	5.55
	-70	26824	5.40
	-60	25439	4.95
	-50	24769	4.70
	-30	27283	4.60
	-20	23677	4.65
	-10	27773	4.85
	0	28020	5.35
	25	26990	5.40
	50	29717	5.30
	75	27479	5.30
	100	28182	5.20
	125	26833	5.25
	151	27408	5.30
	175	27674	5.30
	200	27529	5.40
	225	26475	5.25
	250	27694	5.30
2	275	26491	5.25
	300	26151	5.20
	325	26046	5.25
	351	24656	5.05
	245	26350	5.10
	400	24687	5.25
	425	26655	5.15
	450	28051	5.00
	475	26256	5.25
	500	26068	5.40
	510	27001	5.35
	520	25956	5.35
	530	25724	5.45
	540	26152	5.25
	550	26369	5.20
	560	24390	5.20
	570	24523	5.10
	580	25205	5.10
	590	25280	5.00
	600	26901	4.80
Subsection 1	Overall Mean	26994	5.17
	Standard Deviation	1304	0.27
	Coeff of Variation	4.83%	5.25%
Subsection 2	Overall Mean	25946	5.19
	Standard Deviation	933	0.15
	Coeff of Variation	3.60%	2.97%

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. Electrical Resistivity Probe Check and Sensor Spacing

Table B-5. TDR Probes Calibration

Figure B-1. TDR Traces Obtained During Calibration

PAVEMENT
MANAGEMENT
SYSTEMS

March 14, 1995
50451025-12.17

Mr. Al Blazucki
Special Projects Engineer
Maryland State Highway Administration
2323 West Joppa Road, Room 152
Brooklandville, Maryland 21022

RE: Seasonal Monitoring of GPS 241634 - Installation Planning Meeting

Dear Mr. Blazucki:

As per our telephone conversation of March 13, 1995, Brandt Henderson and myself will attend the meeting you have arranged for 9am in your office on April 12, 1995, to discuss details of installation of instrumentation for seasonal monitoring of the GPS 241634 site, Ocean City, Maryland.

It is expected that traffic control at the site will be needed for two days, that coring equipment and field crew would be needed for one day, and that a temporary benchmark can be referenced so as to establish a datum for measuring volume changes. The NA Region's FWD will make initial observations.

It is expected that a date(s) for the installation can be scheduled, (week of May 22, 1995) and contacts and communication links established for coordination of installation activities. Monitoring of the site will likely not begin until the fall of 1995. A tentative monitoring schedule will be provided shortly.

Copies of the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines", FHWA-RD-94-110, April 1994, were sent out earlier this year, but additional copies are available on request.

Thank you for your participation in this major LTPP project.

Yours Sincerely,

William A. Phang
Program Manager
Pavement Management Systems Limited

C.C. I.J. Pecnik, B. Henderson

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

ORIGINAL

PAVEMENT
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FAX MEMO

TO	Al Blazucki - MD SHA (410) 321-2208	**DATE**	April 20, 1995
		PAGES	1
FROM	Brandt Henderson BH	**PROJECT**	50451025
SUBJECT	Seasonal Site 241634 (MD90) Ocean City Pre-Installation Inspection	**FILE**	12.17

As per our discussion, I will be visiting the LTPP seasonal site 241634 on MD90 eastbound on April 26, 1995 to establish a suitable location for the instrumentation/equipment cabinet and review site condition pertinent to installation and data collection.

Plans are to meet with George Wilson, Geotechnical Services at the end of the ramp for 90 at 10:30am to discuss the drilling plan, determine potential depth to water table and stake out location for underground utility clearance.

A site plan view with visit comments will follow.

C.C. I.J. Pecnik, RE, NARO
W.A. Phang, NARO

415 LAWRENCE BELL DRIVE, Unit 3, Amherst, N.Y. 14221 Tel. (716) 632-0804; Fax (716) 632-4808

FAX TRANSMITTAL

To:	Al Blazucki	**Fax No.:**	410-321-2208
		Date:	May 4, 1995
		Project No.:	5-045-10-25
Sender:	Brandt Henderson		
		Includes cover sheet plus 3 pages	
Reference:	Seasonal Site Review	☑	Original will follow by mail

FAXED

MESSAGE:

To follow up the site visit of April 26, 1995, please find enclosed a site plan view and diagram of projected instrument placement in the outer wheel path of 90 eastbound at station 5+20 GPS 241634.

The drilling and sampling records from 1989 field sampling did not include a shoulder bore identifying the depth to water table. From the site review the pavement is elevated 3 - 4 ft from the adjacent cultivated fields. Visually there was nothing to indicate that we may encounter the water table within the 7 ft depth proposed for the instrument hole. A shallow drainage ditch exists approximately 1500 ft south of the roadway which was moist but not flowing at the time of review.

The location of the piezometer, instrumentation, equipment cabinet and weather instrumentation pole as identified in the planview have been marked with stakes and white paint for utility clearance identification. Utility clearances are to be arranged by George Wilson prior to the drilling and trenching on May 10, 1995. If there is any problem with clearances we can review and arrange alternate locations as part of the preinstallation meeting on May 9, 1995.

From our discussions on Wednesday it sounds like preparation for arranging equipment and supplies for the installation are well underway. The following summarizes the supply items requested from the agency.

- Cold or Hot Mix Patching Material
- Filter Sand
- Bentonite
- Concrete Mix (Sacrete)
- Surface Access Cover for Piezometer

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

We also require the loan of a standard procter mold, hammer and balance capacity (11.5 kg readable 5 gm) for density determination of the subgrade material. As verification of field moisture we are also requesting the agency provided laboratory moisture values for soil samples taken at each TDR installation location (10 in total). The Pavement Management System employees coming for the installation are:

Brandt Henderson	Team Leader
Alfred Lip	Engineering Assistant
Doug Marshall	FWD Operator
James Orzulak	Instrument Technician
Dilan Singaraja	Engineering Assistant

Aramis Lopez will be the representative from FHWA-LTPP. As the site is close to Washington there may be some interest from other FHWA personnel.

Accommodation arrangements have been made at the Fenwick Inn, Ocean City.

The pre installation meeting is scheduled for Tuesday May 9 at 1:30 pm at the Snow Hill Garage off Route 113. This meeting is to review the equipment and supply status along with a discussion on the installation day schedule of activities.

If you have any questions or need further information do not hesitate to call. I can be reached at 519-622-3005 for the remainder of this week.

We look forward to seeing you and your coworkers on May 9.

Copies: Aramis Lopez, (w/o attachments)

Table B-1. Air Temperature Thermistor Calibration

LTPP Seasonal Monitoring Study	State Code	[24]
Air Temperature Thermistor Calibration	Test Section Number	[1634]

Before Operation Checks	Calibration Date dd-mm-yy	05-05-95
	Probe S/N	24AAT
	Operator	JO

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
20.77	19.67	21.70	22.0	1400	0.818	1600	62.30	1200	y

Probe Accepted	J.O.	(Initials)

Table B-2. MRC Probe Calibration

LTPP Seasonal Monitoring Study	State Code	[24]
MRC Probe Calibration	Test Section Number	[1634]

Before Operation Checks	Calibration Date dd-mm-yy	05-05-95
	Probe S/N	24AT
	Operator	JO

	Mobile Datalogger (24 hour)			Water Room Temp Time 1400	Ice Bath 0 °C (+/- 1 °C) Time 1600	Hot Water 50 °C (+/-) Time 1200	ok
No.	Mean	Min.	Max.	Reading	Reading	Reading	y/n
1	20.59	19.74	20.87	22.9	0.68	63.2	y
2	20.65	19.79	20.97	22.1	0.49	63.9	y
3	20.77	19.98	21.08	21.9	1.93	63.8	y
4	20.90	20.14	21.18	22.1	3.62	49.7	y
5	20.97	20.32	21.21	21.9	1.93	51.9	y
6	21.15	20.76	21.78	21.9	2.10	51.7	y
7	20.97	20.50	21.42	21.9	2.21	51.8	y
8	20.91	20.45	21.39	21.9	2.07	52.7	y
9	20.83	20.37	21.26	22.1	2.00	51.4	y
10	20.83	20.32	21.21	21.8	1.11	52.6	y
11	20.74	20.35	21.23	21.7	1.39	51.8	y
12	20.70	20.27	21.16	21.6	1.07	52.7	y
13	20.60	20.25	21.16	21.5	1.22	53.6	y
14	20.40	20.19	21.06	21.6	1.00	54.1	y
15	20.48	20.07	20.98	21.7	0.64	54.0	y
16	20.38	19.98	20.79	21.8	0.50	54.1	y
17	20.21	19.88	20.64	21.9	0.17	52.6	y
18	20.16	19.98	20.33	21.9	1.37	51.8	y

Probe Accepted:	J.O.	(Initials)
Probe Length:	1.852	(meters)

Thermistor distance from top of probe in meters									
4	0.020	7	0.247	10	0.625	13	1.083	16	1.540
5	0.094	8	0.322	11	0.780	14	1.236	17	1.694
6	0.170	9	0.473	12	0.932	15	1.388	18	1.844

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	0.176	
	3	0.326	
2	4	0.020	1.851 m long by 25.4 mm PVC tube installed in the base and subgrade.
	5	0.094	
	6	0.170	
	7	0.247	
	8	0.322	
	9	0.473	
	10	0.625	
	11	0.780	
	12	0.932	
	13	1.083	
	14	1.236	
	15	1.388	
	16	1.540	
	17	1.694	
	18	1.844	

Table B-4. Resistivity Probe and Sensor Spacing

LTPP Seasonal Monitoring Program Data Sheet SMP-C03 Resistivity Probe Check					Agency Code [24] LTPP Section ID [1634]		
Connector Pin No.	Electrode Number	Distance from Top (m)			Continuity x	Spacing (m)	Comments
		Line 1	Line 2	Avg.			
36	1	0.034	0.033	0.034	x	0.048	
35	2	0.083	0.081	0.082	x	0.050	
34	3	0.132	0.131	0.132	x	0.050	
33	4	0.183	0.181	0.182	x	0.053	
32	5	0.236	0.234	0.235	x	0.048	
31	6	0.284	0.282	0.283	x	0.052	
30	7	0.336	0.334	0.335	x	0.050	
29	8	0.386	0.384	0.385	x	0.050	
28	9	0.436	0.434	0.435	x	0.050	
27	10	0.485	0.485	0.485	x	0.051	
26	11	0.537	0.535	0.536	x	0.053	
25	12	0.590	0.588	0.589	x	0.051	
24	13	0.641	0.639	0.640	x	0.050	
23	14	0.691	0.689	0.690	x	0.050	
22	15	0.741	0.739	0.740	x	0.051	
21	16	0.792	0.790	0.791	x	0.052	
20	17	0.844	0.842	0.843	x	0.050	
19	18	0.894	0.892	0.893	x	0.050	
18	19	0.944	0.942	0.943	x	0.051	
17	20	0.995	0.993	0.994	x	0.052	
16	21	1.046	1.045	1.046	x	0.051	
15	22	1.098	1.096	1.097	x	0.050	
14	23	1.148	1.146	1.147	x	0.051	
13	24	1.198	1.198	1.198	x	0.050	
12	25	1.248	1.247	1.248	x	0.051	
11	26	1.299	1.298	1.299	x	0.050	
10	27	1.349	1.349	1.349	x	0.052	
9	28	1.401	1.400	1.401	x	0.051	
8	29	1.452	1.451	1.452	x	0.052	
7	30	1.504	1.503	1.504	x	0.050	
6	31	1.554	1.553	1.554	x	0.051	
5	32	1.605	1.604	1.605	x	0.049	
4	33	1.654	1.653	1.654	x	0.051	
3	34	1.705	1.704	1.705	x	0.051	
2	35	1.756	1.755	1.756	x	0.050	
1	36	1.806	1.805	1.806	x		
	Bottom	1.830	1.830	1.830			

Prepared by	JO	Employer	PMSL
Date (dd-mm-yy)	05-05-95		

Table B-5. TDR Probes Calibration

LTPP Seasonal Monitoring Study	State Code	[24]
TDR Probes	Test Section Number	[1634]

Before Operation Checks	AL/JO	Initial	Calibration Date (dd-mm-yy)	10-05-95
			Seasonal Site	24SA

No.	Probe (S/N)	Resistance (ohms)		Probe Shorted		Air	Alcohol	Water
		Core	Shield	Begin Length	End Length	Begin Length	Begin Length	Begin Length
1	24A01	0.3	0.3	16.31	16.53	16.32	16.32	16.36
2	24A02	0.4	0.3	16.32	16.53	16.32	16.35	16.36
3	24A03	0.3	0.3	15.88	16.10	15.88	15.91	15.91
4	24A04	0.3	0.3	16.33	16.53	16.33	16.35	16.37
5	24A05	0.8	0.3	16.34	16.52	16.34	16.34	16.34
6	24A06	0.4	0.3	15.87	16.07	15.87	15.92	15.92
7	24A07	0.3	0.3	15.88	16.04	15.88	15.91	15.91
8	24A08	0.4	0.3	16.36	16.53	16.36	16.36	16.38
9	24A09	0.4	0.3	16.33	16.54	16.33	16.35	16.42
10	24A10	0.4	0.3	*	16.56	16.36	16.38	16.38

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	0.22	1.19	y	1.18	34.47	y	1.85	84.4	y
2	0.22	1.19	y	1.10	29.96	y	1.83	82.92	y
3	0.22	1.19	y	1.10	29.96	y	1.84	83.80	y
4	0.20	0.99	y	1.15	32.74	y	1.85	84.74	y
5	0.18	0.80	y	1.15	32.74	y	1.87	86.58	y
6	0.20	0.99	y	1.15	32.74	y	1.85	84.74	y
7	0.20	0.99	y	1.18	34.47	y	1.87	86.58	y
8	0.20	0.99	y	1.17	33.89	y	1.87	86.58	y
9	0.21	1.09	y	1.17	33.89	y	1.85	84.74	y
10	0.20	0.99	y	1.18	34.47	y	1.85	84.74	y

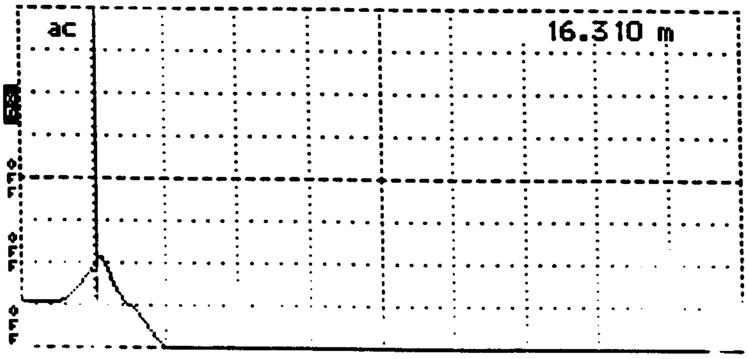
* Note: This trace has been misplaced.

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A01 Date (dd/mm/yy): 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 16.310 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac

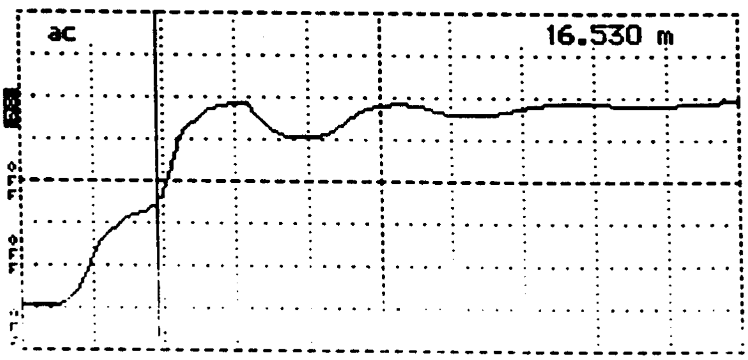


Tektronix 1502B TDR
Date 05-09-95
Cable #1
Notes 241634 MD Short start

Input Trace
Stored Trace
Difference Trace

Trace 2 -Probe Shorted at End

Cursor .... 16.530 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 05-09-95
Cable #1
Notes Short end

Input Trace
Stored Trace
Difference Trace

Figure B-1. TDR Traces Obtained During Calibration

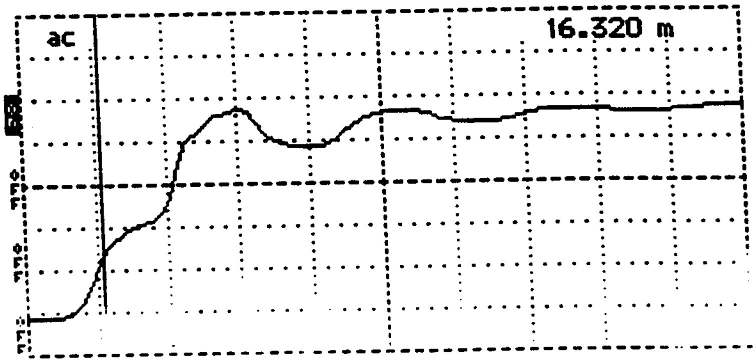
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A01 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.320 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

0.22



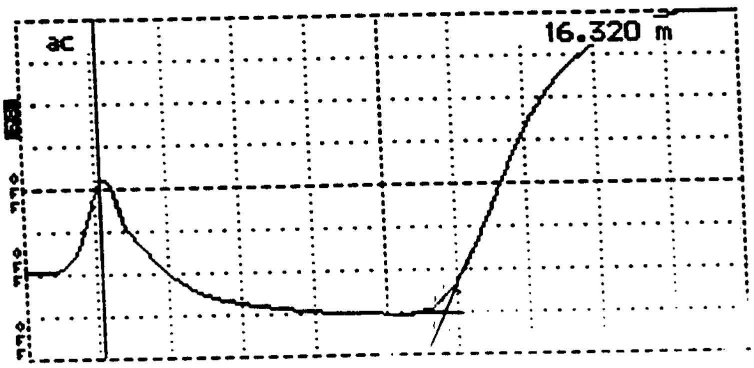
Tektronix 1502B TDR
Date 05-09-95
Cable #1
Notes 241634 MD AIR

Input Trace ———
Stored Trace -------
Difference Trace ....

Trace 4 - Probe in Alcohol

Cursor .... 16.320 m
Distance/Div ..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.4.

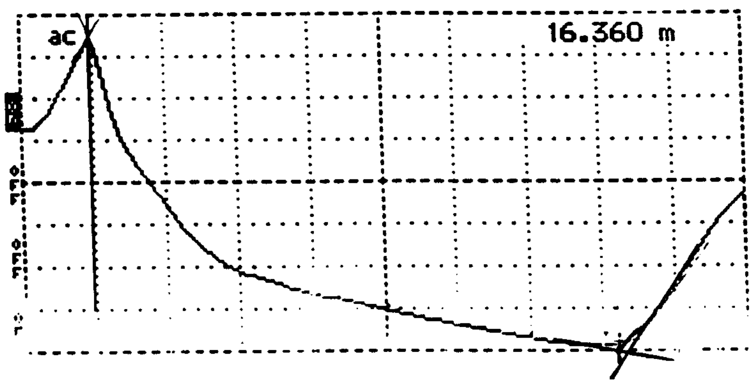


Tektronix 1502B TDR
Date 05-09-95
Cable #1
Notes 241634 Alcohol

Input Trace ———
Stored Trace -------
Difference Trace ....

Trace 5 - Probe in Water

Cursor .... 16.360 m
Distance/Div ..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 05-09-95
Cable #1
Notes 241634 MD WATER

Input Trace ———
Stored Trace -------
Difference ....

1.85? 1.84.

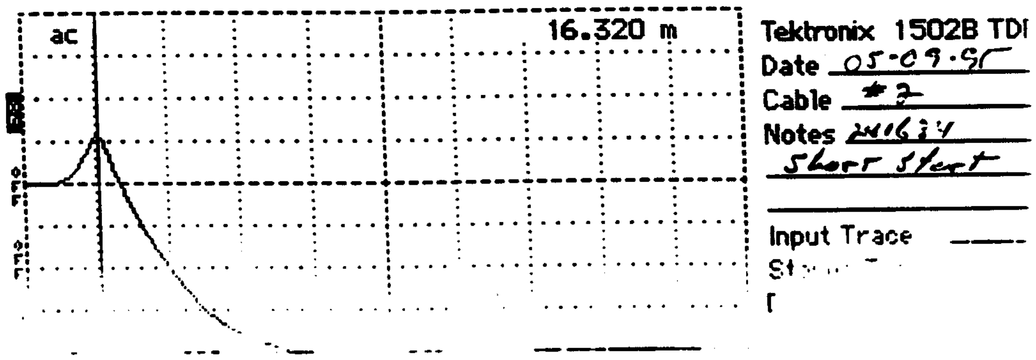
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A02 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 16.320 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac



Trace 2 -Probe Shorted at End

Cursor .... 16.530 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac

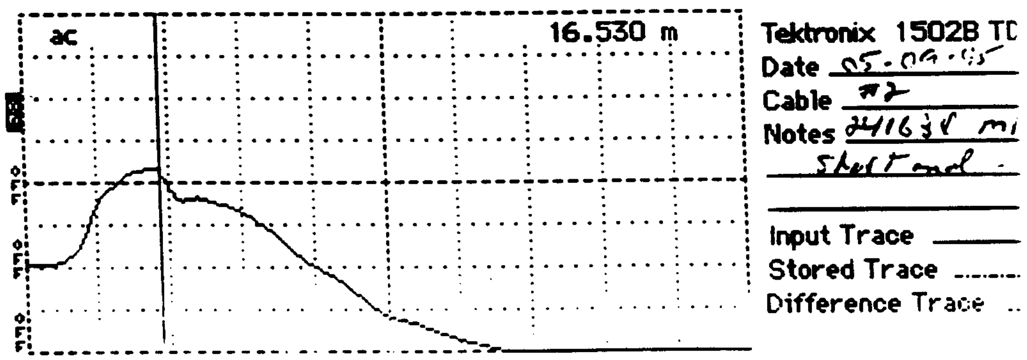


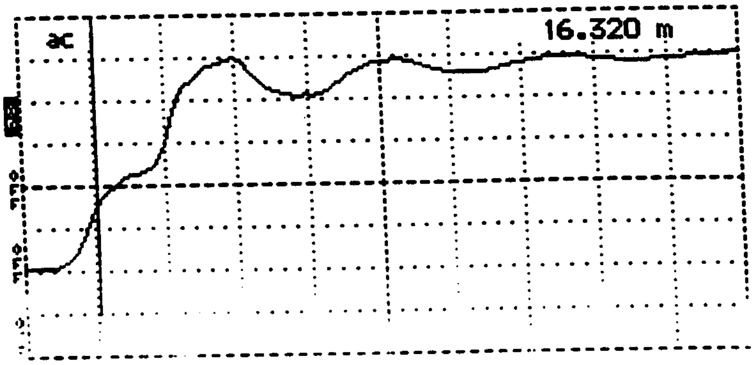
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: LTPP Section ID:	[24] [1634]

Probe Serial Number: 24A02 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.320 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



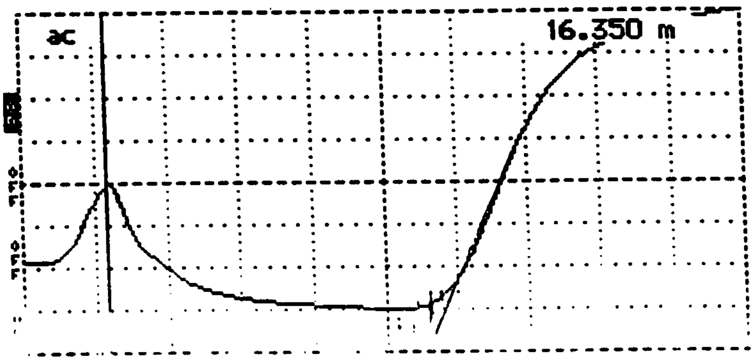
Tektronix 1502B TDR
Date 05-09-95
Cable #2
Notes 241634
air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor .... 16.350 m
Distance/Div..... .25 m/div
Vertical Scale.... 106 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac

1.15
1.20

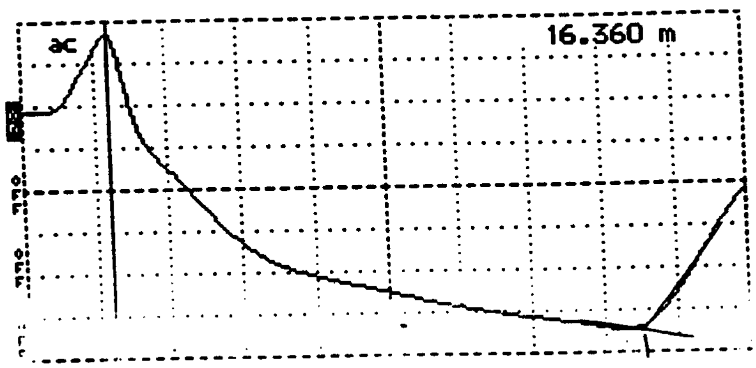


Tektronix 1502B TDR
Date 05-09-95
Cable #2
Notes 241634
alcohol

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor .... 16.360 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 05-09-95
Cable #2
Notes WATER 241

Input Trace
Stored Trace
Difference Trace
1.83 m.

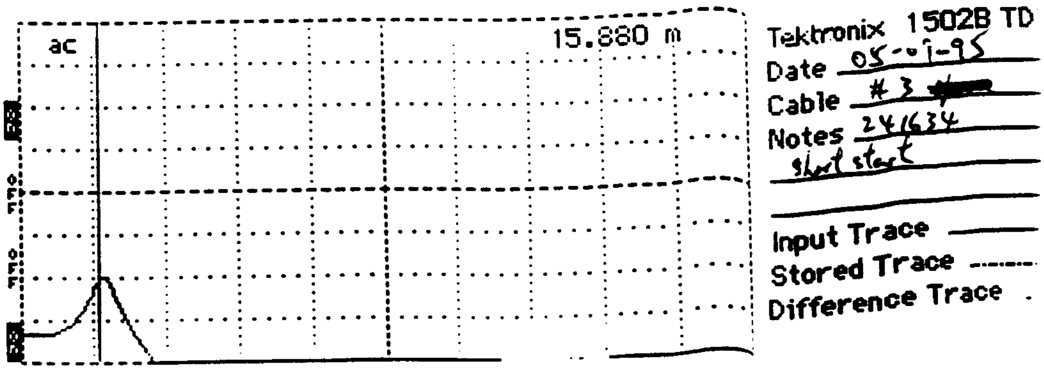
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: LTPP Section ID:	[24] [1634]

Probe Serial Number: 24A03 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 15.880 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac



Trace 2 -Probe Shorted at End

Cursor .... 16.100 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac

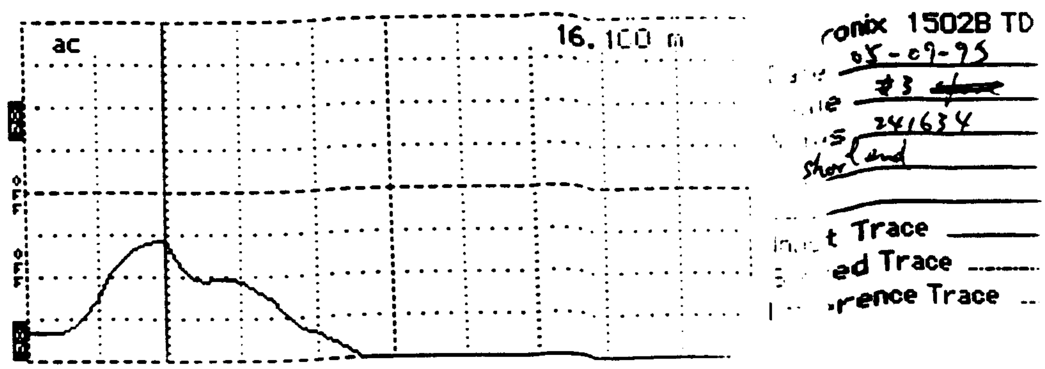


Figure B-1(cont.). TDR Traces Obtained During Calibration

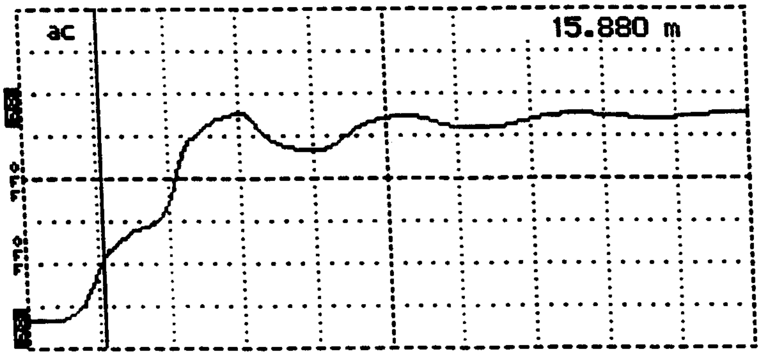
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24AD3 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 15.880 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

0.22



Tektronix 1502B TDR
Date 05-09-95
Cable #3
Notes 241634
Air

Input Trace ———
Stored Trace ------
Difference Trace ...

Trace 4 - Probe in Alcohol

Cursor .... 15.910 m
Distance/Div ..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

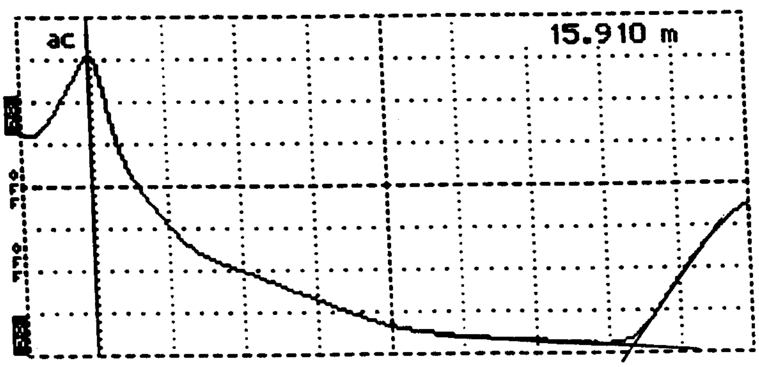
1.1

Tektronix 1502B TDR
Date 05-09-95
Cable #3
Notes 241634
Alcohol

Input Trace ———
Stored Trace ------
Difference Trace ...

Trace 5 - Probe in Water

Cursor .... 15.910 m
Distance/Div ..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 05-09-95
Cable #3
Notes 241634
Water

Input Trace ———
Stored Trace ------
Difference Trace ...

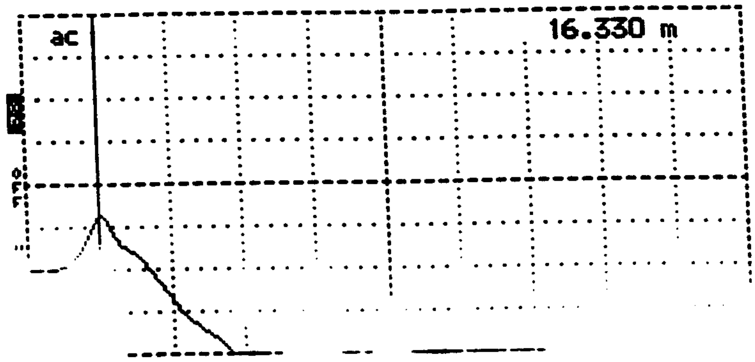
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A04 Date (dd/mm/yy): 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 16.330 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

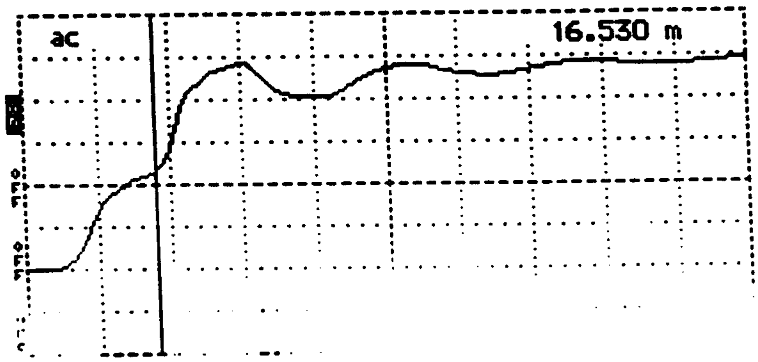


Tektronix 1502B TDR
Date 05-09-95
Cable #4
Notes 24/1634
short start

Input Trace ———
Stored Trace ....
Difference Trace

Trace 2 -Probe Shorted at End

Cursor .... 16.530 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 05-09-95
Cable #4
Notes 24/1634
short end

Input Trace ———
Stored Trace ....
Difference Trace

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

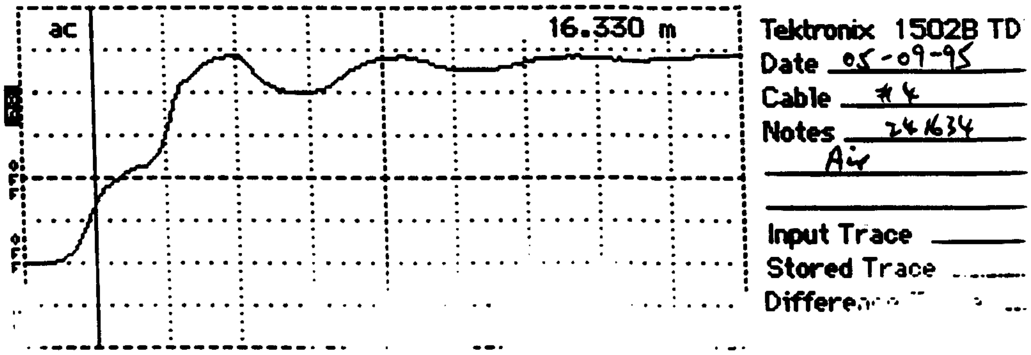
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A04 Date (dd/mm/yy): 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.330 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

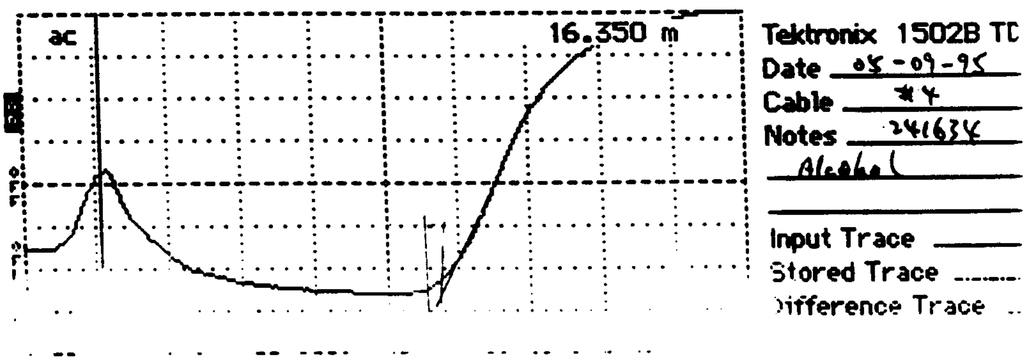
0.20



Trace 4 - Probe in Alcohol

Cursor .... 16.350 m
Distance/Div ..... .25 m/div
Vertical Scale.... 109 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.15



Trace 5 - Probe in Water

Cursor .... 16.370 m
Distance/Div ..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.85

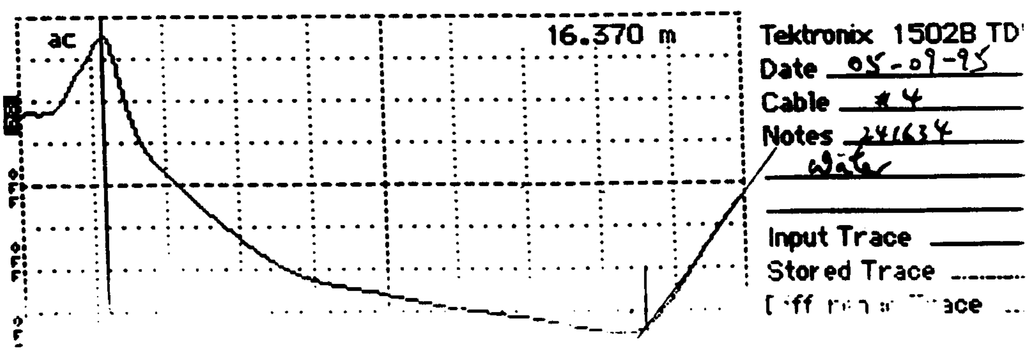


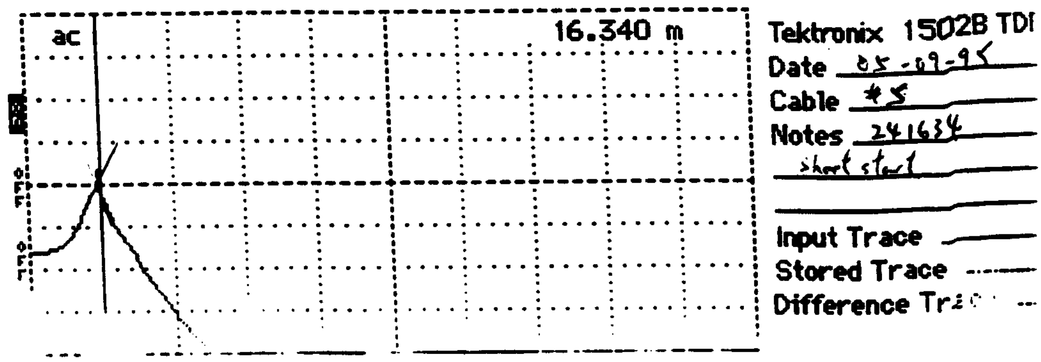
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A05 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 16.340 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Trace 2 -Probe Shorted at End

Cursor .... 16.520 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac

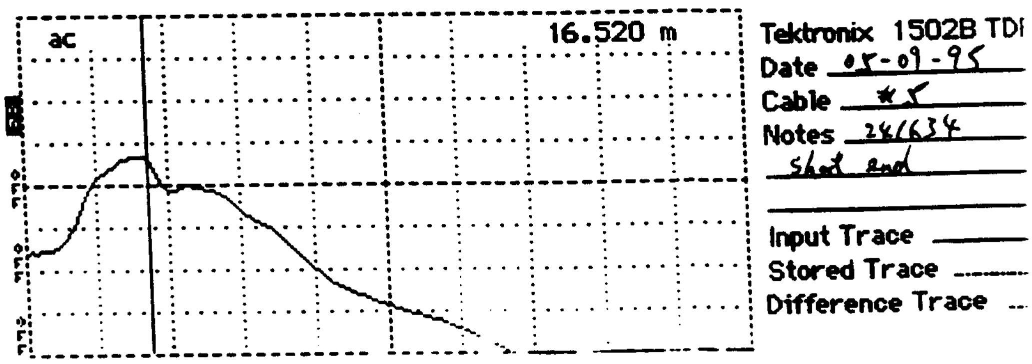


Figure B-1(cont.). TDR Traces Obtained During Calibration

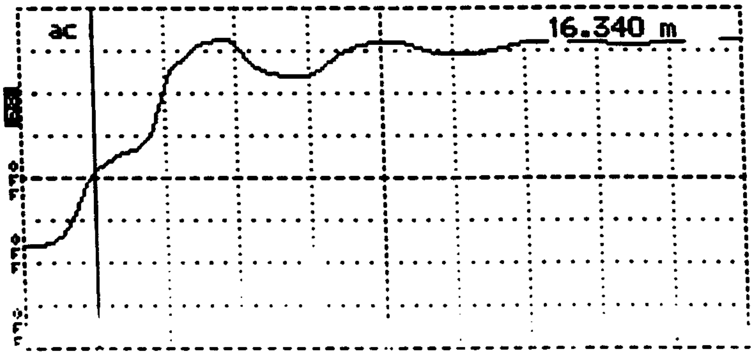
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A05 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.340 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

0.18



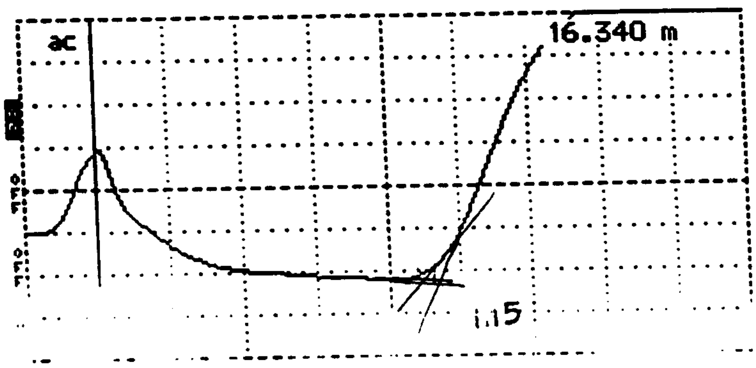
Tektronix 1502B TDR
Date 05-09-95
Cable #5
Notes 241634
Air

Input Trace ______
Stored Trace ......
Difference Trace ....

Trace 4 - Probe in Alcohol

Cursor .... 16.340 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.15



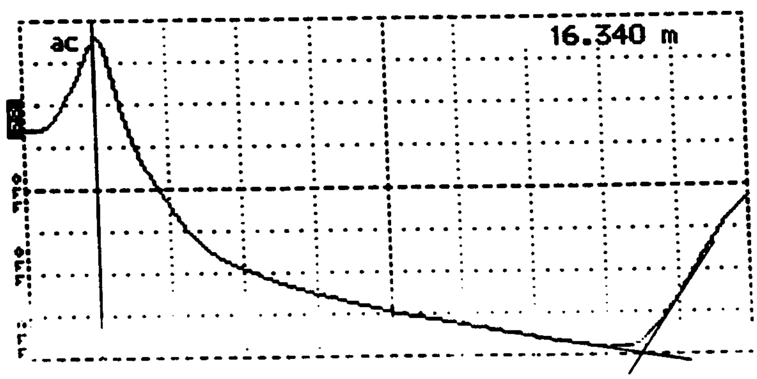
Tektronix 1502B TDR
Date 05-09-95
Cable #5
Notes 241634
Alcohol

Input Trace ______
Stored Trace ......
Difference Trace ....

Trace 5 - Probe in Water

Cursor .... 16.340 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.87



Tektronix 1502B TDR
Date 05-09-95
Cable #5
Notes 241634
Water

Input Trace ______
Stored Trace ......
Difference Trace ....

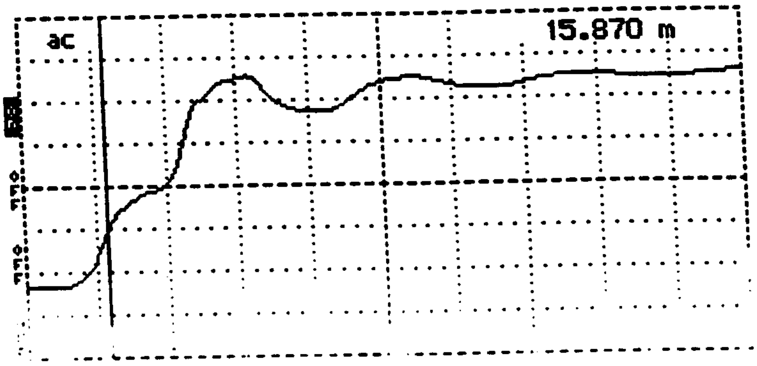
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: LTPP Section ID:	[24] [1634]

Probe Serial Number: 24A06 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 15.870 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac

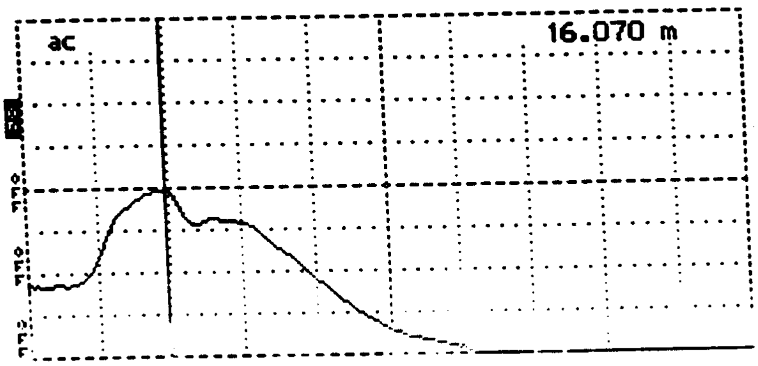


Tektronix 1502B TDR
Date 05-09-95
Cable #6
Notes 241634
short start

Input Trace
Stored Trace
Difference Trace

Trace 2 -Probe Shorted at End

Cursor .... 16.070 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TD
Date 05-09-95
Cable #6
Notes 241634
short end

Input Trace
Stored Trace
Difference Trace

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

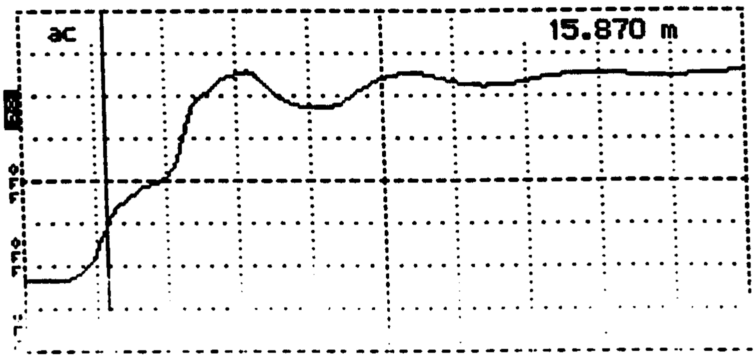
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A06   Date (dd/mm/yy): 09/05/95

Trace 3 - Probe in Air

Cursor .... 15.870 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac

0·2



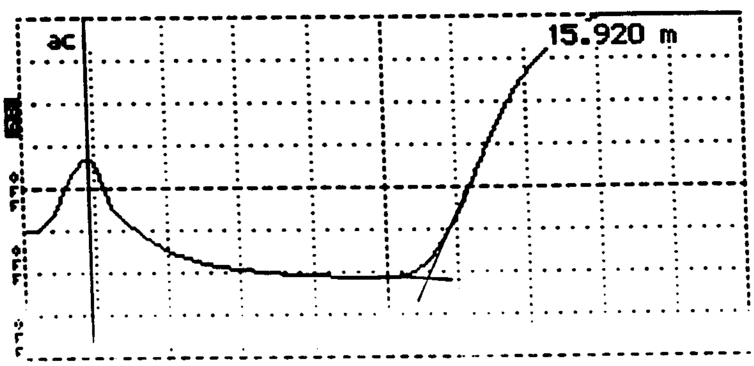
Tektronix 1502B TDR
Date 05-09-95
Cable #6
Notes 241634
Air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor .... 15.920 m
Distance/Div ..... .25 m/div
Vertical Scale.... 109 mρ/div
VP 0.99
Noise Filter ..... 1 avg
Power .... ac

1·15



Tektronix 1502B TDR
Date 05-09-95
Cable #6
Notes 24 1634
Alcohol

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor .... 15.920 m
Distance/Div ..... .25 m/div
Vertical Scale.... 79.2 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac

1·85

Tektronix 1502B TDR
Date 05-09-95
Cable #6
Notes 241634
Water

Input Trace
Stored Trace
Difference Trace

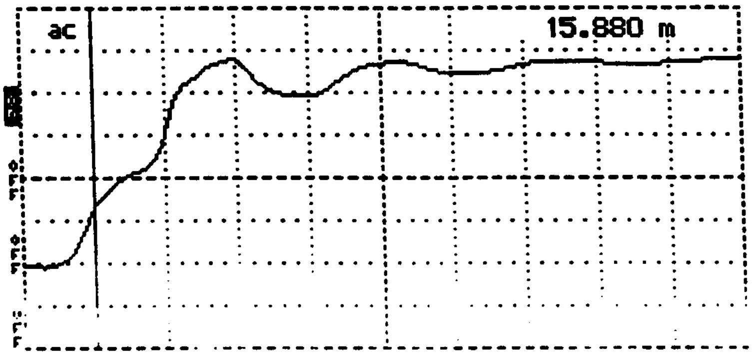
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A07 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 15.880 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

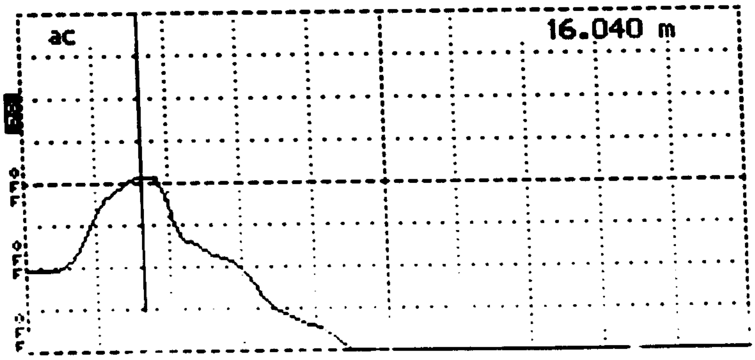


Tektronix 1502B TDR
Date 15-09-95
Cable #7
Notes 241634
short start

Input Trace ———
Stored Trace ....
Difference Trace ...

Trace 2 -Probe Shorted at End

Cursor .... 16.040 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac



Tektronix 1502B TD
Date 05-09-95
Cable #7
Notes 241634
short end

Input Trace ———
Stored Trace ....
Difference Trace ..

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

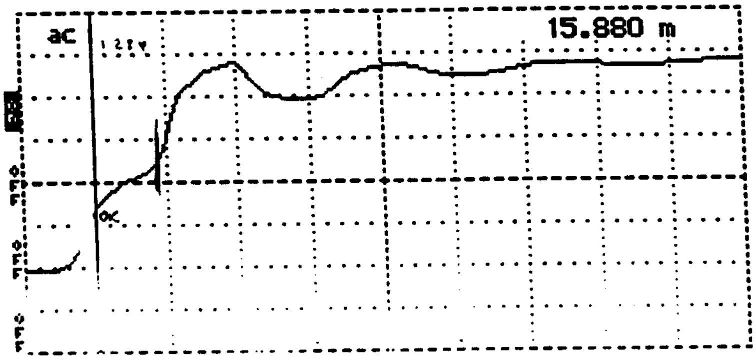
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A07 Date (dd/mm/yy): 09/05/95

Trace 3 - Probe in Air

Cursor .... 15.880 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

0·16 (.20)



Tektronix 1502B TDR
Date 05-09-95
Cable #7
Notes 241634
Air

Input Trace ———
Stored Trace ....
Difference Trace ...

Trace 4 - Probe in Alcohol

Cursor .... 15.910 m
Distance/Div ..... .25 m/div
Vertical Scale.... 109 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1·27

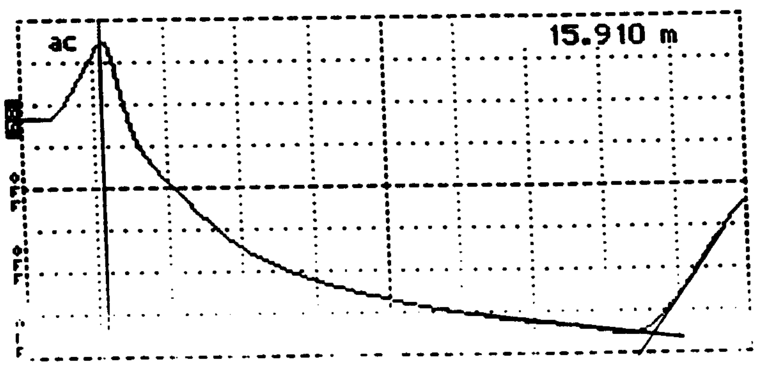
Tektronix 1502B TDR
Date 05-09-95
Cable #7
Notes 241634
Alcohol

Input Trace ———
Stored Trace ....
Difference Trace ...

Trace 5 - Probe in Water

Cursor .... 15.910 m
Distance/Div ..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.95



Tektronix 1502B TDR
Date 05-09-95
Cable #7
Notes 241634
Water

Input Trace ———
Stored Trace ....
Difference Trace ...

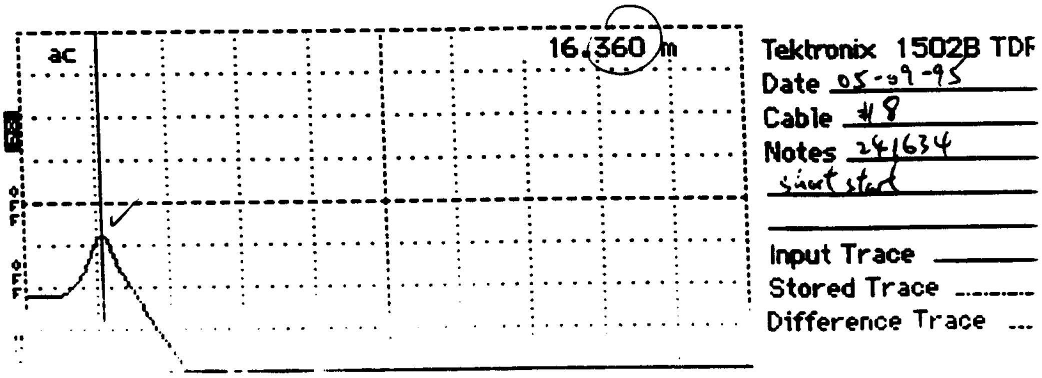
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: LTPP Section ID:	[24] [1634]

Probe Serial Number: 24A08 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 16.360 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac



Trace 2 -Probe Shorted at End

Cursor .... 16.530 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

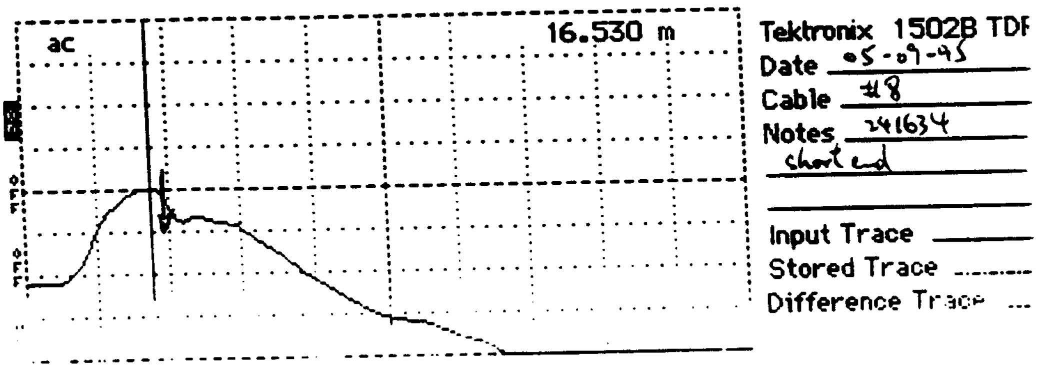


Figure B-1(cont.). TDR Traces Obtained During Calibration

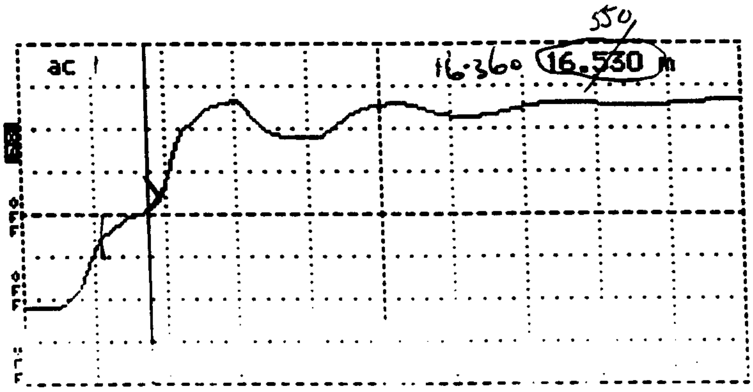
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A08 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.530 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac

0.17 (0.19)



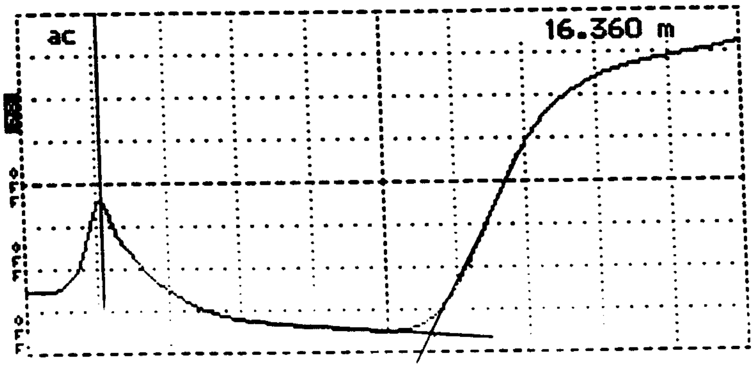
Tektronix 1502B TDR
Date 05-09-95
Cable #8
Notes 241634
Air

Input Trace ———
Stored Trace - - - -
Difference Trace ....

Trace 4 - Probe in Alcohol

Cursor .... 16.360 m
Distance/Div ..... .25 m/div
Vertical Scale.... 109 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac

1.17



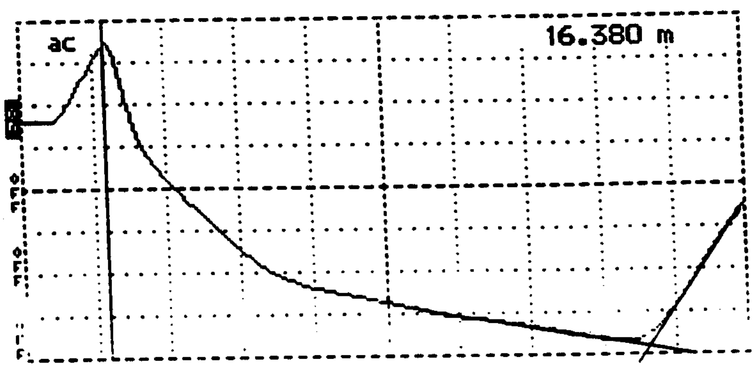
Tektronix 1502B TDR
Date 05-09-95
Cable #8
Notes 241634
Alcohol

Input Trace ———
Stored Trace - - - -
Difference Trace ....

Trace 5 - Probe in Water

Cursor .... 16.380 m
Distance/Div ..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power............ ac

1.95



Tektronix 1502B TDR
Date 05-09-95
Cable #8
Notes 241634
Water

Input Trace ———
Stored Trace - - - -
Difference Trace ....

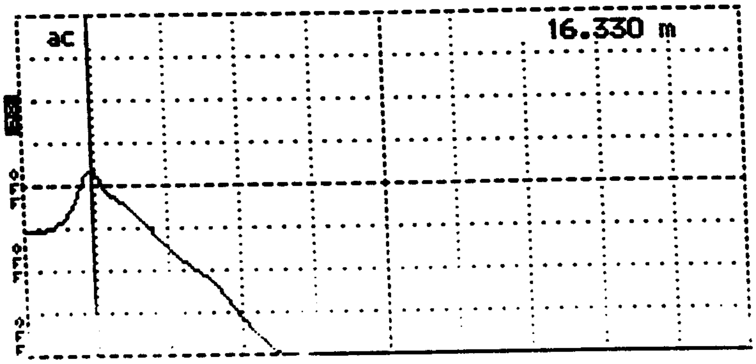
Figure B-1(cont.). TDR Traces Obtained During Calibration

LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A09 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Cursor .... 16.330 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power.......... ac

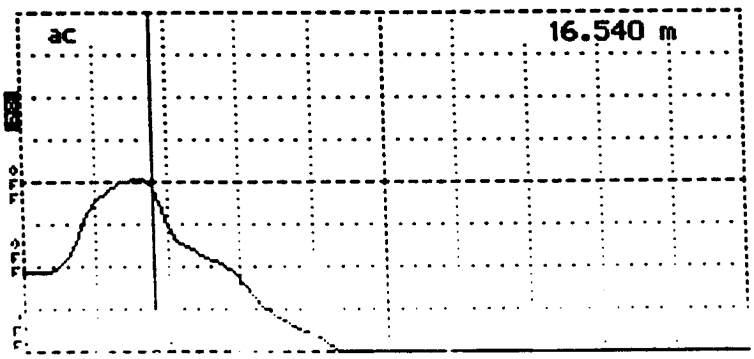


Tektronix 1502B TDR
Date 05-09-95
Cable #9
Notes 241634
short start

Input Trace ———
Stored Trace ....
Difference Trace ....

Trace 2 -Probe Shorted at End

Cursor .... 16.540 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power.......... ac



Tektronix 1502B TDR
Date 05-09-95
Cable #9
Notes 241634
short end

Input Trace ———
Stored Trace ....
Difference Trace ....

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

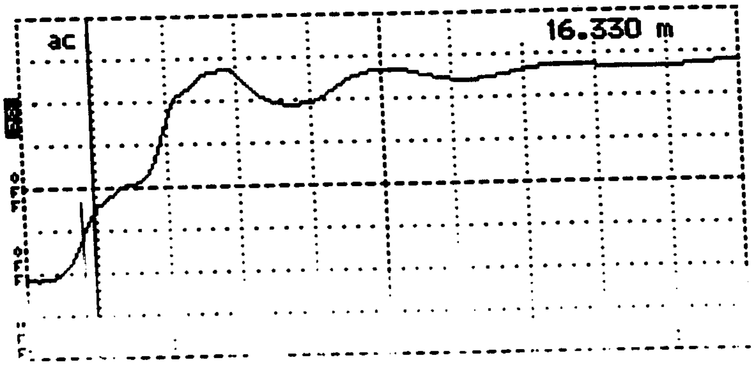
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: [24] LTPP Section ID: [1634]

Probe Serial Number: 24A09 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.330 m
Distance/Div ..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac

0.21



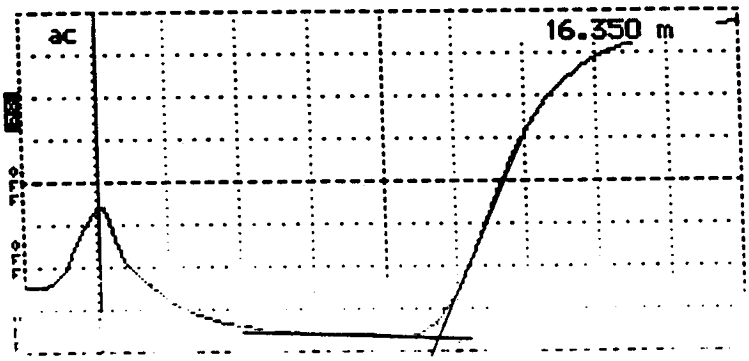
Tektronix 1502B TDR
Date 05-09-95
Cable #9
Notes 241634
Air

Input Trace ———
Stored Trace ....
Difference Trace ...

Trace 4 - Probe in Alcohol

Cursor .... 16.350 m
Distance/Div ..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac

1.17



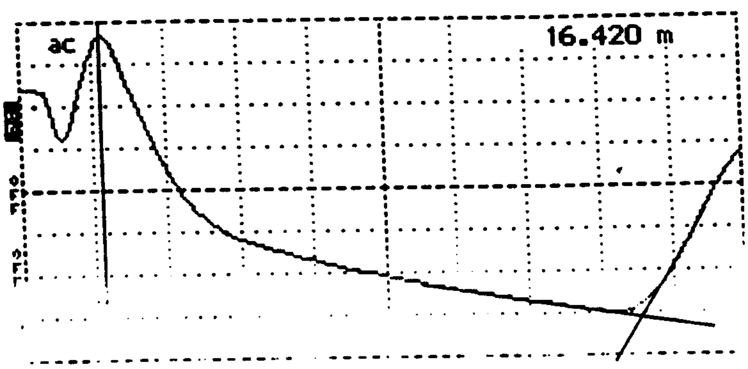
Tektronix 1502B TDR
Date 05-09-95
Cable #9
Notes 241634
Alcohol

Input Trace ———
Stored Trace ....
Difference Trace

Trace 5 - Probe in Water

Cursor .... 16.420 m
Distance/Div ..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac

1.85



Tektronix 1502B TD
Date 05-09-95
Cable #9
Notes 241634
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: LTPP Section ID:	[24] [1634]

Probe Serial Number: 24A10 **Date (dd/mm/yy):** 09/05/95

Trace 1 - Probe Shorted at Start

Trace 2 -Probe Shorted at End

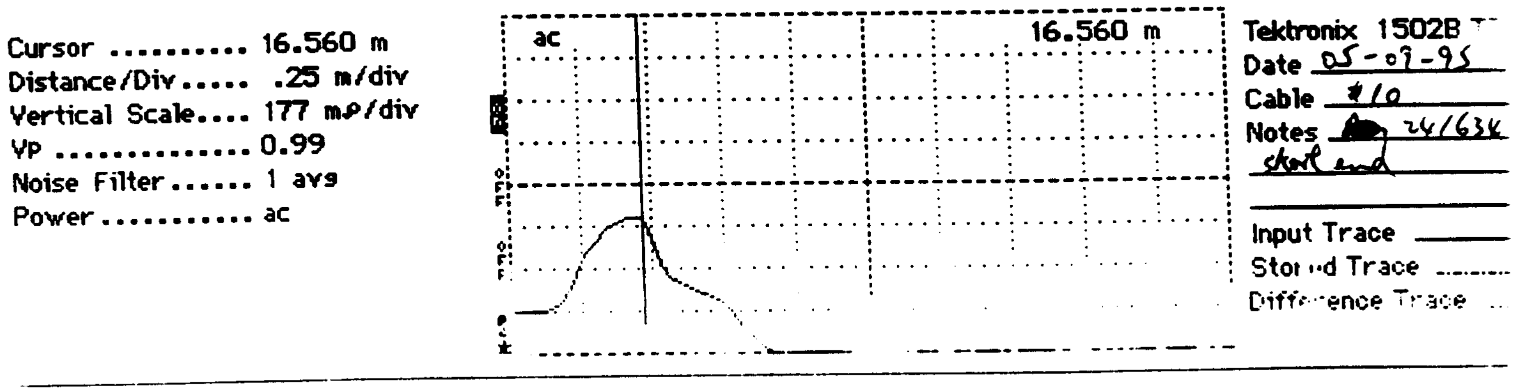


Figure B-1(cont.). TDR Traces Obtained During Calibration

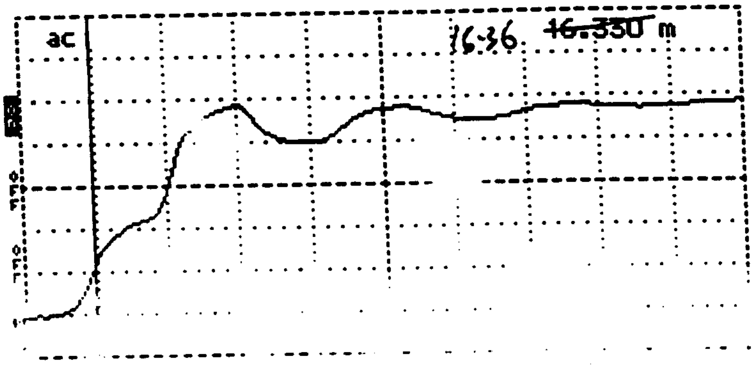
LTPP Seasonal Monitoring Program TDR Probe Calibration	Agency Code: LTPP Section ID:	[24] [1634]

Probe Serial Number: 24A10 **Date (dd/mm/yy):** 09/05/95

Trace 3 - Probe in Air

Cursor .... 16.330 m
Distance/Div..... .25 m/div
Vertical Scale.... 177 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

0.20



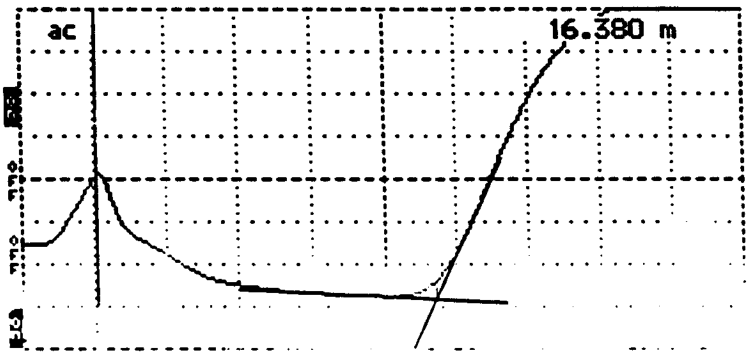
Tektronix 1502B TDR
Date 05-09-95
Cable #10
Notes 241634
Air

Input Trace
Stored Trace
Difference Trace

Trace 4 - Probe in Alcohol

Cursor .... 16.380 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.18



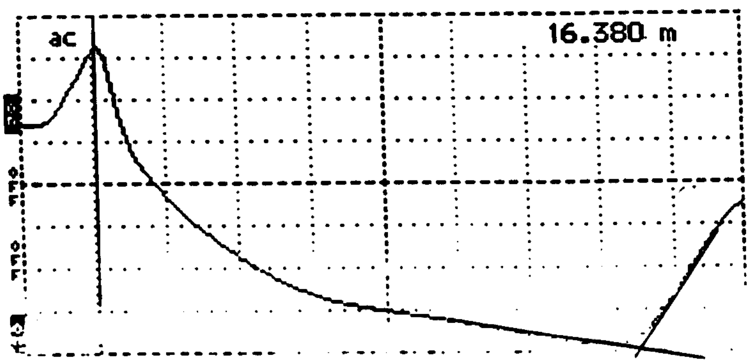
Tektronix 1502B TDR
Date 05-09-95
Cable #10
Notes [redacted] 241634
Alcohol

Input Trace
Stored Trace
Difference Trace

Trace 5 - Probe in Water

Cursor .... 16.380 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power .... ac

1.85



Tektronix 1502B TDR
Date 05-09-95
Cable #10
Notes 241634
Water

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:

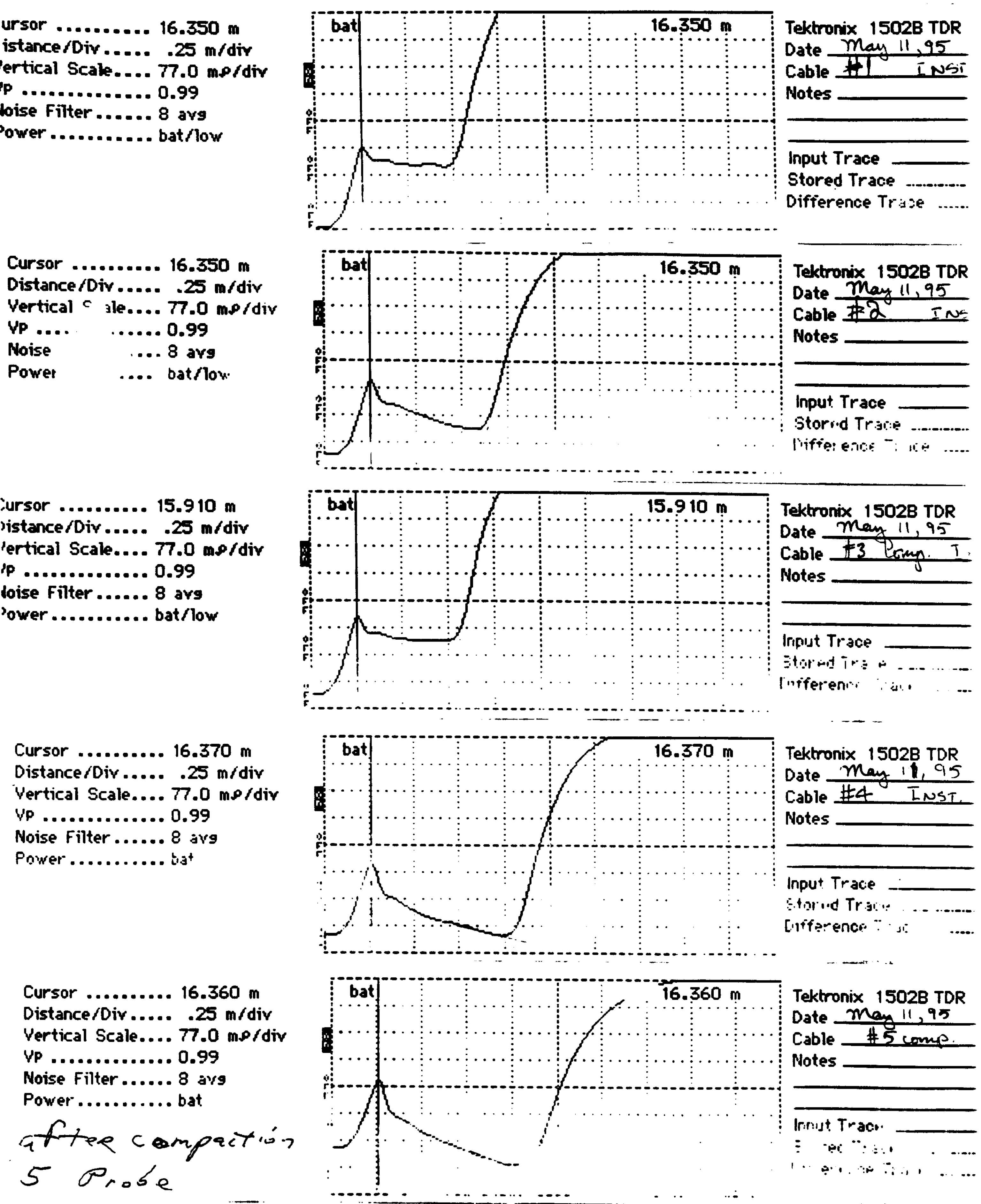
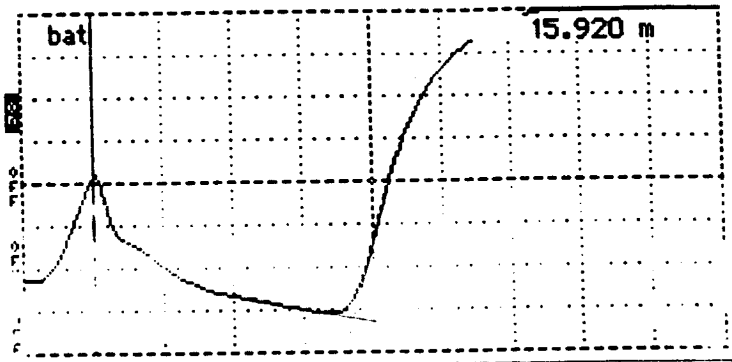


Figure C-1. TDR Traces Measured Manually During Installation

Cursor .... 15.920 m
Distance/Div..... .25 m/div
Vertical Scale.... 77.0 mρ/div
Vp 0.99
Noise Filter...... 8 avg
Power........... bat

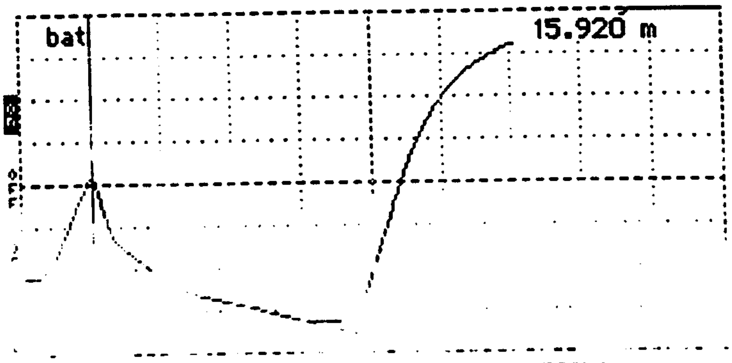
After compaction
Probe #6



Tektronix 1502B TDR
Date May 11, 95
Cable #6 comp. I
Notes
Input Trace
Stored Trace
Difference Trace

ursor .... 15.920 m
istance/Div..... .25 m/div
ertical Scale.... 77.0 mρ/div
P 0.99
oise Filter...... 8 avg
ower........... bat

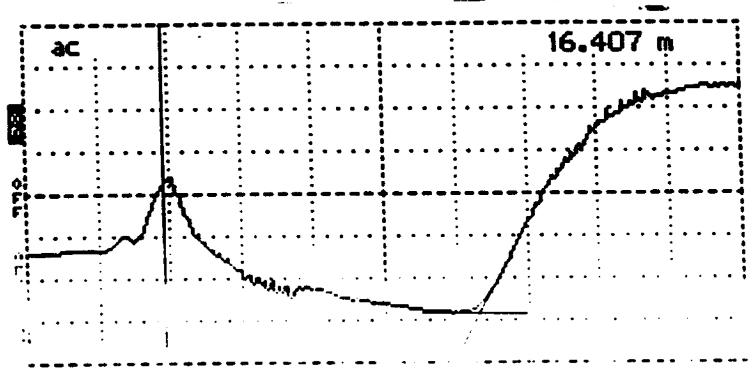
#7



Tektronix 1502B TDR
Date May 11, 95
Cable #7 INST.
Notes
Input Trace
Stored Trace
Difference Trace

rsor .... 16.407 m
stance/Div..... .25 m/div
rtical Scale.... 94.1 mρ/div
P 0.99
ise Filter...... 8 avg
wer........... ac

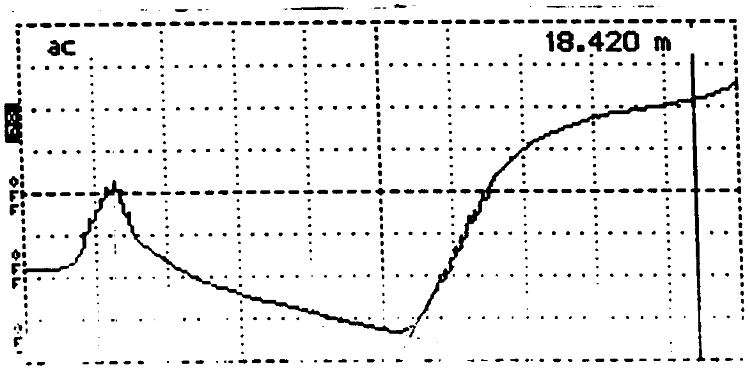
Probe #8



Tektronix 1502B TDR
Date May 11, 95
Cable #8 INST.
Notes
Input Trace
Stored Trace
Difference Trace

ursor .... 18.420 m
stance/Div..... .25 m/div
ertical Scale.... 94.1 mρ/div
P 0.99
oise Filter...... 8 avg
ower........... ac

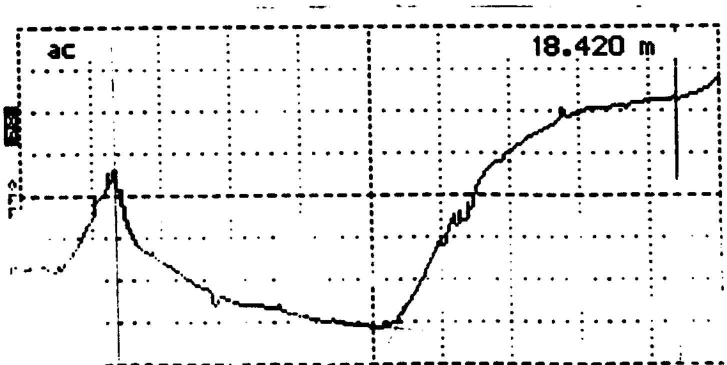
Probe #9



Tektronix 1502B TDR
Date May 11, 95
Cable #9 INS
Notes
Input Trace
Stored Trace
Difference Trace

Cursor .... 18.420 m
Distance/Div..... .25 m/div
Vertical Scale.... 94.1 mρ/div
Vp 0.99
Noise Filter...... 8 avg
Power........... ac

Probe #10



Tektronix 1502B TDR
Date May 11, 95
Cable #10 INST
Notes
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 (%)
24A01	0.368	0.50	6.19	10.83	1790	6.05
24A02	0.514	0.65	10.46	19.82	1790	11.07
24A03	0.660	0.55	7.49	13.74	1790	7.68
24A04	0.813	0.80	15.85	29.04	1790	16.22
24A05	0.990	0.85	17.89	31.98	1790	17.87
24A06	1.118	0.90	20.06	34.81	1900	18.32
24A07	1.295	0.95	22.35	37.51	1900	19.74
24A08	1.422	1.05	27.30	42.45	1900	22.34
24A09	1.727	1.05	27.30	42.45	1900	22.34
24A10	2.184	1.00	24.76	40.06	1900	21.08

Table C-2. Field Measured Moisture Content

LTPP Seasonal Monitoring Study	State Code		[24]
In-Situ Moisture Tests	Test Section Number		[1634]

Weight (gm)	Probe 1	Probe 2	Probe 3	Probe 4	Probe 5
Weight of Pan + Wet Soil	302.1	265.5	317.9	298.1	229.0
Weight of Pan + Dry Soil	295.1	260.0	311.4	285.0	225.7
Weight of Pan	201.2	190.1	201.5	190.4	201.3
Weight of Dry Soil	93.9	69.9	109.9	94.6	24.4
Weight of Wet Soil	100.9	75.4	116.4	107.7	27.7
Weight of Moisture	7.0	5.5	6.5	13.1	3.3
Wt of Moisture/Dry Wt x 100	7.4	7.8	5.9	13.8	13.5

Weight (gm)	Probe 6	Probe 7	Probe 8 *	Probe 9 *	Probe 10 *
Weight of Pan + Wet Soil	334.6	326.5			
Weight of Pan + Dry Soil	310.3	302.6			
Weight of Pan	190.5	201.6			
Weight of Dry Soil	119.8	101.0			
Weight of Wet Soil	144.1	124.9			
Weight of Moisture	24.3	23.9			
Wt of Moisture/Dry Wt x 100	20.3	23.7			

Prepared by:	DM	Employer:	PMSL
Date (dd-mm-yy)	11-05-96		

* Note: No moisture samples were taken

Table C-3. Field Measured Dry Density

LTPP Seasonal Monitoring Program Data Sheet SMP-I07 Representative Dry Density	Agency Code LTPP Section ID	[24] [1634]

Depth of Representative Sample (from pavement surface): 0.65 m

Dry Density Determination:

a.	Tare Weight of Empty Mold:	5714g	(12.60 lb)
b.	Weight of Mold and Compacted Soil:	7623 g	(16.81 lb)
c.	Weight of Compacted Soil (b-a):	1909 g	(4.21 lb)
d.	Unit Weight of Compacted Soil = (c/943.0) =		2.02 g/cm^3
	= [c/(1/30)] =		(126.4 lb/ft^3)
e.	Dry Density of Compacted Soil = [d/(1+r/100)] =		1.79 g/cm^3
			(112.0 lb/ft^3)

Moisture Content Determination:

m.	Tare Weight of Pan:	197.4 g
n.	Weight of Pan and Moisture Sample:	463.0 g
o.	Weight of Pan and Dry Sample:	433.2 g
p.	Weight of Moisture (n -o):	29.8 g
q.	Weight of Dry Sample (o - m):	235.8 g
r.	Moisture Content by Weight = [(p/q)*100] =	12.6 %

Prepared by:	DM	Employer:	PMSL
Date (dd/mm/yy):	11/05/95		

Table C-4. Field Measured Dry Density

LTPP Seasonal Monitoring Program Data Sheet SMP-I07 Representative Dry Density	Agency Code LTPP Section ID	[24] [1634]

Depth of Representative Sample (from pavement surface): 1.3 m

Dry Density Determination:

a.	Tare Weight of Empty Mold:	2322 g	(5.12 lb)
b.	Weight of Mold and Compacted Soil:	4364 g	(9.62 lb)
c.	Weight of Compacted Soil (b-a):	2042 g	(4.50 lb)
d.	Unit Weight of Compacted Soil = (c/943.0) =		2.17 g/cm^3
	= [c/(1/30)] =		(135 lb/ft^3)
e.	Dry Density of Compacted Soil = [d/(1+r/100)] =		1.90 g/cm^3
			(118.2 lb/ft^3)

Moisture Content Determination:

m.	Tare Weight of Pan:	201.1 g
n.	Weight of Pan and Moisture Sample:	550.1 g
o.	Weight of Pan and Dry Sample:	506.6 g
p.	Weight of Moisture (n -o):	43.5 g
q.	Weight of Dry Sample (o - m):	305.5 g
r.	Moisture Content by Weight = [(p/q)*100] =	14.2%

Prepared by:	DM	Employer:	PMSL
Date (dd/mm/yy):	11/05/95		

PREFIX: AW 511-993-077

SOILS LAB
MOISTURE SAMPLE WORKSHEET

Md.90 @ U.S.50

9LP1

1- LOG NO.	1 ( )	2 ( )	3 ( )	4 ( )	5 ( )
2- CONTRACT NO.	AW 511-993-077	*	*	*	*
3- STATION	4+00 30" LT.	*	*	*	*
4- LOCATION	MD 90 REF. LINE	*	*	*	*
5- M.S. @	—	—	—	—	—
6- REPRESENTS	— TO —	— TO —	— TO —	— TO —	— TO —
7- DATE REC'D. / BY	5-12-95 / BD	* / *	* / *	* / *	* / *
8- WET WT.	441.2	463.4	550.0	458.2	550.3
9- DRY WT.	431.3	451.3	535.1	438.0	517.8
10- CAN WT.	288.1	290.3	288.8	288.6	289.9
11- WATER WT.	9.9	12.1	14.9	20.2	32.5
12- DRY SOIL WT.	143.2	161.0	246.3	149.4	227.9
13- % MOISTURE	6.9	7.5	6.0	13.5	14.3
REPORTED	5-16-95 BD	*	*	*	*
1- LOG NO.	6 ( )	7 ( )	( )	( )	( )
2- CONTRACT NO.	*	*			
3- STATION	*	*			
4- LOCATION	*	*			
5- M.S. @	—	—			
6- REPRESENTS	— TO —	— TO —	TO	TO	TO
7- DATE REC'D. / BY	* / *	* / *	/	/	/
8- WET WT.	454.4	401.8			
9- DRY WT.	426.8	381.3			
10- CAN WT.	287.6	288.1			
11- WATER WT.	27.6	20.5			
12- DRY SOIL WT.	139.2	93.2			
13- % MOISTURE	19.8	22.0			
REPORTED	*	*			

* = SAME AS PRECEEDING SAMPLE. (LINE 11 = LINE 8 - LINE 9)
(LINE 12 = LINE 9 - LINE 10) (LINE 13 = LINE 11 / LINE 12 x 100)

CALC. BY:

CHARGED OUT:

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

Table D-1. Data from the Onsite Datalogger During Initial Data Collection, May 13, 1995

```
5,1995,132,1600,12.69,21.53,0
6,1995,132,1600,33.38,30.55,24.91,21.71,20.7
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6,1995,132,2000,24.86,25.6,24.39,22.76,21.79
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2,1995,132,2400,24.21,24.92,23.87,22.43,21.57,20.94,20.39,20.01,19.35,18.72,18.22,17.74,17.24,16.81,16.36,16.0
5,15.73,15.42
3,1995,132,2400,34.58,1529,30.65,1545,25.37,1646,22.81,1919,21.92,2130,21.37,2242,20.84.2347,20.4,2329,19.5
3,2348,18.84,1535,18.33,1540,17.83,1604,17.31,1628,16.86,1540,16.42,1540,16.11,2014,15.78,2021,15.46,1903
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6,1995,133,600,13.46,15.54,18.36,20.07,20.4
5,1995,133,700,12.65,9.48,0
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5,1995,133,800,12.66,13.29,0
6,1995,133,800,14.58,15.31,17.69,19.48,19.91
5,1995,133,900,12.66,16.03,0
6,1995,133,900,17.91,16.74,17.74,19.24,19.7
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6,1995,133,1000,22.44,19.3,18.33,19.14,19.5
5,1995,133,1100,12.67,20.25,0
6,1995,133,1100,27.54,22.62,19.42,19.25,19.45
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Section 241634

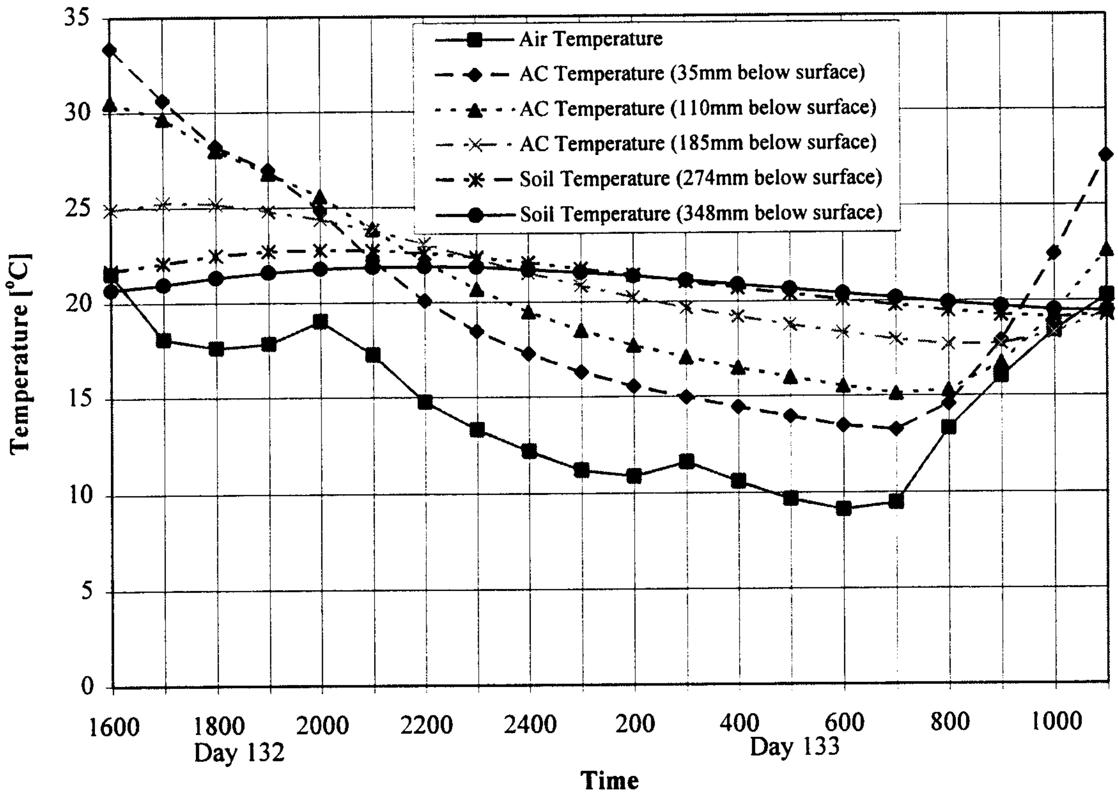

Figure D-1. Air Temperature and First Five Sub-Surface Temperatures From Initial Data Collection, May 13, 1995

Site 241634

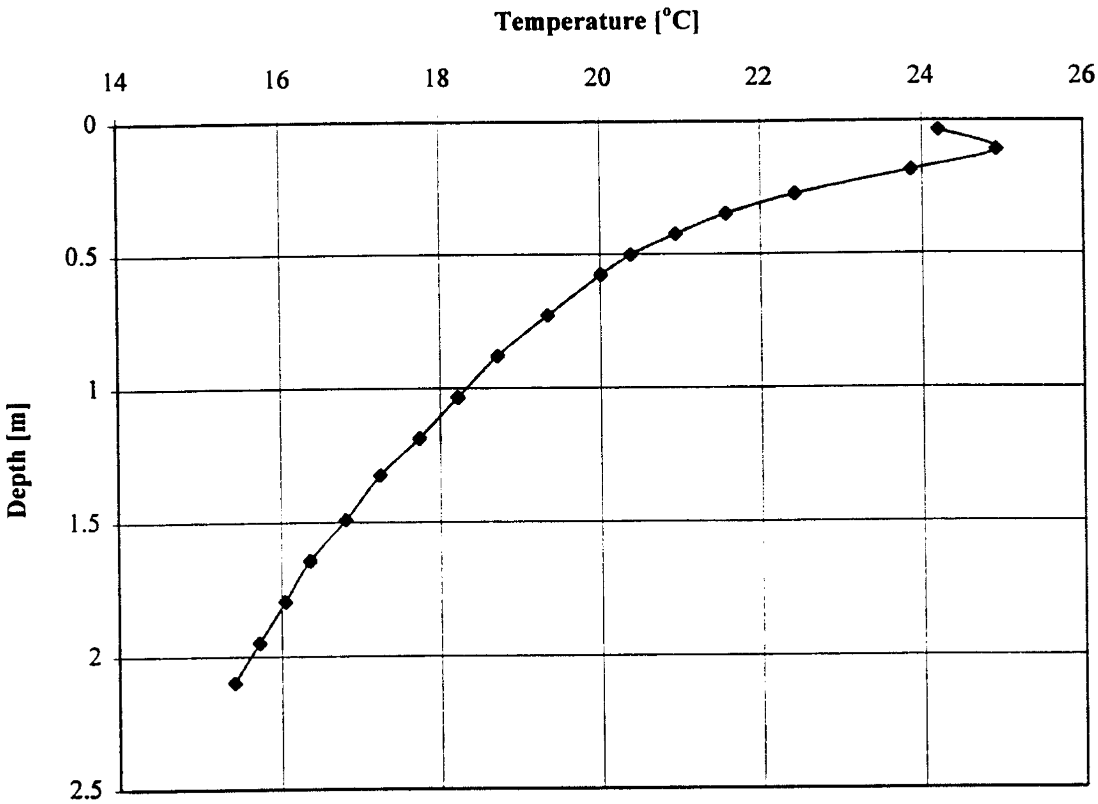

Figure D-2. Average Subsurface Temperature for all 18 Sensors From Initial Data Collection, May 13, 1995

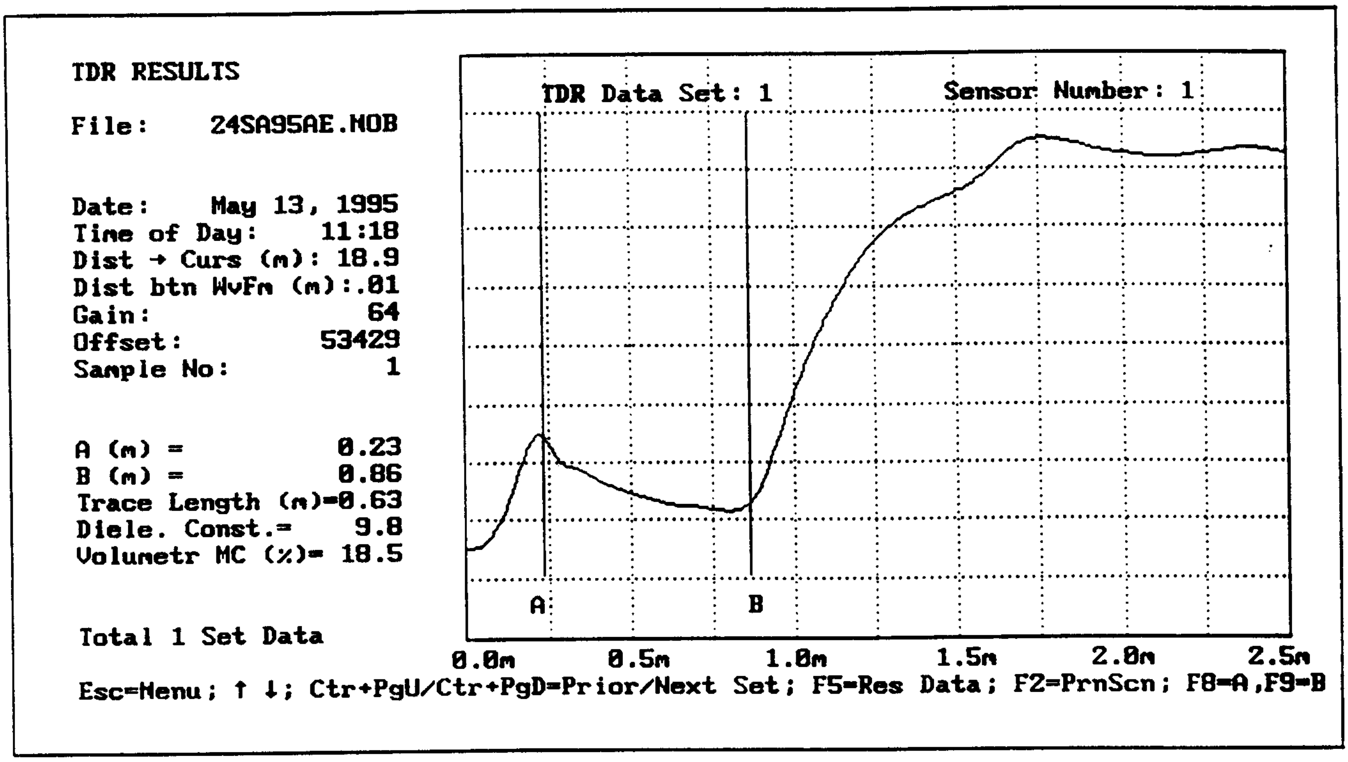

Figure D-3. Initial First Set of TDR Traces Measured with the Mobile Unit

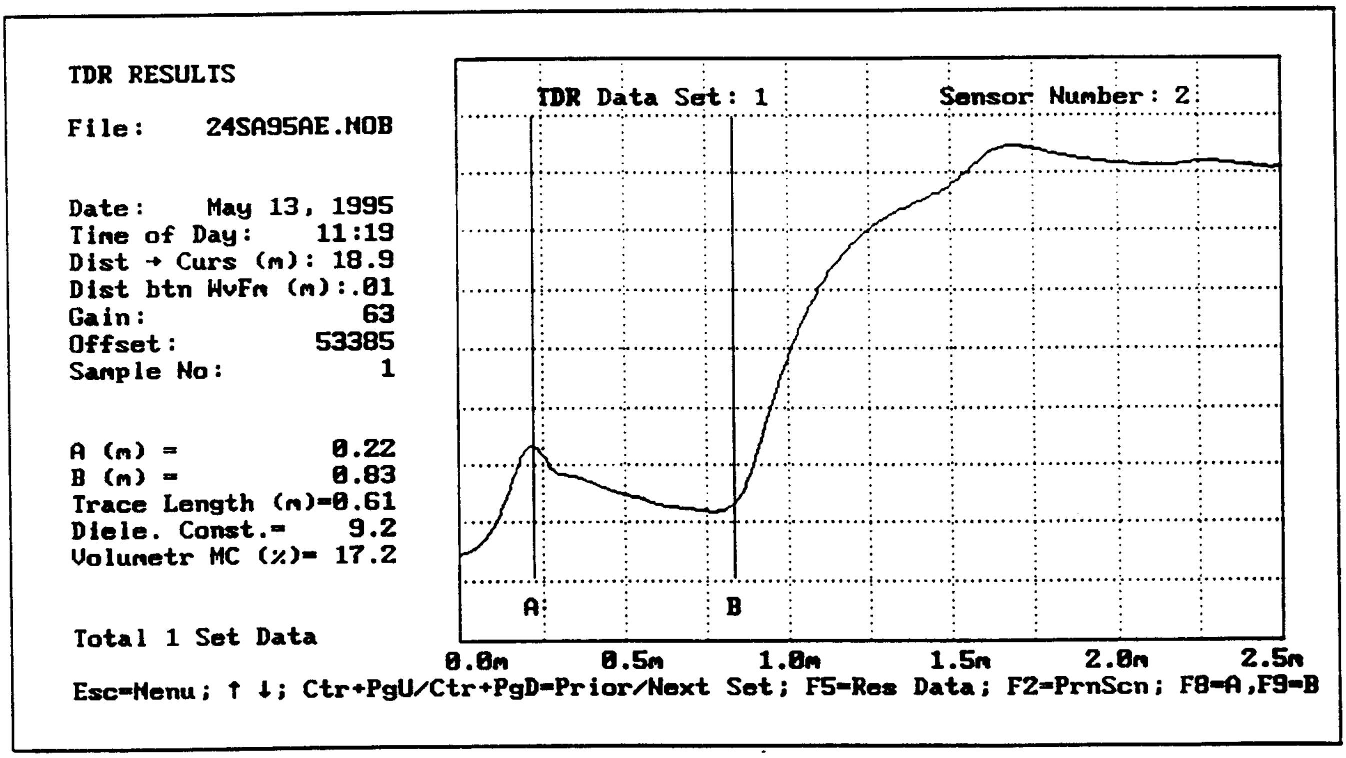

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

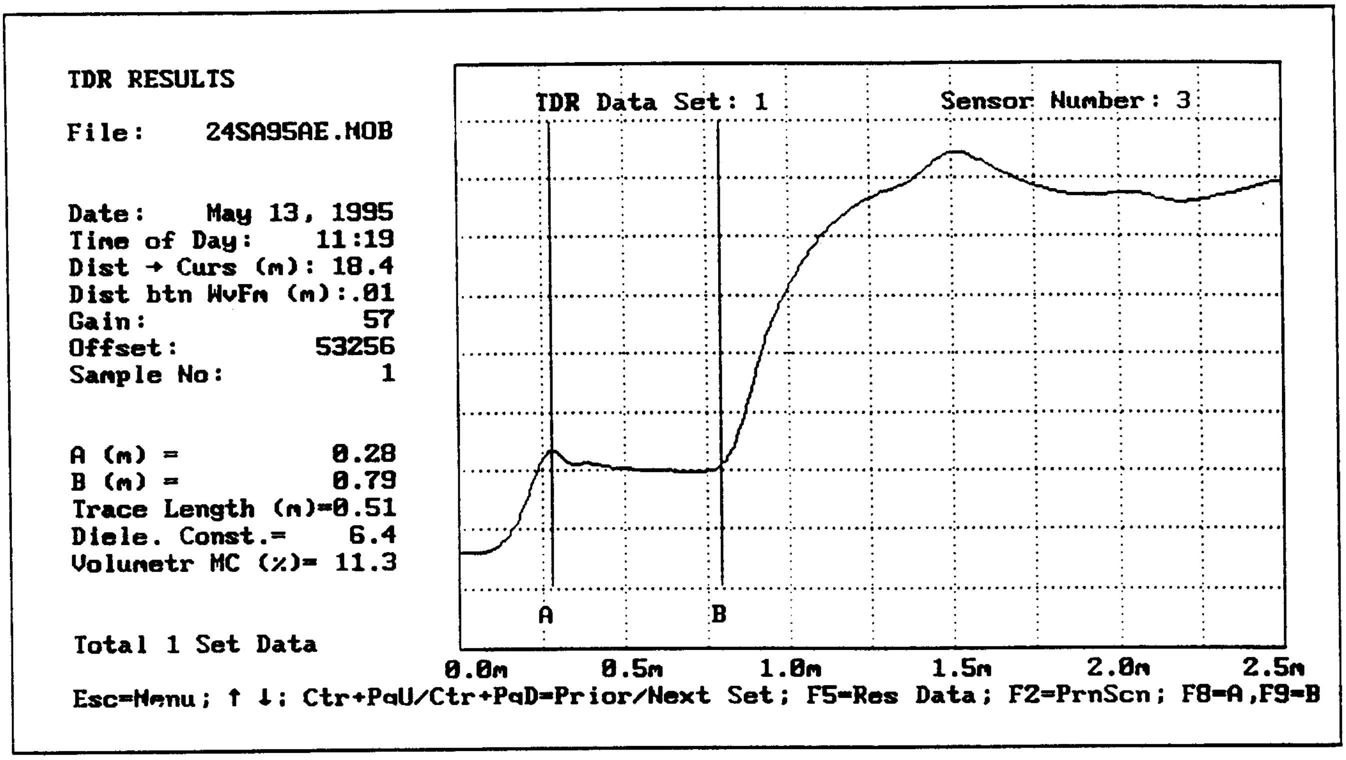

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

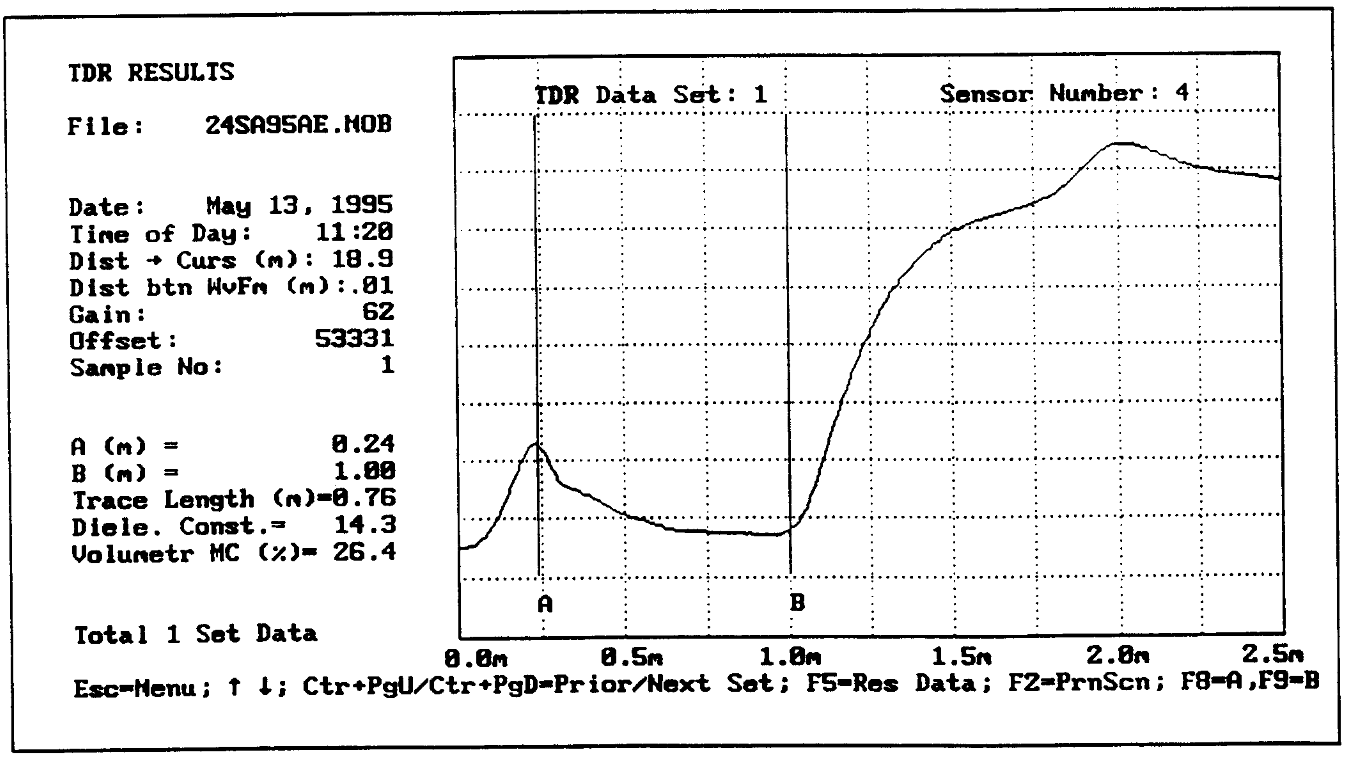

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

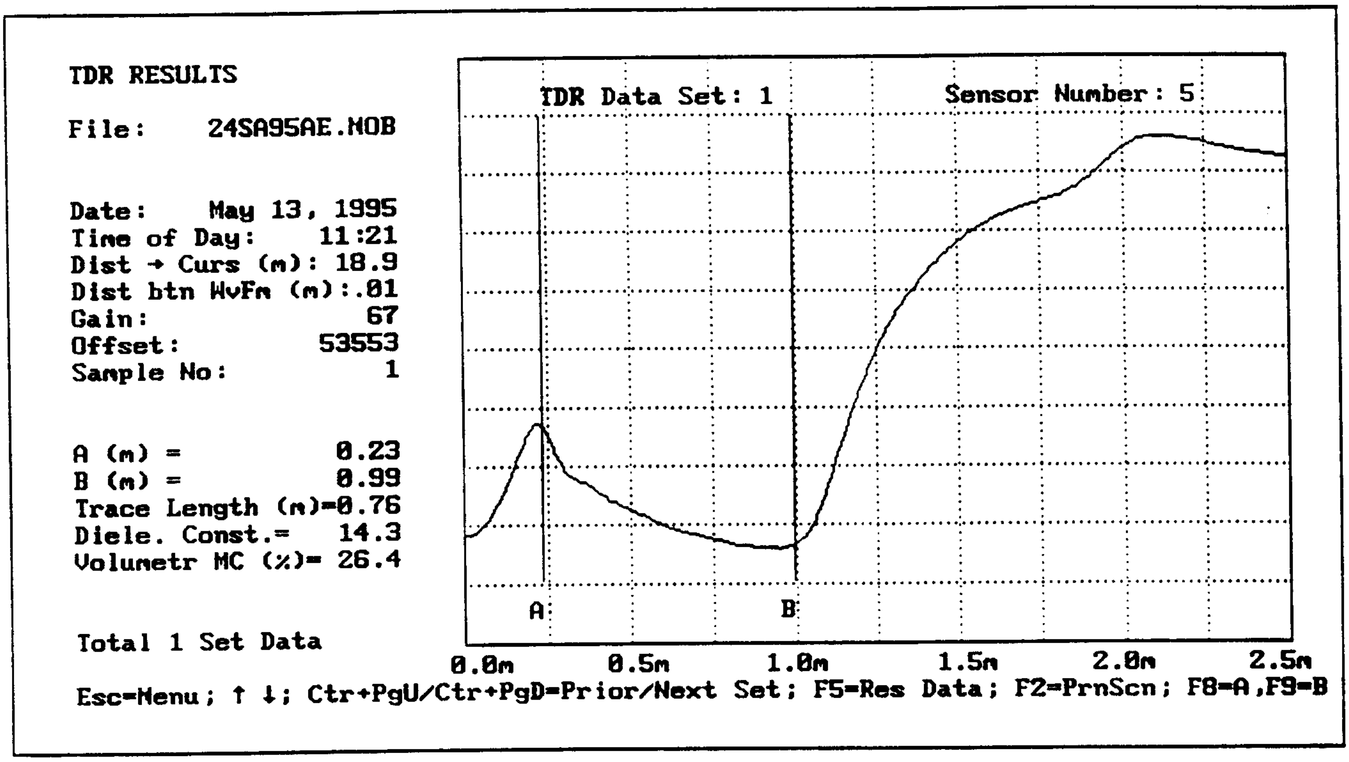

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

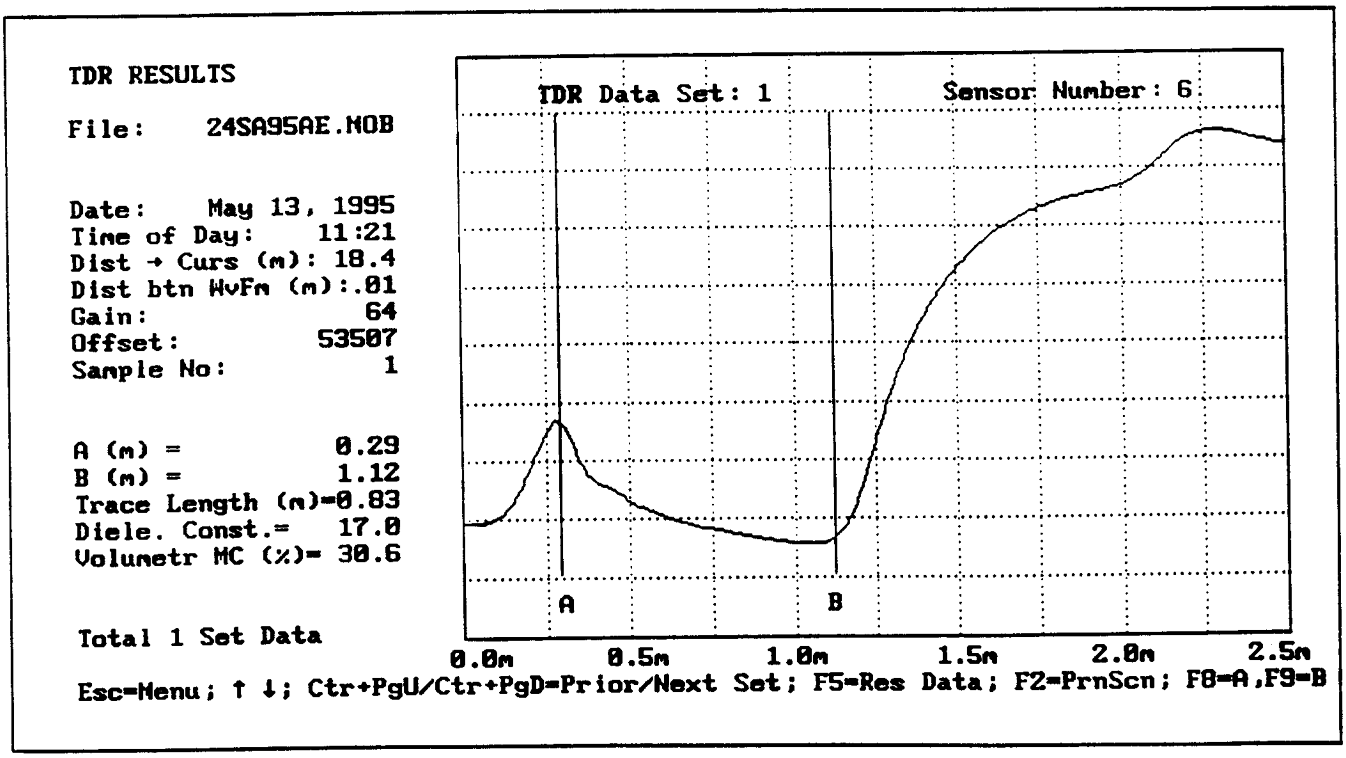

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

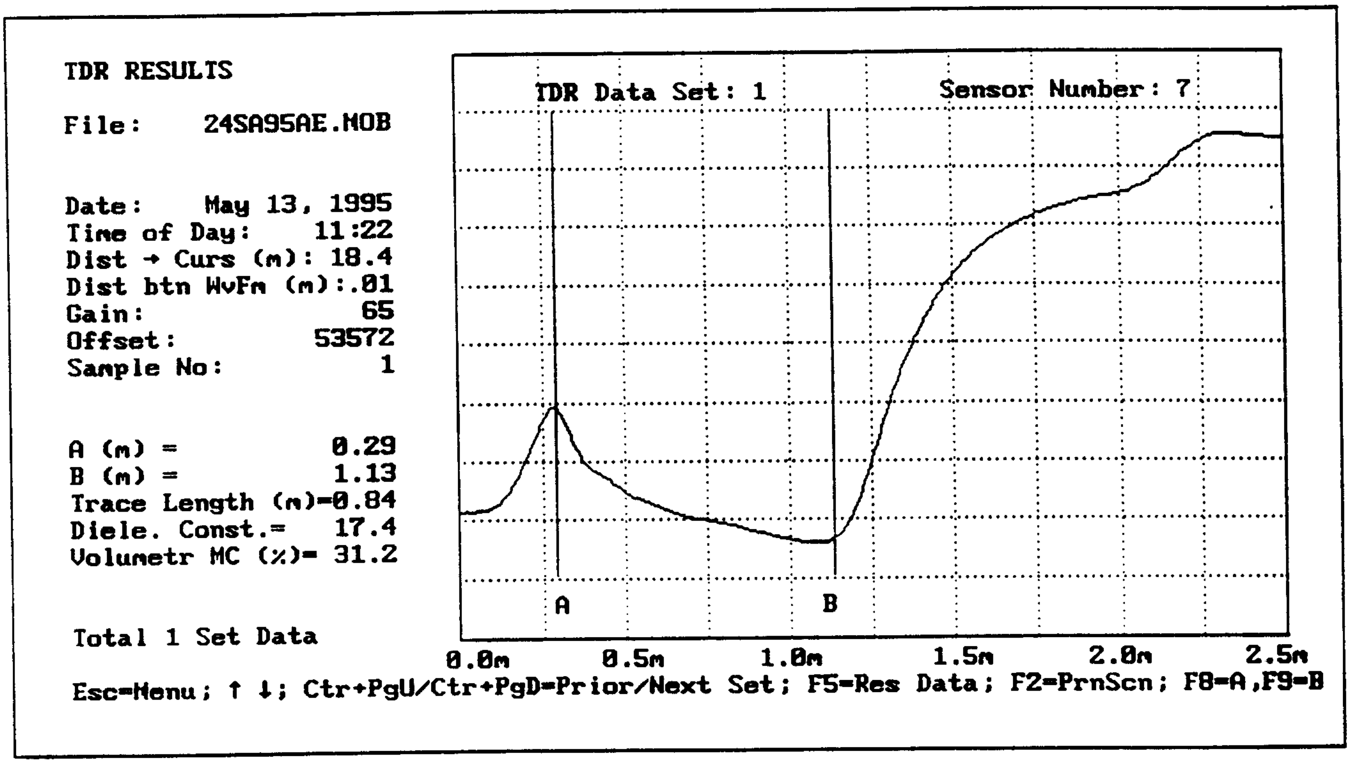

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

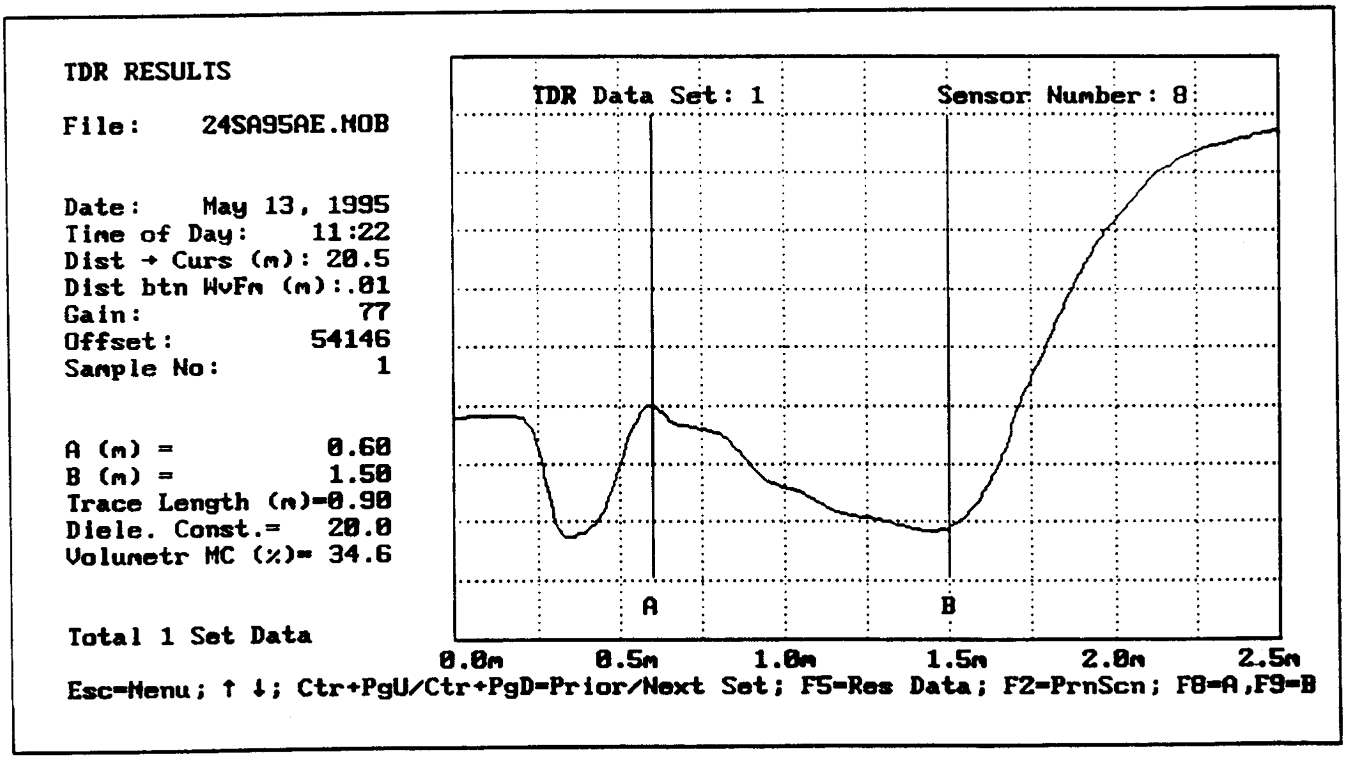

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

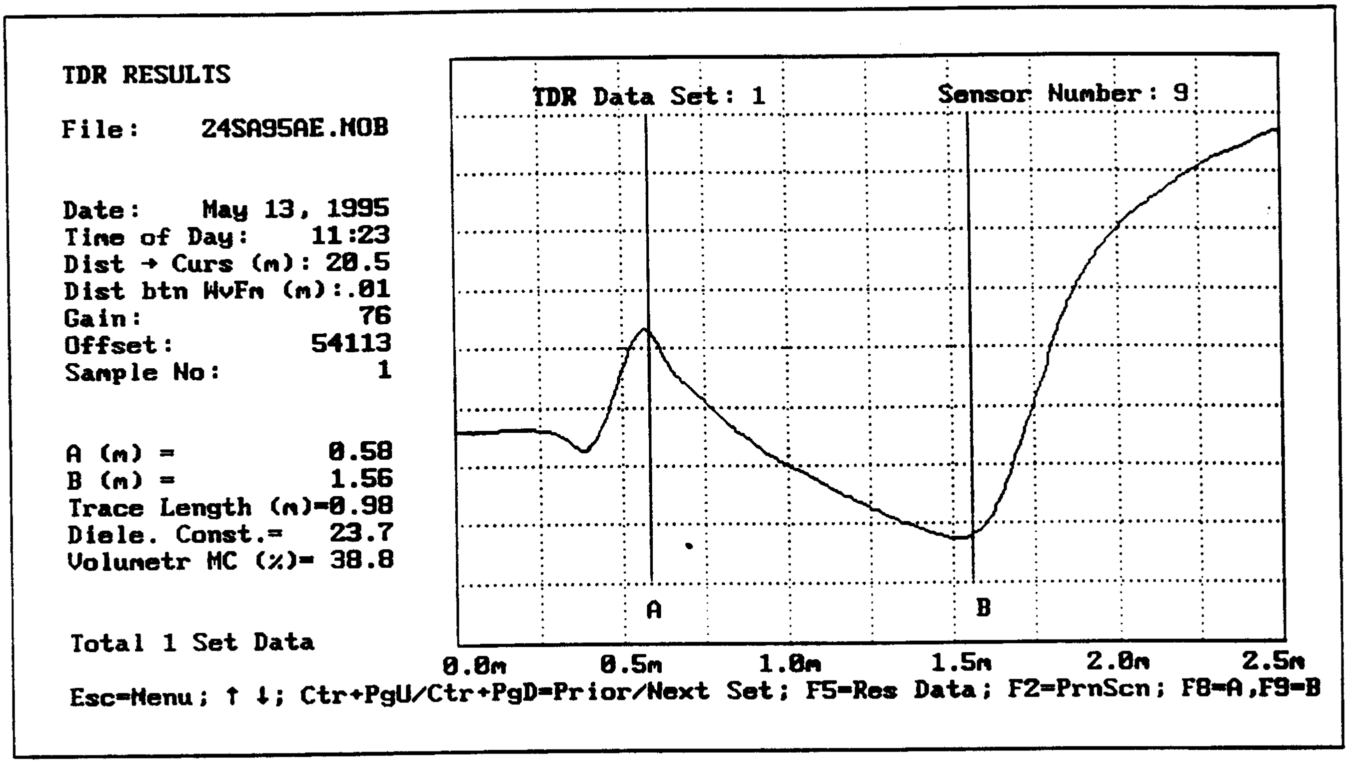

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

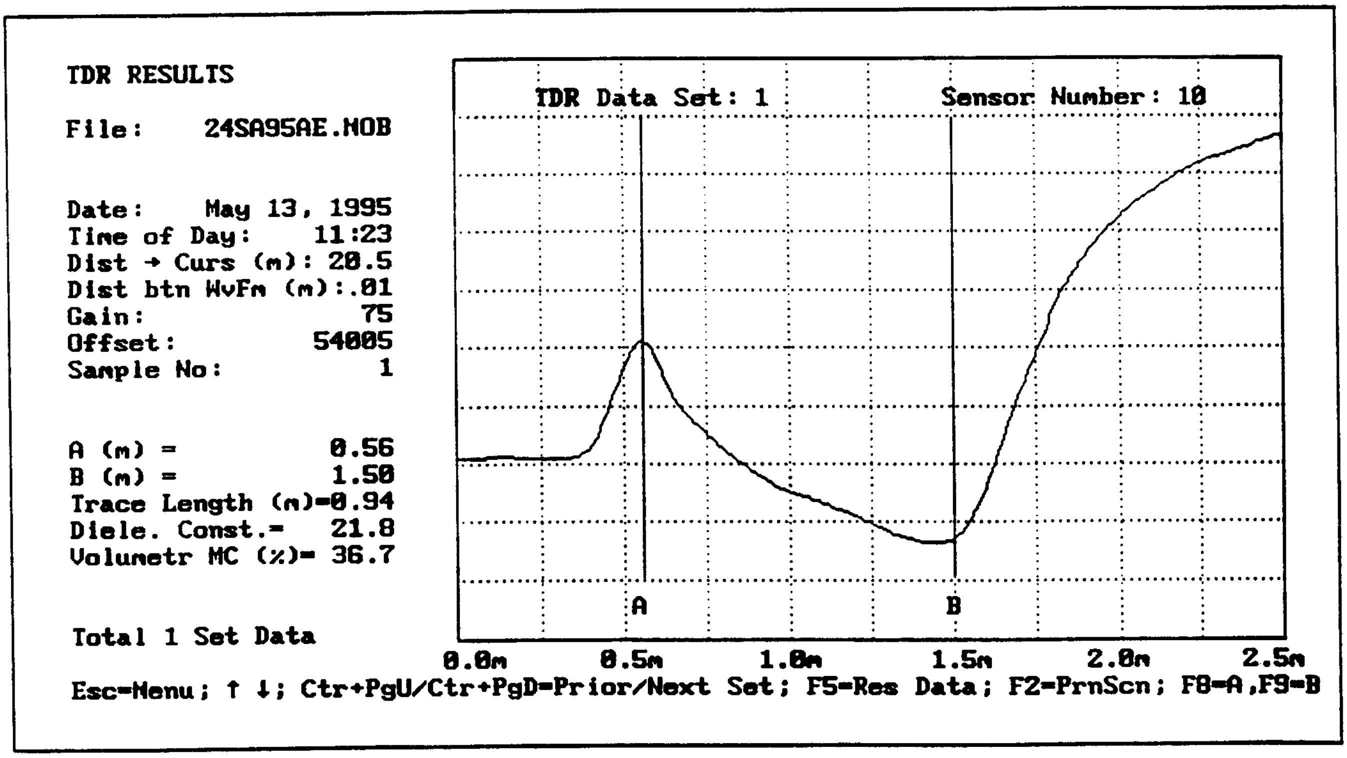

Figure D-3(cont.). Initial First Set of TDR Traces Measured with the Mobile Unit

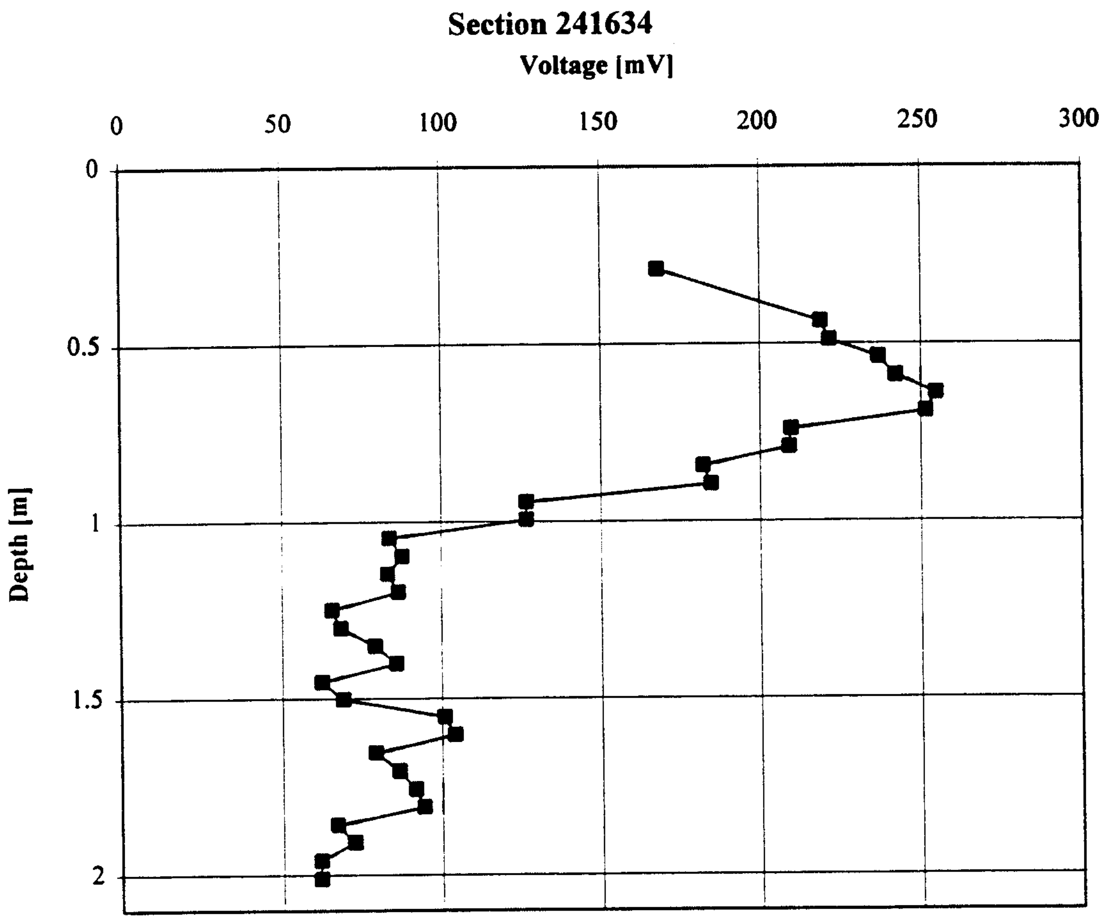

Figure D-4. Voltages Measured Using the Mobile Data System During Initial Data Collection, May 12, 1995

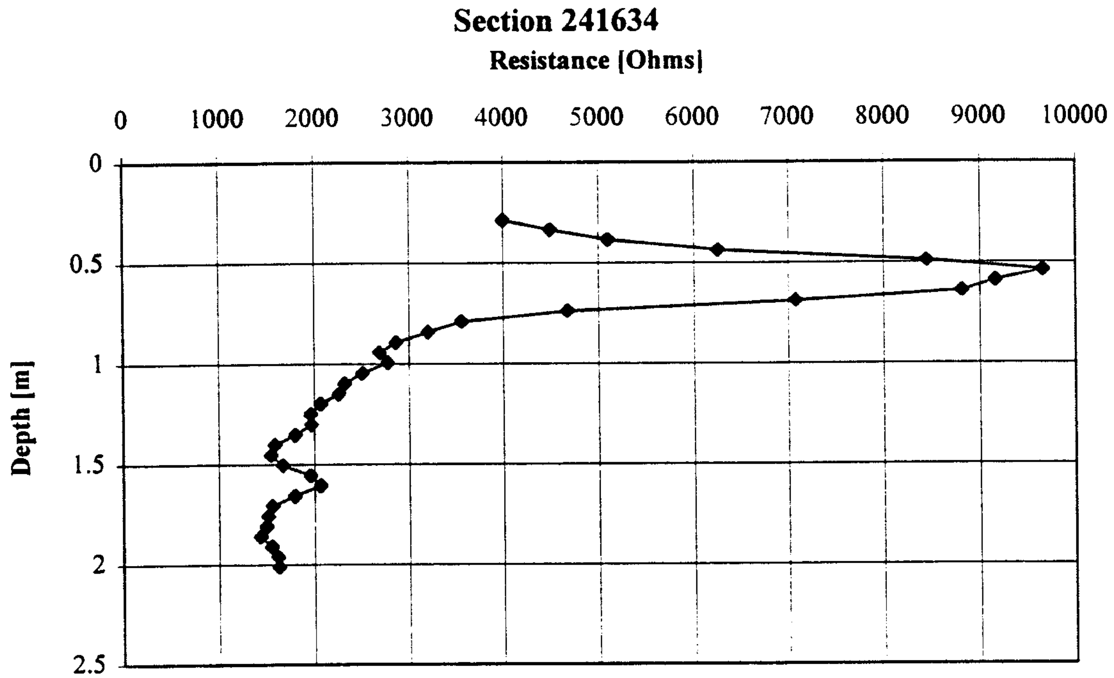

Figure D-5. Manually Collected Contact Resistance During Initial Data Collection, May 12, 1995

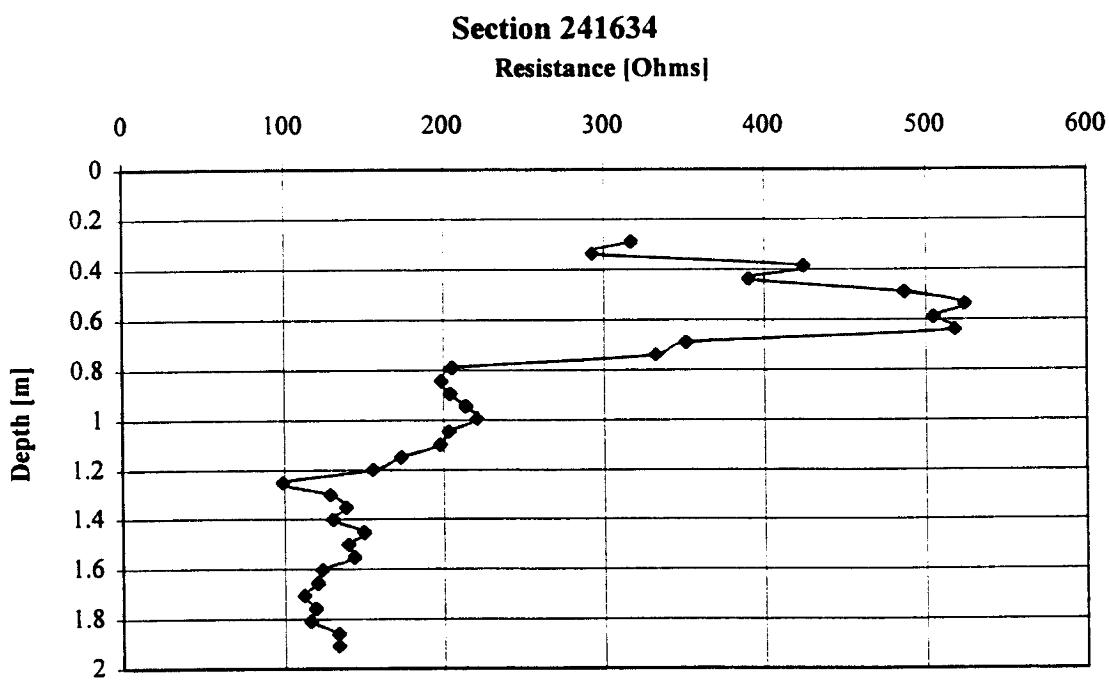

Figure D-6. Manually Collected Four-Point Resistivity During Initial Data Collection, May 12, 1995

Table D-2. Contact Resistance After Installation

LTPP Seasonal Monitoring Study	State Code	[24]
Data Sheet SMP-D03		
Contact Resistance Measurements	Test Section Number	[1634]

1. Date (dd-mm-yy)		[12-05-95]
2. Time Measurements Began (Military)		[1032]
3. Comments	After Installation	* Note: Known Resistors

Test Position	Connections		Voltage (ACV)		Current (ACA)		notes
	I1 V1	I2 V2	Range Setting	Reading	Range Setting	Reading	
1	1	2	mV	145.9	uA	36.5	
2	2	3	mV	150.0	uA	33.3	
3	3	4	mV	153.6	uA	30.1	
4	4	5	mV	158.3	uA	25.3	
5	5	6	mV	163.8	uA	19.4	
6	6	7	mV	166.1	uA	17.2	
7	7	8	mV	165.8	uA	18.1	
8	8	9	mV	165.7	uA	18.8	
9	9	10	mV	160.7	uA	22.7	
10	10	11	mV	149.4	uA	31.9	
11	11	12	mV	140.0	uA	39.3	
12	12	13	mV	136.0	uA	42.4	
13	13	14	mV	131.6	uA	46.0	
14	14	15	mV	129.6	uA	48.2	
15	15	16	mV	131.2	uA	47.3	
16	16	17	mV	126.9	uA	50.6	
17	17	18	mV	123.8	uA	53.3	
18	18	19	mV	122.8	uA	54.3	
19	19	20	mV	118.8	uA	57.5	
20	20	21	mV	116.5	uA	59.4	
21	21	22	mV	116.5	uA	59.2	
22	22	23	mV	112.7	uA	62.7	
23	23	24	mV	107.0	uA	67.5	
24	24	25	mV	105.5	uA	68.5	
25	25	26	mV	108.9	uA	65.4	
26	26	27	mV	116.1	uA	59.3	
27	27	28	mV	118.2	uA	57.3	
28	28	29	mV	112.1	uA	62.6	
29	29	30	mV	105.9	uA	68.0	
30	30	31	mV	104.3	uA	69.2	
31	31	32	mV	105.6	uA	70.8	
32	32	33	mV	103.8	uA	72.6	
33	33	34	mV	107.4	uA	69.5	
34	34	35	mV	109.2	uA	67.8	
35	35	36	mV	109.2	uA	67.2	
36 *	36	37	mV	1.4	uA	161.3	
37 *	37	38	mV	15.8	uA	149.8	
38 *	38	39	mV	88.1	uA	88.0	
39 *	39	00	mV	190.1	uA	0.4	

Prepared by	DS/AL	Employer	PMSL

Table D-3. Four-Point Resistivity After Installation

LTPP Seasonal Monitoring Study	State Code	[24]
Data Sheet SMP-D04		
Four-Point Resistivity Measurements	Test Section Number	[1634]

1. Date (dd-mm-yy)	[12-05-95]
2. Time measurements Began (Military)	[1045]
3. Comments	After Installation

Test Position	Connections				Voltage (ACV)		Current (ACA)		Notes
	I_1	V_1	V_2	I_2	Range Setting	Reading	Range Setting	Reading	
1	1	2	3	4	mV	9.7	uA	30.6	
2	2	3	4	5	mV	7.7	uA	26.3	
3	3	4	5	6	mV	8.7	uA	20.5	
4	4	5	6	7	mV	8.0	uA	20.5	
5	5	6	7	8	mV	9.3	uA	19.1	
6	6	7	8	9	mV	8.7	uA	16.6	
7	7	8	9	10	mV	10.3	uA	20.4	
8	8	9	10	11	mV	11.6	uA	22.4	
9	9	10	11	12	mV	8.7	uA	24.8	
10	10	11	12	13	mV	10.3	uA	31.0	
11	11	12	13	14	mV	8.2	uA	39.9	
12	12	13	14	15	mV	8.3	uA	41.8	
13	13	14	15	16	mV	8.7	uA	42.6	
14	14	15	16	17	mV	10.3	uA	48.2	
15	15	16	17	18	mV	10.2	uA	46.2	
16	16	17	18	19	mV	9.8	uA	48.2	
17	17	18	19	20	mV	10.4	uA	52.5	
18	18	19	20	21	mV	9.1	uA	52.6	
19	19	20	21	22	mV	8.4	uA	54.1	
20	20	21	22	23	mV	8.8	uA	88.9	
21	21	22	23	24	mV	7.8	uA	60.5	
22	22	23	24	25	mV	8.3	uA	59.9	
23	23	24	25	26	mV	8.0	uA	61.4	
24	24	25	26	27	mV	8.7	uA	58.2	
25	25	26	27	28	mV	8.4	uA	60.1	
26	26	27	28	29	mV	8.8	uA	61.4	
27	27	28	29	30	mV	7.3	uA	59.1	
28	28	29	30	31	mV	7.3	uA	60.5	
29	29	30	31	32	mV	7.3	uA	65.1	
30	30	31	32	33	mV	8.0	uA	67.1	
31	31	32	33	34	mV	7.4	uA	63.7	
32	32	33	34	35	mV	8.7	uA	65.2	
33	33	34	35	36	mV	8.5	uA	63.6	

Prepared by	DS/AL	Employer	PMSL

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

Seasonal Uniformity Survey	Falling Weight Deflectometer
Site Number: 241634	Data Collection and
Date Surveyed: May 11 - May 12, 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	
-18 to 200 **May 11** @ 0804	9.88	0.71	1.44	0.05	22460	5326	5.49	0.43	72.0
-18 to 200 **May 11** @ 1645	11.19	0.85	1.47	0.14	23684	4546	5.05	0.37	87.9

* Note: Sensors number 6 and 7 had high variances throughout the day. This is the primary reason for the high standard deviations. Time constraints did not permit checking the equipment or re-testing.

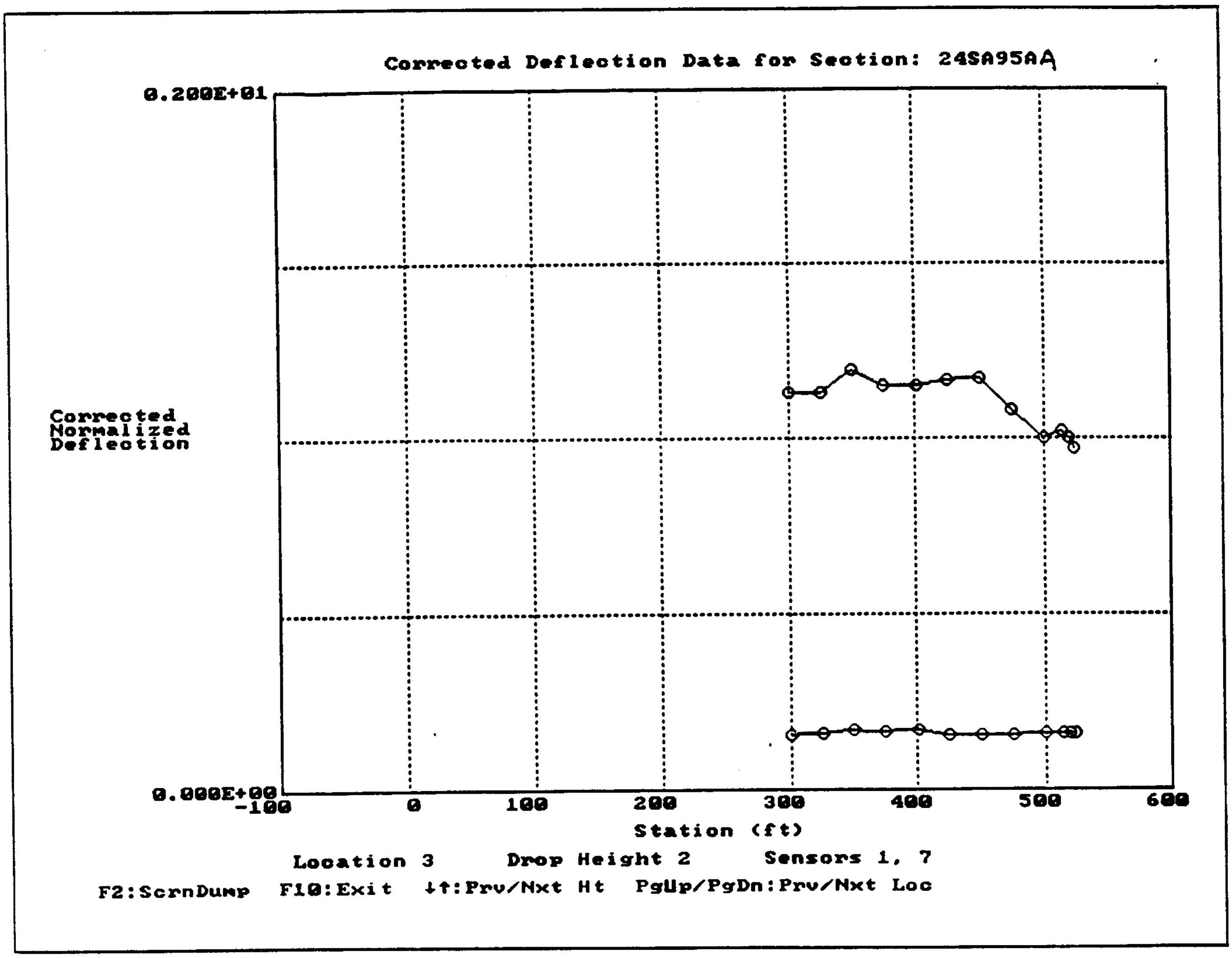

Figure D-7. Deflection Profiles from FWDCHECK
(Test Date and Time May 11, 1995 @ 0804)

Table D-5. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 11, 1995 @ 0804)

Flexible Pavement Thickness Statistics - 24SA95AA - Drop Height 2			
Subsection	Station	Subgrade Modulus *	Effective SN
1	300	26201	5.15
	325	24991	5.20
	350	23885	5.10
	375	24743	5.15
	401	10312	6.45
	425	18881	5.40
	450	26099	5.05
	475	13508	6.15
	500	25138	5.55
	515	25156	5.50
	520	25290	5.55
	525	25311	5.60
Subsection 1	Overall Mean	22460	5.49
	Standard Deviation	5326	0.43
	Coeff of Variation	23.71%	7.86%

* Note: Sensors number 6 and 7 had high variances throughout the day. Time constraints did not permit checking the equipment or re-testing.

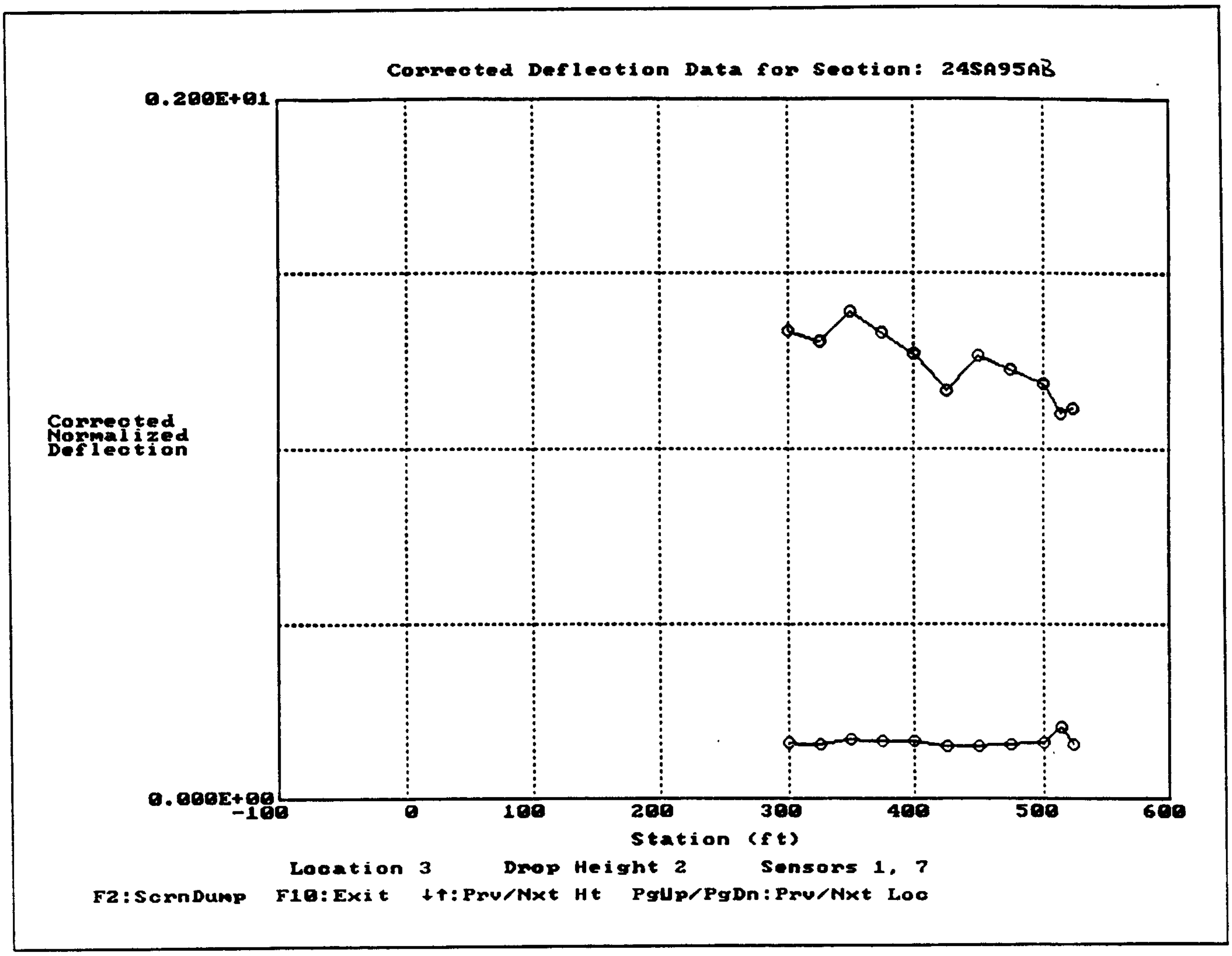

Figure D-8. Deflection Profiles from FWDCHECK
(Test Date and Time May 11, 1995 @ 1645)

Table D-6. Subgrade Modulus and Structural Number from FWDCHECK
(Test Date and Time May 11, 1995 @ 1645)

Flexible Pavement Thickness Statistics - 24SA95AB - Drop Height 2			
Subsection	Station	Subgrade Modulus *	Effective SN
1	300	25477	4.75
	325	25787	4.80
	350	23937	4.70
	375	24528	4.80
	400	11118	5.90
	425	26385	5.05
	450	26349	4.85
	475	25815	4.95
	500	25349	5.05
	515	19936	5.55
	525	25837	5.20
Subsection 1	Overall Mean	23684	5.05
	Standard Deviation	4546	0.37
	Coeff of Variation	19.20%	7.36%

* Note: Sensors number 6 and 7 had high variances throughout the day. Time constraints did not permit checking the equipment or re-testing.

Table D-7. Surface Elevation Measurements

LTPP Seasonal Monitoring Study	State Code	[24]
Surface Elevation Measurements	Test Section Number	[1634]

Survey Date	May 11, 1995
Surveyed By	DS/AL
Surface Type	A/C
Benchmark	Observation Piezometer - 1.000 meters - assumed

STATION		PE m offset 0.00m	OWP m offset 0.76m	ML m offset 1.83m	IWP m offset 2.74m	ILE m offset 3.66m
0-18	3+00	1.5250	1.5450	1.5675	1.5800	1.5825
0-12	3+25	1.5350	1.5525	1.5800	1.5875	1.6025
0-07	3+50	1.5475	1.5625	1.5900	1.5975	1.5975
0+00	3+75	1.5500	1.5675	1.5875	1.6000	1.6150
0+25	4+00	1.5500	1.5700	1.5950	1.6050	1.6075
0+50	4+25	1.5625	1.5725	1.5975	1.6075	1.6225
0+75	4+50	1.5725	1.5825	1.6050	1.6125	1.6200
1+00	4+75	1.5925	1.6050	1.6250	1.6375	1.6475
1+25	5+00	1.5950	1.6125	1.6350	1.6475	1.6500
1+50	5+15	1.6025	1.6150	1.6400	1.6475	1.6650
1+75	5+20	1.6000	1.6125	1.6400	1.6500	1.6550
2+00	5+25	1.6050	1.6175	1.6400	1.6475	1.6625

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

APPENDIX E

Photographs

Figure E-1. Augering the Piezometer Hole

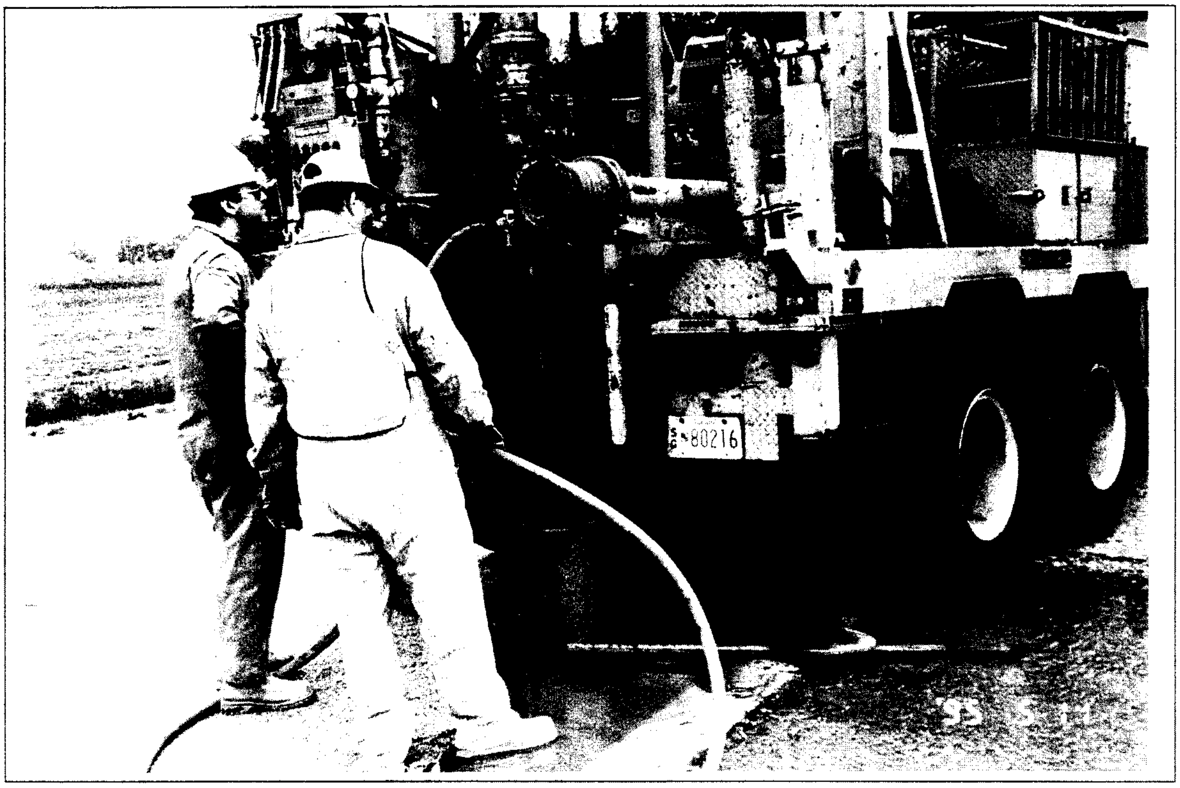

Figure E-2. Coring Asphalt for the Instrument Hole

Figure E-3. Compacting the Instrumentation Hole

Figure E-4. Sawcutting Trench

Figure E-5. Digging the Trench

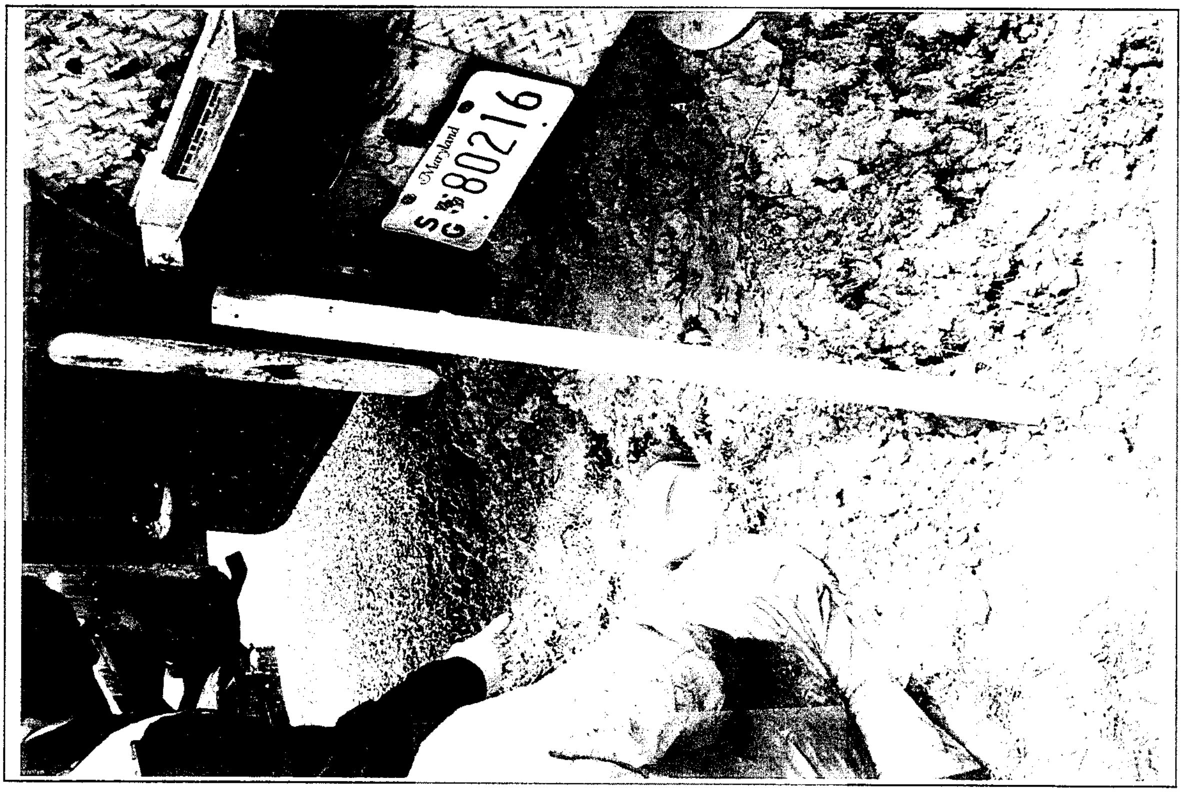

Figure E-6. Installation of Piezometer

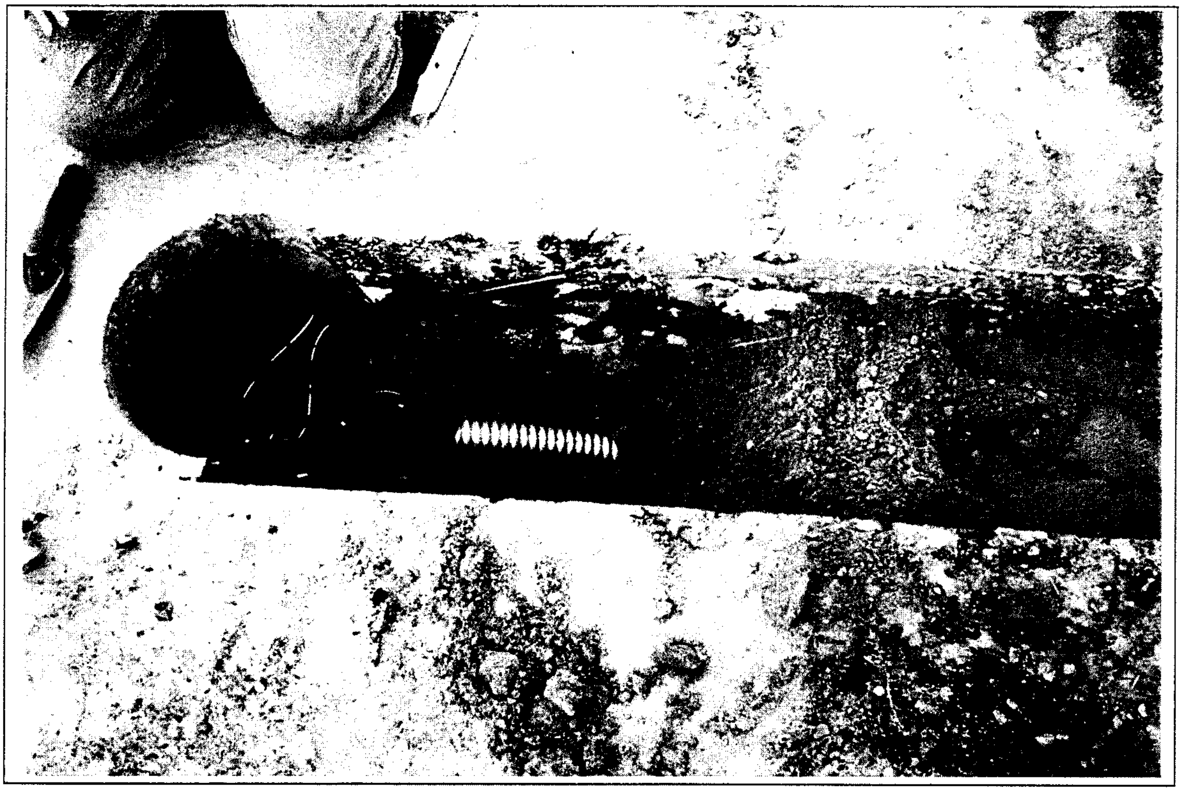

Figure E-7. Instrument Hole and Conduit

Figure E-8. Piezometer after Completion

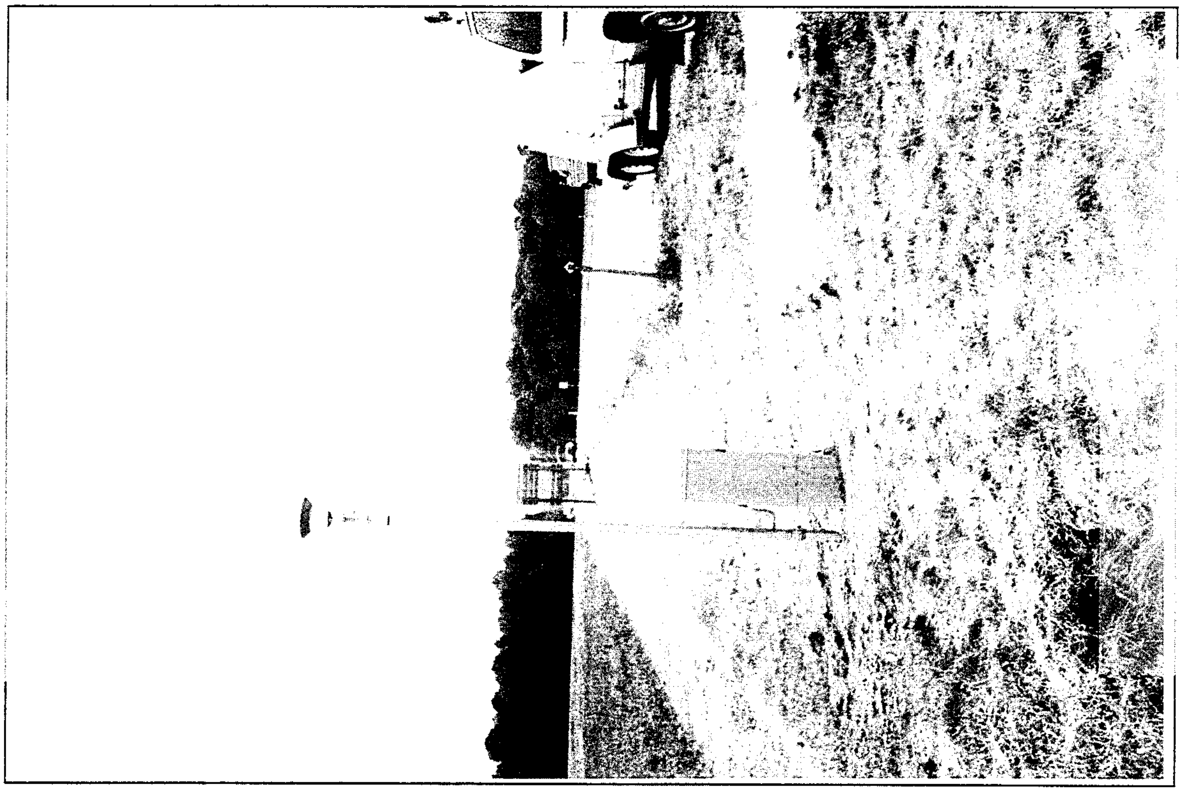

Figure E-9. Weather Station and Equipment Cabinet - Facing West

Figure E-10. Weather Station and Equipment Cabinet - Facing East

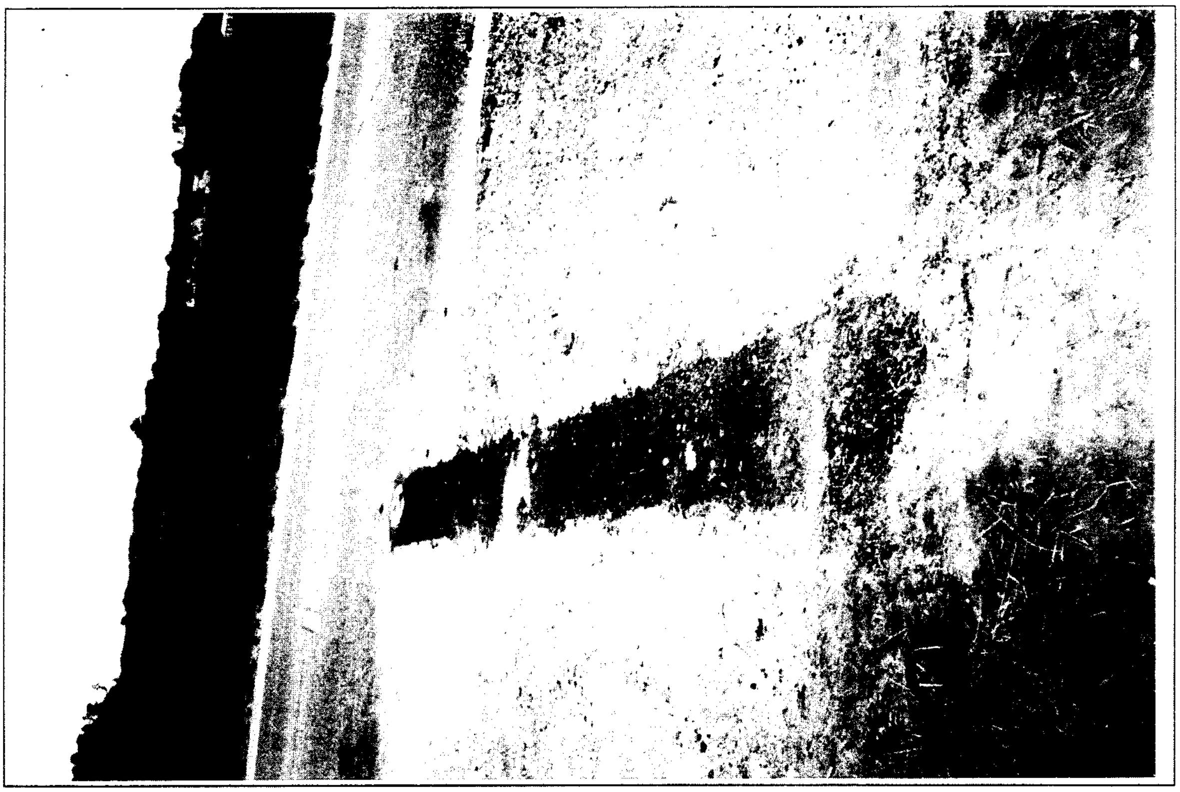

Figure E-11. Completed Instrument Hole and Trench - Facing North

Figure E-12. Completed Instrument Hole and Trench - Facing East

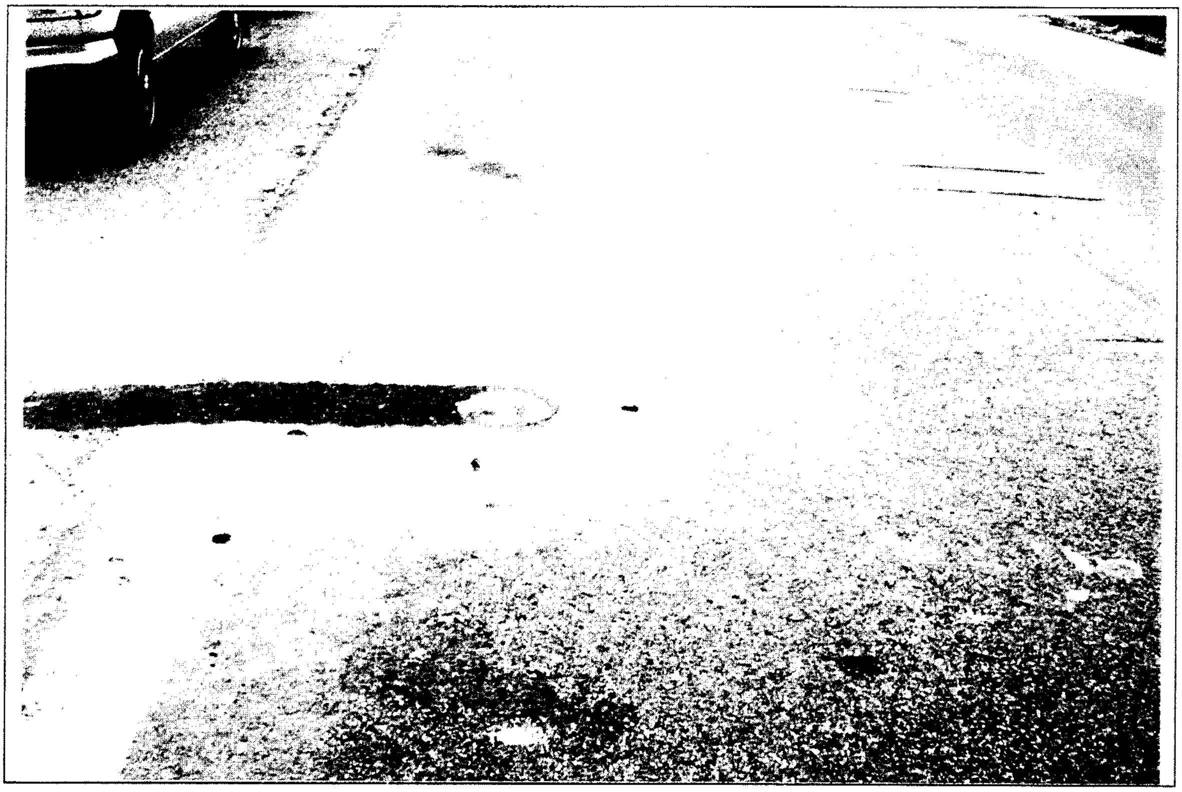

Figure E-13. Completed Instrument Hole and Trench - Facing West

Figure E-14. Instrument Hole Location - January 17, 1996