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Administration

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection

Section 081053, Delta Colorado

Report No. FHWA-08-1053

January 1994

Notice

LTPP Seasonal Monitoring Program

Site Installation and Initial Data Collection
Section 081053, Delta Colorado

Report No. FHWA-08-1053

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16. Abstract

This report contains a description of the instrumentation installation activities and initial data collection for test section 081053 which is a part of the LTPP Core Seasonal Monitoring program. This asphalt concrete surfaced pavement test section, which is located on U.S. Highway 50 just south of Delta Colorado, was instrumented on June 30, 1993. The instrumentation installed included time domain reflectometery probes for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature, tipping bucket rain gage, piezometer to monitor the ground water table, and an on-site data logger. Initial data collection was performed on July 1, 1993 which consisted of deflection measurements with a Falling Weight Deflectometer, elevation measurements, temperature measurements, TDR measurements, and electrical resistance and resistivity measurements. The report contains a description of the test site and its location, the instruments installed at the site and their locations, characteristics of the installed instruments and probes, problems encountered during installation, specific site circumstances and deviations from the standard guidelines, and a summary of the initial data collection.

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I. Introduction

The installation of instrumentation on seasonal site 081053 near Delta Colorado was performed on June 30 - July 1, 1993.

The site is located on northbound U.S. Highway 50, approximately one mile south of the Delta city limits (Figure A-1 in Appendix A). The test section is located on a divided highway consisting of two 3.7m wide travel lanes in each direction. The outside shoulder is 2.4m wide. The test section is classified as a GPS-1 project and it serves as the control section for the SPS-3 test sections present on this project. The SPS-3 test sections are located to the south of the test section.

The pavement structure consists of 117mm of asphalt concrete over an average of 137mm granular aggregate base. The 597mm subbase layer contains gravel, cobbles and boulders. The subgrade is classified as a lean inorganic clay. Pavement structure information from the GPS material drilling logs is presented in Figure A-2. Properties determined from the laboratory material tests are presented in Table 1.

Deflection profiles and analysis results from the FWDCHECK program are presented in Appendix A.

The climate at the site is classified as a dry-freeze zone (cell #3). Summary data from the LTPP climate database indicates the following climatic conditions based on 7 years of data:

Freezing Index (C-Days)	240
Precipitation (mm)	254
No. of Freeze Thaw Cycles	146
Days Above 32° C	45
Days Below 0° C	150
Wet Days	75

The estimated annual average daily traffic (AADT) in 1989 was 6600 (two-way) of which 10% was truck traffic. The GPS lane carried about 45% of the total AADT. The estimated annual ESALs on the GPS lane were about 61,000.

Installation of the instrumentation was a cooperative effort between Colorado Department of Transportation (CDOT), Nichols Consulting Engineers (NCE) LTPP Western Region Coordination Office staff, FHWA staff from the LTPP Division. The installation at this site was performed as part of the workshop on seasonal monitoring and instrumentation held for the other LTPP regions.

The following personnel participated in the instrumentation installation:

Gary E. Elkins	Nichols Consulting Engineers
Aramis Lopez	FHWA-LTPP Division
Ronald Urbach	Braun Intertec / NCRCO
Robert VanSambeek	Braun Intertec/NCRCO
Richard Smith	Nichols Consulting Engineers
Scott Sands	FHWA
Jason Dietz	Nichols Consulting Engineers
Haiping Zhou	Nichols Consulting Engineers
Larry Peirce	BRE Inc/SRCO
D. Jeff Jackson	TXDOT/CTR-UT
Doyt Bolling	FHWA - Region 8
Barry Siel	FHWA - Region 8
Brandt Henderson	Pavement Management Systems (NARCO)
Scott Comstock	Pavement Management Systems
Ahmad Ardani	Colorado DOT
John Klemunes	FHWA-LTPP Division
Gonzalo R. Rada	PCS/Law Engineering (TAC)

Table 1. Material properties.

Description	Surface	Base	Subbase	Subgrade
Material (Code)	Dense Graded HMAC (01)	Crushed Gravel (304)	Coarse soil aggregate mixture (308)	Lean Inorganic Clay (102)
Thickness (mm)	117	137	597	∞
In-situ dry density (kg/m^3)	---	2162[1]	2162[1]	1634[1]
Specific gravity	---	2.16	2.16	1.63
In-situ MC (%)	---	4.3[1]	5.4[1]	23.3[1]
Lab max dry density (kg/m^3)	---	2195[1]@6.7%MC 2195[2]@5.6%MC	2130[1]@7.8%MC 2146[2]@6.3%MC	1602[1]@20.5%MC
Liquid limit	---	---	0	40
Plastic limit	---	---	0	18
Plastic index	---	NP	NP	22
% pass #200	---	7.9	8.5	92

[1] Test pit @ station 5+64 [2] At station 0-45 MC = Moisture content

II. Instrumentation Installation

Meeting with Highway Agency and Site Inspection

A pre-installation planning was held with CDOT officials on May 6, 1993. This meeting was held with in the CDOT Denver office with Ahmad Ardani-CDOT, Denis Donnely-CDOT, Cal Berge-WRE, Gary Elkins-WRCOC, and other personnel from the CDOT Materials Staff and the Colorado FHWA Division office. In addition to the plans for the installation of seasonal monitoring instrumentation and monitoring requirements, the status of the SPS-2 and 8 project in Colorado, and the status of the SPS-9 experiment were also discussed. Requirements, roles and responsibilities for the instrumentation installation were discussed. Notes from the planning meeting and site inspection trip are included in Appendix B.

At the planning meeting, CDOT informed us that they had employed a videographer and were planning to make a video showcasing the instrumentation, installation and seasonal monitoring program. At their request, the WRCOC prepared an outline for the video and supplied background information on the seasonal monitoring program.

A site inspection was performed on May 7, 1993 by Gary Elkins. Cal Berge and Ahmad Ardani accompanied Mr. Elkins on the inspection. The section was found to exhibit rutting and bleeding in both wheel paths. The 0- end of the test section was selected for instrumentation because the deflection profile was more uniform and the instrumentation area on the 5+ end was adjacent to a driveway accessing the adjacent field. An underground water line runs parallel to the test section at the right of way line. This line appears to be used for irrigation purposes and does not appear to pass beneath the test section.

Equipment Installed

The equipment installed at the test site included instrumentation for measuring air and subsurface temperature, subsurface moisture content, frost depth, rainfall, and depth to water table. An equipment cabinet was installed to house cable leads from the instrumentation, the datalogger, and battery pack. The equipment installed are shown in Table 2.

Equipment Check/Calibration

Prior to field installation, all equipment were checked or calibrated. The air temperature probe, thermistor probe, and the tipping bucket rain gauge were connected to the CR10 datalogger for calibration and function checks. The tipping bucket rain gage was calibrated using 473ml of water placed in a plastic container with a tiny hole in the bottom. The hole size was adjusted so that 45 minutes were required to drain all of the water out of the container. For the 473ml of water, the tipping bucket was found to be within the range of 100 tips ± 3 tips. The calibration results indicated that the air temperature probe and thermistor probe were working and the tipping bucket measurement was also within the manufacturer's specification. The air temperature and thermistor probes were checked for proper functioning by placing them in an ice bath and in direct sun light and comparing the measured temperatures. In direct sun light it

Table 2. Equipment installed.

Equipment	Quantity	Serial Number
Instrument Hole		
MRC Thermistor Probe	1	195 (08AT)
CRREL Resistivity Probe	1	08AR
TDR Sensors	10	08A01-08A10
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16557
Battery Package	1	5539
Weather Station		
TE525 MM Rain Gauge	1	11930
Air Temperature Probe (Model 107)	1	421316
Radiation Shield	1	41301
Observation Well/Bench Mark	1	None

was found that one of the thermistor sensors did not operate correctly. This sensor was returned to the manufacturer for repair and another thermistor sensor used. The spacings between the thermistor sensors in the plastic tube were measured and recorded. These measurements are shown in Table 3.

The wiring of the resistivity probe was checked using continuity measurements between the each electrode and to the pins in the connector. The distance between each electrode was measured and recorded. These spacing are shown in Table 4. Electrical resistance and resistivity measurements were performed with the probe immersed in a water bath. The results of these measurements are shown in Appendix B. The checks on the resistivity probe indicated all electrodes were functioning.

The functioning of the TDR sensors were checked by performing measurements in air, with the prongs shorted at beginning of the sensor and not shorted, and in water. The TDR measurements indicated that all sensors produced the expected traces and appeared to be functioning properly. Results of these TDR measurements are presented in Appendix B.

Equipment Installation

Installation of the measurement equipment was started on June 30, 1993. A pre-installation meeting was held with CDOT the previous day to finalize all details and responsibilities. CDOT provided traffic control, pavement sawing, auguring and pavement repair. Installation of the measurement equipment, the observation well, and cabinet was performed by NCE staff, FHWA staff and the other participants listed above.

Installation of the instrumentation was completed in two days. The first day activities included the set-up of traffic control, site layout and marking, installation of piezometer,

Table 3. Description of MRC thermistor probe and sensor spacing.

Unit	Channel No.	Distance from Top of Unit(cm)	Remarks
1	1	1.3	This unit was installed in the AC layer.
	2	15.2	
	3	29.2	
2	4	2.4	This unit was installed in the base and subgrade.
	5	10.1	
	6	17.7	
	7	25.3	
	8	32.8	
	9	48.3	
	10	63.4	
	11	78.8	
	12	93.8	
	13	109.1	
	14	124.2	
	15	139.5	
	16	154.6	
	17	170.0	
	18	182.7	

thermistor probe, resistivity probe, TDR sensors, air temperature probe, rain gauge, and cabinet, and site clean up. Wiring of all cables to the cabinet was also completed in the first day.

The instrumentation was installed on the approach end of the test section at approximate station 0-19. The in-pavement sensors were installed in a 356mm square hole cut into the AC surface, located in the outside wheel path, 914mm from the edge of the travel lane. A 229mm diameter auger was used to bore the instrument hole approximately 2.13m deep. Wires from the instrumentation were placed in a 51mm diameter steel conduit and buried in a 76mm wide trench leading to the equipment cabinet located approximately 8.5m away from the instrument hole. The observation piezometer/benchmark was located on the edge of the pavement shoulder adjacent to test section station 1+00.

The installation generally followed the procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines", except for boring of the instrumentation hole. Due to problems encountered in auguring through subbase

Table 4. Resistivity probe and sensor spacing.

Connector Pin Number	Electrode Number	Continuity ✓	Measurement	Spacing (cm) Line 1	Line 2	Avg	Dist. from top (cm)
1	1	✓	Top-1	2.8	2.8	2.80	2.8
20	2	✓	1-2	5.1	5.2	5.15	8.0
2	3	✓	2-3	5.1	5.2	5.15	13.1
21	4	✓	3-4	4.8	4.9	4.85	18.0
3	5	✓	4-5	4.9	5.2	5.05	23.0
22	6	✓	5-6	5.1	5.0	5.05	28.1
4	7	✓	6-7	5.0	5.2	5.10	33.2
23	8	✓	7-8	4.8	5.0	4.90	38.1
5	9	✓	8-9	4.9	5.0	4.95	43.0
24	10	✓	9-10	5.0	5.2	5.10	48.1
6	11	✓	10-11	4.9	5.0	4.95	53.1
25	12	✓	11-12	5.0	5.3	5.15	58.2
7	13	✓	12-13	5.0	5.0	5.00	63.2
26	14	✓	13-14	5.1	5.2	5.15	68.4
8	15	✓	14-15	5.0	5.0	5.00	73.4
27	16	✓	15-16	5.0	4.9	4.95	78.3
9	17	✓	16-17	5.1	5.0	5.05	83.4
28	18	✓	17-18	5.2	5.2	5.20	88.6
10	19	✓	18-19	5.1	5.1	5.10	93.7
29	20	✓	19-20	5.1	5.1	5.10	98.8
11	21	✓	20-21	5.1	5.1	5.10	103.9
30	22	✓	21-22	5.0	5.1	5.05	108.9
12	23	✓	22-23	5.2	5.2	5.20	114.1
31	24	✓	23-24	5.0	5.0	5.00	119.1
13	25	✓	24-25	5.1	5.0	5.05	124.2
32	26	✓	25-26	5.0	5.1	5.05	129.2
14	27	✓	26-27	5.2	5.2	5.20	134.4
33	28	✓	27-28	5.0	5.1	5.05	139.5
15	29	✓	28-29	5.0	4.9	4.95	144.4
34	30	✓	29-30	5.0	5.1	5.05	149.5
16	31	✓	30-31	5.1	5.1	5.10	154.6
35	32	✓	31-32	5.1	5.1	5.10	159.7
17	33	✓	32-33	5.1	5.1	5.10	164.8
36	34	✓	33-34	5.1	5.2	5.15	169.9
18	35	✓	34-35	5.1	4.9	5.00	174.9
37	36	✓	35-36	5.0	5.0	5.00	179.9
			36-End	2.4	2.4	2.40	182.3

layer, which contained boulders and cobbles, excavation of the instrumentation hole took longer than normal, ~2 hours. One large boulder was encountered at approximately .9m which could not be removed. To proceed, the auger was moved slightly to the edge of the hole. In backfilling the material around the TDR probes, only small grain size materials were placed in the immediate vicinity of the probes. Rocks and cobbles in the base were placed between TDR sensor locations. Due to the lack of material, extra base material was obtained from the well site and used near the surface of the instrument hole.

To check for breakage of the TDR sensors during installation, each probe was connected to the 1502B cable tester and its wave form monitored during compaction of the material around it. During compaction, it was noticed that the trace moved up and down slightly. During installation, the TDR was connected to the 120v electrical connection on the FWD due to a low battery. This caused noticeable spikes to occur in the TDR signal traces, as shown in the traces for probes 6, 7, and 8 included in Appendix C.

Table 5 presents the installed depths of the TDR probes, Table 6 the thermistor sensors, and Table 7 the electrodes of the resistivity probe. Table 8 gives the TDR moisture content and field measured moisture content during installation. TDR traces obtained during installation are presented in Appendix C.

Table 5. Installed depths of TDR sensors.

Sensor #	Depth from pavement surface (m)	Layer
08A01	0.184	Base
08A02	0.333	Subbase
08A03	0.489	
08A04	0.641	
08A05	0.798	
08A06	0.927	Subgrade
08A07	1.099	
08A08	1.251	
08A09	1.562	
08A10	1.859	

Upon completion of the installation, all wiring to the cabinet were carefully examined. The Version 1.0 of the ONSITE computer program was downloaded to the onsite CR10 datalogger mounted in the cabinet. The datalogger was left to collect data overnight so that the results could be evaluated the next day.

Table 6. Installed location of MRC thermistor sensors.

Unit	Channel Number	Depth from Pavement Surface (m)	Remarks
1	1	.013	This unit was installed in the AC layer.
	2	.060	
	3	.106	
2	4	.168	This unit was installed in the base and subgrade.
	5	.245	
	6	.321	
	7	.397	
	8	.472	
	9	.627	
	10	.778	
	11	.932	
	12	1.082	
	13	1.235	
	14	1.386	
	15	1.539	
	16	1.690	
	17	1.844	
	18	1.971	

Site Repair

The instrumentation hole was repaired by reinstalling the asphalt concrete block originally cut from the pavement. A thin layer of cold mix asphalt concrete repair material was spread over the surface of the instrumentation area. Then the concrete block was positioned and secured into the pavement using PC-7 epoxy. Self-leveling 888 crack sealant was used in the pavement surface temperature grove and around the edges of the block. The conduit trench was repair by first apply an asphaltic tacking compound and then placing and compacting a cold mix asphalt concrete patching material.

Table 7. Location of electrodes of the resistivity probe.

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
1	1	.172
20	2	.224
2	3	.275
21	4	.324
3	5	.374
22	6	.425
4	7	.476
23	8	.525
5	9	.574
24	10	.625
6	11	.675
25	12	.726
7	13	.776
26	14	.828
8	15	.878
27	16	.927
9	17	.978
28	18	1.030
10	19	1.081
29	20	1.132
11	21	1.183
30	22	1.233
12	23	1.285
31	24	1.335
13	25	1.386
32	26	1.436
14	27	1.488
33	28	1.539
15	29	1.588
34	30	1.639
16	31	1.690
35	32	1.741
17	33	1.792
36	34	1.843
18	35	1.893
37	36	1.943

Table 8. Field measured moisture content during installation.

Sensor Number	Sensor Depth (m)	Layer	TDR Moisture Content (by wt)	Measured Moisture[4] Content (by wt)
08A01	0.184	Base[1]	6.02%	5.65%[5]
08A02	0.333	Subbase[2]	6.57%	5.65%[5]
08A03	0.489		4.40%	2.83%[6]
08A04	0.641		5.51%	4.97%
08A05	0.798		6.57%	5.65%
08A06	0.927	Subgrade[3]	11.35%	1.52%[7]
08A07	1.099		10.18%	1.52%[7]
08A08	1.251		11.35%	13.20%
08A09	1.562		19.82%	29.50%
08A10	1.859		26.69%	27.82%

[1] Conversion factor = 2.16
[2] Conversion factor = 2.16
[3] Conversion factor = 1.63
[4] Raw data are given in Appendix C
[5] A new batch of material premixed with water
[6] Cobbles were not included in this measurement
[7] Clayey ball material was removed

III. Initial Data Collection

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

Air Temperature, Subsurface Temperature, Rain-fall Data

The air temperature, pavement and subsurface temperature profile, and rainfall monitored overnight by the onsite CR10 datalogger were examined. The equipment and data logger appeared to be functioning properly. The battery voltages were checked and found to be acceptable. Raw data collected at the site are presented in Appendix D. Note that in this data file, the resistance measurement function was active, although it was not connected to the resistivity probe, and produced a series of large negative numbers. This is data type 6, identified by the first number on the line.

Figure D-1 shows the air temperature data collected from 5:00 p.m. (June 30) through 8:00 a.m. (July 1). Figure D-2 shows the hourly average subsurface temperature for the first 5 sensors. Figure D-3 shows the average subsurface temperature for all 18 sensors. There was no precipitation that night. All these results indicated that the onsite CR10 datalogger and measurement equipment were working.

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

TDR Measurements

TDR data were collected using the mobile system provided by the FHWA. The mobile system contains a CR10 datalogger, a battery pack, two TDR multiplexers, and a resistance multiplexer circuit board. Version 1.0 of the MOBILE program used to collect and record the TDR wave form traces for each sensor.

Figures D-4 to D-13 show the TDR wave form traces collected with the MOBILE data acquisition system for all 10 sensors. These figures indicate that the multiplexers of the mobile systems and TDR sensors were working.

Resistance Measurement Data

Resistance data were collected in two modes: automated and manual. The MOBILE data acquisition system automatically performs two point contact resistance measurements and stores the values in terms of millivolts between adjacent electrodes. Figure D-14 shows pavement depth versus measured voltage produced by the MOBILE system. At the time, the MOBILE system was thought to be functioning properly because the magnitude of the record voltage changed with depth. However, on subsequent investigation, it was found the resistance multiplexer board had been improperly wired and these traces were erroneous.

Manual contact resistance and resistivity measurements were performed using a Simpson Model 420D function generator, two Beckman HD-110 digital multi-meters and a manual circuit board. The measured contact resistance data are plotted in Figure D-15 and in Figure D-16 for the 4-point resistivity. Raw data are given in Appendix D. Figure D-15 shows a typical profile of the contact resistance for the pavement consisting of a course granular material and a fine subgrade soil. Between 0.172m and 0.8m from the surface, the contact resistance measurement shows a wider range of variation with "spike" type signatures. This type of profile is characteristic of a very non-homogeneous gravel material. Below about 0.8m, the contact resistances are much lower and fairly uniform, indicative of a fine grained soil. The manually collected contact resistance results match fairly well with the inventory data and field investigation in terms of the layer material type and the thickness.

Comparison between Figure D-14 (voltage output results from automated mode) and Figure D-15 (contact resistance results from manual mode) indicates that the automated mode was not functioning. For a pavement consisting of different types of materials, the voltage outputs were expected to have some variations rather than a linear output as shown in Figure D-14.

Deflection Measurement Data

Deflection measurement followed procedures described in the "LTPP Seasonal Monitoring Program: Instrumentation Installation and Data Collection Guidelines." No analysis had been performed on the deflection test data.

Elevation Surveys

One set of surface elevation surveys was performed following the guidelines. It was assumed the elevation of the well top was 1.000 meters. The survey results are presented in Appendix D.

IV. Summary

The instrumentation installation on test section 081053 was completed on the June 30, 1993 and initial data collection was completed on July 1, 1993. The instrumentation installed included time domain reflectometery probes for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature, tipping bucket rain gage, piezometer to monitor the ground water table, and an on-site data logger.

The test section is located in the north bound lanes of U.S. Highway 50 just south of Delta Colorado. The pavement structure on this test section consists of 117mm of asphalt concrete over an average of 137mm granular aggregate base. The 597mm subbase layer contains gravel, cobbles and boulders. The subgrade is classified as a lean inorganic clay.

All of equipment installed onsite appeared to be functioning properly. As noted in the report, the automated resistance data acquisition system did not function properly, although this was difficult to determine in the field. The malfunction was subsequently traced to a faulty wiring connection. In the future, all data acquisition systems should be thoroughly tested in the office prior to field use. This was not possible on this site since the mobile data acquisition system was assembled in the hotel the week of the installation. A program which plots the data collected by the dataloggers is also needed as a field quality control check.

The major difficulty encountered at this site was that associated with auguring through the layer of boulder and cobbles. There is also concern on how representative the TDR measurements will be since these larger stones were purposely not placed next to the probes due to damage concerns. Note that TDR measurements sense the volume of moisture near the probes. It is recommended that consideration be given to not using TDR probes on sites which contain layers of cobbles or larger size rocks. Due to the difficulty of auguring through these layers, sites with cobbles or larger sized rocks are not recommended for use in the LTPP Core Seasonal Monitoring Program.

Handling of the asphalt concrete block was difficult, particularly after the sides had been coated with epoxy. It is recommended that for future installations, that some sort of handle mechanism be attached to the block, such as anchor bolts connected to a cross brace.

The piezometer was installed with a utility cover assembly placed on top of a portland cement concrete base layer. It is thought that this construction may pose problems due to water accumulations inside the cover assembly. In future installations, some form of positive drainage of the cover assembly or placement of the cover assembly in such a way that water can not accumulate inside the cover assembly should be taken.

The Colorado Department of Transportation produced a video titled "SHRP - Seasonal

Monitoring Program". This video chronicles the installation of instrumentation at this site, the initial data collection and discusses the background for the seasonal monitoring program, and the training workshop held in conjunction with this installation.

APPENDIX A

Test Section Background Information

Appendix A Includes the Following Supporting Information:

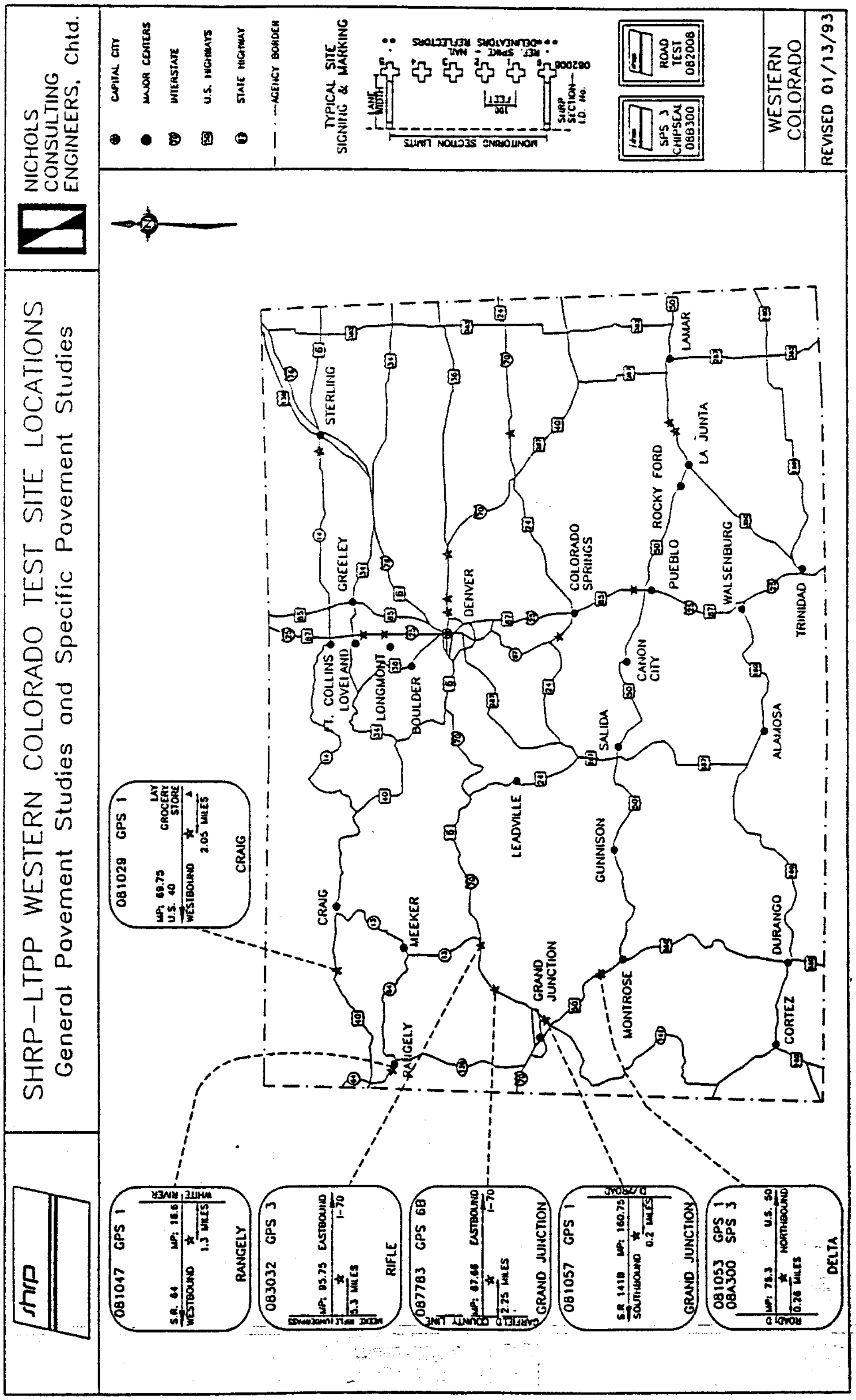


Figure A-1. Location of test site, GPS test section 081053.

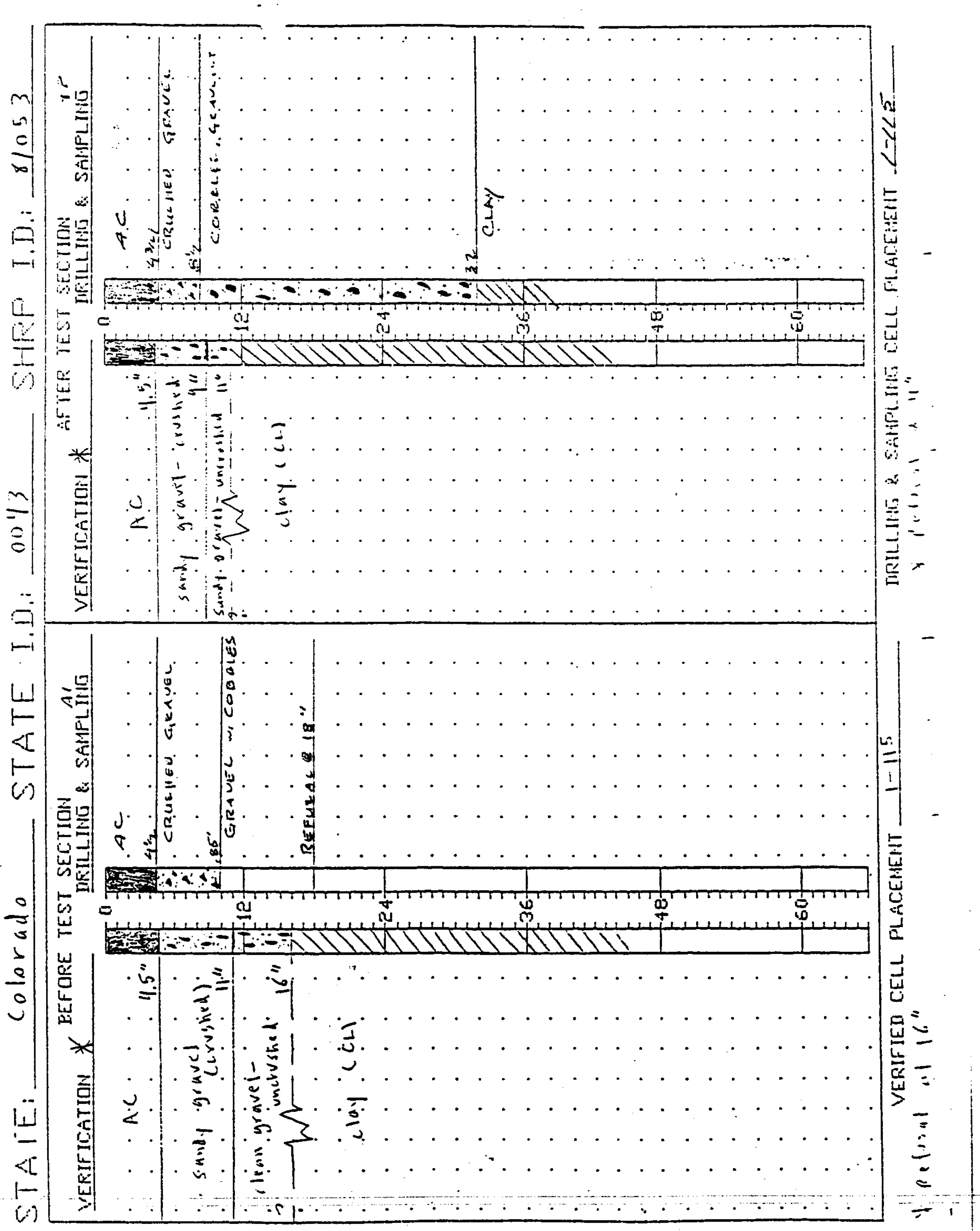


Figure A-2. Profile of test tection.

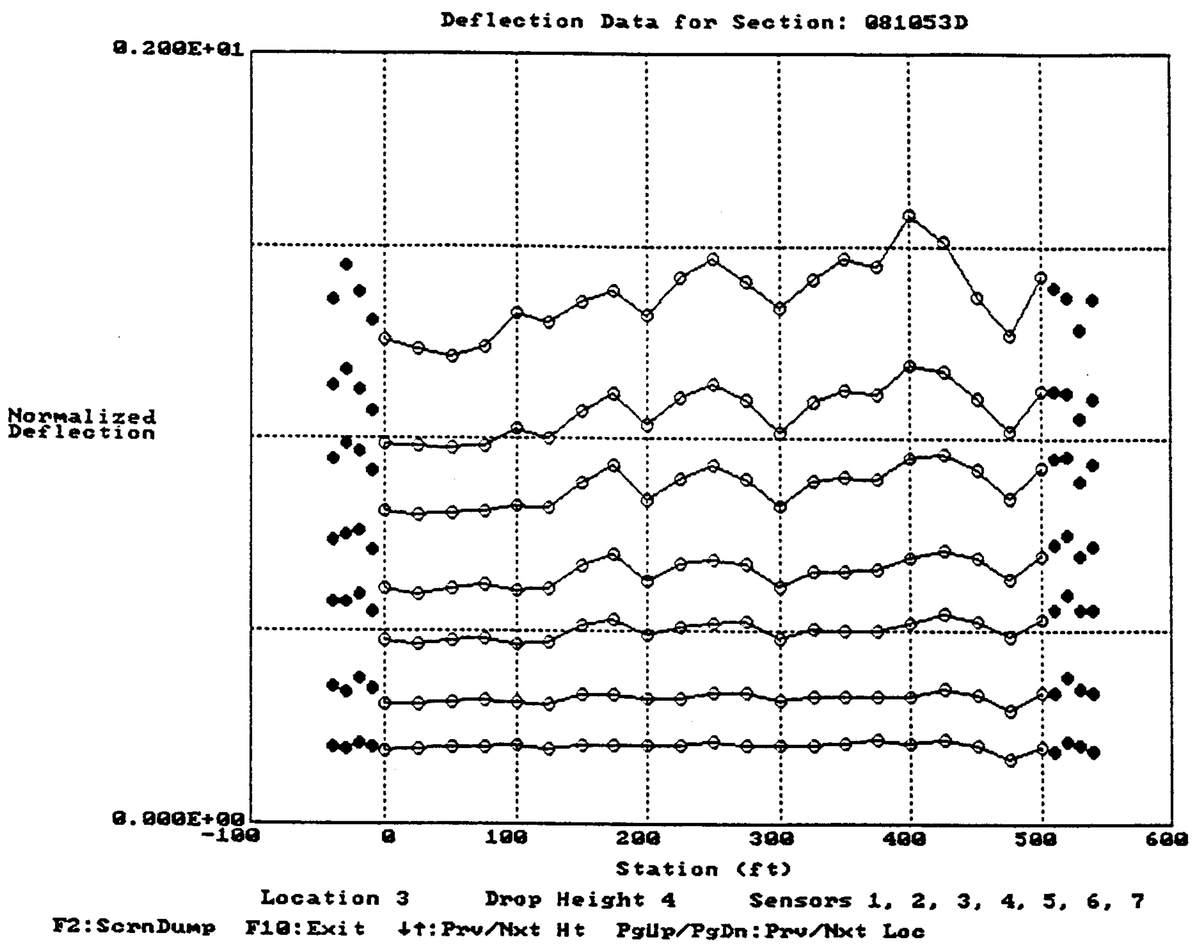


Figure A-3. Deflection profiles from FWDCHECK.

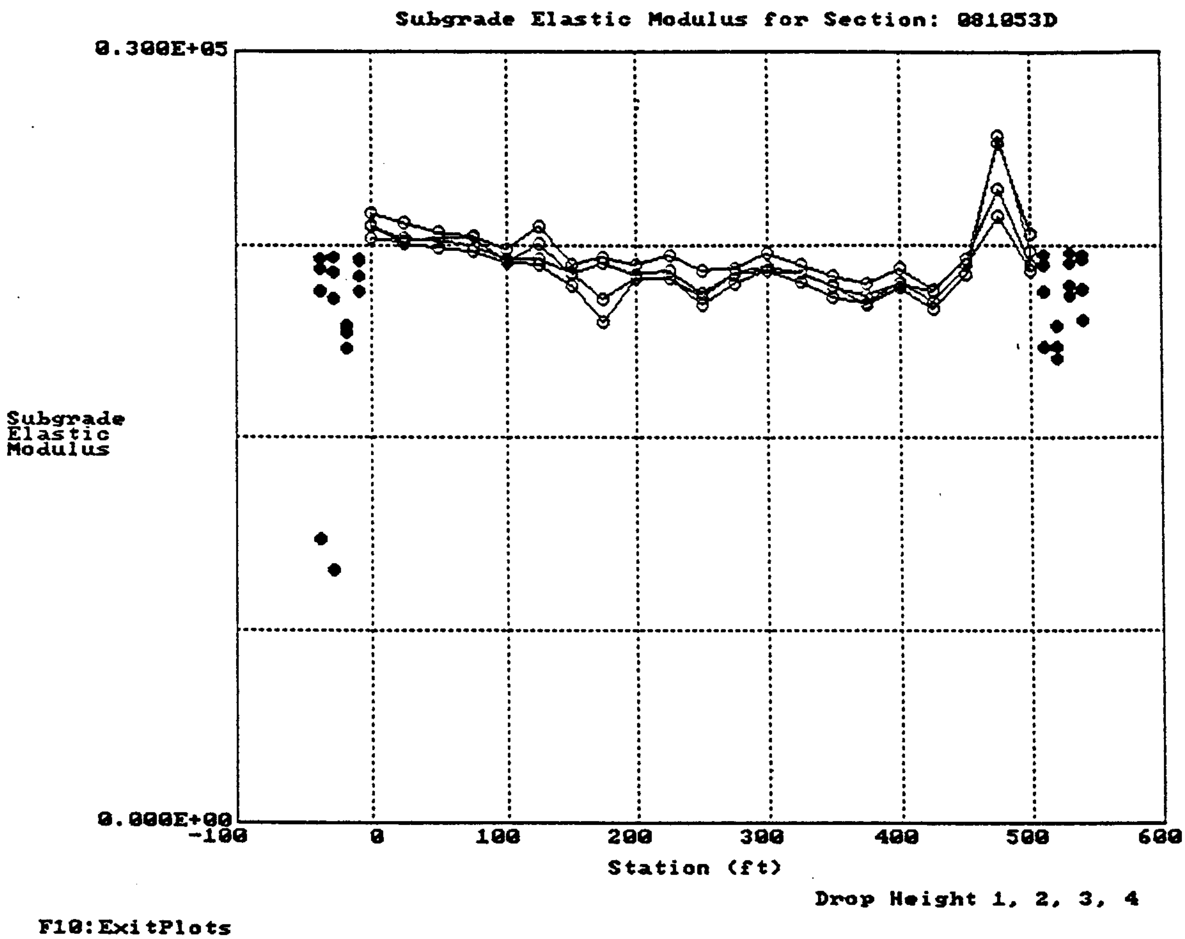


Figure A-4. Subgrade modulus profiles from FWDCHECK.

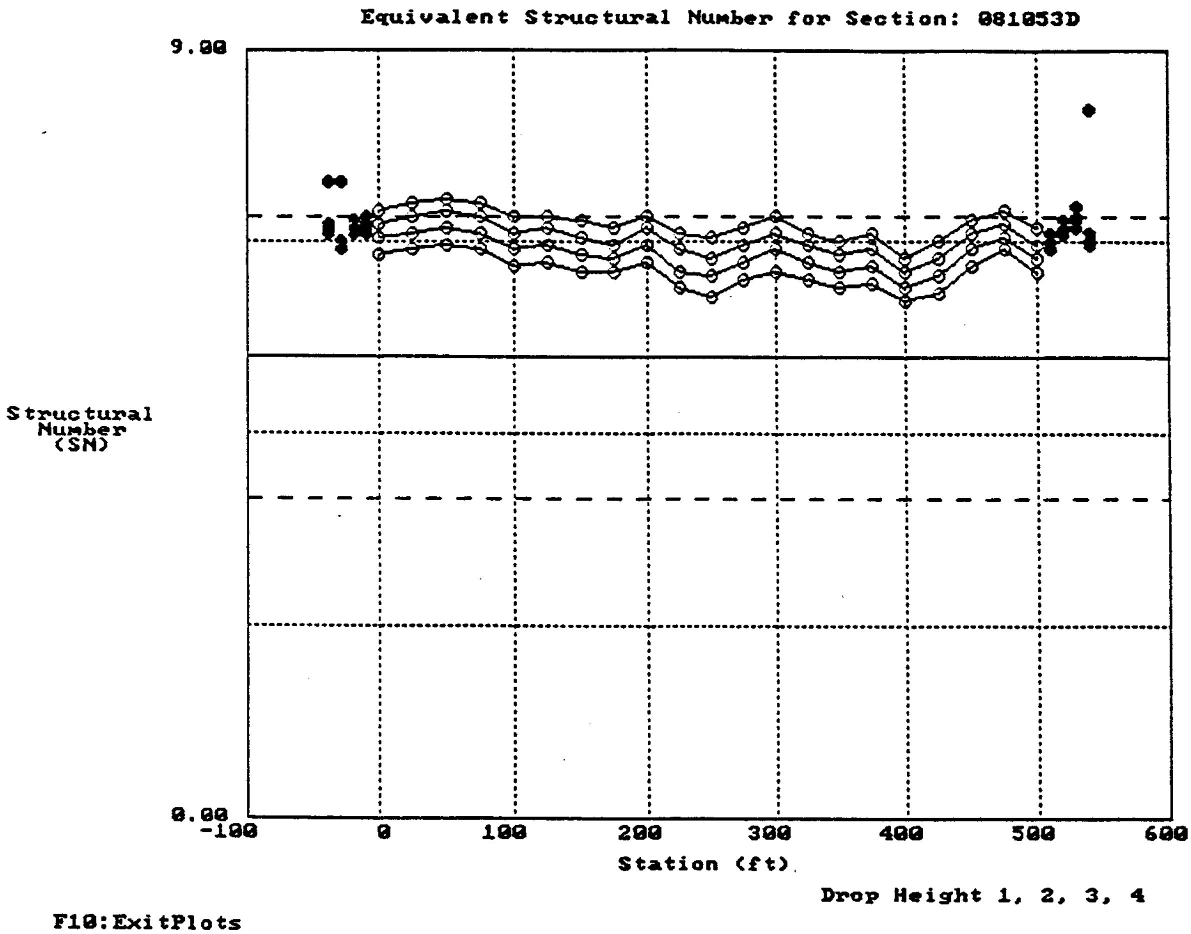


Figure A-5. Structural Number profiles from FWDCHECK.

APPENDIX B

Supporting Site Visit and Installed Instrument Information

Appendix B contains the following supporting information:

NICHOLS
CONSULTING
ENGINEERS, Chtd.

MEMORANDUM

TO: Ahmad Ardani, Cal Berge DATE: May 11, 1993
FROM: Gary Elkins
SUBJECT: Notes from Planning Meeting and Site Review, Colorado Seasonal Monitoring Site
DISTRIBUTION: Aramis Lopez, Gonzalo Rada

Planning Meeting

A preliminary planning meeting for instrumentation installation on the seasonal monitoring site in Colorado was held May 6, 1993 at the Colorado DOT headquarter offices in Denver. Also discussed were the status of SPS-9 and the SPS-2 projects. Attending the meeting were Ahmad Ardani - CDOT Research, Denis Donnely - CDOT Materials Engineer, personnel from CDOT Staff Materials, FHWA division office, Cal Berge, and Gary Elkins. The attached agenda and meeting materials were used at the meeting.

Seasonal Monitoring

CDOT has employed a videographer to make a video of the instrumentation installation. The purpose of this video is to describe the objectives of the seasonal study, explain the measurements and instrumentation and show the installation process. The target audience is CDOT engineers and employees. Gary Elkins is to prepare an outline for the video and supply background information.

Preparations for the installation were discussed. CDOT stated that they did not think that they had a 12" core barrel. They have a 10" core barrel that could be used. It was noted that the pavement saw could be used in place of a core. They were also unsure if they had a 9" auger. A 9" diameter auger is the minimum size since the TDR probes are 8" long. CDOT said that they would check on what they had or could obtain. The drill crew will come from the central CDOT geology unit. Traffic control and maintenance will be provided by the local CDOT district office.

Ahmad Ardani indicated that the test section was exhibiting flushing. At the current time they do not know of any planned major rehabilitation activities in the next five years. Some type of surface treatment maybe applied. Ahmad said that he would check on any planned maintenance or rehabilitation activities.

The following schedule for the installation and training activities was discussed:

- Mon., June 28 - 1:00 p.m. — Internal planning meeting (FHWA, NCE, TAC, PMS).
- Mon., June 28 - 3:00 p.m. — Final planning meeting with local CDOT district.
- Tues., June 29 - 8:00 a.m.-5:00 p.m. — RCOC instrumentation training.
- Wed., June 30 - 8:00 a.m.~5:00 p.m. — Instrumentation installation.
- Thurs., July 1 - 8:00 a.m.~5:00 p.m. — Cabinet wiring and initial measurements.
- Fri., July 2 - 8:00 a.m.-12:00 p.m. — Close-out meeting with RCOC, contingency day.

1885 S. Arlington Ave., Suite 111
Reno, Nevada 89509
Telephone (702) 329-4955
Fax (702) 329-5098

SPS-9

During the meeting we discussed CDOT's participation in the SPS-9 study. CDOT has invested in European asphalt concrete mix design and evaluation technology. On an SPS-9 project they wish to evaluate their "European" style dense graded mix against a SUPERPAVE™ mix. We discussed delays in equipment procurement to support the SUPERPAVE™ design method. By 1994 they should have their European mix designs ready. The possibility of SUPERPAVE™ mix designs being performed by an external laboratory was discussed.

SPS-2

CDOT will apply FHWA demonstration money available after October 1993 to construct a "European" style PCC supplemental test section on their SPS-2 project. Ahmad said that he would let us know where the test section would be located. This will allow development of a materials sampling plan for the test section. It was mentioned that changes were being made to the SPS-2 and 8 materials sampling plans. We told Ahmad that we would change the plans as soon as we received the new guidelines. He said that we needed to hurry since construction of the project has started. He also mentioned that they may change the construction sequence and construction of the SPS-2 test sections may be accelerated. A coordination meeting needs to be set up with CDOT, NCE, and the construction contractor.

Site Visit

Cal Berge, Ahmad Ardani and I visited the seasonal monitoring site the morning of May 7, 1993. The test section is located approximately 5 miles south of Delta on U.S. 50. This is a divided highway with two lanes in each direction. The test section is located in the north bound lanes. The SPS-3 test sections on this project are located south of the GPS test section. The test section is located on approximately 3' fill over a clay subgrade. The outside shoulder has an asphaltic concrete surface and is approximately 10' wide. The soil adjacent to the shoulder is a clay. Due to rain, the flushing of the AC surface could not be seen. However, moderate rutting of the test section was observed.

The best end of the test section for instrumentation appears to be the 0 - end. The 5+ end is located adjacent to a driveway accessing the nearby field. The portion of the test section between 3+00 and 5+00 has a stiff location in the subgrade at approximately 4+75, as determined from analysis of the FWD data.

An underground water line appears to be located along the test section near the fence line. The location of subsurface utilities at the site needs to be identified. Ahmad will discuss this with district personnel.

Potential problems with the test section include the influence of the ruts on deflection testing in the wheel path, the presence of cobbles in the subbase (the boreholes during material sampling were able to penetrate this layer), and potential rehabilitation and maintenance treatments. At this time, none of these problems appear to significantly compromise the site.

A hardware store and electrical supply store are located in Delta. A number of restaurants are also located in Delta.

Although a Best Western Motel with 41 rooms is located in Delta, it was felt that it would be better for participants to stay at a hotel in Grand Junction near the airport where adequate meeting facilities exist. The site is located approximately 35 miles from Grand Junction and requires a 40 minute trip. The CDOT district office is located in Grand Junction while a local maintenance yard is located in Delta. G. Elkins obtained the brochures of most of the hotels located near the airport. Due to the large number of people who will attend this installation, I recommend that we organize transportation to the site so that we do not have an excessive number of vehicles. It may be best for us to rent one or two vans for transportation of personnel to the site. G. Elkins will arrange for a block of rooms plus a meeting room for Tuesday and Friday at a selected motel.

Action Items

Ahmad Ardani

Seasonal Monitoring Site

1. Check on availability of drill crew, core barrel (12" desired 10" acceptable), concrete saw, 9" diameter (minimum) auger to go 7' deep, and 6" or 4" diameter auger to go ~ 15' deep.

2. Make arrangements for traffic control and pavement patching.

3. Obtain materials for the observation well, including sand, bentonite, PCC, and utility access cover.

4. Check on rehabilitation and maintenance activities planned on the test section.

5. Determine the location of subsurface utilities at the test section site.

SPS-2

1. Send to G. Elkins information on the location of the new European test section.

2. Set up a meeting with the construction contractor, materials sampling contractor, the Western Region RCOC (NCE) and appropriate CDOT personnel to discuss construction sequence, timing, material sampling and testing and data collection activities.

3. Talk to CTL Thompson to find out what the results of their PCC mix design tests were. Provide this information to G. Elkins.

Gary Elkins

Seasonal Study

1. Discuss test section condition and adequacy as a seasonal site with Aramis Lopez and PCS/Law.

2. Advise Ahmad as soon as possible on the final schedule.

3. Coordinate hotel accommodations and meeting room for LTPP participants.

4. Coordinate acquisition of monitoring well/frost free bench mark hardware.

5. Develop outline for video and send to Ahmad.

SPS-2 and 8

1. Revise material sampling plan to include new European test section and changes in the sampling and testing guidelines.

2. Coordinate with Ahmad on meeting with construction contractor.

Cal Berge

1. Develop some example introductory remarks that Dwight Bower might use in the video. (enclosed)

The Strategic Highway Research Program was established by the 1987 Transportation Act to conduct research in six major technical areas relative to factors that have adversely affected highways so that better pavement performance and extended service life can be achieved - in other words get a "bigger bang for the buck." Colorado has certainly experienced some of these problems and thus has been very active in the SHRP Research Program. We are participating in special studies such as experimental designs to improve new construction or reconstruction; to look at the most cost effective way to rehabilitate our existing pavements; and to determine best ways to maintain our pavements. Colorado is also experimenting with European designs for asphaltic concrete and Portland cement concrete pavements.

Of the 135 products coming out of SHRP todate, I am sure that several of them will be directly applicable to Colorado and I intend to implement them. Some of them of course will require field or laboratory evaluation and validation; others will require some additional research; and still others will require extensive additional research.

One of the problem areas recognized by SHRP is that environmental conditions can adversely impact the "strength of the pavement structure." We in Colorado are well aware of that because after a very severe winter if you do not restrict load limits on some roads there can be very serious roadway damage to the extent of very heavy maintenance or even rebuilding.

SHRP and FHWA in cooperation with the states has developed a specialized study to determine how much adverse environmental conditions impact pavement strength. Of the 800 General Pavement Study Sites, 64 with sixteen in each environmental zone, have been selected for an extensive study relative to factors such as moisture, temperature, and frost depth and their affect on pavement strength. These sites will be monitored each month by the Regional SHRP team and twice during each of the spring-break up months.

Pilot installations were made on a flexible pavement at Syracuse, New York and on a concrete site at Boise, Idaho in the summer and fall of 1991. As a result, the type of instrumentation was finalized and a third installation was made near Billings, Montana in August 1992.

I am pleased to say that Colorado has agreed to conduct a demonstration installation at our selected site on U.S. 50 near Delta. This demonstration will provide training for staff from each of the other three SHRP Regions to insure that each of the 64 installations will be made uniformly and that SHRP will be able to collect reliable data, conduct a meaningful analyses, and provide some worthwhile recommendations.

Colorado Seasonal Monitoring Instrumentation Pilot
SPS-9 Status, European PCC section on SPS-2 project
Planning Meeting May 6, 1992

Site
- Location
- Layout

Equipment and Responsibilities
- Instrumentation
  - TDR Probes
  - Resistivity Instrumentation
  - Temperature Probe
  - Equipment Cabinet
  - Air Temperature and Precipitation
- Monitoring Well - Bench Mark
- Drill Rig
- Core Rig / Pavement Saw
- Tools
- Pavement Repair Materials

Tentative Schedule

Mon	June 28	Final Internal Planning Meeting, NCE, FHWA, TAC (1 pm)
Mon	June 28	Meeting with local Colorado DOT District Personnel (3 pm)
Tue	June 29	Training of RCOC personnel (8 am - 5 pm)
Wed	June 30	Sensor installation (8am ~ 5pm)
Thr	July 1	Completion of cabinet wiring, initial measurements (8am~5pm)
Fri	July 2	Follow-up project review meeting, contingency day (8am~12pm)

Install Team

NCE	
Colorado DOT	Drill Crew
	Traffic Control
	Colorado DOT Project Contacts
	Videographer
Others	FHWA-LTPP Division
	Other FHWA?
	LTPP - TAC
	Other RCOC staff

SPS-9 Status

European PCC Test Section on SPS-2 Project

Installation Responsibilities

Colorado Transportation Department Forces

Traffic control
Drill rig and crew to perform coring and auguring (12" core, 10" auger, 6" auger)
Materials for piezometer (sand, bentonite, PCC, utility type access cover)
Assistance with installation of piezometer
AC patching material
Patching pavement, compaction
Portable electrical generator
Extra Base material

LTPP

TDR, resistivity, thermistor, rainfall and air temperature probes
Installation of TDR, thermistor, and resistance probes
Piezometer hardware
Equipment Cabinet
Conduit
Installation tools
Support instrumentation equipment
FWD

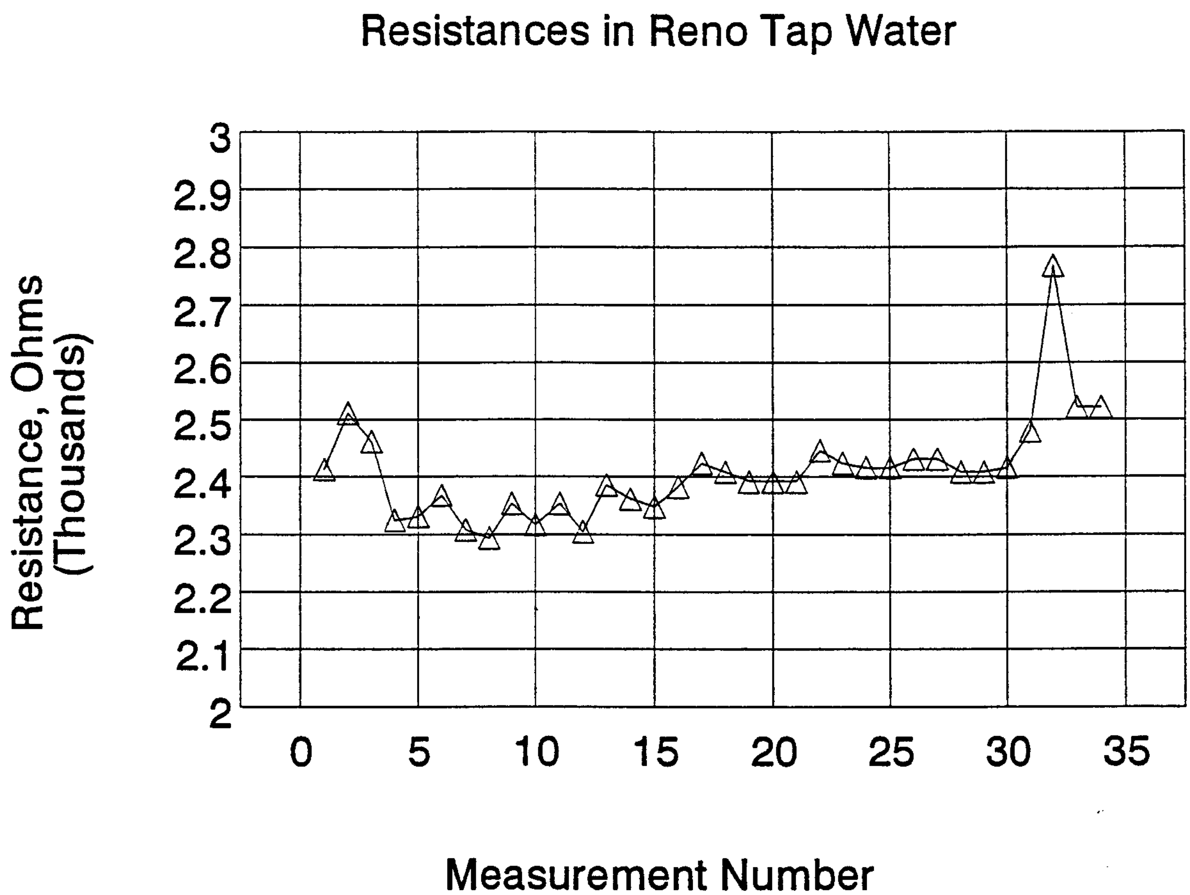


Figure B-1. Contact resistance measured in Reno tap water.

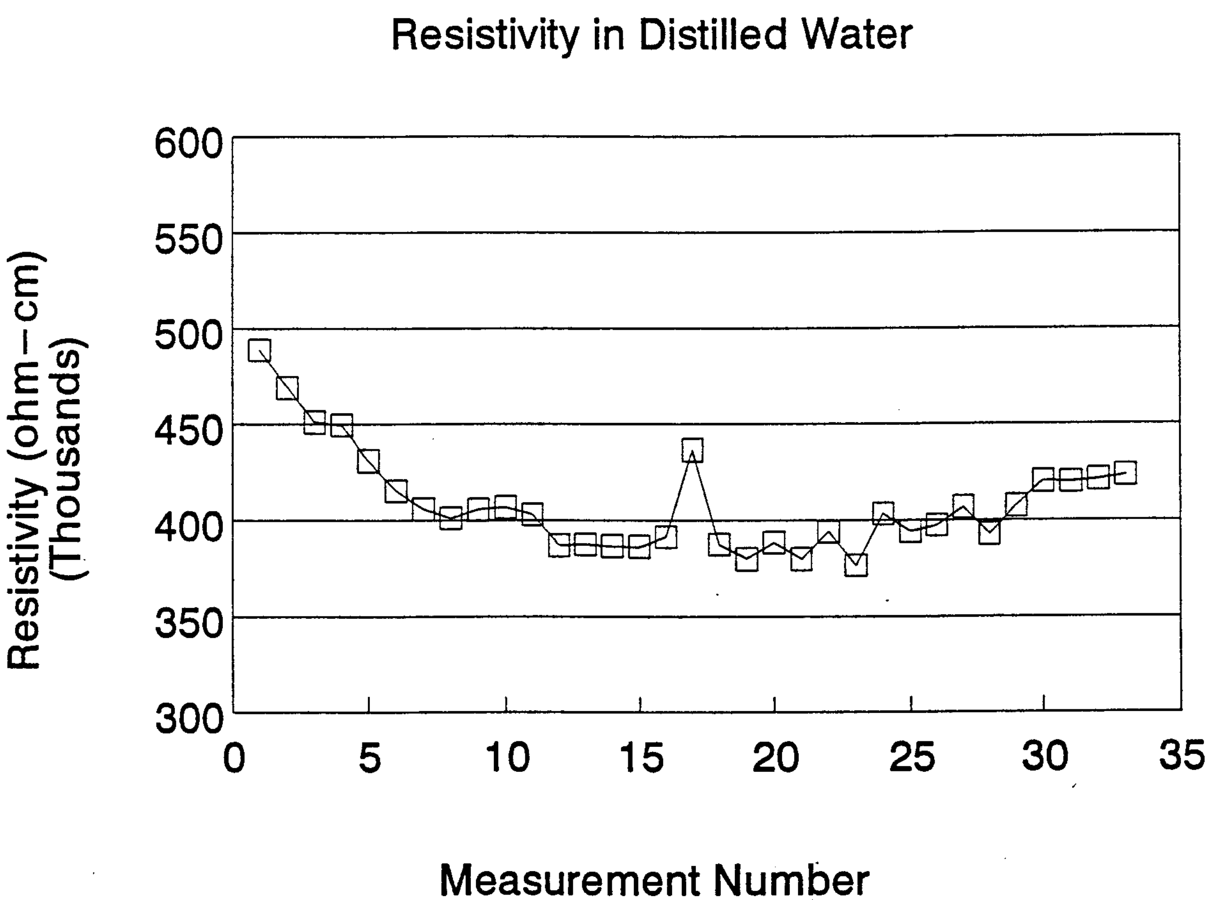
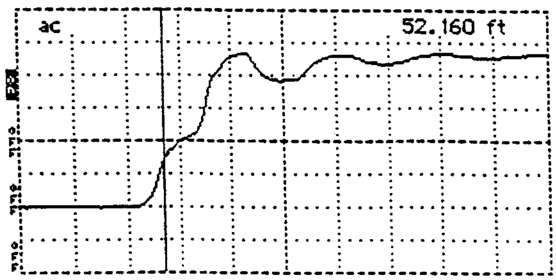


Figure B-2. Four-point resistivity measured in distilled water.

Cursor .... 52.160 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 182 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac

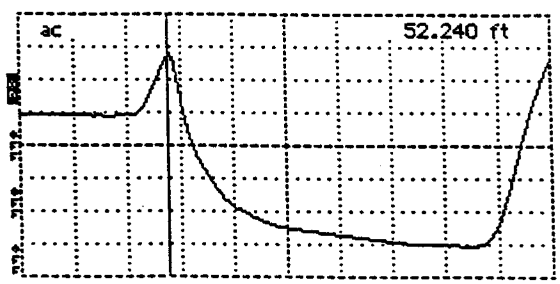
Tektronix 1502B TDR
Date 6/18/93
Cable C8A01
Notes In Air
Shortened at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.160 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 182 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable C8A01
Notes In Air
Input Trace
Stored Trace
Difference Trace

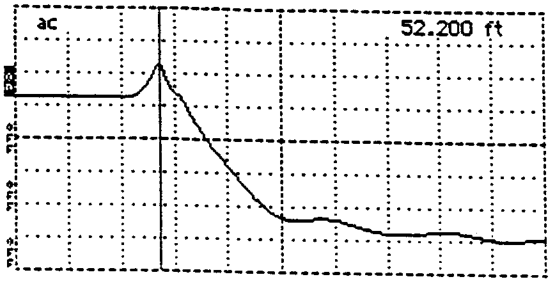
Cursor .... 52.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 74.8 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/19/93
Cable C8A01
Notes 6" Depth
of Probes in Distilled
Water 71°F
Input Trace
Stored Trace
Difference Trace

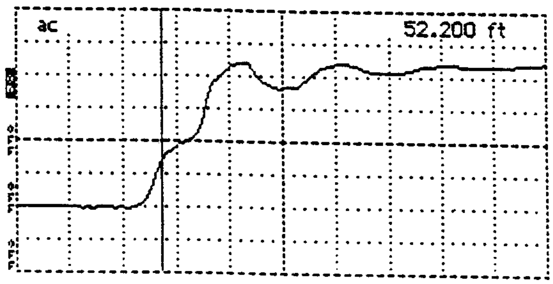
Figure B-3. TDR traces obtained during calibration.

Cursor .... 52.200 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 193 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac



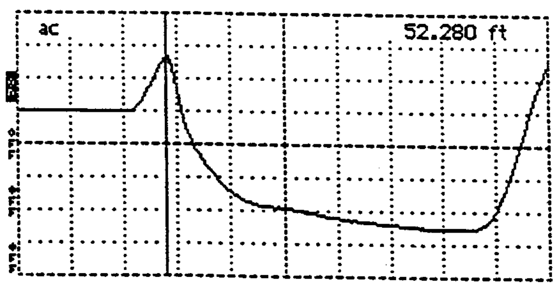
Tektronix 1502B TDR
Date 6/18/93
Cable 08A02
Notes In Air
Shortened at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.200 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 193 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A02
Notes In Air
Input Trace
Stored Trace
Difference Trace

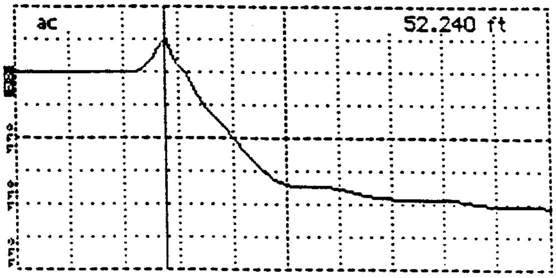
Cursor .... 52.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 83.9 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A07
Notes 6" Depth of
Probes in Distilled
water 71°F
Input Trace
Stored Trace
Difference Trace

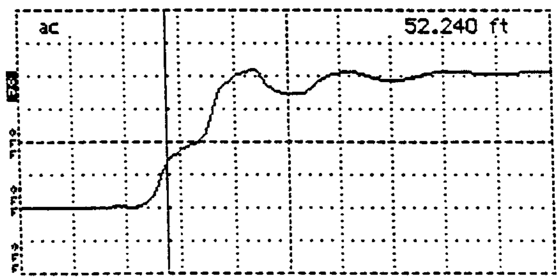
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 200 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



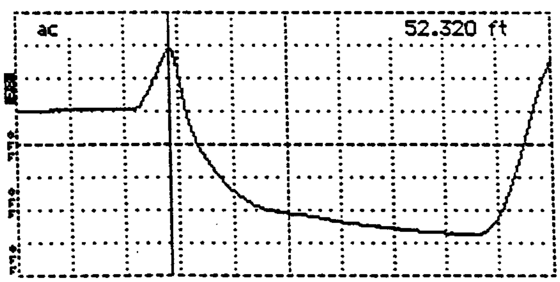
Tektronix 1502B TDR
Date 6/18/93
Cable 05A03
Notes In Air
Short ended at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 205 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 05A03
Notes In Air
Input Trace
Stored Trace
Difference Trace

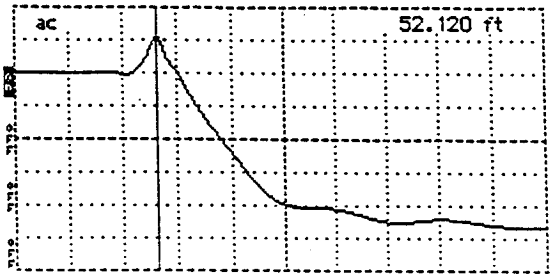
Cursor .... 52.320 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 77.0 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 05A03
Notes 6" Depth of
Probes in Distilled
Water 71°F
Input Trace
Stored Trace
Difference Trace

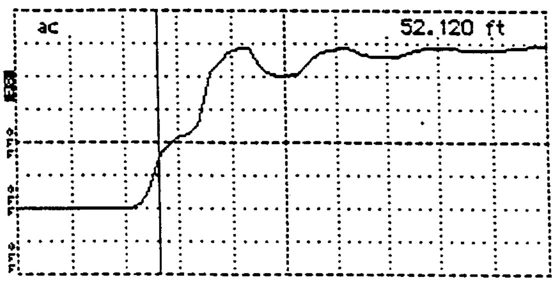
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



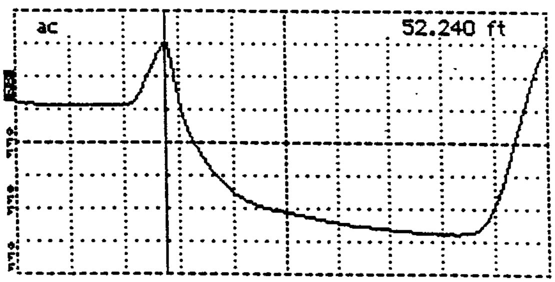
Tektronix 1502B TDR
Date 6/15/93
Cable 08 A04
Notes In Air
Shorted at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 177 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08 A04
Notes In Air
Input Trace
Stored Trace
Difference Trace

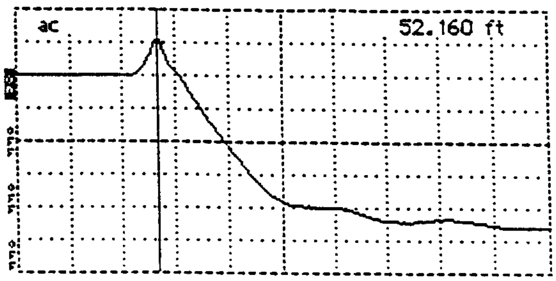
Cursor .... 52.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 77.0 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08 A04
Notes 6" Depth
of Probes in
Distilled Water 71°
Input Trace
Stored Trace
Difference Trace

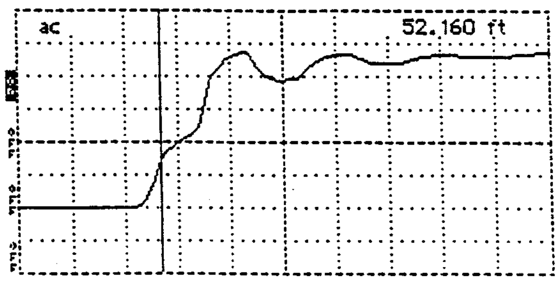
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.160 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 182 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



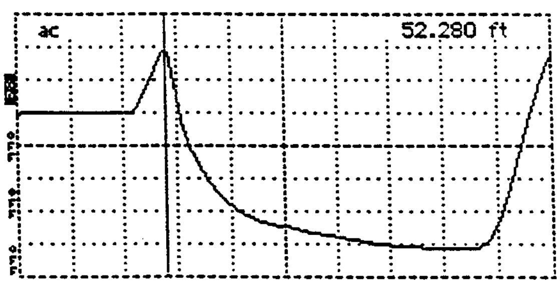
Tektronix 1502B TDR
Date 6/14/93
Cable ~~05A05~~
Notes In Air
Shorted at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.160 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 182 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/14/93
Cable 05A05
Notes In Air
Input Trace
Stored Trace
Difference Trace

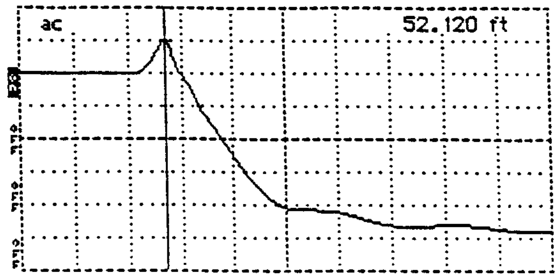
Cursor .... 52.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/14/93
Cable 05A05
Notes 6" Depth of Probes in Distilled Water 71°F
Input Trace
Stored Trace
Difference Trace

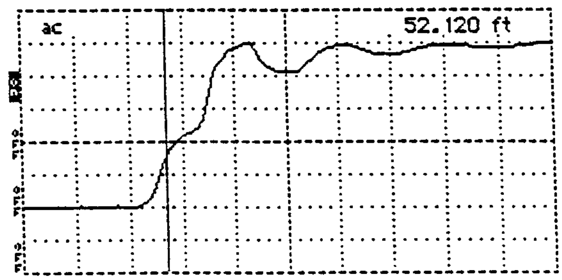
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale .... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac



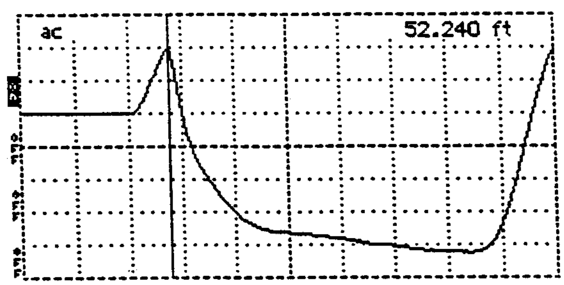
Tektronix 1502B TDR
Date 6/18/93
Cable 08A06
Notes In Air
Shortened at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale .... 177 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A06
Notes In Air
Input Trace
Stored Trace
Difference Trace

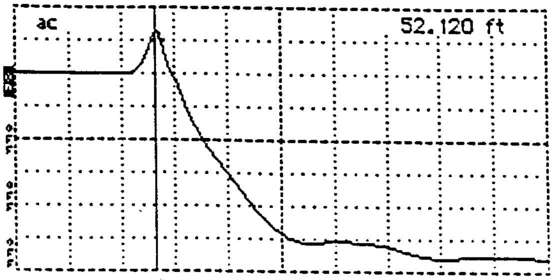
Cursor .... 52.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale .... 70.6 mρ/div
Vp 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A06
Notes 6" Depth
of Probes in
Distilled Water 71°
Input Trace
Stored Trace
Difference Trace

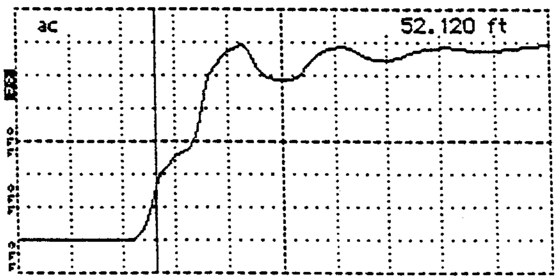
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 145 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



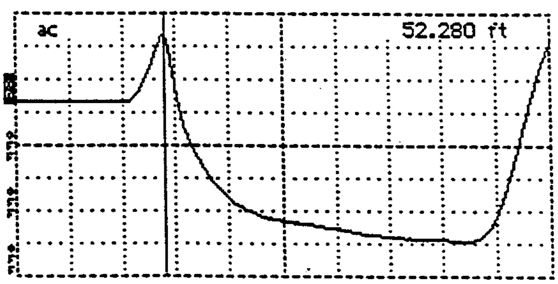
Tektronix 1502B TDR
Date 6/18/93
Cable 08A07
Notes In Air
Shorted at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 145 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A07
Notes In Air
Input Trace
Stored Trace
Difference Trace

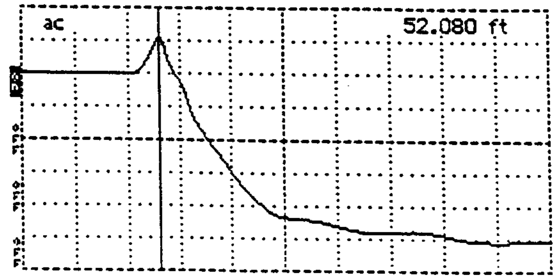
Cursor .... 52.280 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 70.6 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A07
Notes 2" Depth
of Probes in
Distilled Water 71°F
Input Trace
Stored Trace
Difference Trace

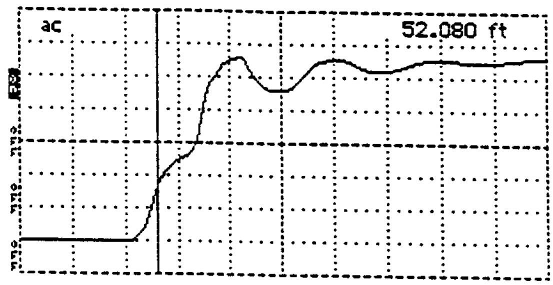
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.080 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 163 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



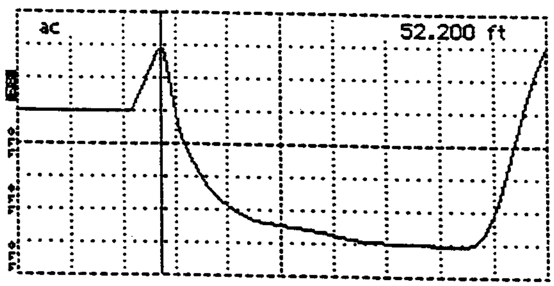
Tektronix 1502B TDR
Date 6/18/93
Cable 08A08
Notes In Air
Shortened at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.080 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 154 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A08
Notes In Air
Input Trace
Stored Trace
Difference Trace

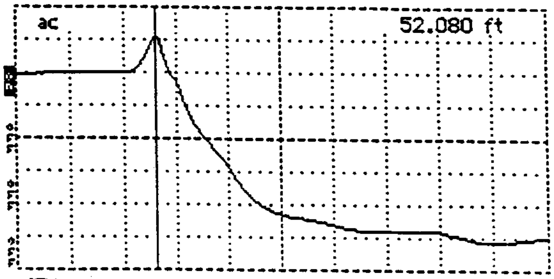
Cursor .... 52.200 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 72.7 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08A08
Notes 6" Depth of
Probes in Distilled
Water 71°F
Input Trace
Stored Trace
Difference Trace

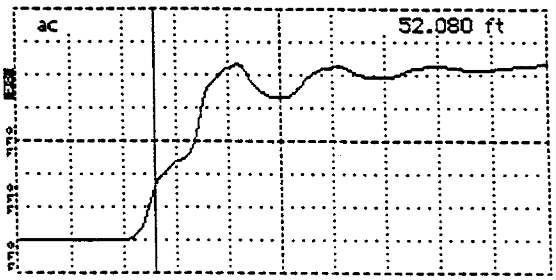
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.080 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 163 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



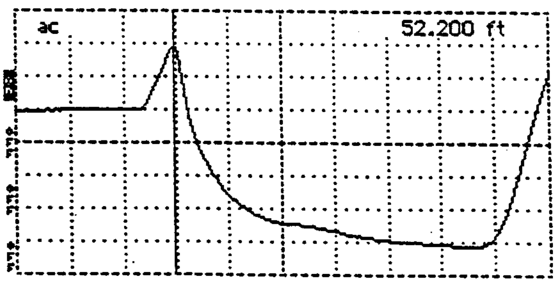
Tektronix 1502B TDR
Date 6/18/93
Cable CS 409
Notes In Air
Shorted at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.080 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 163 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable CS 409
Notes In Air
Input Trace
Stored Trace
Difference Trace

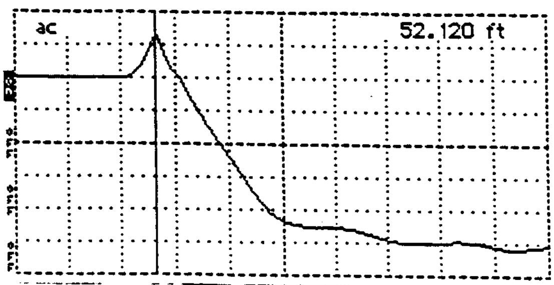
Cursor .... 52.200 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 74.8 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/18/93
Cable CS 409
Notes 6" Depth
of Probes in
Distilled Water 71°F
Input Trace
Stored Trace
Difference Trace

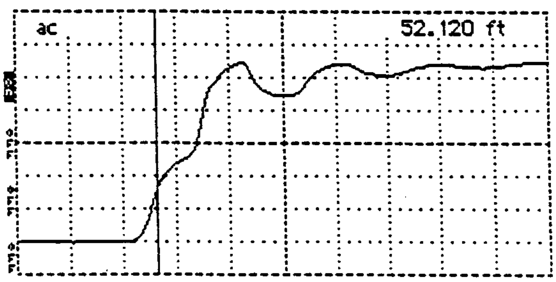
Figure B-3. TDR traces obtained during calibration (cont.).

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 158 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



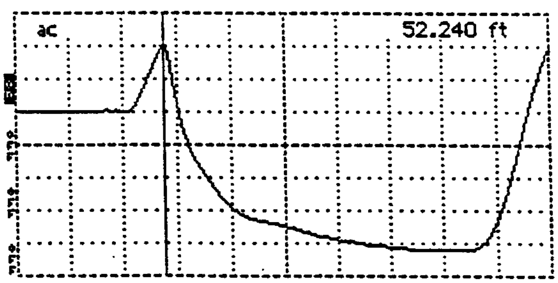
Tektronix 1502B TDR
Date 6/?/93
Cable CS 410
Notes In Air
Shortened at
Beginning
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.120 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 158 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08410
Notes In Air
Input Trace
Stored Trace
Difference Trace

Cursor .... 52.240 ft
Distance/Div ..... 1 ft/div
Vertical Scale.... 70.6 mρ/div
VP 0.99
Noise Filter ...... 1 avg
Power .... ac



Tektronix 1502B TDR
Date 6/18/93
Cable 08410
Notes 6" Depth
of Probes in
Distilled Water 71°F
Input Trace
Stored Trace
Difference Trace

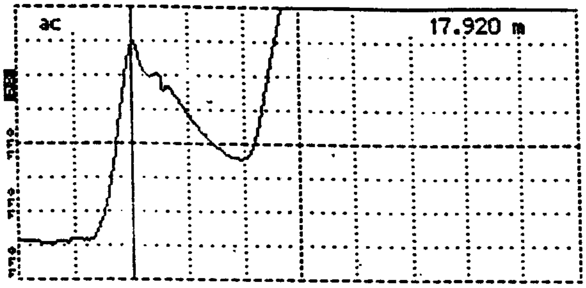
Figure B-3. TDR traces obtained during calibration (cont.).

APPENDIX C

Supporting Instrumentation Installation Information

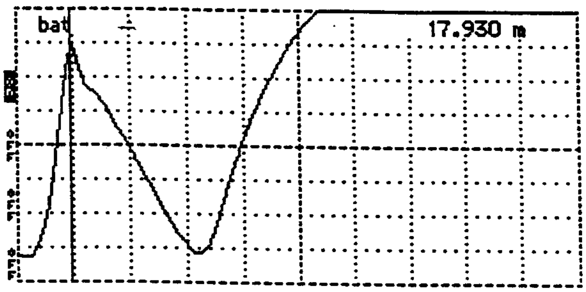
Appendix C contains the following supporting information:

Cursor .... 17.920 m
Distance/Div..... .25 m/div
Vertical Scale.... 32.5 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... ac



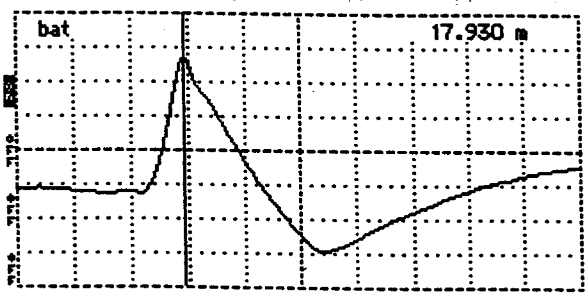
Tektronix 1502B TDR
Date 6/30/93
Cable 08A01
Notes DURING INSTAL -MOISTURE ADDED T BACKFILL MATER
Input Trace
Stored Trace
Difference Trace

Cursor .... 17.930 m
Distance/Div..... .25 m/div
Vertical Scale.... 32.5 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... bat



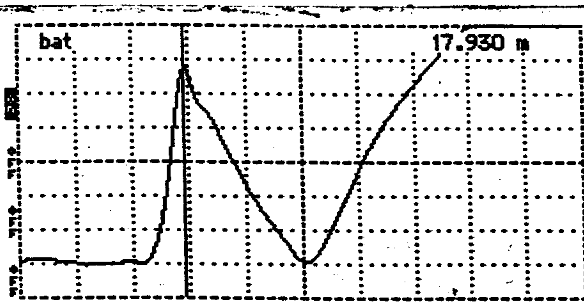
Tektronix 1502B TDR
Date 6/30/93
Cable 08A02
Notes DURING INSTAL -MOISTURE ADS TO BACKFILL
Input Trace
Stored Trace
Difference Trace

Cursor .... 17.930 m
Distance/Div..... .25 m/div
Vertical Scale.... 50.0 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... bat



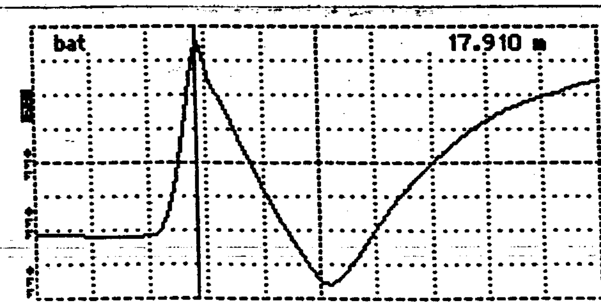
Tektronix 1502B TDR
Date 6/30/93
Cable 08A03
Notes DURING INSTALL -MOISTURE ADDED T BACKFILL
Input Trace
Stored Trace
Difference Trace

Cursor .... 17.930 m
Distance/Div..... .25 m/div
Vertical Scale.... 34.4 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... bat



Tektronix 1502B TDR
Date 6/30/93
Cable 08A04
Notes During Instal.
Input Trace
Stored Trace
Difference Trace

Cursor .... 17.910 m
Distance/Div..... .25 m/div
Vertical Scale.... 34.4 mρ/div
Vp 0.99
Noise Filter...... 1 avg
Power........... bat



Tektronix 1502B TDR
Date 6/30/93
Cable 08A05
Notes During Instal.
Input Trace
Stored Trace
Difference Trace

Figure C-1. TDR traces measured during installation.

Cursor .... 17.932 m
Distance/Div...... .25 m/div
Vertical Scale.... 74.8 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac

Tektronix 1502B TDR
Date 6/30/93
Cable 08A06
Notes During Inst.

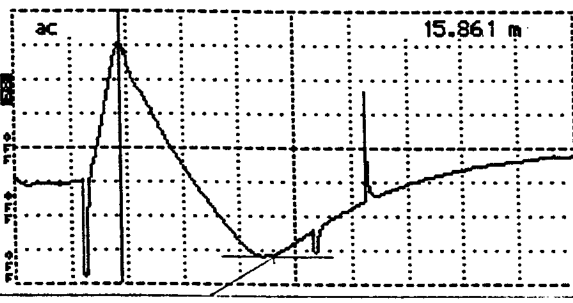
Input Trace
Stored Trace
Difference Trace

Cursor .... 15.881 m
Distance/Div...... .25 m/div
Vertical Scale.... 44.6 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac

Tektronix 1502B TDR
Date 6/30/93
Cable 08A07
Notes During Instal

Input Trace
Stored Trace
Difference Trace

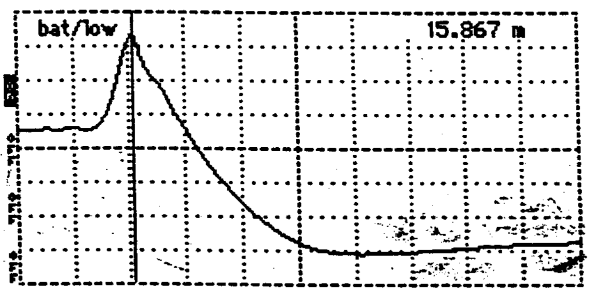
Cursor .... 15.861 m
Distance/Div...... .25 m/div
Vertical Scale.... 48.6 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... ac



Tektronix 1502B TDR
Date 6/30/93
Cable 08A08
Notes During Inst.

Input Trace
Stored Trace
Difference Trace 0.675

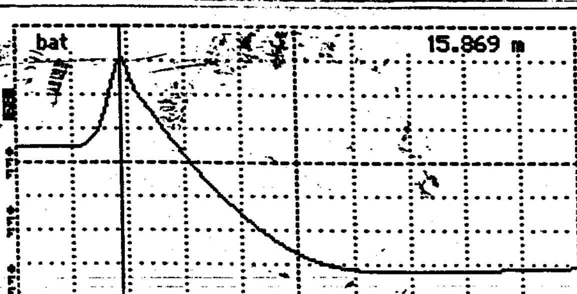
Cursor .... 15.867 m
Distance/Div...... .25 m/div
Vertical Scale.... 74.8 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 6/30/93
Cable 08A09
Notes During Probe placement

Input Trace
Stored Trace
Difference Trace

Cursor .... 15.869 m
Distance/Div...... .25 m/div
Vertical Scale.... 81.6 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 6/30/93
Cable 08A10
Notes At placement in Hole

Input Trace
Stored Trace
Difference Trace

Figure C-1. TDR traces teasured during installation (cont.).

LTPP Seasonal Monitoring Study Moisture Contents (%)	* State Code [08] * Test Section Number [1053]

Personnel : Jason M. Dietz
Date : 6/30/93
Start Time : 2:30 PM
Finish Time : 4:00 PM
Surface Type : Asphalt Cement
Weather Conditions : Clear 32.2°C
Unusual Conditions : None

TDR Probe #	Moisture Content (%)
10	27.82
9	29.50
8	13.20
7	1.52(A)
6	1.52(A)
5	5.65
4	4.97
3	2.83(B)
2	5.65(C)
1	5.65(C)

(A) Had to trim away clayey material from auger drill.
(B) Auger drilled into cobbles. Had to pick stones out of hole.
(C) With water, they premixed up a new batch of material for both sets.

Figure C-2. Field measured moisture content.

APPENDIX D

Initial Data Collection

Appendix D contains the following supporting information:

Table D-1 Data from the onsite datalogger during initial data collection, June 30 - July 1, 1993

```
4,0,300,23.19,15.24
5,0,300,23.59,23.67,24.04,23.64,23.5
4,0,400,22.07,5.08
5,0,400,21.47,21.95,22.88,23.12,23.04
4,0,500,21.35,13.72
5,0,500,21.53,21.8,22.42,22.29,22.2
4,0,600,22.89,0
5,0,600,22.48,22.64,23.25,23.62,23.52
6,0,601,269.9,-368.4,-988,-1592,-2101,-2395,-2527,-2582,-2602,-2610,-2613,-2615,-2615,-2615,-2615,-2614,-2613,-2613,-2613,-2613,-2612,-2612,-2612,-2612,-2612,-2612,-2610,-2611,-2611,-2611,-2612,-2612,-2611,-2610,-2609
4,0,700,23.01,8.38
5,0,700,22.49,22.53,22.93,23.85,23.72
4,0,800,22.99,0
5,0,800,22.48,22.47,22.64,23.63,23.48
4,181,1700,32.59,0
5,181,1700,38.77,37.75,36.65,30.6,32.1
4,181,1800,31.67,0
5,181,1800,40.89,38.02,37.27,32.28,31.88
6,181,1801,-57.72,-547.7,-1018,-1467,-1835,-2066,-2186,-2243,-2268,-2280,-2285,-2287,-2288,-2288,-2289,-2289,-2289,-2289,-2290,-2290,-2289,-2289,-2290,-2290,-2289,-2288,-2288,-2288,-2287,-2288,-2288,-2287,-2287,-2287,-2287
4,181,1900,31.5,0
5,181,1900,39.9,38.5,37.9,34.16,32.48
4,181,2000,29.19,0
5,181,2000,36.68,37.31,37.6,34.96,33.09
4,181,2100,25.49,0
5,181,2100,32.34,34.73,36.35,35.2,33.51
4,181,2200,21.23,0
5,181,2200,29.22,32.12,34.58,35.01,33.72
4,181,2300,17.81,0
5,181,2300,26.95,30.04,32.9,34.47,33.69
1,1993,181,25.2,32.84,1700,15.47,2315,0,-6999,-6999,1645,-6999,1645,33.4,34.39,35.51,34.02,33.05,32.45,32.1,31.87,31.28,30.46,29.65,28.82,27.99,27.34,26.19,25.09,23.98,22.81
2,1993,181,41.25,1715,38.58,1815,37.95,1845,35.23,2030,33.75,2200,32.86,1645,32.83,1645,32.55,1645,32.3,1645,31.28,1645,30.34,1645,29.69,1645,29.13,1645,29,1645,27.86,1645,26.67,1645,25.55,1645,24.43,1645
3,1993,181,24.57,0,27.72,0,30.82,0,30.57,1645,31.79,1730,32.02,1830,31.89,1945,31.59,2230,30.79,2330,29.96,0,29.22,0,28.31,0,27.32,0,26.4,0,25.18,0,24.11,0,23,0,21.84,0
4,182,0,15.81,0
5,182,0,25.14,28.3,31.36,33.78,33.49
6,182,1,603.1,-98.6,-781,-1443,-2054,-2439,-2615,-2683,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999
4,182,100,15.31,0
5,182,100,23.76,26.86,29.98,33.02,33.14
4,182,200,13.16,0
5,182,200,22.52,25.61,28.75,32.23,32.73
4,182,300,11.21,0
5,182,300,21.43,24.52,27.67,31.43,32.25
4,182,400,9.66,0
5,182,400,20.38,23.48,26.67,30.66,31.74
4,182,500,8.86,0
5,182,500,19.4,22.5,25.73,29.9,31.21
4,182,600,8.19,0
5,182,600,18.46,21.58,24.82,29.18,30.68
6,182,601,-1196,-1901,-2427,-2680,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999,-6999
4,182,700,10.18,0
5,182,700,18.56,21.01,24.05,28.46,30.15
4,182,800,14.97,0
5,182,800,21.86,21.96,23.85,27.82,29.62
```

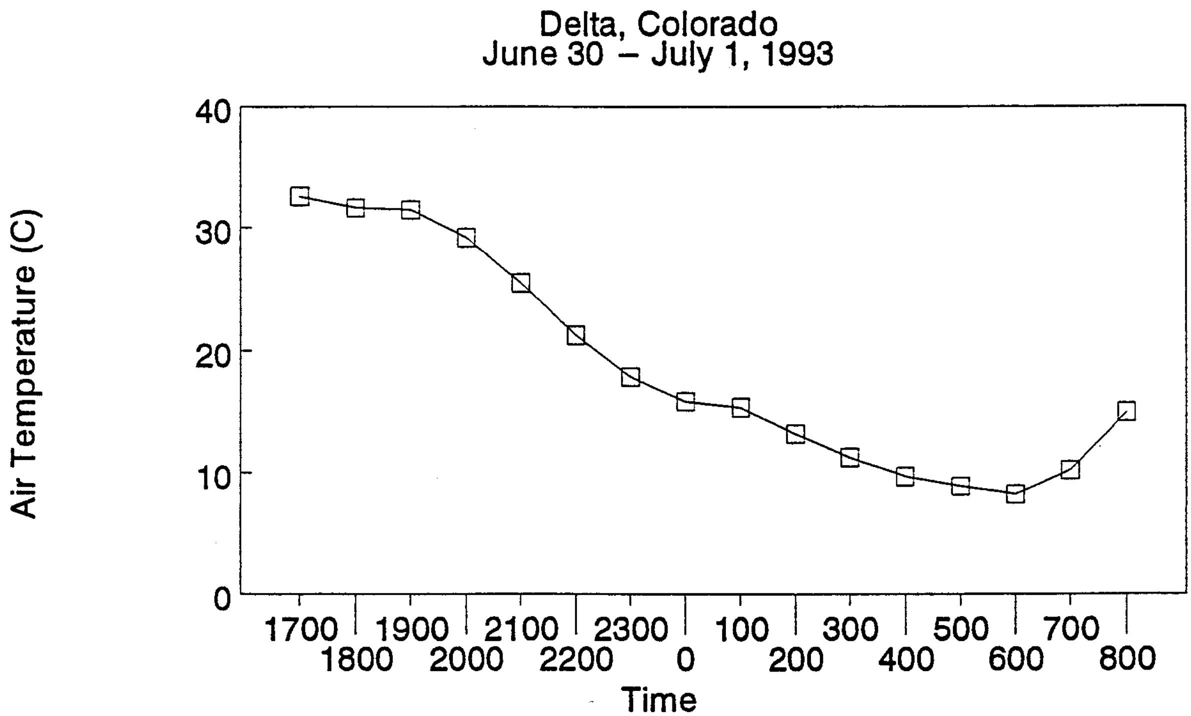


Figure D-1. Measured air temperature during initial data collection.

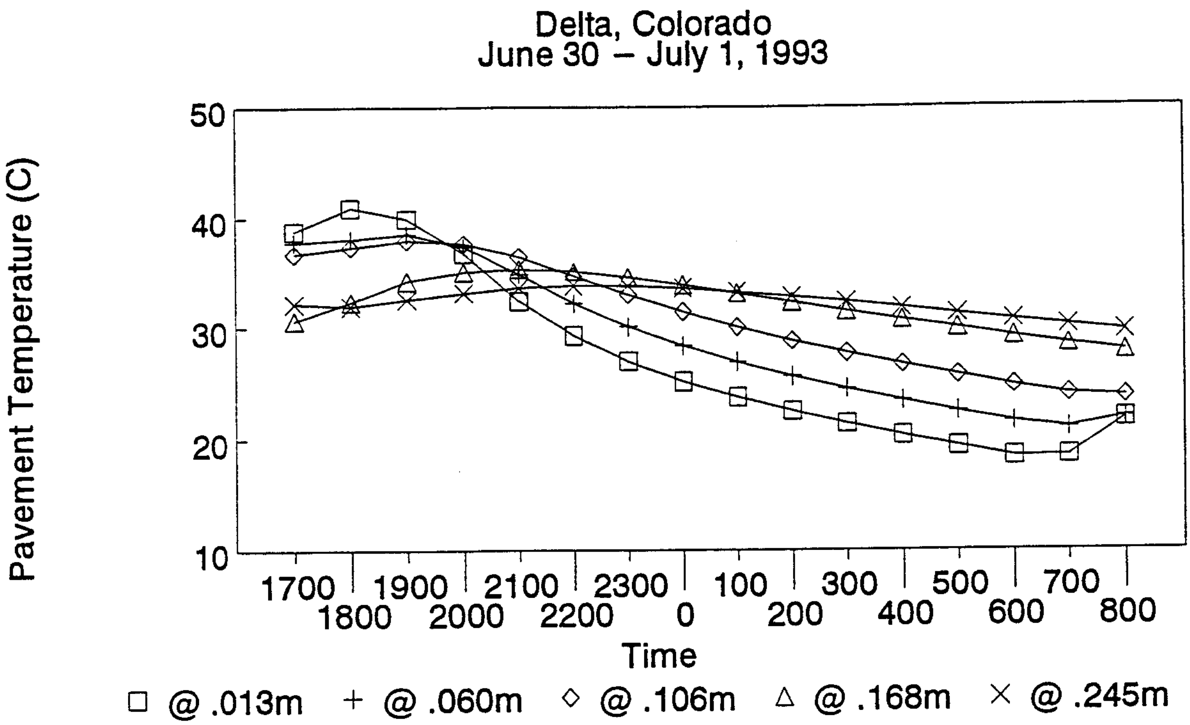


Figure D-2. Measured hourly average subsurface temperature for the first 5 sensors during initial data collection.

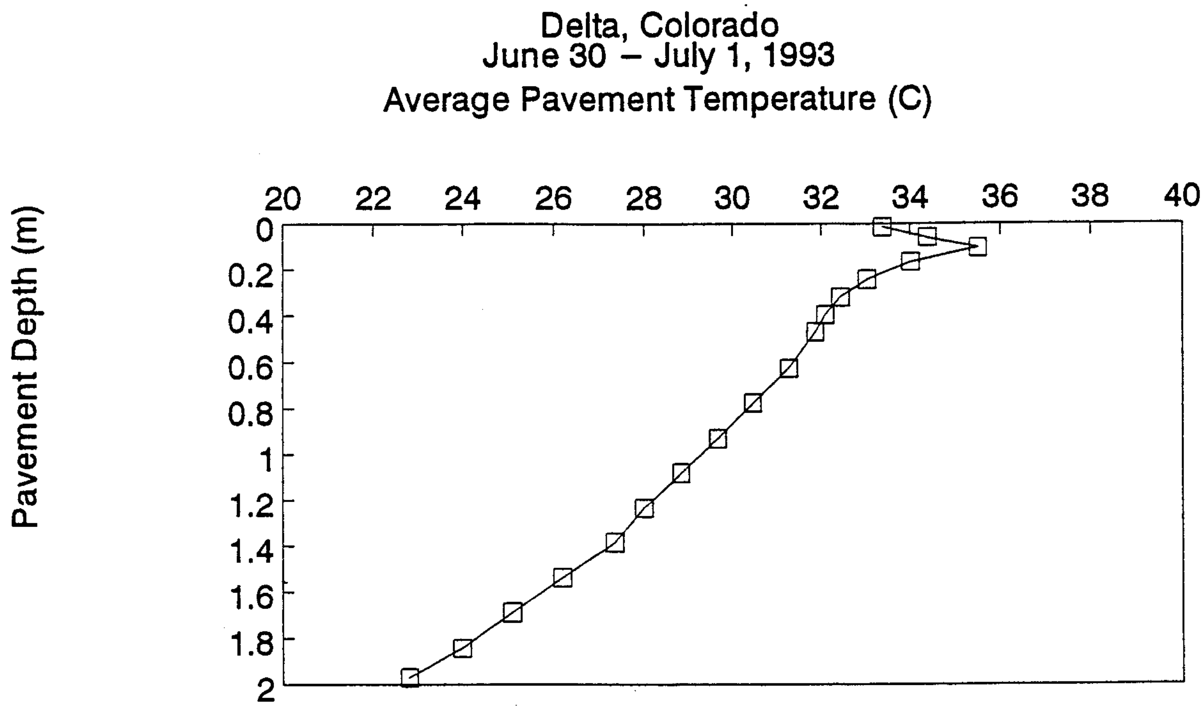


Figure D-3. Measured average subsurface temperature for all 18 sensors during initial data collection.

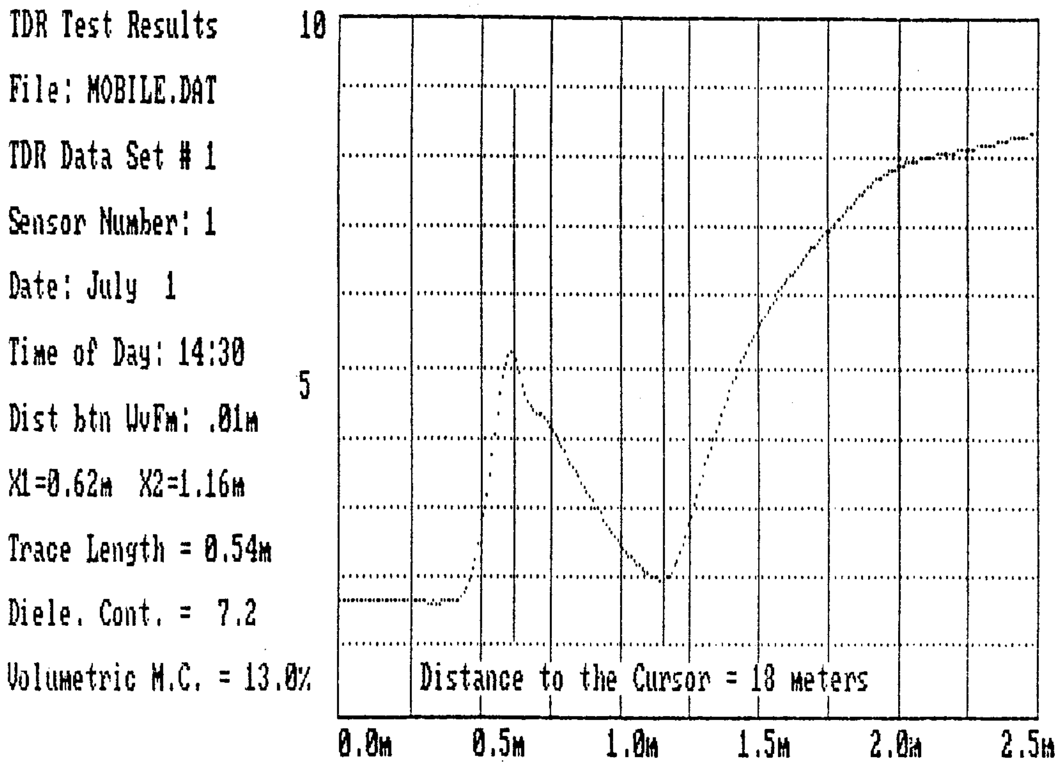


Figure D-4. Trace from TDR sensor 1.

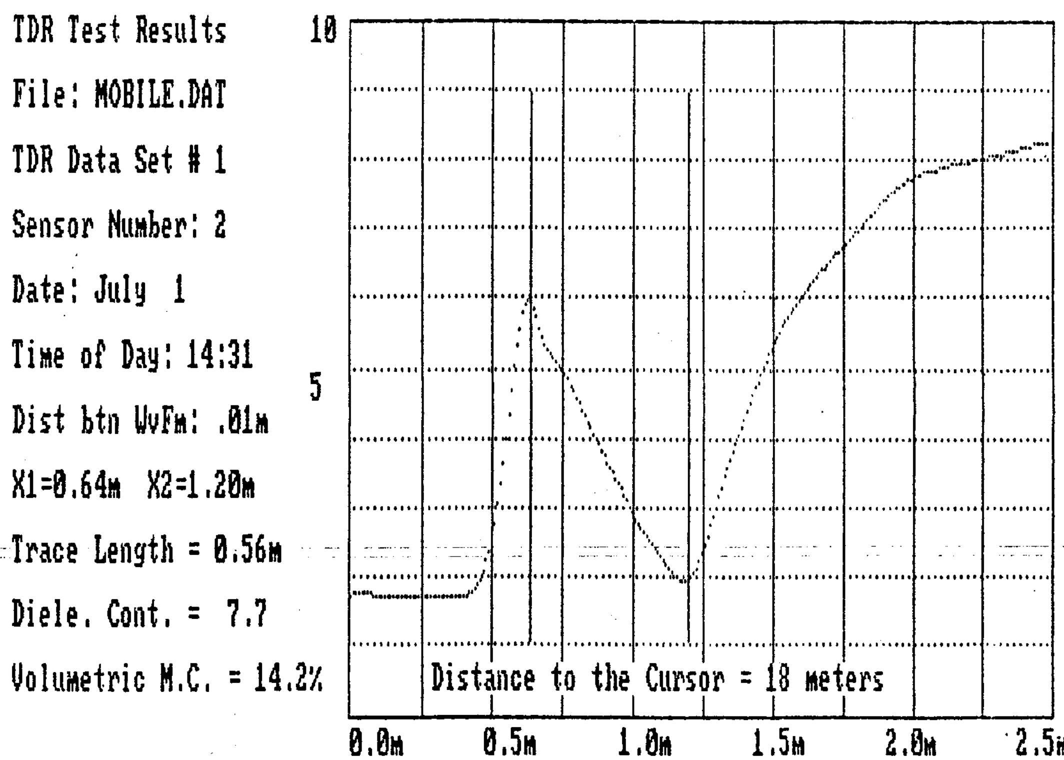


Figure D-5. Trace from TDR sensor 2.

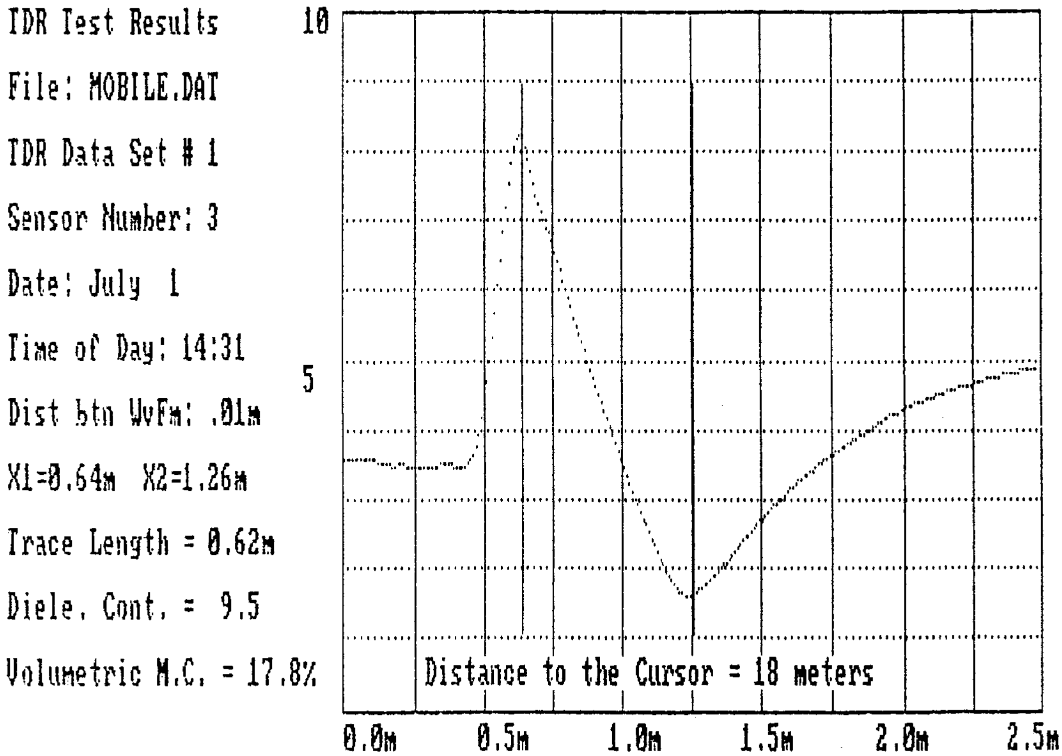


Figure D-6. Trace from TDR sensor 3.

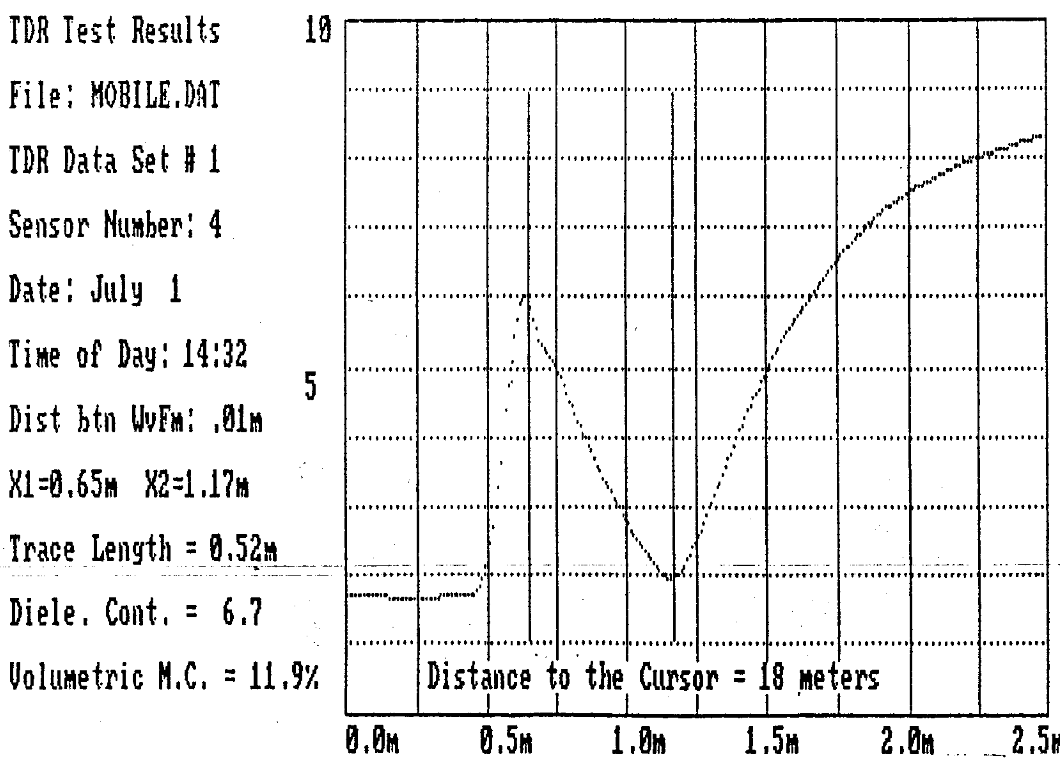


Figure D-7. Trace from TDR sensor 4.

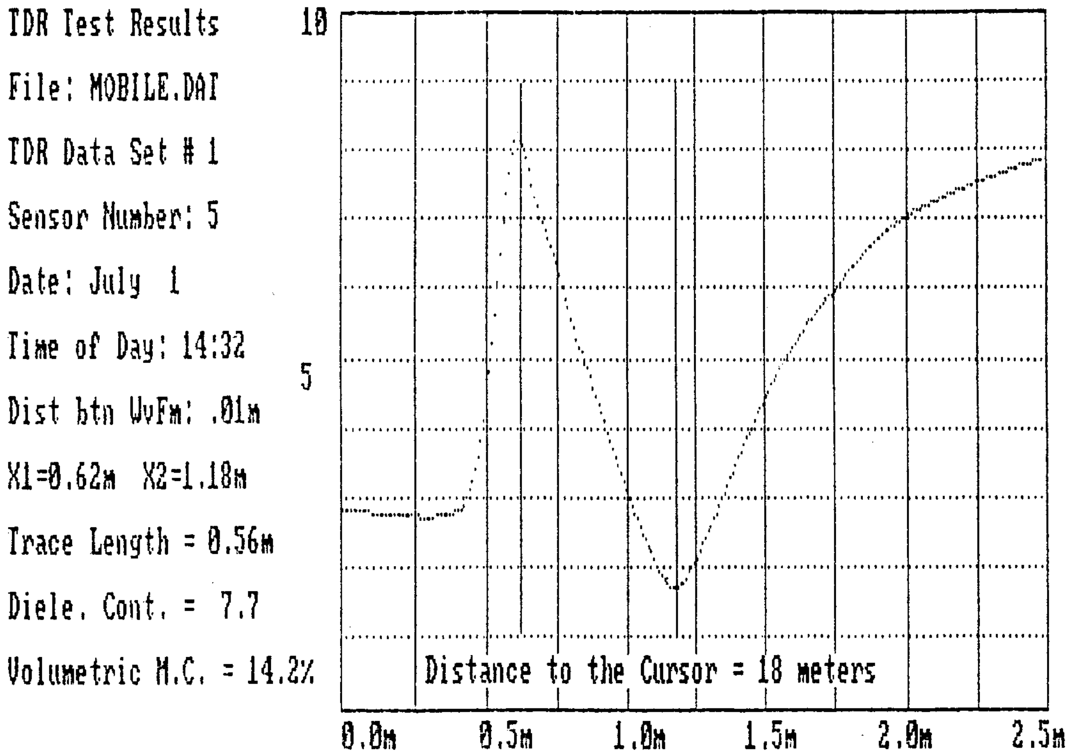


Figure D-8. Trace from TDR sensor 5.

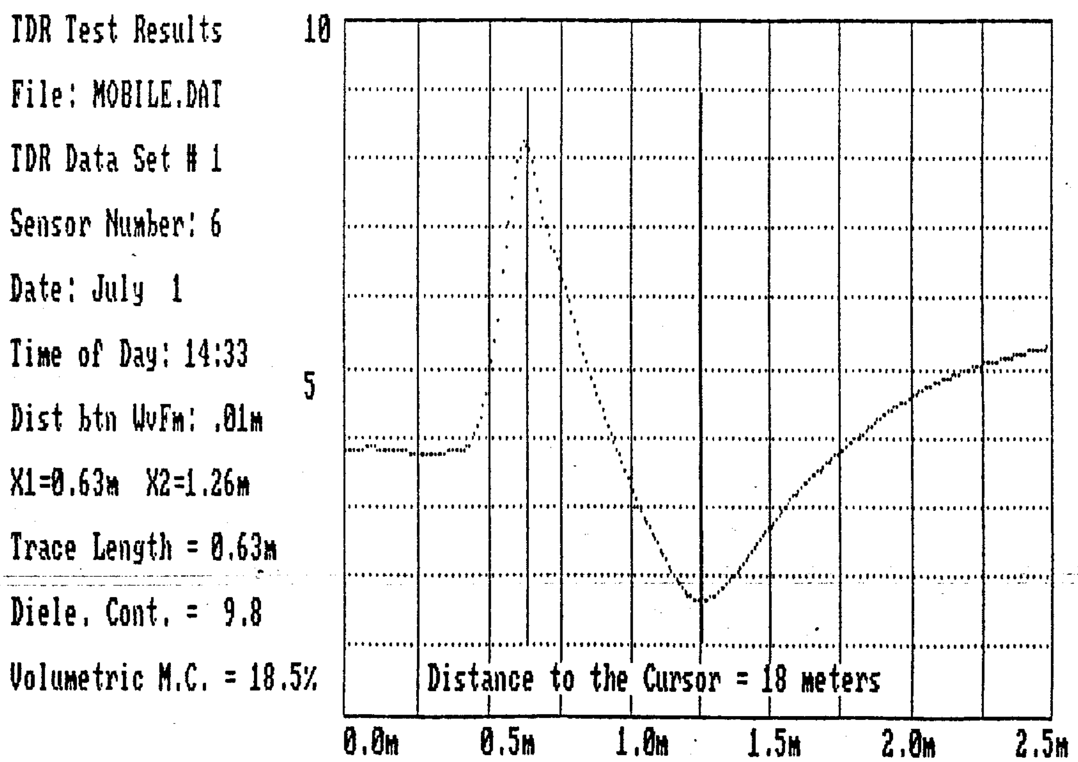


Figure D-9. Trace from TDR sensor 6.

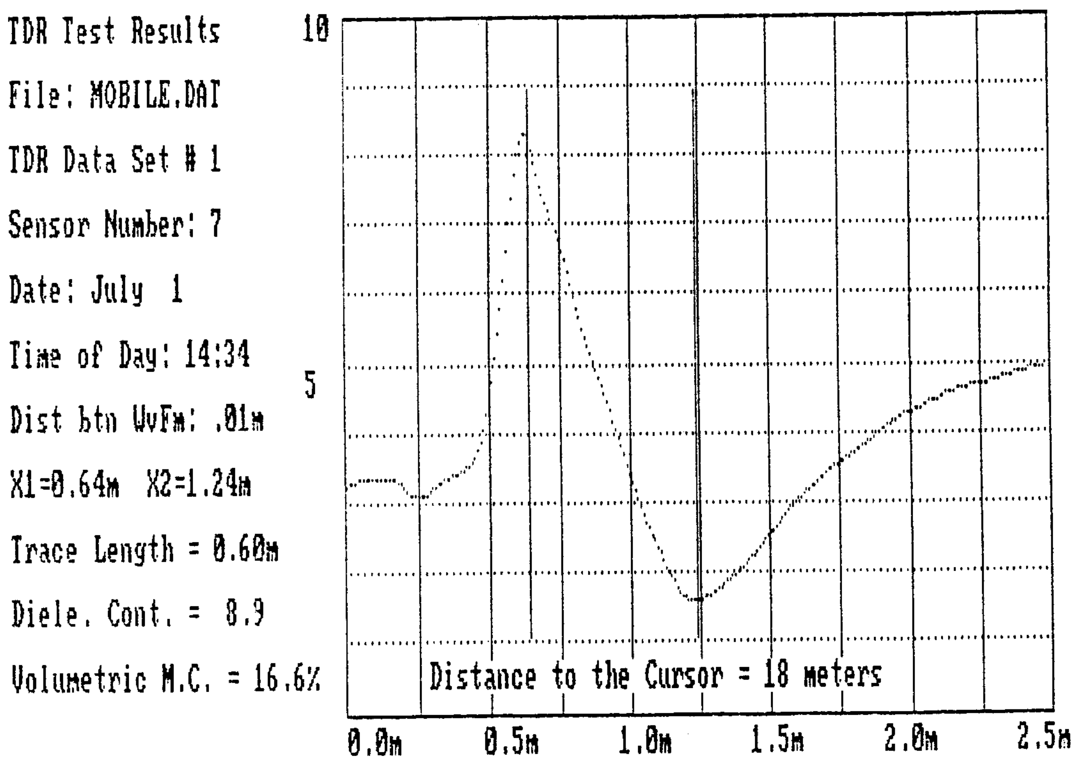


Figure D-10. Trace from TDR sensor 7.

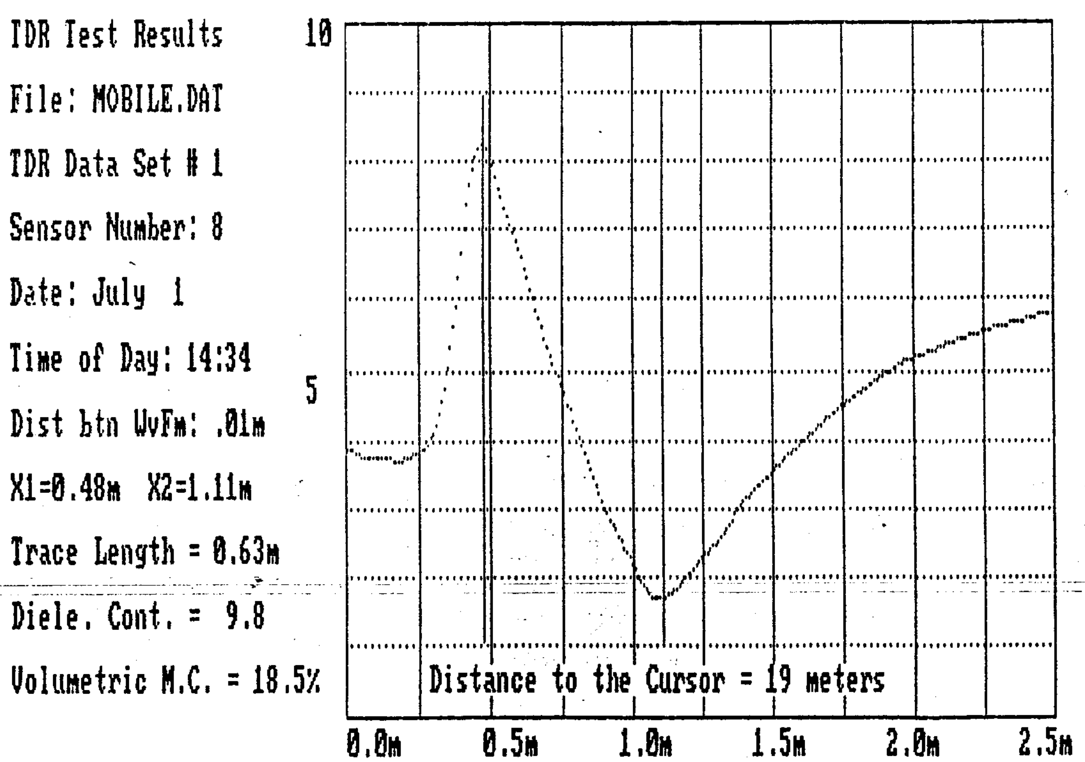


Figure D-11. Trace from TDR sensor 8.

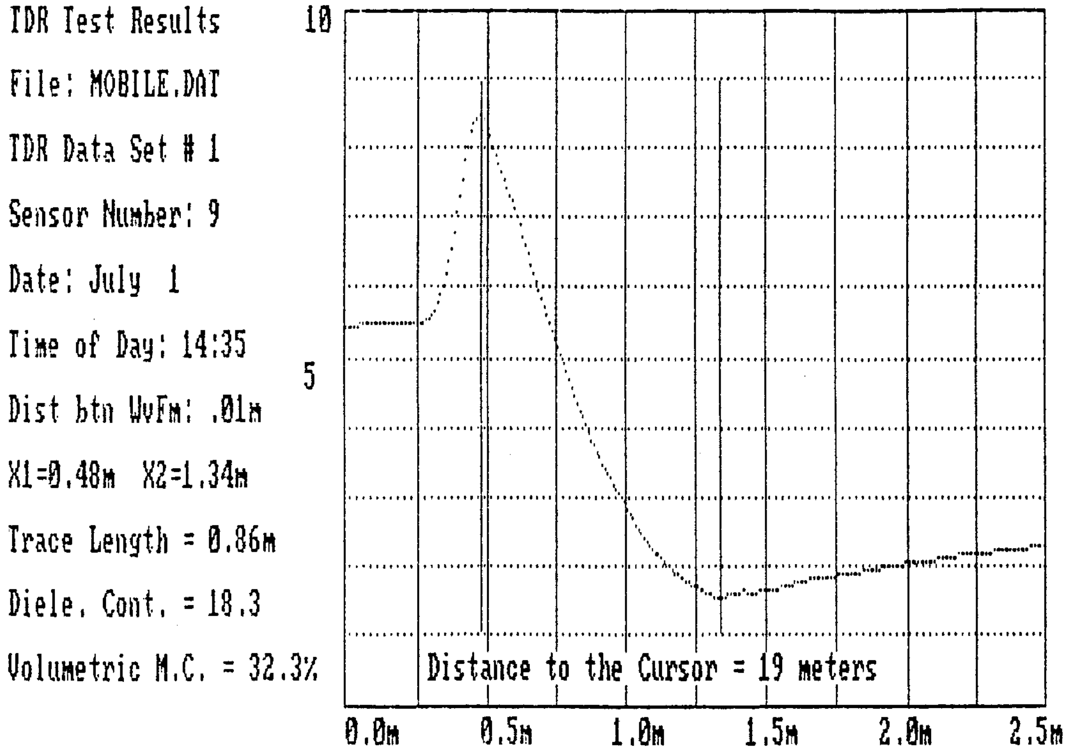


Figure D-12. Trace from TDR sensor 9.

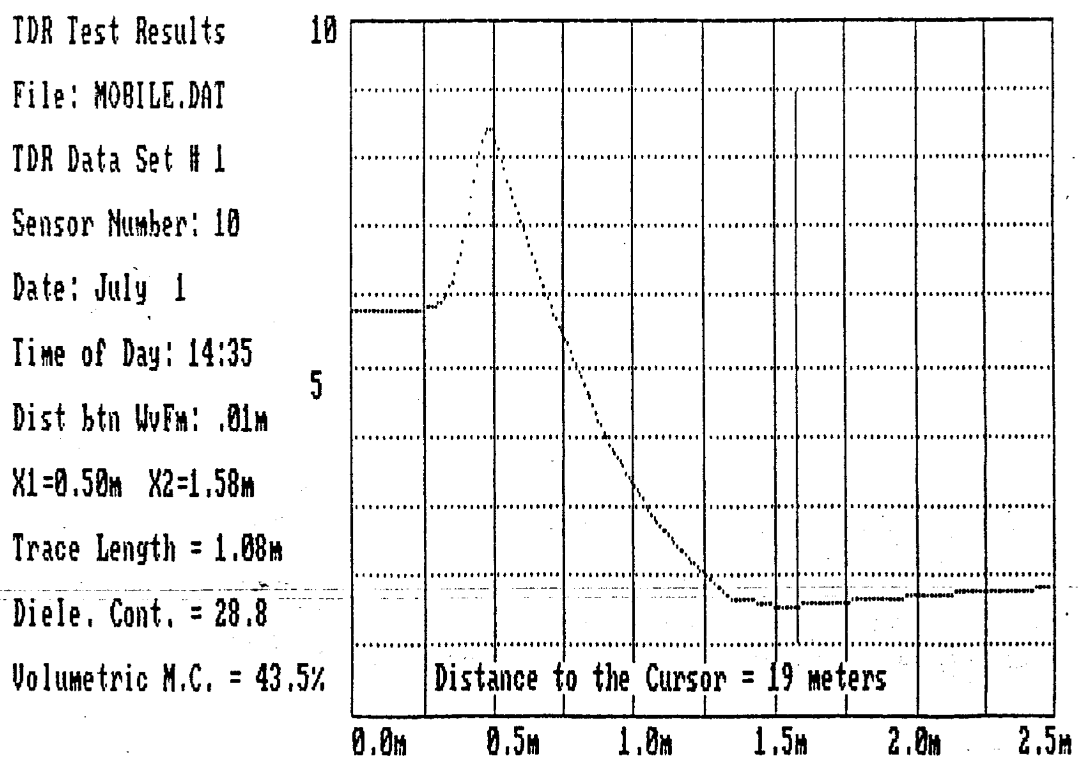


Figure D-13. Trace from TDR sensor 10.

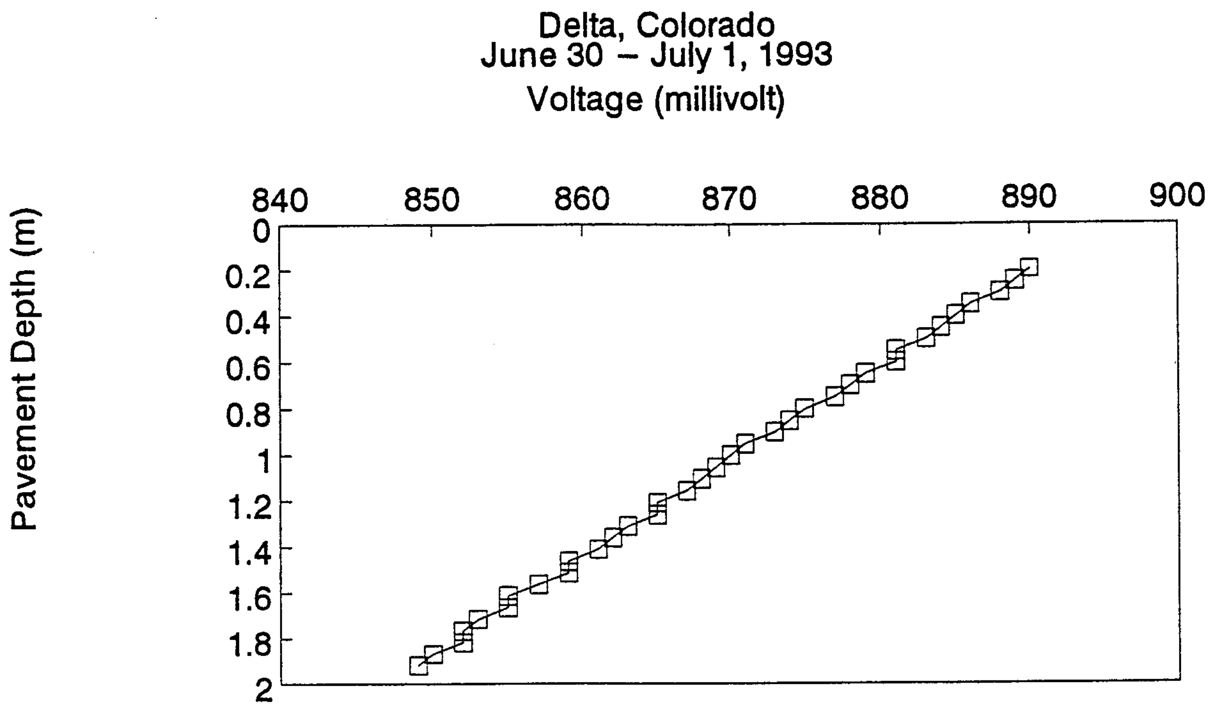


Figure D-14. Voltages measured using the Mobile System.

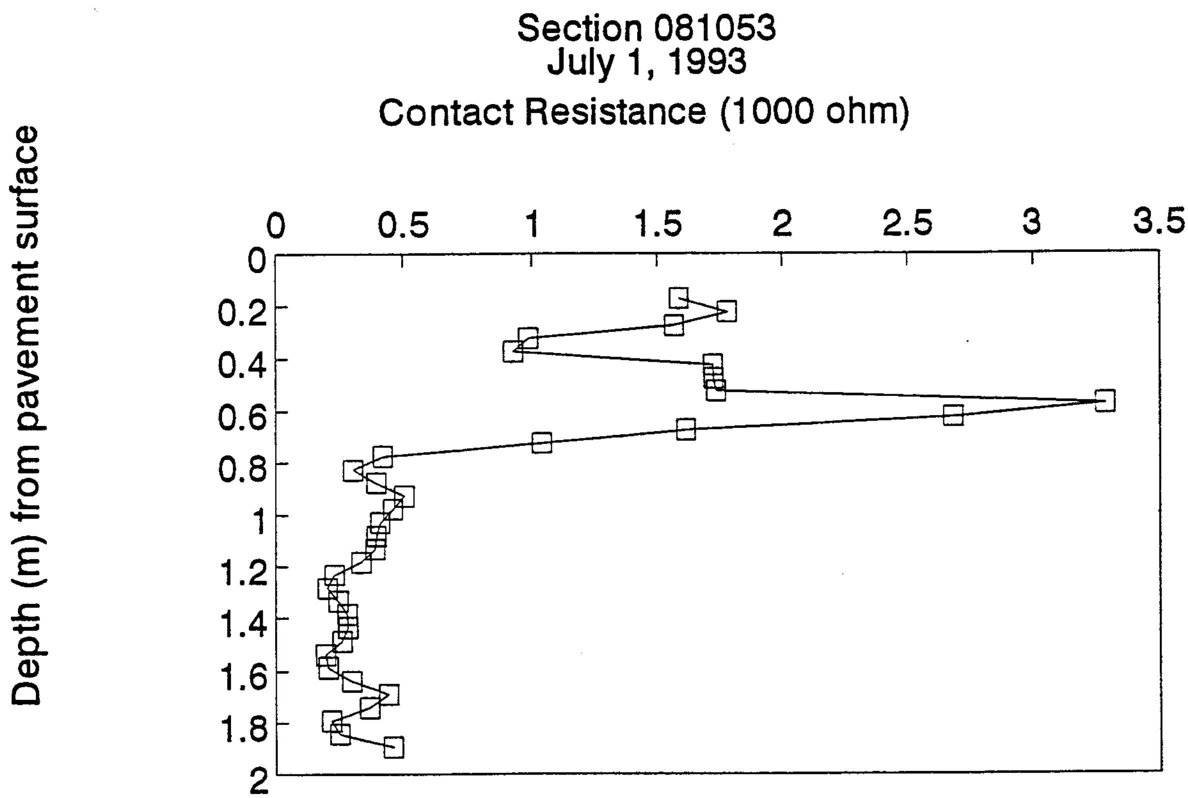


Figure D-15. Manually collected contact resistance.

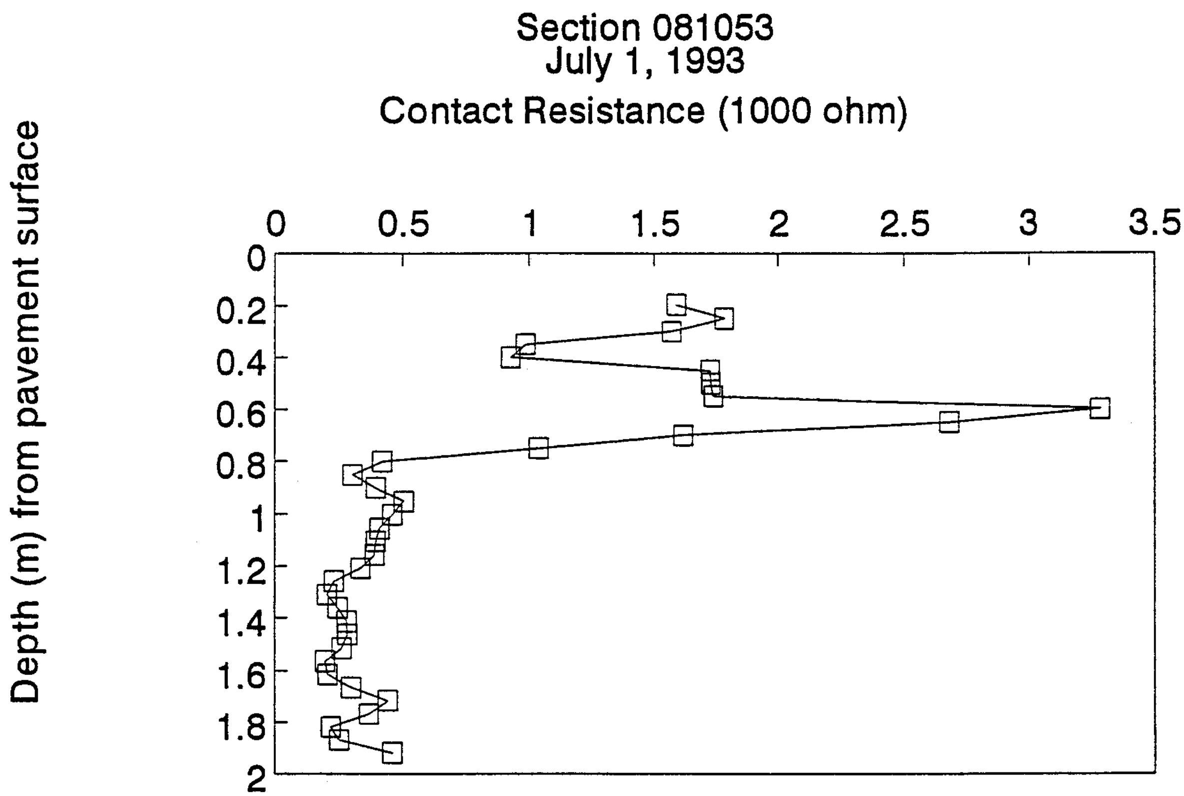


Figure D-16. Manually collected 4-point resistivity.

Table D-2. Contact resistance measurement data sheet.

SEASONAL INSTRUMENTATION DATA COLLECTION SHEET

Resistant Measurements

Site No: 081053

Sheet ____ of ____

Collected by: TT2

Time Collected: 15:00

Date: 7/1/93

Weather Conditions: Sunny

FWD Run? Y

Connections	Voltage		Current		Comments
I_1, V_1	Range Setting	Reading	Range Setting	Reading	
1, 2	20V	8.27	20m	5.20	
2, 3	"	8.53	"	4.78	
3, 4		8.23	"	5.24	
4, 5		7.03		7.12	
5, 6		6.85		7.38	
6, 7		8.44		4.89	
7, 8		8.44		4.88	
8, 9		8.43		4.85	
9, 10		9.63		2.93	
10, 11		9.30		3.47	
11, 12		8.25		5.10	
12, 13		7.15		6.88	
13, 14		4.57		10.89	
14, 15		3.71		12.23	
15, 16		4.39		11.14	
16, 17		5.07		10.09	
17, 18		4.82		10.46	
18, 19		4.49		10.97	
19, 20		4.40		11.12	
20, 21		4.36		11.17	
21, 22		3.96		11.77	
22, 23		3.06		13.17	
23, 24		2.78		13.60	
24, 25		3.20		12.96	
25, 26		3.51		12.45	
26, 27		3.52		12.44	
27, 28		3.33		12.73	
28, 29		2.69		13.72	
29, 30		2.80		13.54	
30, 31		3.64		12.24	
31, 32		4.68		10.61	
32, 33		4.19		11.39	
33, 34		2.92		13.34	
34, 35		3.23		12.86	
35, 36		4.78		10.40	

suspect low battery

Table D-3. Four-point resistivity measurement data sheet.

SEASONAL INSTRUMENTATION DATA COLLECTION SHEET

Resistivity Measurements

Site No: 081053 Sheet ____ of ____

Collected by: 1tz Time Collected: 15:10 Date: 7/1/93

Weather Conditions: Sunny Hot FWD Run? ✓

Read No.	Connections				Voltage		Current		Comments
	I_1	V_1	V_2	I_2	Range Set	Reading	Range Set	Reading	
1	1	2	3	4	2ACV	.409	20m	5.44	
2	2	3	4	5	"	.317	"	6.10	
3	3	4	5	6	"	.341	"	5.19	
4	4	5	6	7	"	.239	"	4.61	
5	5	6	7	8	"	.363	"	7.13	
6	6	7	8	9	"	.268	"	4.50	
7	7	8	9	10	"	.122	"	2.95	
8	8	9	10	11	"	.312	"	5.90	
9	9	10	11	12	"	.189	"	3.80	
10	10	11	12	13	"	.159	"	4.09	
11	11	12	13	14	"	.236	"	6.85	
12	12	13	14	15	"	.188	"	7.15	
13	13	14	15	16	"	.181	"	9.66	
14	14	15	16	17	"	.184	"	10.63	
15	15	16	17	18	"	.206	"	11.16	
16	16*	17/15	18/2	19/1	"	.134	"	10.30	
17	17	18	19	20	"	.130	"	10.32	
18	18	19	20	21	"	.114	"	10.77	
19	19	20	21	22	"	.125	"	11.40	
20	20	21	22	23	"	.130	"	12.19	
21	21	22	23	24	"	.105	"	11.87	
22	22	23	24	25	"	.111	"	12.29	
23	23	24	25	26	"	0.090	"	12.88	
24	24	25	26	27	"	.114	"	12.71	
25	25	26	27	28	"	.076	"	12.57	
26	26	27	28	29	"	.116	"	13.23	
27	27	28	29	30	"	.069	"	12.42	
28	28	29	30	31	"	.109	"	12.16	
29	29	30	31	32	"	.076	"	11.45	
30	30	31	32	33	"	.112	"	13.16	
31	31	32	33	34	"	.111	"	11.97	
32	32	33	34	35	"	.073	"	10.96	
33	33	34	35	36	"	.089	"	10.43	

* Alternate reading configuration for Idaho section (163023).

Suspect low battery

Table D-4. Surface elevation measurement data sheet.

LTPP Seasonal Monitoring Study Surface Elevation Measurements	* State Code [08] * Test Section Number [1053]

Surveyed : Jason M. Dietz
Date : 7/1/93
Start Time : 12:30 PM
Finish Time : 2:00 PM
Surface Type : Asphalt Concrete
Weather Conditions : Clear 32.2°C
Unusual Conditions : None

Beginning Elevation of Frost Free Bench Mark : 1.000 meters
Ending Elevation of Frost Free Bench Mark : 1.000 meters

STATION		OLE 0.000 m	OWP 0.762 m	ML 1.829 m	IWP 2.591 m	ILE 3.658 m
0+00	3+00	1.417	1.416	1.444	1.444	1.462
0+25	3+25	1.368	1.373	1.395	1.398	1.416
0+50	3+50	1.312	1.317	1.342	1.346	1.367
0+75	3+75	1.276	1.276	1.305	1.310	1.333
1+00	4+00	1.226	1.230	1.259	1.267	1.292
1+25	4+25	1.192	1.195	1.222	1.230	1.254
1+50	4+50	1.153	1.156	1.184	1.186	1.208
1+75	4+75	1.114	1.116	1.142	1.145	1.167
2+00	5+00	1.167	1.167	1.195	1.198	1.124

OLE : Outside Lane Edge
OWP : Outer Wheel Path
ML : Mid Lane
IWP : Inner Wheel Path
ILE : Inside Lane Edge

→ Northbound Direction. US 50 South of Delta, CO

0+00 1+00 5+00

o

(Bench Mark)
Observation Well
@ 9.14m from OLE

APPENDIX E

Photographs

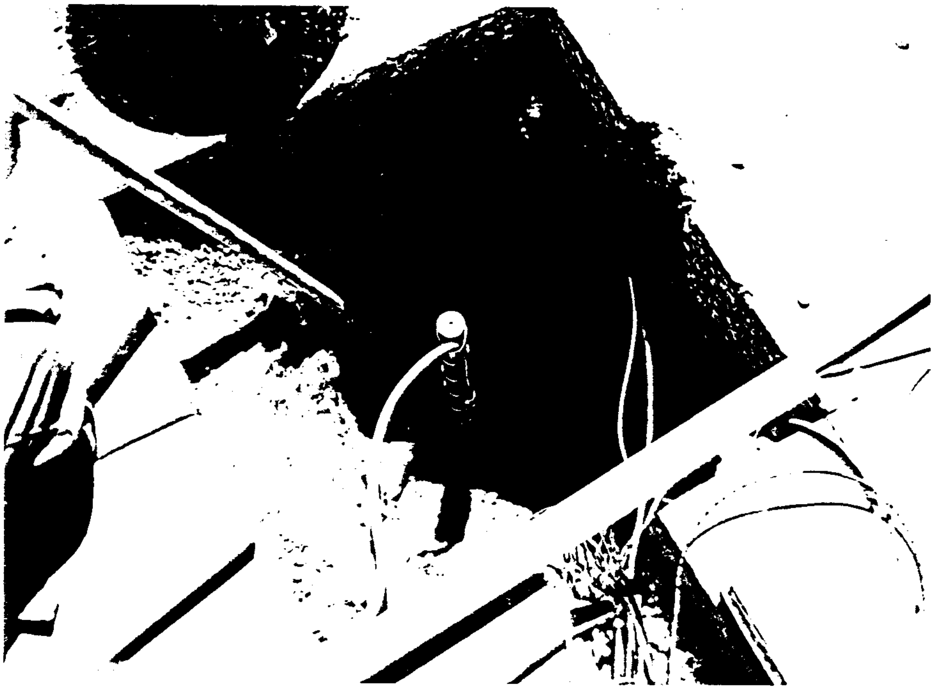


Figure E-1. Instrument hole.

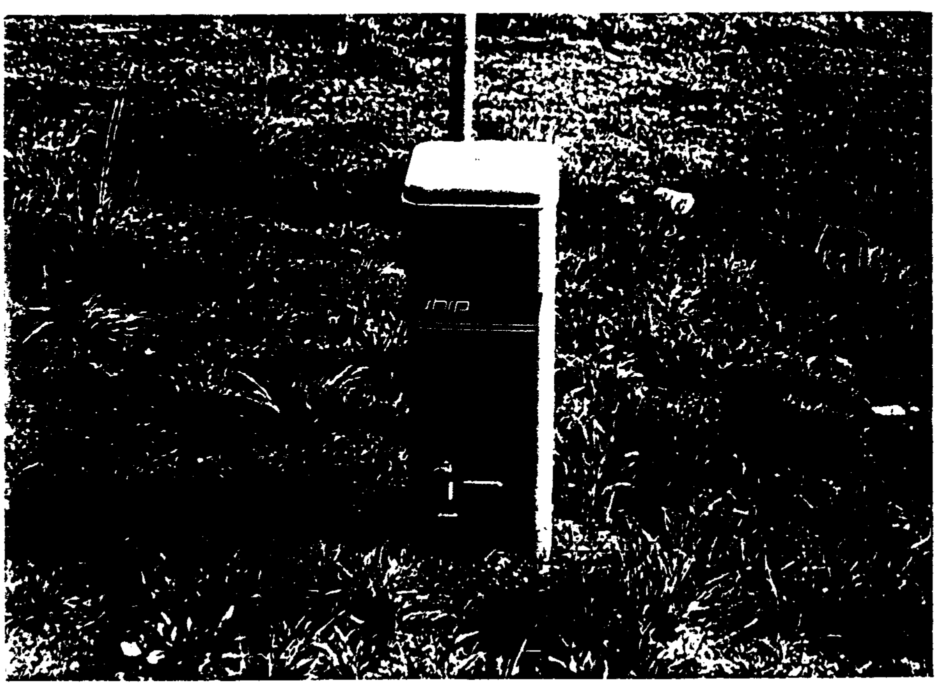


Figure E-2. Equipment cabinet.

Figure E-3. Observation well.

Figure E-4. Overview.