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Administration

LTPP Seasonal Monitoring Program

Site Retrofit Installation and Data Collection

Section 308129
Ryegate Montana

Report No. FHWA-30-8129

March 1994

Notice

LTPP Seasonal Monitoring Program

Site Retrofit Installation and Data Collection
Section 308129, Ryegate Montana

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16. Abstract

This report contains a description of the instrumentation retrofit activities and data collected during the retrofit on test section 308129 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 12 about 60 miles northwest of Billings Montana, was retrofitted on August 12, 1993. The original instrumentation installation was performed on August 11, 1992 and included time domain reflectometery probes for moisture content, electrical resistivity probes for frost location, thermistor probes for temperature and piezometer to monitor the ground water table. The retrofit included installation of a tipping bucket rain gage and an on-site data logger. Data collected on August 12, 1993 included 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 data collected during the retrofit.

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SEASONAL INSTRUMENTATION STUDY
INSTRUMENTATION INSTALLATION (RETROFIT)
MONTANA SECTION 308129

I. Introduction

The retrofit of instrumentation on test section 308129 near Ryegate Montana was performed on August 12, 1993. The installation of the in-pavement instrumentation was performed on August 11, 1992.[1]

The initial installation of instrumentation on this site was used as a pilot exercise to refine the procedures to be used at other Seasonal Monitoring Program (SMP) test sites. The equipment originally installed included a MRC thermistor probe, a CRREL type resistivity probe, 11 TDR sensors, and an equipment cabinet. The climate sensors, which included air temperature and precipitation measurements, climate sensor support pole, and CR10 datalogger were installed during the retrofit.

The site is located on eastbound of U.S. Highway 12, approximately 96 Km northwest of the city of Billings in south-central Montana (Figure A-1 in Appendix A). The test section is located on a two lane undivided highway consisting a 3.7m wide travel lane in each direction. The outside shoulder is approximately 1.2m wide. The test section is classified as GPS-1 project and in Cell 3 of the SMP experiment design.

The pavement structure consists of 76mm asphalt concrete (AC) over an average of 483mm granular aggregate base. The subgrade is primarily sandy clay with trace gravel. Pavement structure information from the GPS material drilling log is presented in Figure A-2. Properties determined from the laboratory material tests are presented in Table 1.

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

Freezing Index (C-Days)	605
Precipitation (mm)	305
No Freeze Thaw Cycles	145
Days Above 32° C	24
Days Below 0° C	171
Wet Days	92

[1] "Seasonal Instrumentation Pilot Study, Instrumentation Installation Montana Section 308129," Nichols Consulting Engineers, Chtd., Federal Highway Administration, December 1992.

The estimated annual average daily traffic (AADT) in 1989 was 1030 (two-way) of which 17.5% was truck traffic. The GPS lane carried about 50% of the total AADT. The truck AADT on the GPS lane was 97. The estimated annual ESALs on the GPS lane were about 45,000.

The retrofit of the instrumentation was a cooperative effort between Nichols Consulting Engineers (NCE) LTPP Western Region Coordination Office staff and staff from the FHWA LTPP Division.

The following personnel participated in the retrofit of the instrumentation:

Gary E. Elkins	Nichols Consulting Engineers
Jason Dietz	Nichols Consulting Engineers
Haiping Zhou	Nichols Consulting Engineers
John Klemunes	FHWA LTPP Division

Table 1. Material Properties

Description	Surface Layer	Base Layer	Subgrade
Material	AC	Aggregate	Sandy clay
Thickness (mm)	76	483	∞
In Situ Dry Density (kg/m^3)	---	2212	1816
In Situ Moisture Content (%)	---	4.5	17.5
Lab Max Dry Density (kg/m^3)	---	2211 @ 6% MC	1890 @ 10% MC
Liquid Limit	---	NP	31
Plastic Limit	---	NP	15
Plastic Index	---	NP	16
% Passing #200	---	7.2	57.8

MC - Moisture Content
NP - Non Plastic

II. Instrumentation Installation

Equipment Installed

All of the equipment installed at the site are shown in Table 2. This includes instrumentation for measuring air and subsurface temperature, subsurface moisture content, frost depth, rainfall, and depth to water table. Two different type of TDR probes were installed. One type of probe was fabricated by Nichols Consulting Engineers, Chtd. (NCE) and the other by the FHWA. The probes fabricated by NCE were the same as used at the previous pilot SMP test site in Idaho. Each TDR probe had three steel rods with the primary difference between the two types being the way the coaxial wire was connected to the metal rods. A printed circuit board with a BNC connector was used on the FHWA fabricated probes and plastic coated wires secured with a wire tie was used on the NCE fabricated probes. An equipment cabinet was installed to house cable leads from the instrumentation, the datalogger, and battery pack.

Table 2. Equipment installed.

Equipment	Quantity	Serial Number
Instrument Hole		
MRC Thermistor Probe	1	30AT
CRREL Resistivity Probe	1	30AR
TDR Sensors	11	30A01-30A11
NCE Fabricated Sensors	6	30A01, 30A02, 30A04, 30A06, 30A08, 30A10
FHWA Fabricated Sensors	5	30A03, 30A05, 30A07, 30A09, 30A11
Equipment Cabinet		
Campbell Scientific CR10 Datalogger	1	16562
Battery Package	1	5534
Weather Station		
TE525 MM Rain Gauge	1	12067
Air Temperature Probe (Model 107)	1	421316
Radiation Shield	1	41301
Observation Well/Bench Mark	1	None

Equipment Check/Calibration

Prior to installation, the air temperature probe and rain gauge were checked. The air temperature probe and the tipping bucket rain gauge were connected to the CR10 datalogger which was wired following the Guidelines. To check the calibration of the tipping bucket, 473ml of water was poured into a plastic container that has a tiny hole at the bottom. The calibration results indicated that the air temperature probe was working and producing reasonable temperature measurements and the tipping bucket measurement were within the manufacturer's specification.

The MRC thermistor probe, resistivity probe, and TDR sensors were checked previously before the initial installation. Field data collected during the past 12 months indicated that these instrument have been working. The only exception was that the TDR sensor placed at the bottom of the instrumentation hole, number 30A11 was damaged during the initial installation and has never functioned properly. The installed depths of the TDR probes, thermistor sensors, and electrodes of the resistivity probe are presented in Tables 3 to 5.

Table 3. Installed location of TDR sensors.

Sensor #	Depth from Pavement Surface (m)	Layer
30A01	0.229	Base
30A02	0.305	
30A03	0.457	
30A04	0.610	Subgrade
30A05	0.762	
30A06	0.914	
30A07	1.067	
30A08	1.207	
30A09	1.372	
30A10	1.524	
30A11	1.803	

Note: 30A11 was damaged during initial installation.

Location of Instrumentation

The instrumentation was installed on the leave end of the test section. The instrumentation hole, a 356mm square, was located in the outside wheel path, 914mm away from the edge of the travel lane, approximately 2m deep. The installed instrument included an MRC thermistor probe, 11 TDR sensors, and a CRREL type resistivity probe. Wires from the instrumentation were placed in a 64mm 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 weather station was installed about 0.3m behind the equipment cabinet. The observation well was located approximately 30.5m east of the test section limit, on the edge of the pavement shoulder at test section station 4+00.

Table 4. Installed location of MRC thermistor sensors.

Unit	Channel Number	Depth from Pavement Surface (m)	Remarks
1	1	0.003	AC layer
	2	0.038	
	3	0.072	
2	4	0.102	Base
	5	0.178	
	6	0.251	
	7	0.330	
	8	0.403	
	9	0.559	Subgrade
	10	0.718	
	11	0.861	
	12	1.013	
	13	1.162	
	14	1.318	
	15	1.477	
	16	1.629	
	17	1.784	
	18	1.918	

Table 5. Location of electrodes of the resistivity probe.

Connector Pin Number	Electrode Number	Depth from Pavement Surface (m)
1	1	0.114
2	2	0.165
3	3	0.216
4	4	0.267
5	5	0.318
6	6	0.372
7	7	0.419
8	8	0.470
9	9	0.521
10	10	0.575
11	11	0.622
12	12	0.676
13	13	0.727
14	14	0.778
15	15	0.829
16	16	0.880
17	17	0.927
18	18	0.981
19	19	1.032
20	20	1.083
21	21	1.134
22	22	1.184
23	23	1.235
24	24	1.287
25	25	1.334
26	26	1.388
27	27	1.438
28	28	1.489
29	29	1.538
30	30	1.591
31	31	1.642
32	32	1.692
33	33	1.743
34	34	1.794
35	35	1.845
36	36	1.896

Retrofit

The retrofit was performed on August 12, 1993. The activities included installation of the weather station, the CR10 datalogger and rewiring of all TDR sensor connectors and MRC thermistor connectors. The retrofit installation was completed in approximately 4 hours. A hand augur was used to make the hole for the climatic sensor support.

Upon completion of the retrofit, all wiring to the cabinet were carefully examined. Version 1.0 of the ONSITE computer program was downloaded from the notebook computer to the onsite CR10 datalogger mounted in the cabinet. The functioning of the datalogger and the instrumentation was monitored for a short period of time to make sure all equipment were working properly.

Initial examination of the onsite data showed that the MRC thermistor probe was not functioning properly. It was found that the wire color scheme on the MRC probe was different than on the MRC probes furnished to the FHWA. (This probe had been previously purchased from MRC and was not part of the larger FHWA bulk purchase.) The proper wiring positions were determined using the RD100 readout device through trial and error. The MRC probe was then reconnected to the wiring panel and its function verified through monitoring of the CR10 unit.

III. Initial Data Collection

Air Temperature, Subsurface Temperature, Rainfall Measurement

The air temperature, subsurface temperature profile, and rainfall data were monitored and stored by the onsite CR10 datalogger. Observations of the Onsite datalogger indicated that all equipment were functioning properly.

TDR Measurements

TDR data were collected using the Mobile data acquisition system. Version 1.0 of the MOBILE program was used to collect and record the TDR wave form traces for each sensor. The malfunction of TDR probe number 11 was verified using the cable tester in the manual mode. The Mobile unit was connected to the first 10 TDR probes since TDR probe 11 malfunctioned. The TDR data collected with the Mobile system showed a flat trace for all sensors. Using the cable tester in the manual mode, it was discovered that the distance to the TDR probes at this site needed to be set to approximately 20m in order to obtain a trace. The TDR cables used at this pilot study were slightly longer than 12.19m, the standard cable length used in regular seasonal instrumentation sites.

The manually collected TDR data are presented in Appendix B.

Resistance Measurements

Electrical resistance data were collected in the automated and manual mode. Contact resistance measurements with the Mobile system were not made during the retrofit since the resistivity probe installed at this site is wired differently than those at the other sites.

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 switch board. The measured contact resistance data are plotted in Figure B-2. In Figure B-3 the 4-point electrical resistivity profile computed from 4-point measurements are plotted. The raw measurement data are given in Tables B-1 and B-2 in Appendix B.

Deflection Measurements

No deflection measurements were performed.

Elevation Survey

An elevation survey was not performed.

IV. Summary

The retrofit of the SMP instrumentation on tests section 308129 was performed on August 12, 1993. The climatic sensors were installed and the previously installed instrumentation were connected to the Onsite CR10 data logger. Since the wire color scheme used on the MRC temperature probe was different than the other probes, a different wiring pattern was used.

The distances set in the Mobile data acquisition system program need to be changed to correspond to the proper lengths of the cables.

The resistivity probe installed at this site is wired differently than the probe installed at the other SMP sites. A jumper cable needs to be fabricated to switch the pin-electrode assignments to the standard wiring pattern used in the other resistivity probes.

After the retrofit, all equipment were functioning. The resistivity board on the mobile system was not wired for the type of resistivity probe installed at this site, therefore, resistance measurements were not performed with the Mobile data acquisition system. Since this was a retrofit of a pilot SMP site, deflection measurements were not performed.

APPENDIX A

Test Section Background Information

Appendix A Includes the Following Supporting Information:

Figure A-1 Site Location Map

Figure A-2 Test Section Profile

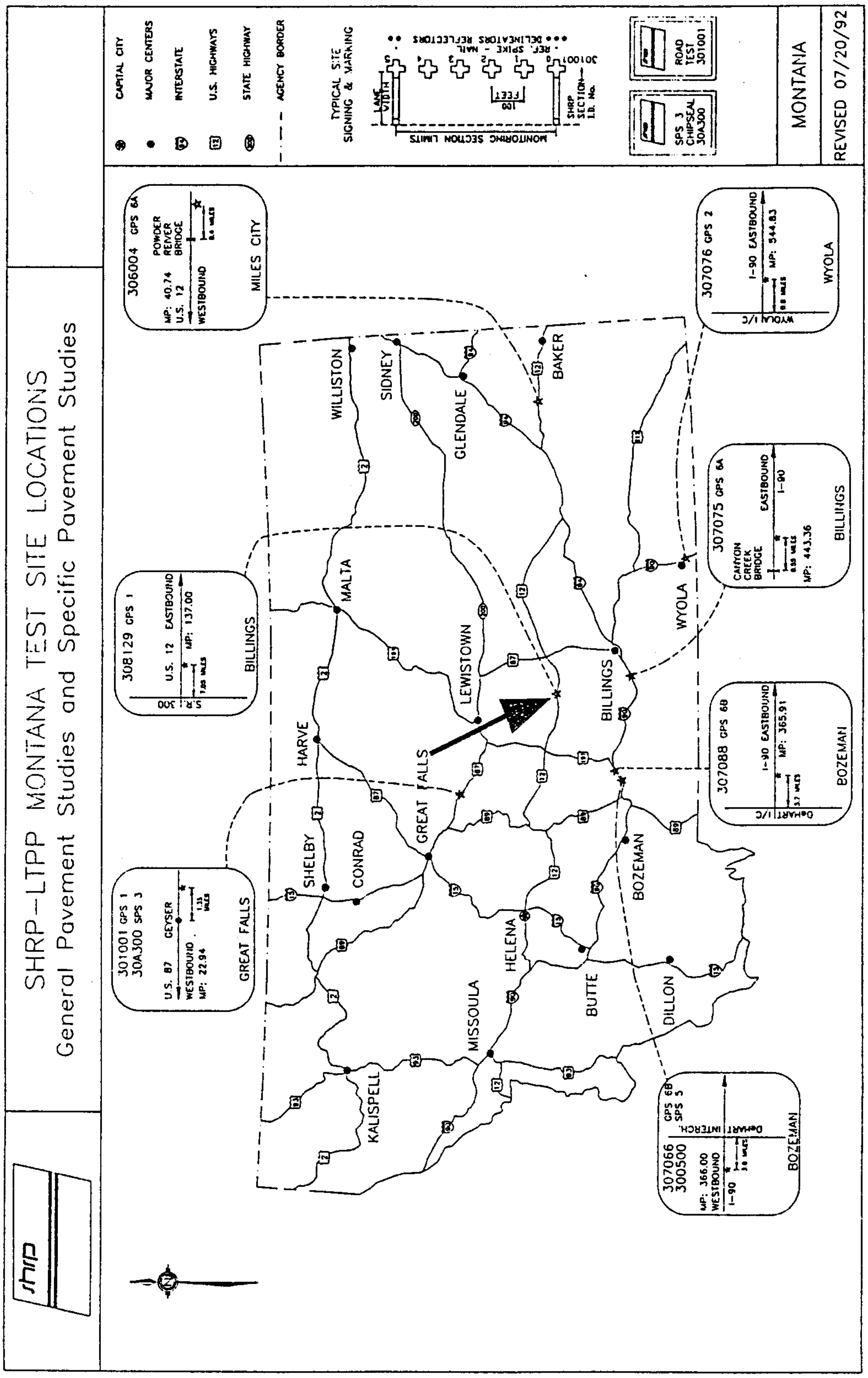
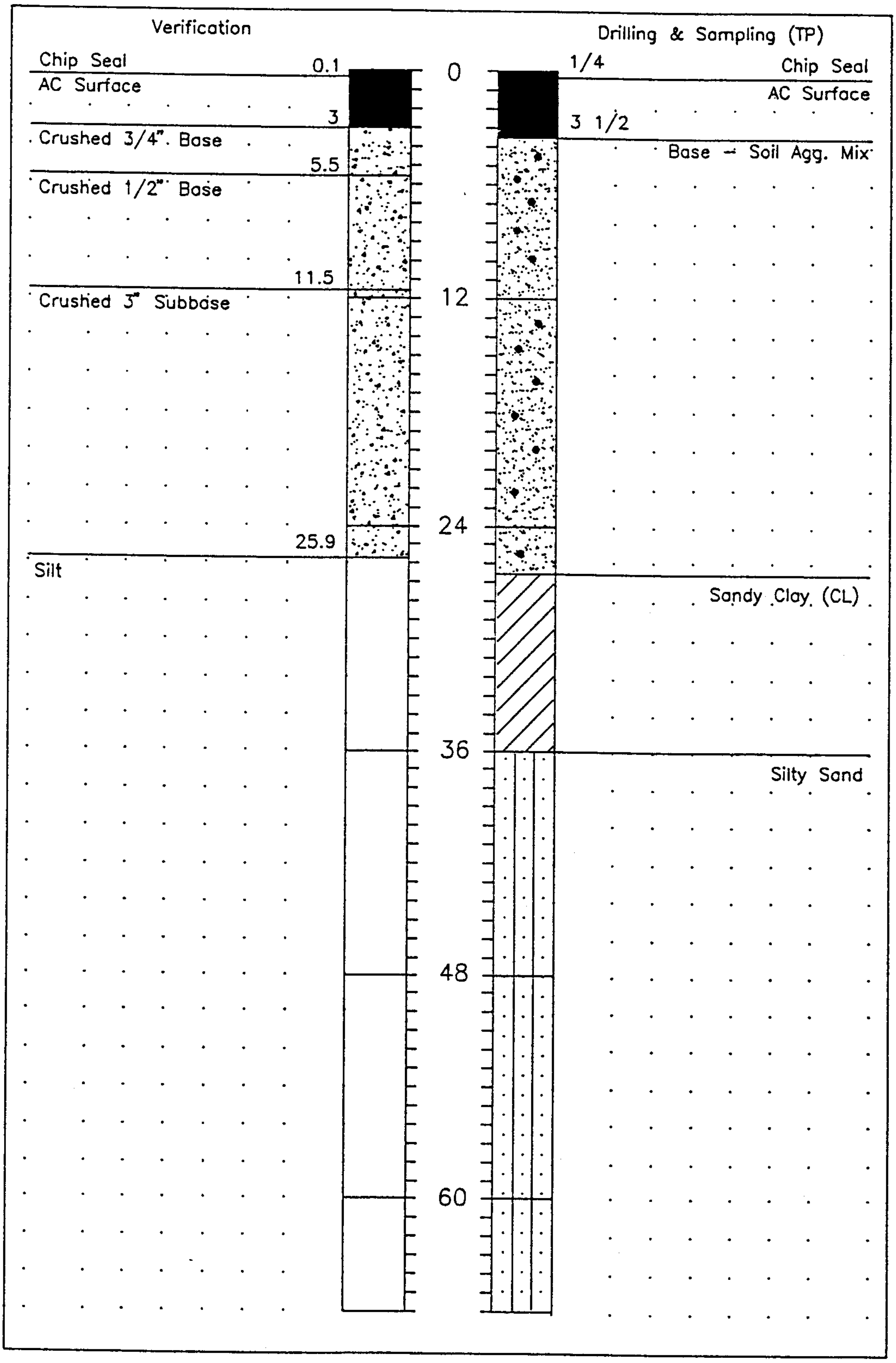


Figure A-1. Location of test site, GPS test section 308129.



DRILLING & SAMPLING CELL PLACEMENT 1-99

Figure A-2. Profile of test section.

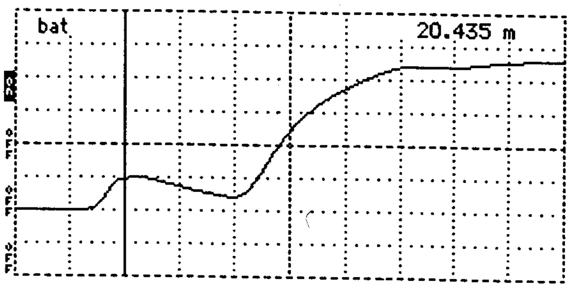
APPENDIX B

Initial Data Collection

Appendix B Includes the Following Supporting Information:

Figure B-1	Manually collected TDR traces
Figure B-2	Manually collected contact resistance
Figure B-3	Manually collected 4-point resistivity
Table B-1	Contact resistance measurement data sheet
Table B-2	Four-point resistivity measurement data sheet

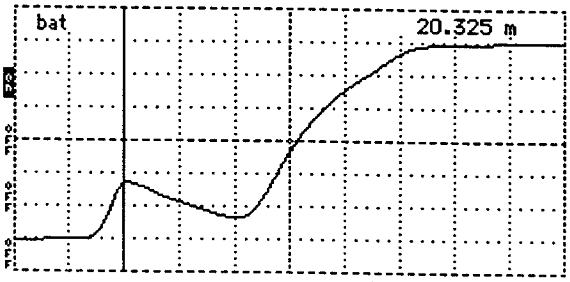
Cursor .... 20.435 m
Distance/Div ..... .25 m/div
Vertical Scale.... 115 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat



Tektronix 1502B TDR
Date 8/12/93
Cable #1
Notes Site 308129

Input Trace
Stored Trace
Difference Trace

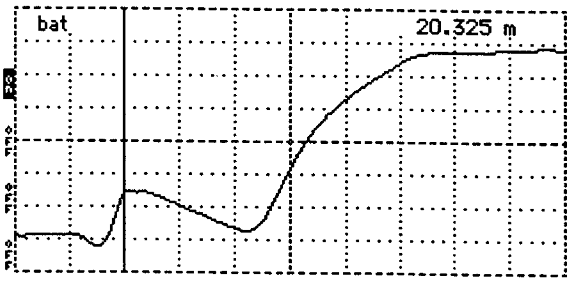
Cursor .... 20.325 m
Distance/Div ..... .25 m/div
Vertical Scale.... 96.9 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #2
Notes Site 308129

Input Trace
Stored Trace
Difference Trace

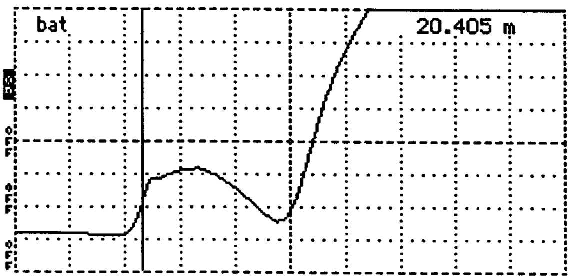
Cursor .... 20.325 m
Distance/Div ..... .25 m/div
Vertical Scale.... 86.4 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #3
Notes Site 308129

Input Trace
Stored Trace
Difference Trace

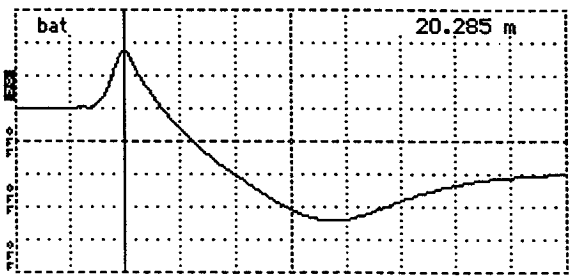
Cursor .... 20.405 m
Distance/Div ..... .25 m/div
Vertical Scale.... 53.0 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #4
Notes Site 308129

Input Trace
Stored Trace
Difference Trace

Cursor .... 20.285 m
Distance/Div ..... .25 m/div
Vertical Scale.... 83.9 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low

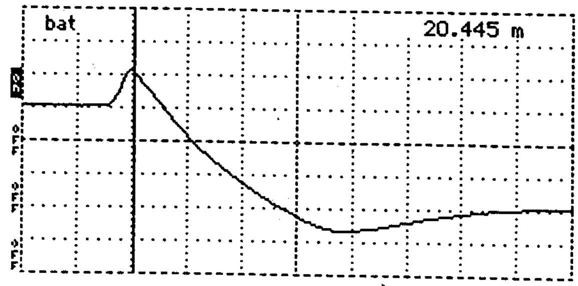


Tektronix 1502B TDR
Date 8/12/93
Cable #5
Notes Site 308129

Input Trace
Stored Trace
Difference Trace

Figure B-1. Manually collected TDR traces.

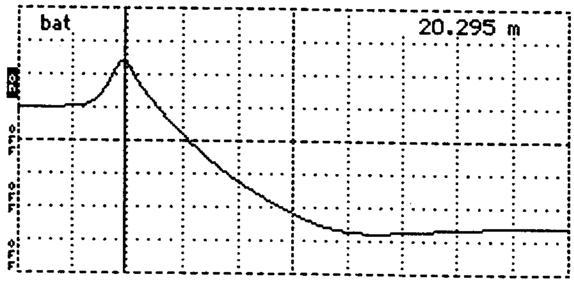
Cursor .... 20.445 m
Distance/Div..... .25 m/div
Vertical Scale.... 83.9 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #6
Notes
site 308129

Input Trace
Stored Trace
Difference Trace

Cursor .... 20.295 m
Distance/Div..... .25 m/div
Vertical Scale.... 100 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #7
Notes
site 308129

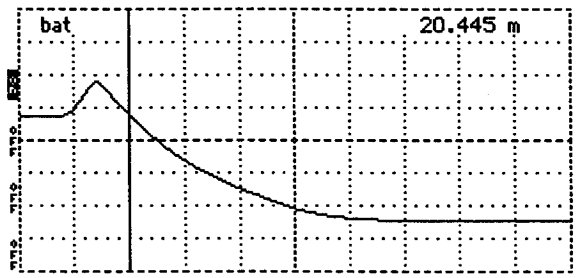
Input Trace
Stored Trace
Difference Trace

Cursor .... 20.445 m
Distance/Div..... .25 m/div
Vertical Scale.... 137 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low

Tektronix 1502B TDR
Date 8/12/93
Cable #8
Notes
site 308129

Input Trace
Stored Trace
Difference Trace

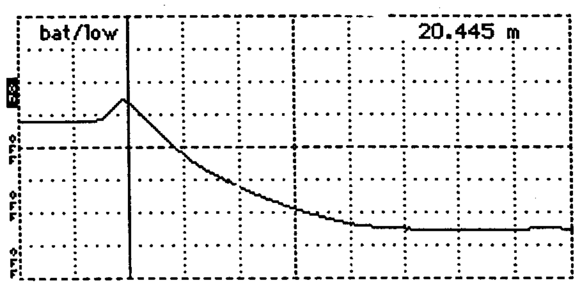
Cursor .... 20.445 m
Distance/Div..... .25 m/div
Vertical Scale.... 137 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #9
Notes
site 308129

Input Trace
Stored Trace
Difference Trace

Cursor .... 20.445 m
Distance/Div..... .25 m/div
Vertical Scale.... 137 mρ/div
VP 0.99
Noise Filter...... 1 avg
Power........... bat/low



Tektronix 1502B TDR
Date 8/12/93
Cable #10
Notes
site 308129

Input Trace
Stored Trace
Difference Trace

Figure B-1. Manually collected TDR traces (cont.).

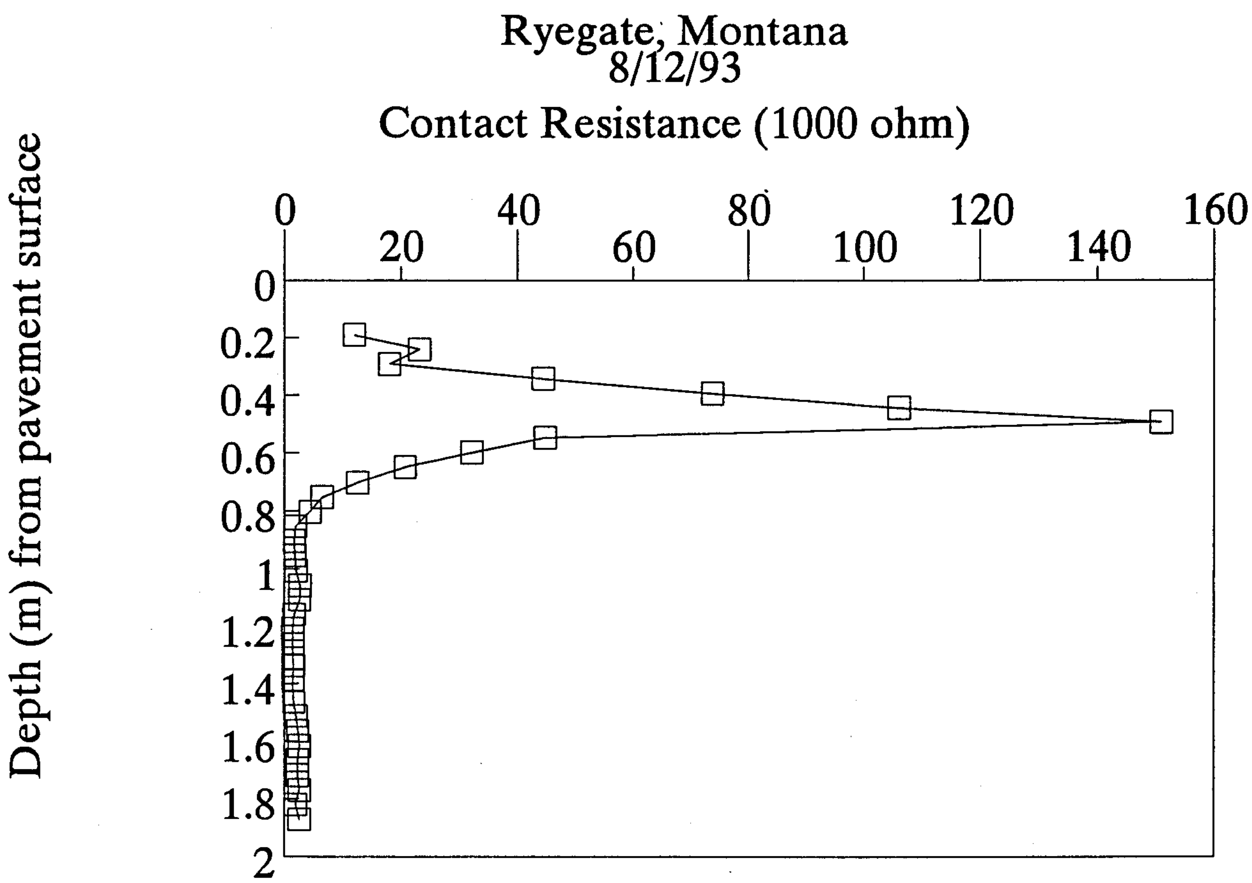


Figure B-2. Manually collected contact resistance.

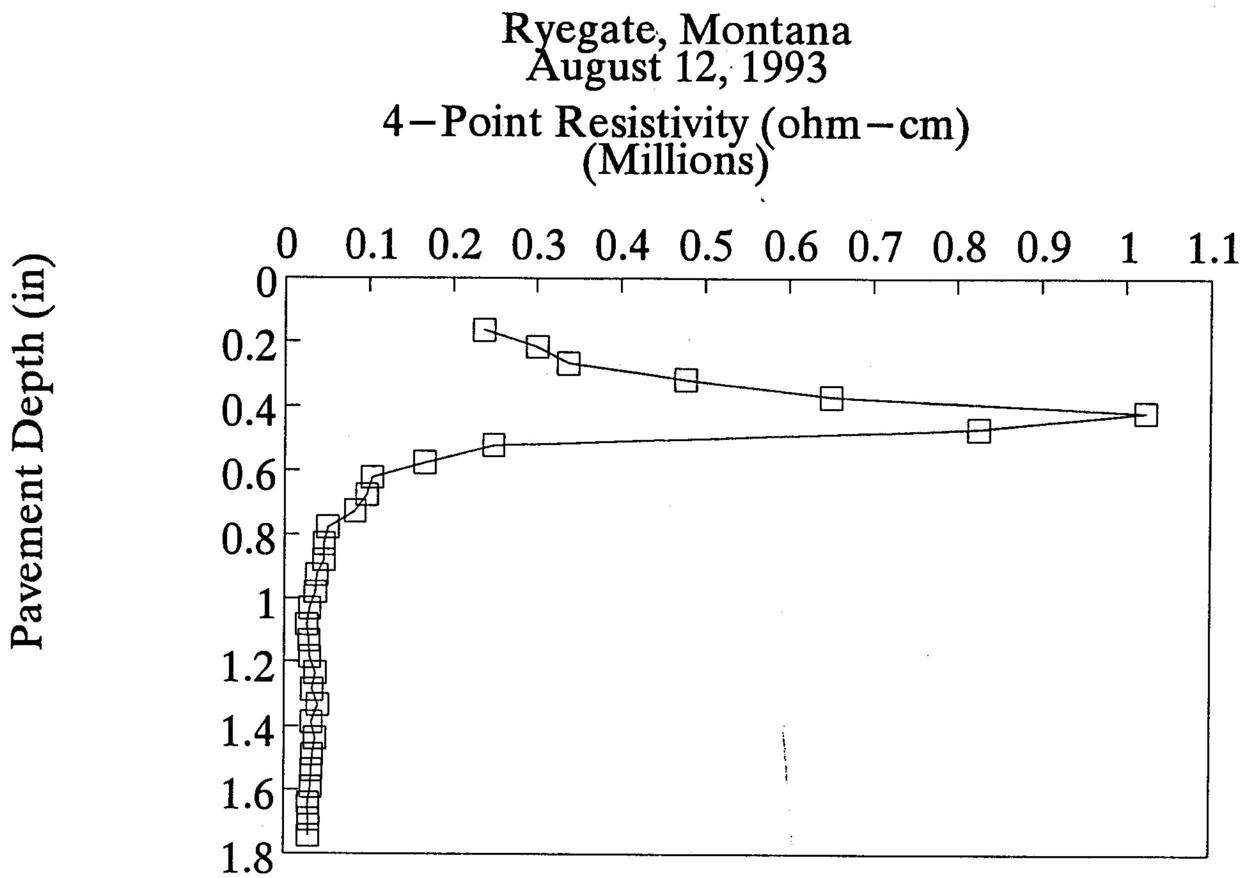


Figure B-3. Manually collected 4-point resistivity.

Table B-1. Contact resistance measurement data sheet.

LTPP Seasonal Monitoring Study Data Sheet R1 Contact Resistance Measurements	* State Code [3 0] * Test Section Number [8 1 2 9]

1. Date (Month - Day - Year) [8 - 12 - 93]

2. Time Measurements Began (Military) [1 4:0 0]

3. Comments

Test Position	Connections I_1 V_1	Connections I_2 V_2	Voltage (ACV) Range Setting	Voltage (ACV) Reading	Current (ACA) Range Setting	Current (ACA) Reading	Notes
1	1	2	20ACV	6.93	200 u	3.7	
2	3	2		6.83	2 m	.572	
3	3	4		8.93		.335	
4	5	4		8.89		.494	
5	5	6		10.18		.229	
6	7	6		10.19		.138	
7	7	8		10 72		.101	
8	9	8		10.72		.071	
9	9	10		9.15		.205	
10	11	10		9.17		.285	
11	11	12		6.72		.375	
12	13	12		6.62		.528	
13	13	14		4.27		.664	
14	15	14		4.16		.950	
15	15	16		2.26		1.193	
16	17	16		2.19		1.287	
17	17	18		2.13		1.159	
18	19	18		2.11		1.070	
19	19	20		2.34		.876	
20	21	20		2.32		.858	
21	21	22		1.47		.900	
22	23	22		1.46		1.040	
23	23	24		1.53		1.028	
24	25	24		1.53		1.043	
25	25	26		1.59		1.057	
26	27	26		1.59		1.095	
27	27	28		1.75		1.099	
28	29	28		1.79		.915	
29	29	30		2.02		.892	
30	31	30		2.04		.794	
31	31	32		1.77		.806	
32	33	32		1.78		.796	
33	33	34		1.89		.797	
34	35	34		1.89		1.012	
35	35	36		2.35		.931	
36	37	38	20 ACV	11.57	200u	16.6	
37	38	39		7.14	20m	7.18	
38	39	40	200m	19.9	20m	18.35	

Preparer ______________________ Employer ______________________

Figure III-5 - Contact Resistant Measurements - Data Sheet R1

Table B-2. Four point resistivity measurement data sheet.

LTPP Seasonal Monitoring Study Data Sheet R2 Four-Point Resistivity Measurements	* State Code [30] * Test Section Number [8129]

1. Date (Month - Day - Year) [8-12-93]

2. Time Measurements Began (Military) [14:05]

3. Comments

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	2ACV	.543	200μ	.1	
2	2	3	4	5		.562		151.8	
3	3	4	5	6		.195		43.4	
4	4	5	6	7		.335		58.2	
5	5	6	7	8		.195		28.5	
6	6	7	8	9		.240		22.2	
7	7	8	9	10		.363		23.7	
8	8	9	10	11		.241		17.1	
9	9	10	11	12		.154		45.1	
10	10	11	12	13		.160		56.2	
11	11	12	13	14		.156		100.3	
12	12	13	14	15		.140		91.5	
13	13	14	15	16		.151		115.7	
14	14	15	16	17		.105		123.3	
15	15	16	17	18		.090		134.1	
16	16	17	18	19		.104		130.7	
17	17	18	19	20		.071		123.7	
18	18	19	20	21		.069		120.6	
19	19	20	21	22	200m	58.0		122.3	
20	20	21	22	23		50.3		122.4	
21	21	22	23	24		56.1		122.9	
22	22	23	24	25		62.3		123.5	
23	23	24	25	26		63.2		122.1	
24	24	25	26	27		69.7		123.1	
25	25	26	27	28		70.1		120.0	
26	26	27	28	29		63.0		119.1	
27	27	28	29	30		64.6		118.5	
28	28	29	30	31		62.3		114.8	
29	29	30	31	32		55.9		117.9	
30	30	31	32	33		55.2		113.0	
31	31	32	33	34		50.6		111.3	
32	32	33	34	35		54.8		120.2	
33	33	34	35	36		46.3		102.8	

Preparer ____________________ Employer ____________________

Figure III-6 - Four-Point Resistivity Measurements - Data Sheet R2