STATE OF FLORIDA

Forensic Investigation
SR-471 Hot-in-Place Recycled Project
Sumter County, Florida

Research Report
FL/DOT/SMO/06-490

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STATE MATERIALS OFFICE

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1 Introduction

1.1 Background

In 2002 approximately five miles of SR-471 in Sumter County, Florida, was resurfaced using a hot-in-place recycling (HIPR) process. The Florida Department of Transportation (FDOT) required a three-year warranty for this project. A detailed report on the rehabilitation project was prepared by FDOT[1].

The contractor for the project was H.I.P. Paving, LLC, of Safety Harbor, Florida, (herein referred to as H.I.P.). H.I.P. used the “mixed in place” process in which the recycled material was never removed from the roadway. The existing pavement materials were softened with heat, and approximately 2 inches were removed by milling. The milled material was mixed with a rejuvenator and new hot mix asphalt materials were added, if necessary, to correct cross slope. The rejuvenated material was re-laid on the roadway.

The as-produced mixture met all project specification requirements. Post-construction testing indicated that the rideability and friction resistance were good. However, rutting began to occur within 6 to 12 months. By December 2004, this rutting had exceeded the warranty criterion in several lots within the project. The cause of the rutting was unknown.

1.2 Objective

The objective of this investigation was to conduct forensic analysis of the recycled pavement to determine the cause of the rutting.

1.3 Scope

This report describes the test plan and presents the results of the forensic investigation on the warranted pavement on SR-471 in Sumter County. The HIPR project limits are between MP 0.000 and MP 5.115. An adjoining conventionally resurfaced project immediately to the north of the recycled project (MP 5.115 to MP 14.296) was used as a control section. Resurfacing on the control project was completed approximately three months after the recycled project was completed.

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[1] Sholar, G.A; G.C. Page; J.A. Musselman; and H. L. Mosely. *Resurfacing of SR-471 Using the Hot-in-Place Recycling Process.* Research Report FL/DOT/SMO/04-472, State Materials Office, Florida Department of Transportation, Gainesville, June 2004.

2 Pavement Design and Warranty Specification

2.1 Project Description

The HIPR project (Financial Project Number 413535-1-52-01) originated at the Polk/Pasco County line and extended 5.115 miles north into Sumter County. The roadway consisted of two 12-foot wide lanes and two 4-foot wide paved shoulders, except from MP 4.178 to MP 4.210, where the outside right shoulder was 10 feet in width. The last resurfacing of the project prior to recycling occurred in 1991. This pavement was considered deficient due to a low cracking rating (4.5 on a scale of 10).

Construction on the recycling project was begun on November 18, 2002, and completed December 9, 2002. The project was accepted by FDOT on December 30, 2002.

2.2 Pavement Structural Design

The project consisted of removing the top two inches of the existing 3.2 inches of asphalt surfacing and recycling it in place. The design traffic for the project was 576,000 EASLs (Traffic Level B). The pavement structural design parameters are summarized in Table 1.

Table 1. Structural design parameters

Design Parameter	**Value**
Future 18-kip ESALs Over Design Period	576,000
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	94%
Overall Standard Deviation	0.45
Subgrade Resilient Modulus	22,000 psi
Calculated Structural Number for Future Traffic	2.20

The completed structural design is given in Table 2. The supplied structural number was 3.48, greater than the calculated required structural number of 2.20.

Table 2. Structural design

Layer	**Material Description**	**Structural Coefficient**	**Drainage Coefficient**	**Thickness (in.)**
1	Marshall Type S	0.37	1	2
2	Binder	0.15	1	1.2
3	Limerock Base	0.18	1	8.9
4	Type B Stabilized Subgrade	0.08	1	12

2.3 HIPR Mix Design

The mixture was designed using 50-blow Marshall criteria. Two mix designs were employed because the northbound and southbound in situ HMA had slightly different properties. New materials added to the milled HMA included clean concrete sand and an oil-based asphalt-rejuvenating agent (Sundex 540T by Sun Co., Inc.) as necessary to achieve a penetration value of the recovered binder between 40 and 80 (in units of 0.1 mm). The properties of the mix design are tabulated in Table 3. Additional Marshall Type S-III HMA was added to correct cross slope as necessary.

Table 3. Mix design properties

Direction	% Binder Content	% Air Voids	G_{mm}	G_{mb}	Recovered Penetration (0.1 mm)	Rejuvenator Addition		Sand Addition (lbs/sy)
						gal/ton	gal/sy	
NB	5.7	4.1	2.420	2.321	55	1.35	0.13	12.8
SB	5.4	4.3	2.423	2.319	51	1.24	0.12	11.5

2.4 Warranty Specification

The specification for the HIPR section of SR-471 required that the Contractor warranty the project. Highlights of the warranty requirement included the following:

1. The warranty period extends for three years after the final acceptance of the project.

2. A Maintenance Bond in the amount of $720,000 backed the warranty. This provides for milling and replacing two inches of pavement with HMA and associated maintenance of traffic and striping operations.

3. All unresolved disputes between the Department and the Contractor will be addressed by an independent Dispute Review Board, with their majority ruling binding on both parties with no rights to appeal.

4. The warranty does not apply to deficiencies that are a result of factors beyond the control of the Contractor, such as the following:

    a. The pavement thickness is deficient.

    b. The accumulated traffic exceeds that assumed in design by at least 25%.

    c. The deficiencies are due to failures in the base, subgrade or underlying asphalt layers.

    d. The deficiencies are due to work on the roadway by a third party.

5. The Department's Flexible Pavement Condition Survey Program[2] will be used as the basis for determining the extent and magnitude of the pavement distress.

6. The project will be divided into lots of 0.1 mile in length for evaluation purposes.

7. The distresses to be evaluated include rutting, rideability, cracking, raveling, delamination, potholes, slippage and segregated areas. Thresholds and remedial actions for each type of distress are shown in Table 4.

[2] Florida Department of Transportation. *Flexible Pavement Condition Survey Handbook*. State Materials Office, Gainesville, April 2003.

Table 4. Thresholds and remedial action for distress types

Type of Distress	Type of Survey	Threshold Level for Each LOT (0.1 mile) per lane	Remedial Action
Rutting	Any Survey	Depth > 0.25 inch	Remove and replace the distressed LOT(s) to the full distressed depth and full lane width.
		Depth ≤ 0.25 inch	None required.
Rideability	Any Survey	RN < 3.70	Remove and replace the distressed LOT(s) to the full distressed area(s) and full lane width.
Cracking	Any Survey	Cracking >1/8 inch (Class 1B), accumulative cracking length > 30 feet	Remove and replace the distressed LOT(s) to the full distressed depth and full lane width.
Raveling, delamination and other disintegrated areas affecting the friction course	Intermediate Survey	Underlying layer exposed, individual length > 10 feet	Remove and replace the distressed area(s) to the full distressed depth and full lane width or patch the distressed area(s).
		Underlying layer exposed, individual length < 10 feet	Patch the distressed area(s) and remove and replace the distressed area(s) to the full distressed depth and full lane width prior to the final survey.
	Final Survey	Observation by Engineer	Replace the distressed areas (including all patches) and extend 50 feet at both ends at full lane width.
Potholes, slippage area(s), segregated area(s) and other disintegrated areas.	Any Survey	Observation by Engineer	Remove and replace the distressed area(s) to 150% of the area(s) or temporarily patch the distressed area(s) and remove and replace the distressed area(s) to 150% of the area(s) prior to the final survey.

Notes:

1. The Ride Number (RN) established by the laser profiler will express the ride quality of the pavement of a LOT being tested.
2. For any two deficient LOTs not separated by 3 passing LOTs, the repair work shall cover the entire stretch (including the passing LOTs). If the area of cracking, patching or raveling within a LOT exceeds 60% of the LOT area, the total LOT shall be corrected by approved methods.

3 Forensic Plan

3.1 Accumulated Traffic Analysis

Table 5 shows a comparison of the predicted traffic from the pavement design along with the actual accumulated traffic. These data indicate that the accumulated traffic as of late 2005 was approximately 23 percent below the design levels.

Table 5. Predicted and actual traffic

Year	AADT	Actual ESAL	Actual Accumulated ESALs	Predicted Accumulated ESAsL	Accumulated % change
2002	2800	125,731	0	0	0.00%
2003	2300	94,172	94,172	190,000	-50.44%
2004	3000	239,074	333,246	380,000	-12.30%
2005	2500	109,850	443,097	576,000	-23.07%

3.2 December 2004 Pavement Condition Survey

A pavement condition survey was completed on the HIPR pavement in December 2004. Figure 1 shows the rutting recorded on each 0.1-mile lot of the pavement section. The deepest ruts occur toward the northern end of the project, and in several lots the rutting has exceeded the warranty specification.

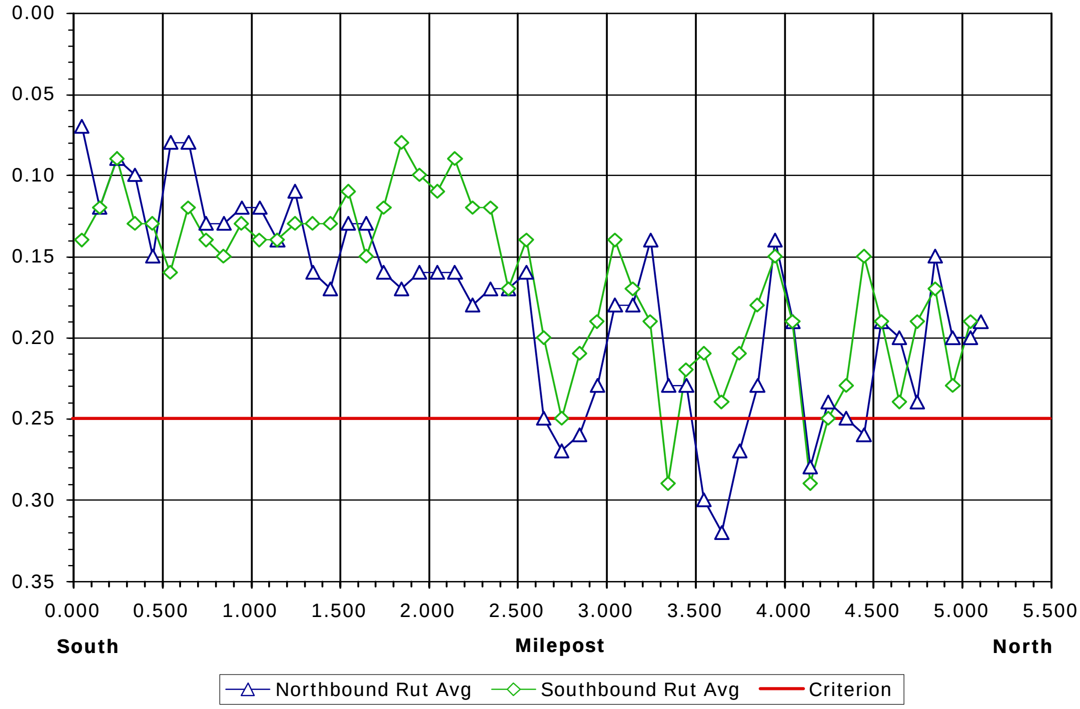


Figure 1. Rutting measurements from December 2004 pavement condition survey

3.3 Test Plan

Table 6 summarizes the plan of test including a brief description of the test procedure, the extents of the testing, and the results from the testing. The trenching and coring plan is shown graphically in Figure 2.

Table 6. Test plan

Procedure	Extent	Results
Pavement Condition Survey (HIPR and Control Sections)	MP 0.000 to MP 14.296 NB and SB	Rutting Cracking Rideability
FWD (General)	MP 0.000 to MP 10.000 NB and SB	Layer stiffness every 0.1-mile
FWD (Detailed)	MP 0.50 to 0.60 NB (low rutting) MP 3.60 to 3.70 NB (high rutting) MP 1.80 to 1.90 SB (low rutting) MP 4.10 to 4.20 SB (high rutting)	Layer stiffness every 50 ft
Trenching	MP 3.65 NB MP 4.15 SB MP 0.55 NB MP 1.85 SB	Layer profile Dynamic Cone Penetrometer (DCP) (2 locations) Base/subgrade in-place moisture and density by nuclear and gravimetric methods Moisture-density relationship Gradation Soil classification
Coring (HIPR Section)	MP 3.65 NB MP 4.15 SB MP 0.55 NB MP 1.85 SB	Standard penetration test 5 DCP tests through core holes Binder viscosity Aggregate gradation Mixture air content, binder content, and specific gravity
Coring (Control Section)	MP 6.50 SB	5 DCP tests through core holes

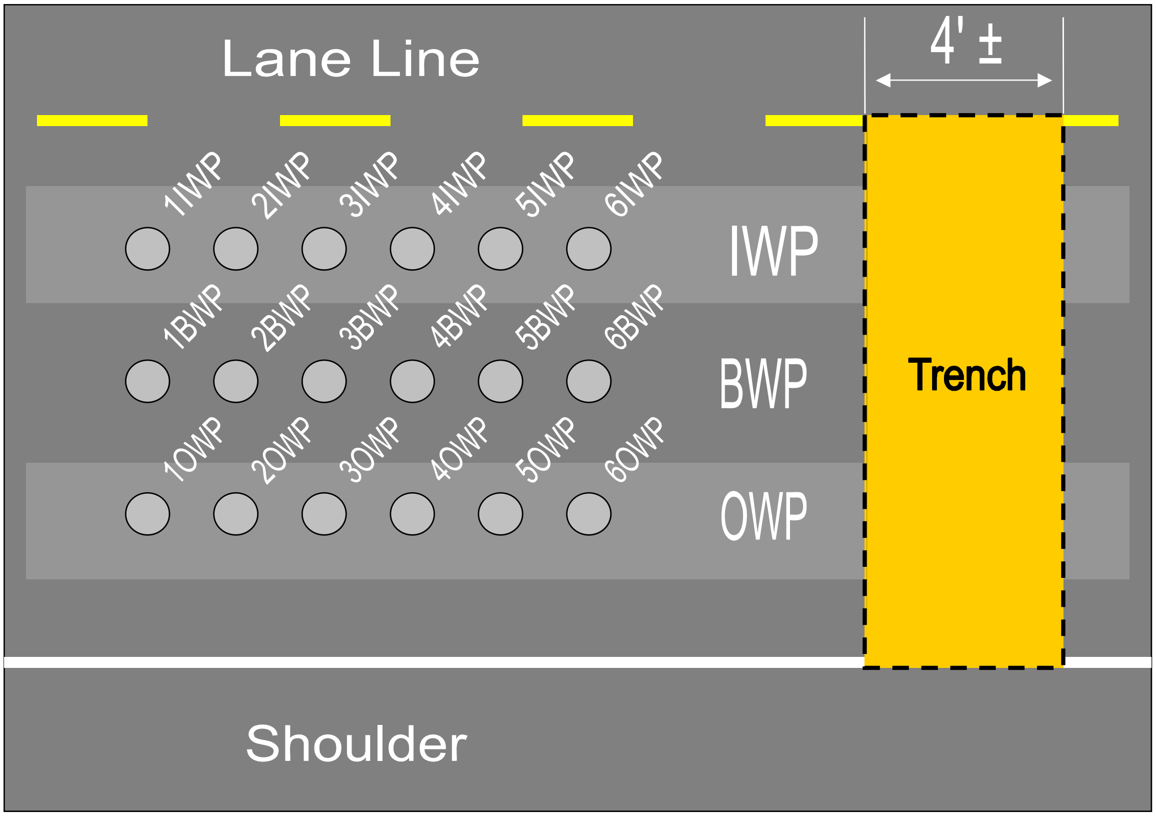


Figure 2. Trenching and coring plan

3.4 Responsible Parties

Table 7 lists the major work items and the responsible parties.

Table 7. Work responsibilities

Work Item	Responsible Party
Test Planning	ARA
Pavement Condition Survey	FDOT SMO
FWD Testing	FDOT SMO
FWD Analysis	ARA
Maintenance of Traffic	FDOT District 5
Trenching and Trench Measurements	FDOT District 5
Geotechnical Investigations	FDOT SMO
DCP Testing	FDOT SMO
DCP Analysis	ARA
Coring	FDOT District 5
Laboratory Tests on Cores	FDOT SMO
Analysis and Reporting	ARA

4 Test Results

4.1 Pavement Condition Survey

On October 10 and 11, 2005, the State Materials Office conducted a pavement condition survey of the HIPR and control sections in both the northbound and southbound traffic lanes. These surveys were completed approximately two years and nine months after acceptance of the pavement. The reports on these evaluations are contained in Appendices A and B.

Figure 3 presents the results of the average rut measurements in the northbound and southbound traffic lanes for both the HIPR and control sections. The rutting in the HIPR section is significantly greater than the rutting in the control section.

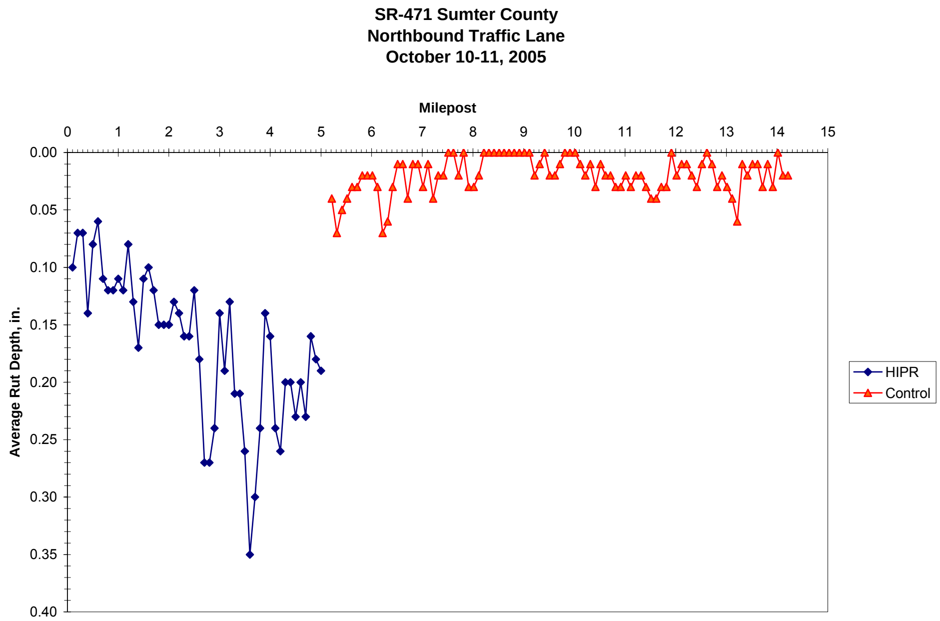
Warranty summaries for the northbound and southbound traffic lanes are tabulated in Table 8 and Table 9, respectively. These summaries indicate that there were five lots in the northbound traffic lane and four lots in the southbound traffic lane that exceeded the rutting criterion (rut depth greater than 0.25 inches) in the warranty specification. One lot in the southbound traffic lane exceeded the ride number criterion (ride number less than 3.70) in the warranty specification.

The rutting depths from all three surveys conducted on the HIPR section are plotted along with the last rut measurements made on the roadway prior to rehabilitation in Figure 4. The maximum rutting in the HIPR is generally occurring in the same locations that maximum rutting occurred in the previous pavement. The rate of rutting in the HIPR appears to have decreased in the nine months between the two most recent surveys.

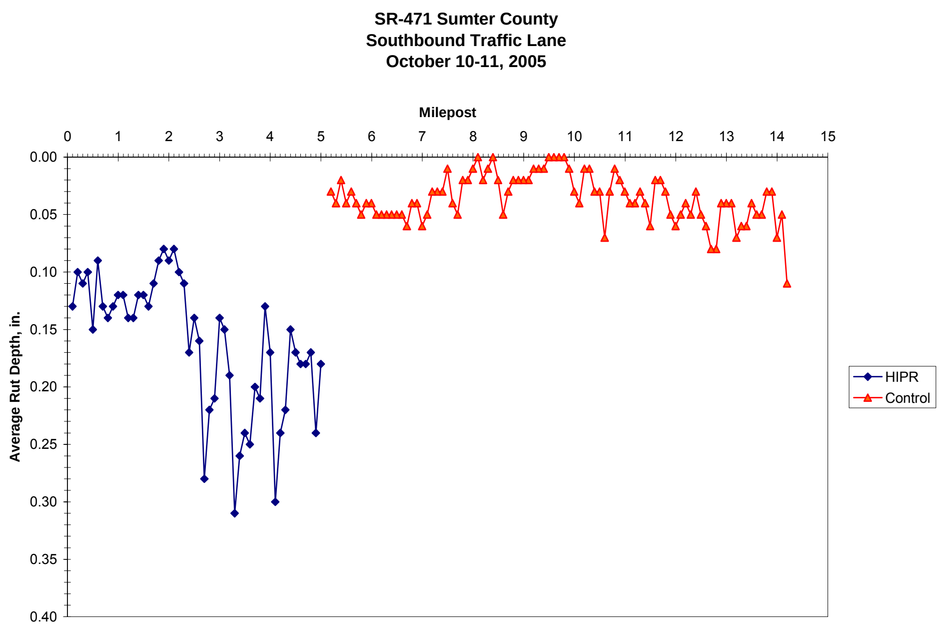
4.2 FWD Tests

On October 12, 2005, FWD tests were conducted on the roadway as prescribed in the testing plan. The data from these tests are tabulated in Appendices C and D for the northbound and southbound travel lanes, respectively. In all forward and back calculation procedures, the first drop of the weight was considered a seating load and not used in the calculations.

From the October 2005 test data, the recommend design resilient modulus was calculated as 18,000 psi, which is less that then 22,000 psi used for the structural design in 2002. However, this difference would not significantly change the required structural number and is inconsequential, because the supplied structural number (3.48) was significantly greater than the design structural number (2.20).



a. Northbound traffic lane



b. Southbound traffic lane

Figure 3. Rutting in October 2005

Table 8. HIPR section northbound traffic lane warranty summary

WARRANTEED ASPHALT PAVEMENT DISTRESS SUMMARY
COUNTY SECTION NO. 18110 FIN. 41353515201
SUMTER COUNTY SR 471 DISTRICT 5
NORTHBOUND TRAFFIC LANE
CATEGORY 1 PAVEMENT EVALUATION REPORT 10/10/2005

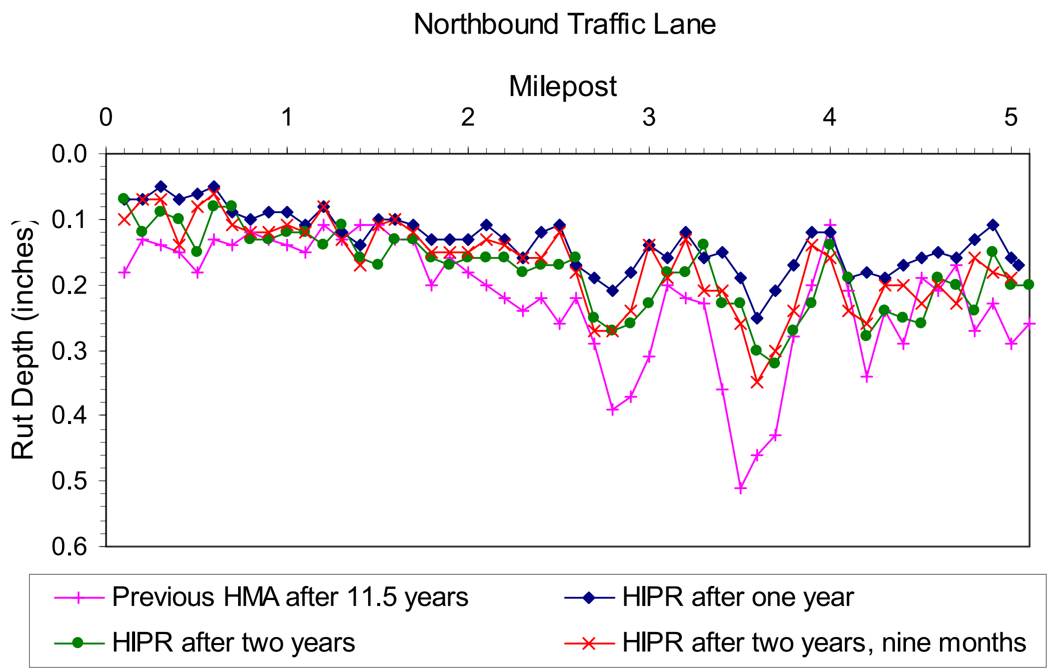
MILEPOST		RUTTING		RIDE		CRACKING	RAVELING / DELAMINATION		POT HOLES / SLIPPAGE AREAS
FROM	TO	RUT AVG.	>0.25 IN.	RN AVG.	RN<3.70	>1/8 in. >30 ft.	<10FT	>=10FT	
2.600	2.700	0.27	YES	4.19	NO	NO	NO	NO	NO
2.700	2.800	0.27	YES	4.26	NO	NO	NO	NO	NO
3.400	3.500	0.26	YES	4.20	NO	NO	NO	NO	NO
3.500	3.600	0.35	YES	4.22	NO	NO	NO	NO	NO
3.600	3.700	0.30	YES	4.11	NO	NO	NO	NO	NO
4.100	4.200	0.26	YES	4.23	NO	NO	NO	NO	NO

Table 9. HIPR section southbound traffic lane warranty summary

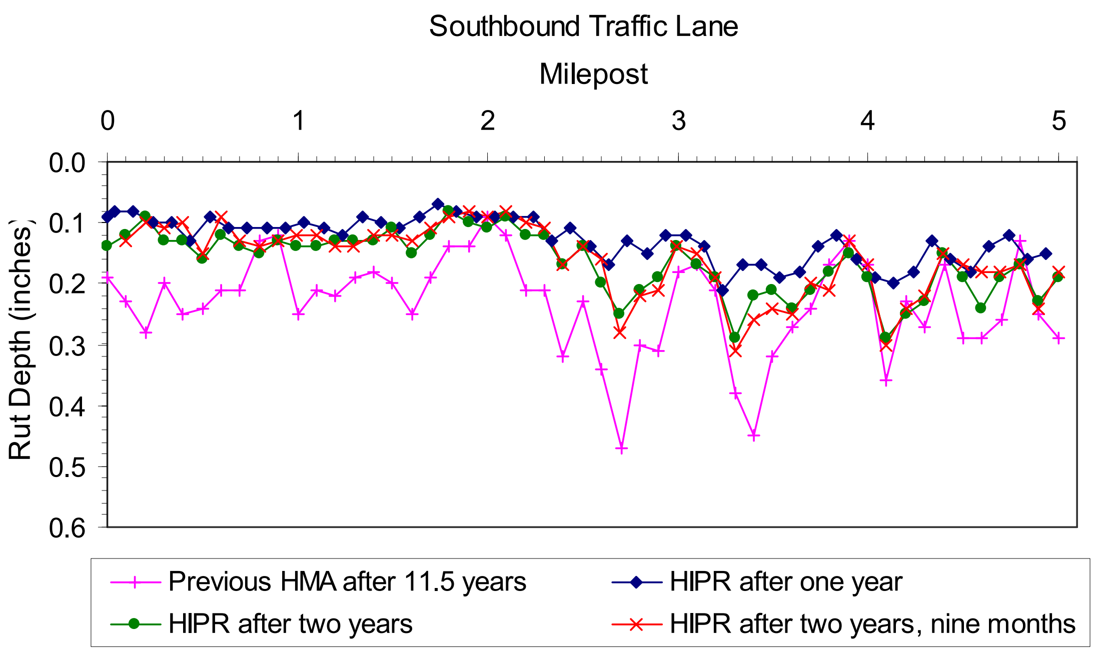
WARRANTEED ASPHALT PAVEMENT DISTRESS SUMMARY
COUNTY SECTION NO. 18110 FIN. 41353515201
SUMTER COUNTY SR 471 DISTRICT 5
SOUTHBOUND TRAFFIC LANE
CATEGORY 1 PAVEMENT EVALUATION REPORT 10/10/2005

MILEPOST		RUTTING		RIDE		CRACKING	RAVELING / DELAMINATION		POT HOLES / SLIPPAGE AREAS
FROM	TO	RUT AVG.	>0.25 IN.	RN AVG.	RN<3.70	>1/8 in. >30 ft.	<10FT	>=10FT	
5.099	4.999	0.18	NO	3.62	YES	NO	NO	NO	NO
4.199	4.099	0.30	YES	4.30	NO	NO	NO	NO	NO
3.499	3.399	0.26	YES	4.25	NO	NO	NO	NO	NO
3.399	3.299	0.31	YES	4.28	NO	NO	NO	NO	NO
2.799	2.699	0.28	YES	4.08	NO	NO	NO	NO	NO

Several deflection basin parameters were calculated directly from the data. These parameters are independent of the thickness of the pavement layers and do not require a back calculation program. Figure 5 presents the deflection at the center of the FWD loading plate (D0). In this figure, the deflections are indicated by the symbols, while the curve represents a moving average of 5 contiguous data points. D0 gives an indication of the overall stiffness of the pavement structure—the less deflection, the stiffer the structure. The pavement structure tends to be stiffer in the control section (MP 5.1 and beyond) than in the HIPR section (MP 0 to 5.1). Using Boussinesq's theory, the composite pavement modulus (E_0) can be directly calculated from D0 and the applied load. A plot of E_0 is shown in Figure 6. As was indicated in Figure 5, the lower stiffness pavement tends to occur near the north end of the HIPR section from about MP 3 to 5, which corresponds with the areas of greatest rutting.



a. Northbound traffic lane



b. Southbound traffic lane

Figure 4. Comparison of rutting in the HIPR section

Figure 7 presents a plot of the deflection at 60 inches from the center of the load plate (D60). D60 is indicative of the embankment response. The data indicate that the embankment stiffness appears to be fairly uniform with no unusually soft spots that would indicate problems with the embankment.

As described in the testing plan, a series of closely-spaced FWD tests were conducted in the immediate vicinity of the locations to be trenched. The average deflection basins in the high and low rut areas are shown in Figure 8. The magnitude of the deflections in the areas with high rutting is approximately 40 percent greater than those in the areas with low rutting.

A series of forward calculations and back calculations were performed on the data in the immediate vicinity of the trenches. These calculations are summarized in Table 10. For the back calculations, the pavement thicknesses were determined from the trench data described in a subsequent section. These results confirm the decreased pavement stiffness in the high rut areas previously described.

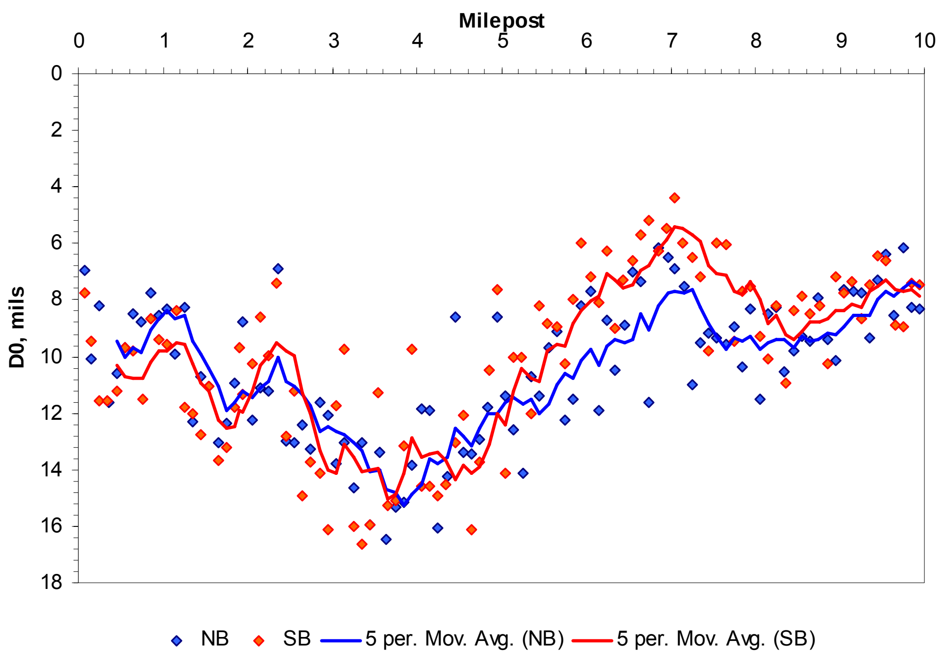


Figure 5. Deflection at center of FWD load plate

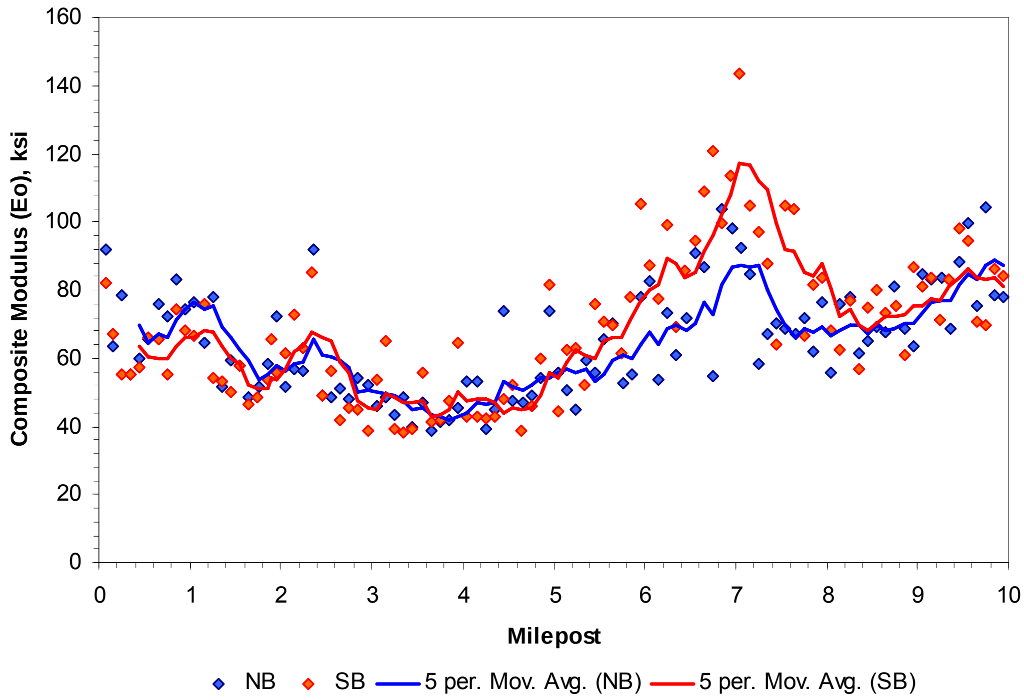


Figure 6. Composite pavement modulus

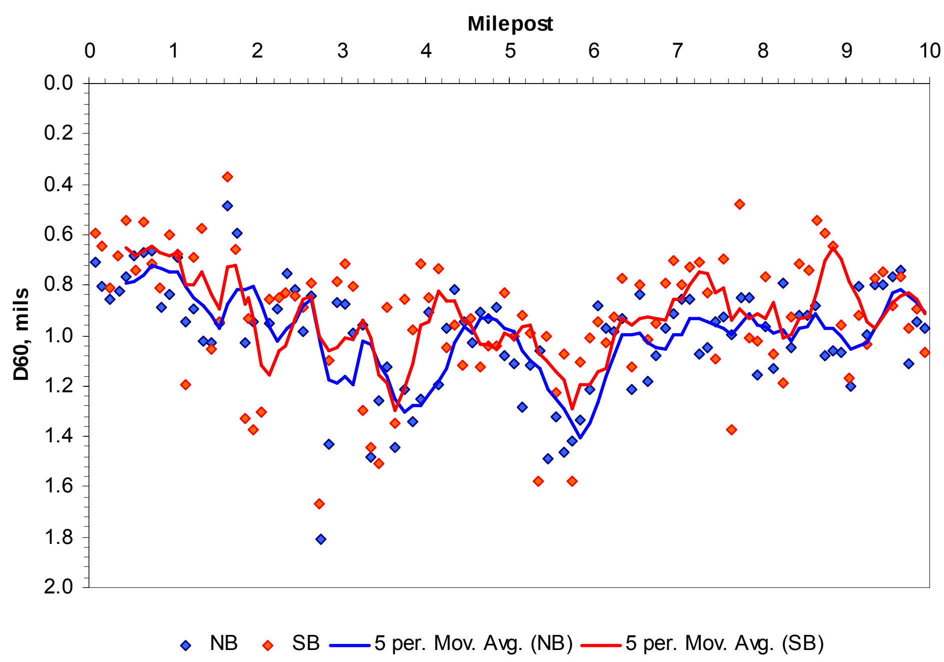


Figure 7. Deflection at 60 inches from the center of FWD load plate

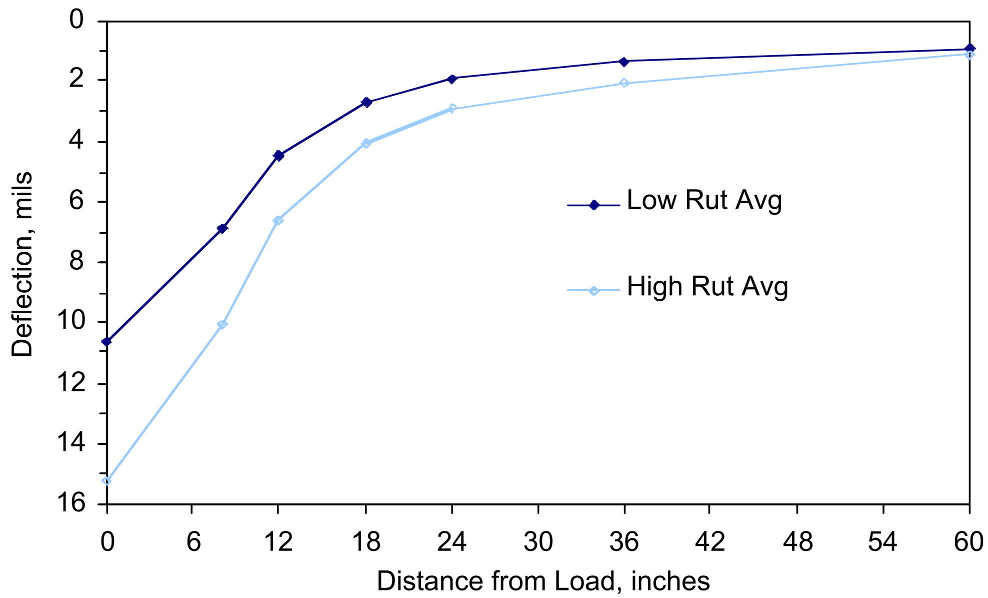


Figure 8. Average deflection basins near high and low rut areas

Table 10. Results of forward and back calculations near trench locations

Location	Low or High Rut	Eo, ksi	AC, ksi	Temperature Corrected AC (20°C), ksi	AC+Base, ksi	AC+Base, ksi	Stabilized Subgrade, ksi	Embankment, ksi	Embankment, ksi
		Forward Method	AREA Method	AREA Method	AREA Method	Back Calculation	Back Calculation	Back Calculation	AASHTO
MP 0.55 NB	Low	63.1	518.6	834.7	94.8	79.3	61.9	45.4	51.9
MP 1.85 SB	Low	57.5	516.7	873.8	89.6	70.8	87.8	31.9	38.9
Average	Low	60.3	517.7	854.2	92.2	75.1	74.8	38.6	45.4
MP 3.65 NB	High	38.4	422.0	694.6	48.7	50.9	39.1	24.8	27.3
MP 4.15 SB	High	46.3	384.7	665.3	67.6	59.6	47.0	31.1	32.9
Average	High	42.4	403.3	680.0	58.2	55.3	43.1	27.9	30.1

4.3 Trenches

Four trenches were cut in the HIRP sections--two within lots of high rutting and two within lots of low rutting. The locations and dates of trenching are indicated in Table 11. Trenches were one full lane width by approximately 4 to 6 feet. A laser level, as shown in Figure 9, was used to determine the transverse surface profile of one edge of the trench in 6-inch increments before the surface material was excavated. A slice of surface material, approximately 6-inches wide (Figure 10), was cut and saved. An excavator was used to assist material removal. In order to minimize disturbance of the lower layer, the last remaining material of each upper layer was removed with hand tools. Nuclear density measurements, soil samples, and moisture samples were collected for each of the subsurface layers including the embankment. Once the trench was excavated into the embankment, the thickness of each layer was recorded at the same increments the surface profile was measured. Figure 11 shows photographs of nuclear testing and layer thickness measurements in the trench. Soil samples were collected and taken to the laboratory for classification and testing.

Table 11. Trenching dates and locations

Date	Location	Traffic Lane	Low or High Rut	Figure
November 15, 2005	MP 3.65	Northbound	High	Figure 13
November 16, 2005	MP 4.15	Southbound	High	Figure 14
November 17, 2005	MP 1.85	Southbound	Low	Figure 15
November 18, 2005	MP 0.55	Northbound	Low	Figure 16

Figure 9. Measuring surface profile with laser level

Figure 10. Excavating trench

Figure 11. Nuclear density tests and layer thickness measurements in trench

A photograph of a typical trench cross section showing the layering of the pavement structure is shown in Figure 12. The results of these measurements are shown in the figures indicated in Table 11. It can be observed that there are some variations in the layer thicknesses. For example, the thickness of the HIPR layer is varying along the width of the roadway, particularly at MP 4.15; however, this thickness variation is probably caused by correction of the cross-slope during rehabilitation. There are also some differences in the total pavement thickness above the subgrade ranging from approximately 25 inches at MP 3.65 to over 30 inches at MP 0.55. The asphalt/base interfaces do not indicate significant rutting. The irregular interfaces between the binder and HIPR layers do not allow a determination of which asphalt layer contributed to the rutting.

Figure 12. Photograph of a typical trench cross-section

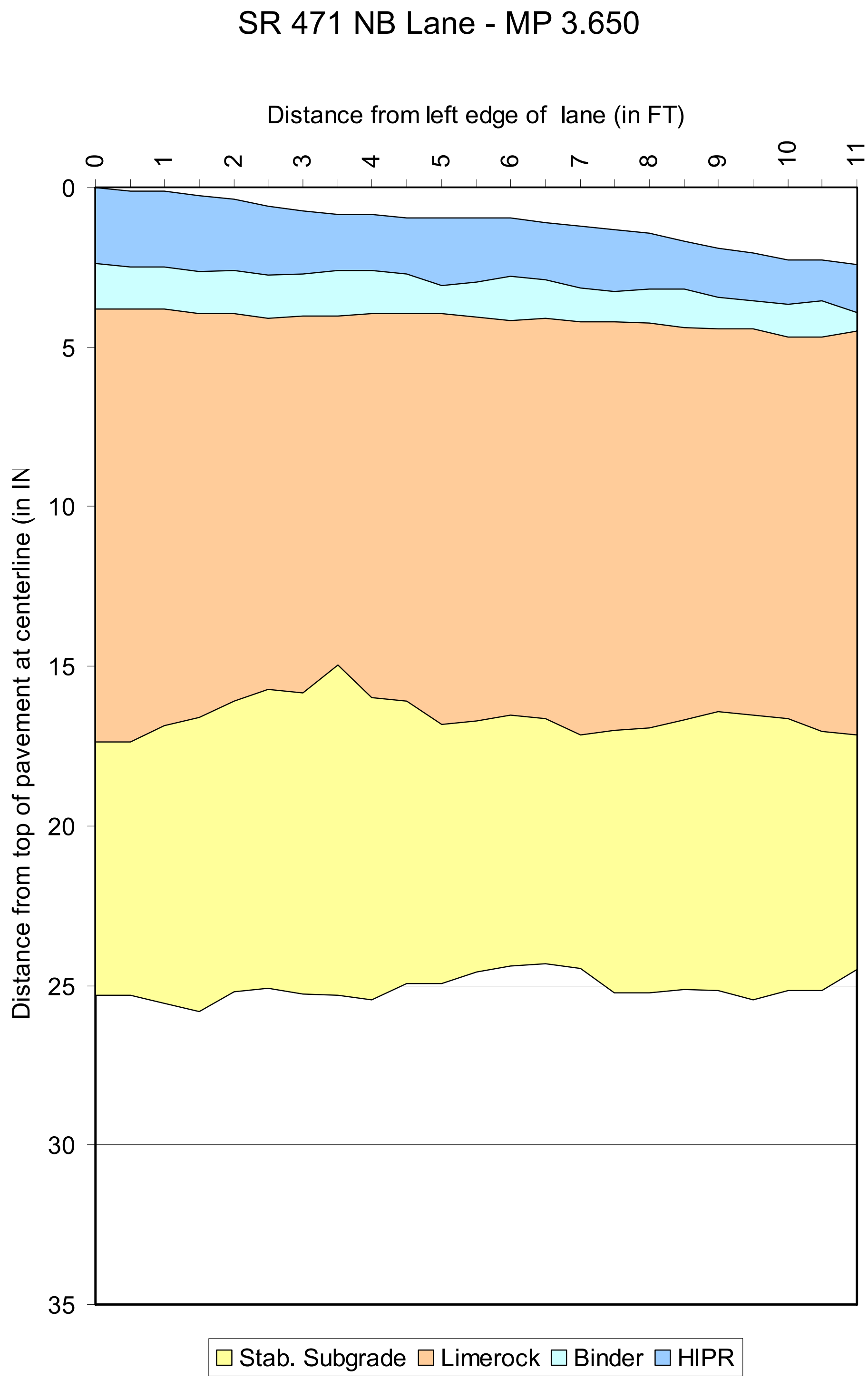


Figure 13. Layer thicknesses, MP 3.65

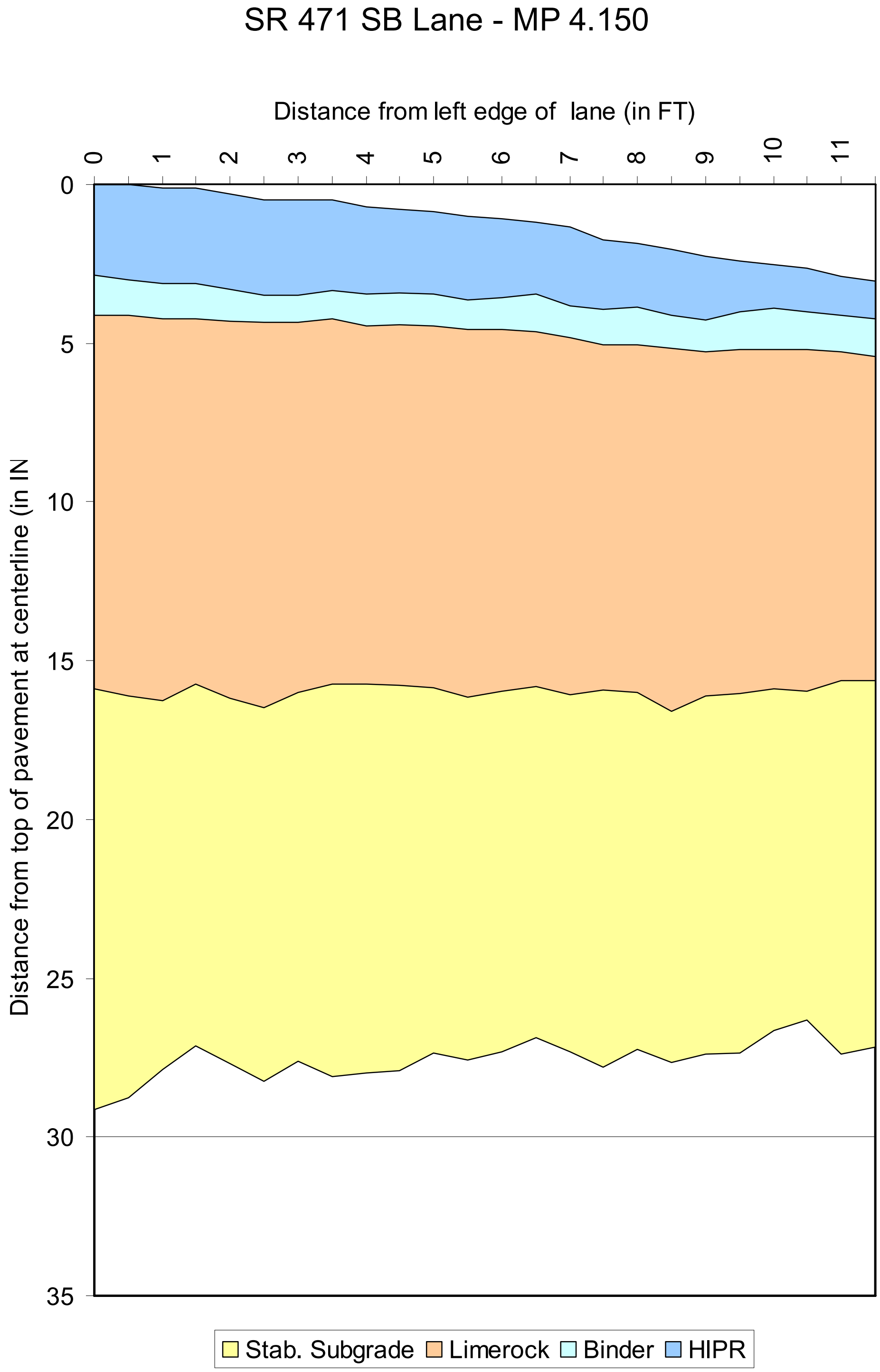


Figure 14. Layer thicknesses, MP 4.15

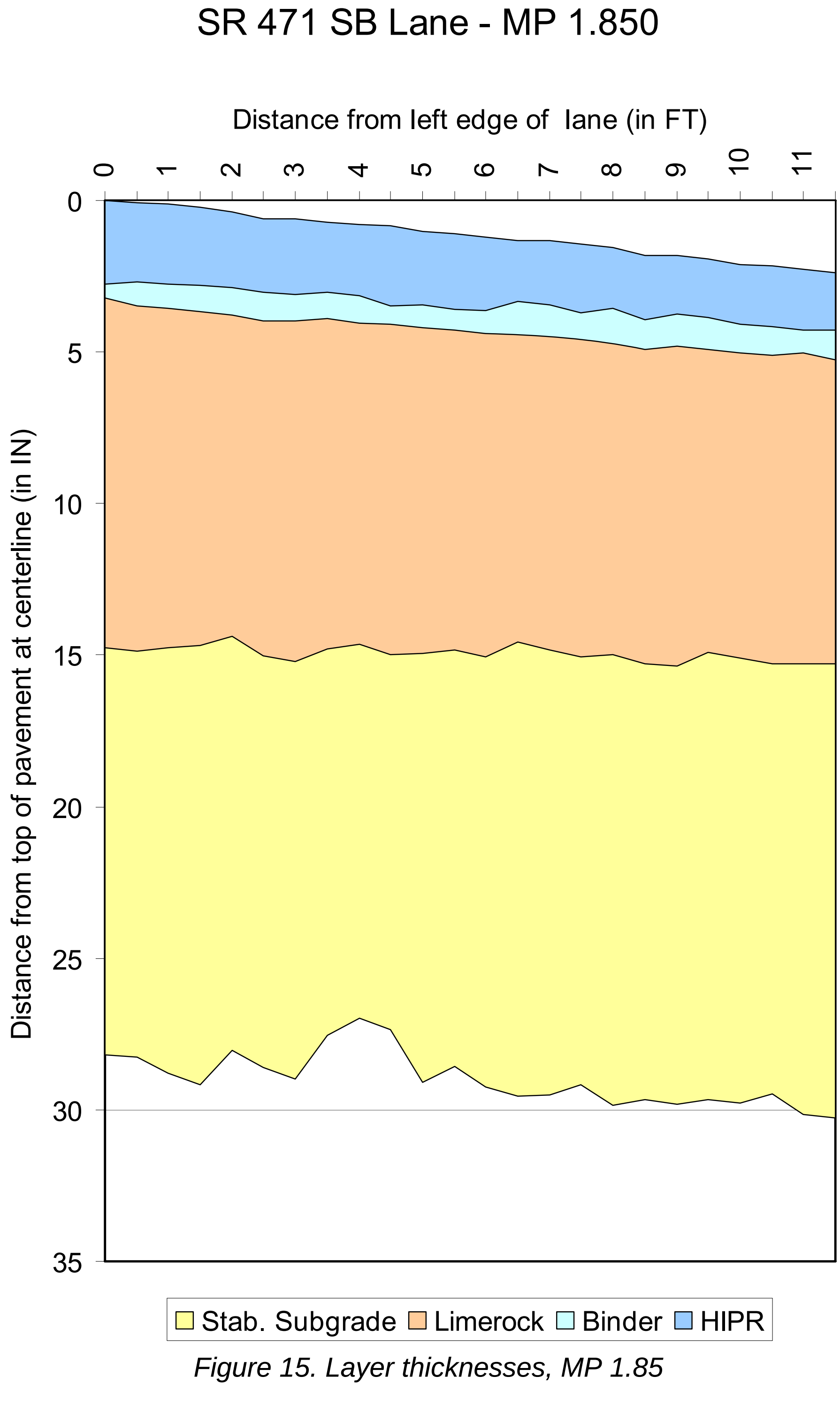


Figure 15. Layer thicknesses, MP 1.85

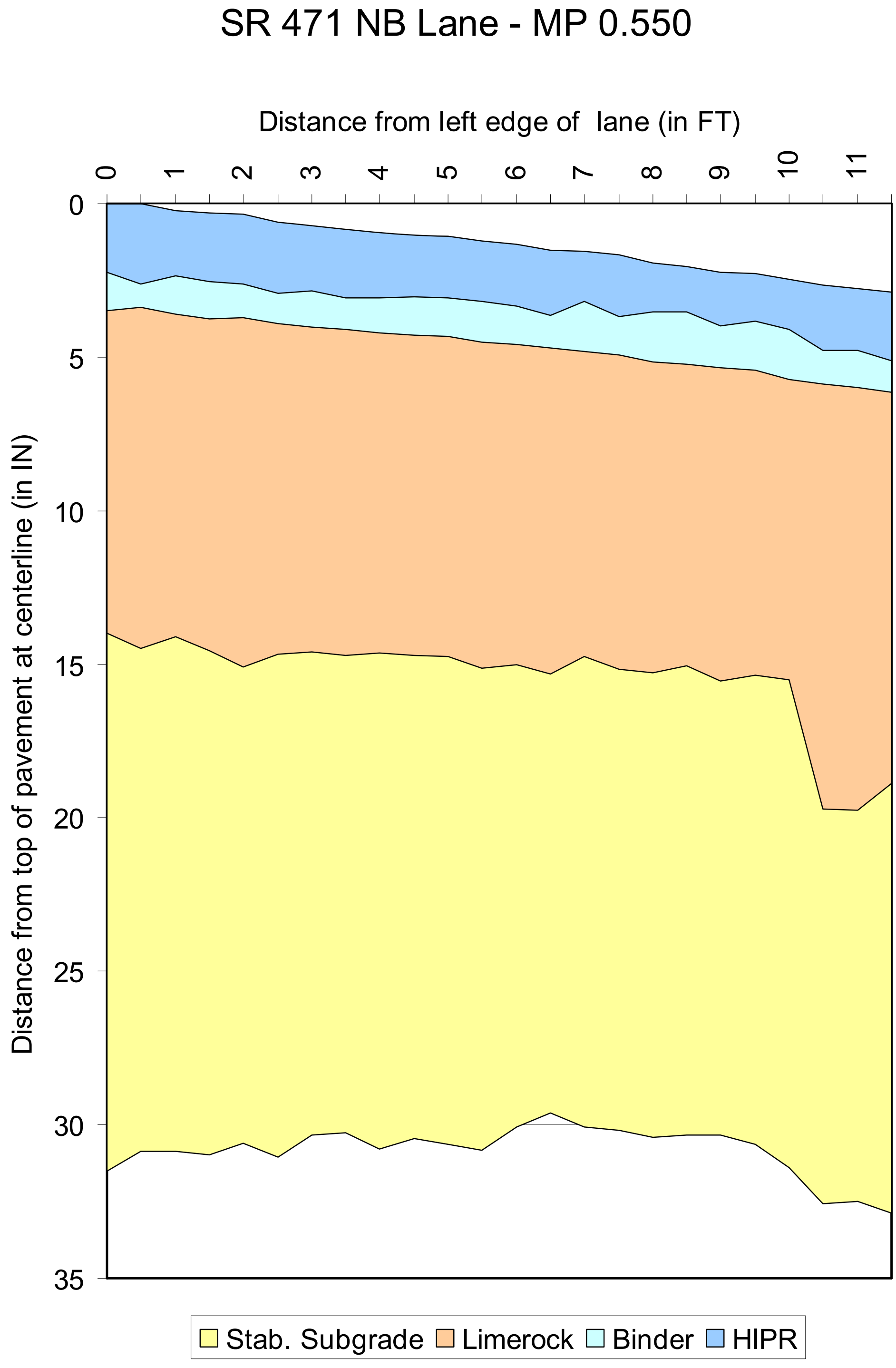


Figure 16. Layer thicknesses, MP 0.55

4.4 Geotechnical Investigations

A standard penetration test (SPT) test using a split-spoon sampler, as seen in Figure 17, was conducted in accordance with AASHTO T 206 to a depth of approximately 15 feet. Data collected from the SPT test includes soil description based on samples retrieved, depth to water table, and a penetration resistance profile. The logs from these tests are contained in Appendix A. The depth of the water table at each trench site is tabulated in Table 12.

Figure 17. Standard penetration test using a split-spoon sample

Table 12. Water table depths at trench locations

Location	Depth to Water Table, ft
MP 0.55	8.0
MP 1.85	6.5
MP 3.65	6.0
MP 4.15	6.5

In-place moisture and density were measured in the trenches by the nuclear method (AASHTO T 310). Moisture contents and dry densities were also obtained by gravimetric methods. These data are tabulated in Appendix B.

Soil samples were collected from the embankment, stabilized subbase and limerock base at each trench location as discussed in Section 4.3. These samples were bagged and transported to the State Materials Office for testing. The tests conducted on the soils included moisture-density relationships (AASHTO T 99 and FM 1-T 180), Atterberg limits, gradation, and soil classification. The results of these tests are tabulated in Table 13. The stabilized subbase was found to be an A-2-4 soil, while the embankment was an A-3 soil.

The geotechnical investigation did not reveal any unexpected or inconsistent results that would indicate any contribution to the rutting observed on the roadway.

4.5 DCP

DCP tests were conducted at two locations in the trench openings and through five core holes near each trench in the HIPR section (Figure 18). In addition, DCP tests were conducted through core holes at MP 6.5 SB in the control section. Appendix C presents tabulated results from each DCP test.

Figure 18. DCP test through core hole

Figure 19 summarizes the results of the DCP tests. Only the average results through core holes are plotted in the figure. The results are plotted as LBR and resilient modulus.

These test results indicate that each layer is competent with no unusual findings. The embankment, in particular, appears to be quite stiff and does not give any indication of that high groundwater levels have weakened the pavement foundation.

4.6 Cores

Sixteen cores were extracted from the HIPR section approximately 40 to 50 feet from the trench: six from the inside wheel path, six from between the wheel paths, and six from the inside wheel paths. The cores were transported to the State Materials Office and subjected to a battery of tests to measure the volumetric properties, asphalt binder properties, and aggregate gradations. The following testing methods were followed:

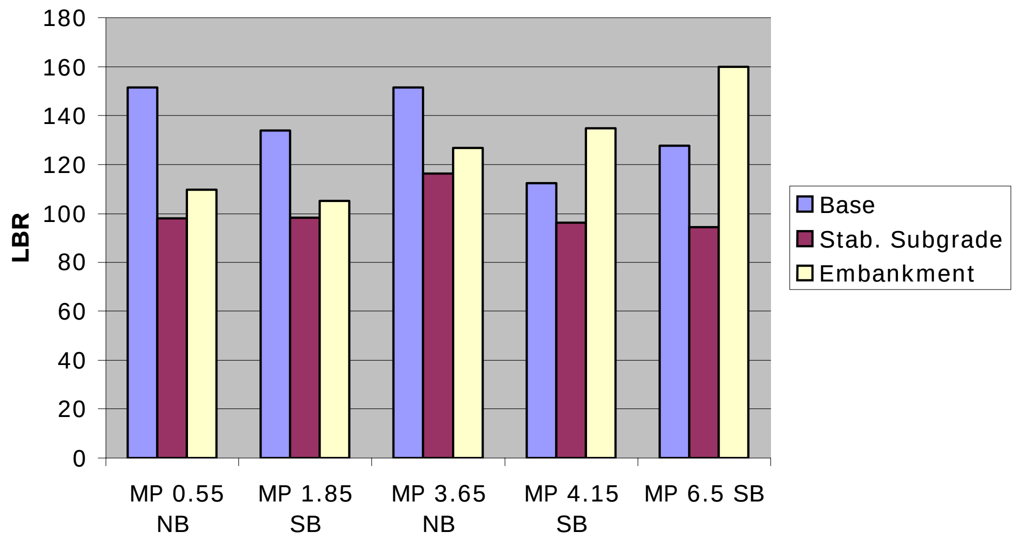
- Binder Extraction (AASHTO T 319)
- Asphalt Binder Content of Hot-Mix Asphalt (HMA) by the Ignition Method (AASTHO T 308)
- Mechanical Analysis of Extracted Aggregate (FM 1-T 030)
- Bulk Specific Gravity of Compacted Bituminous Mixtures (FM 1-T 166)
- Maximum Specific Gravity of Asphalt Paving Mixtures (FM 1-T 209)
- Percent Air Voids in Compacted Dense and Open Asphalt Mixtures (AASHTO T 269)

The results of these tests are presented in Table 14.

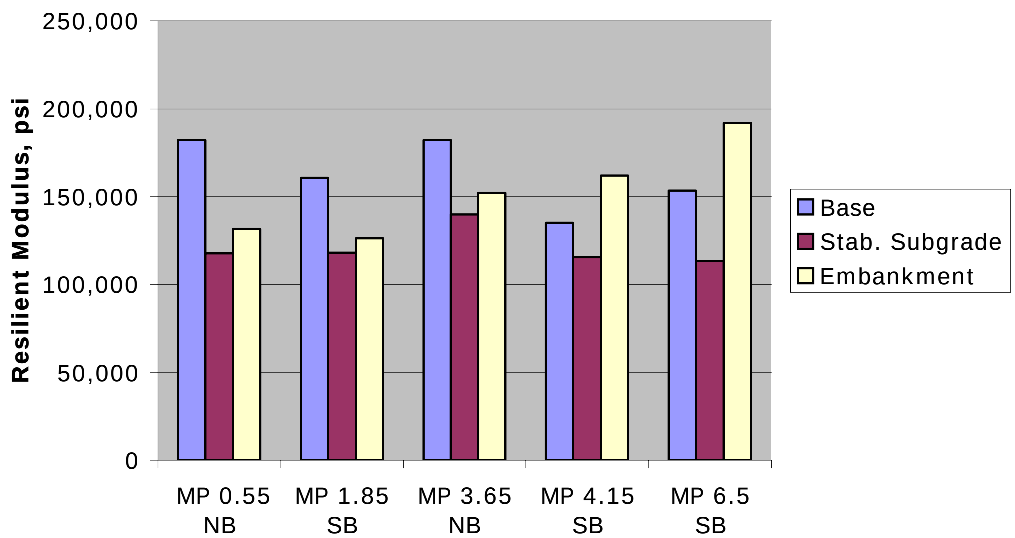
The gradations of the recovered aggregates were consistent throughout. Binder contents were consistent, with all but one test result between 5 and 6 percent. These results compare favorably with the design binder contents of 5.7 and 5.4 percent for the northbound and southbound lanes, respectively. Bulk specific gravities ranged from a low of 2.191 to a maximum of 2.302. The design values were 2.321 and 2.319 for the northbound and southbound lanes, respectively. Maximum specific gravities ranged from 2.381 to 2.406, as compared to the design values of 2.420 for the northbound and 2.423 for the southbound lanes. The oven-dried percent G_{mm} ranged from 91.33 to 96.12. Penetration values ranged from a low of 13 to a high of 35 (measured in 0.1 mm). The design values were 55 and 51, indicating that the aging has stiffened the binder.

Table 13. Results of laboratory tests on soils

MP	Layer	4-inch Depth T99		6-inch Depth " T-180/LBR			PERCENT PASSING					ATTERBURG LIMITS			SOIL CLASS
		MOIST.	**DENSITY**	**MOIST.**	**DENSITY**	**LBR**	**10**	**40**	**60**	**100**	**#200**	**LL**	**PL**	**PI**	
3.65 NB	Embankment	11.7%	108.8	7.8%	111.4	30	100	98	84	43	10	NP	NP	NP	A-3
3.65 NB	Stab. Subgrade	NA	NA	8.7%	115.3	35	98	94	82	45	16	NP	NP	NP	A-2-4
3.65 NB	Limerock Base	NA	NA	10.7%	121.0	123						NP	NP	NP	
4.15 SB	Embankment	11.9%	111.1	9.4%	113.1	48	100	98	85	40	11	NP	NP	NP	A-2-4
4.15 SB	Stab. Subgrade	NA	NA	9.5%	116.8	50	97	92	79	45	19	NP	NP	NP	A-2-4
4.15 SB	Limerock Base	NA	NA	11.1%	121.1	129						NP	NP	NP	
1.85 SB	Embankment	13.0%	109.4	8.9%	110.8	29	100	96	75	35	7	NP	NP	NP	A-3
1.85 SB	Stab. Subgrade	NA	NA	8.4%	114.3	44	98	92	74	45	16	NP	NP	NP	A-2-4
1.85 SB	Limerock Base	NA	NA	10.8%	120.5	122						NP	NP	NP	
0.55 NB	Embankment	13.5%	108.9	9.0%	110.9	23	100	95	72	33	6	NP	NP	NP	A-3
0.55 NB	Stab. Subgrade	NA	NA	11.0%	114.4	42	98	92	75	43	16	NP	NP	NP	A-2-4
0.55 NB	Limerock Base	NA	NA	10.6%	120.2	104						NP	NP	NP	



a. LBR



b. Resilient Modulus

Figure 19. Summary of DCP results through core holes

Table 14. Results of laboratory tests on roadway cores

MP 0.550 (NB) Low Rut	Percent Passing Sieves															
	19	12.5	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075						
	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	% AC	Oven-Dried Gmb	Gmm	% Gmm	Pen (0.1 mm)	Viscosity (Poises)
IWP	100.00	98.23	94.80	64.28	44.51	38.25	34.02	24.96	12.90	8.16	5.60	2.205	2.395	92.07	17	77,598
BWP	100.00	95.50	92.62	63.65	44.12	38.28	33.85	25.07	13.29	8.35	5.57	2.215	2.392	92.60	17	67,406
OWP	100.00	98.05	94.96	65.38	45.69	39.26	34.69	25.94	13.78	8.73	5.75	2.191	2.399	91.33	13	108,999

MP 3.650 (NB) High Rut	Percent Passing Sieves																		
	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	% AC	Oven-Dried Gmb	Gmm	% Gmm	Pen (0.1 mm)	Viscosity (Poises)	Fan-dried Gmb	Gmm	% Gmm
IWP	98.95	96.76	93.34	64.33	45.90	40.01	35.55	25.16	11.85	7.18	5.68	2.283	2.398	95.20	34	17,835	2.304	2.398	96.08
BWP	99.47	98.15	95.49	68.79	48.43	41.54	36.58	26.07	12.47	7.44	6.03	2.211	2.393	92.39	34	15,020	2.239	2.393	93.56
OWP	100.00	97.74	93.41	62.30	43.77	38.34	34.16	24.79	12.35	7.64	5.83	2.302	2.395	96.12	35	14,633	2.317	2.395	96.74

1.850 (SB) Low Rut	Percent Passing Sieves																		
	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	% AC	Oven-Dried Gmb	Gmm	% Gmm	Pen (0.1 mm)	Viscosity (Poises)	Fan-dried Gmb	Gmm	% Gmm
IWP	97.28	94.47	90.26	65.52	46.31	40.33	36.12	27.08	13.79	8.64	8.00	2.299	2.397	95.91	29	12,267	2.310	2.397	96.37
BWP	100.00	98.02	95.84	71.55	51.62	44.06	38.97	29.01	14.50	8.97	5.93	2.269	2.394	94.78	25	19,509	2.288	2.394	95.57
OWP	100.00	96.62	94.21	67.49	48.88	41.80	36.88	27.20	13.31	8.03	5.55	2.250	2.406	93.52	25	24,275	2.281	2.406	94.80

4.150 (SB) High Rut	Percent Passing Sieves															
	3/4"	1/2"	3/8"	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200	% AC	Oven-Dried Gmb	Gmm	% Gmm	Pen (0.1 mm)	Viscosity (Poises)
IWP	100.00	99.37	97.30	73.16	52.23	43.71	38.18	27.74	13.48	8.17	5.78	2.260	2.381	94.92	20	41,245
BWP	100.00	100.00	97.59	70.28	50.39	42.59	37.56	27.77	13.85	8.57	5.98	2.278	2.403	94.80	20	49,213
OWP	100.00	99.52	95.86	68.67	49.16	42.50	37.58	27.88	14.15	8.87	5.91	2.296	2.394	95.91	21	39,628

5 Conclusions and Recommendations

5.1 Conclusions

Just over five miles of SR-471 in Sumter County, Florida were rehabilitated in late 2003 using the HIPR technique with a three-year warranty. Near the end of the third year of the warranty, FDOT performed a pavement condition survey and found five lots in the northbound traffic lane and four lots in the southbound traffic lane exceeded the rutting requirement of the warranty specification. In addition, one lot in the southbound traffic lane exceeded the smoothness requirement. A forensic study was conducted to determine the causes of these distresses and to recommend a course of action.

The project consisted of removing the top two inches of the asphalt surfacing and recycling it in place. The recycled mix was designed using Marshall 50-blow criteria. New materials added to the recycled mix included clean concrete sand and an asphalt-rejuvenating agent. Additional Marshall Type S-III HMA was added to correct cross slope as necessary. The traffic on the section was approximately 23 percent below the design traffic level.

Pavement condition survey data indicated that the location of the maximum rutting in the HIPR section was found to generally occur in the same locations that maximum rutting occurred prior to rehabilitation in 2002.

FWD test results indicated that the composite pavement stiffness was less in the high rut areas. The recommended design resilient modulus was found to be 18,000 psi, which was approximately 18 percent less than the value used in the 2002 rehabilitation design. However, the structural design for the pavement section was adequate for the traffic levels observed on the roadway.

Trenches were excavated in the roadway in the northbound and southbound traffic lanes within lots exhibiting high rutting and low rutting. The thickness of the HIPR layer varied along the width of the roadway; however, this thickness variation was probably caused by correction of the cross-slope during rehabilitation. There are also some differences in the total pavement thickness above the embankment ranging from approximately 25 inches at MP 3.65 to over 30 inches at MP 0.55. The asphalt/base interfaces do not indicate significant rutting. The irregular interfaces between the binder and HIPR layers do not allow a determination of which asphalt layer contributed to the rutting.

Geotechnical and DCP investigations did not reveal any unexpected or inconsistent results that would indicate a significant contribution of the base, stabilized subgrade, or embankment to the rutting observed on the surface of the roadway.

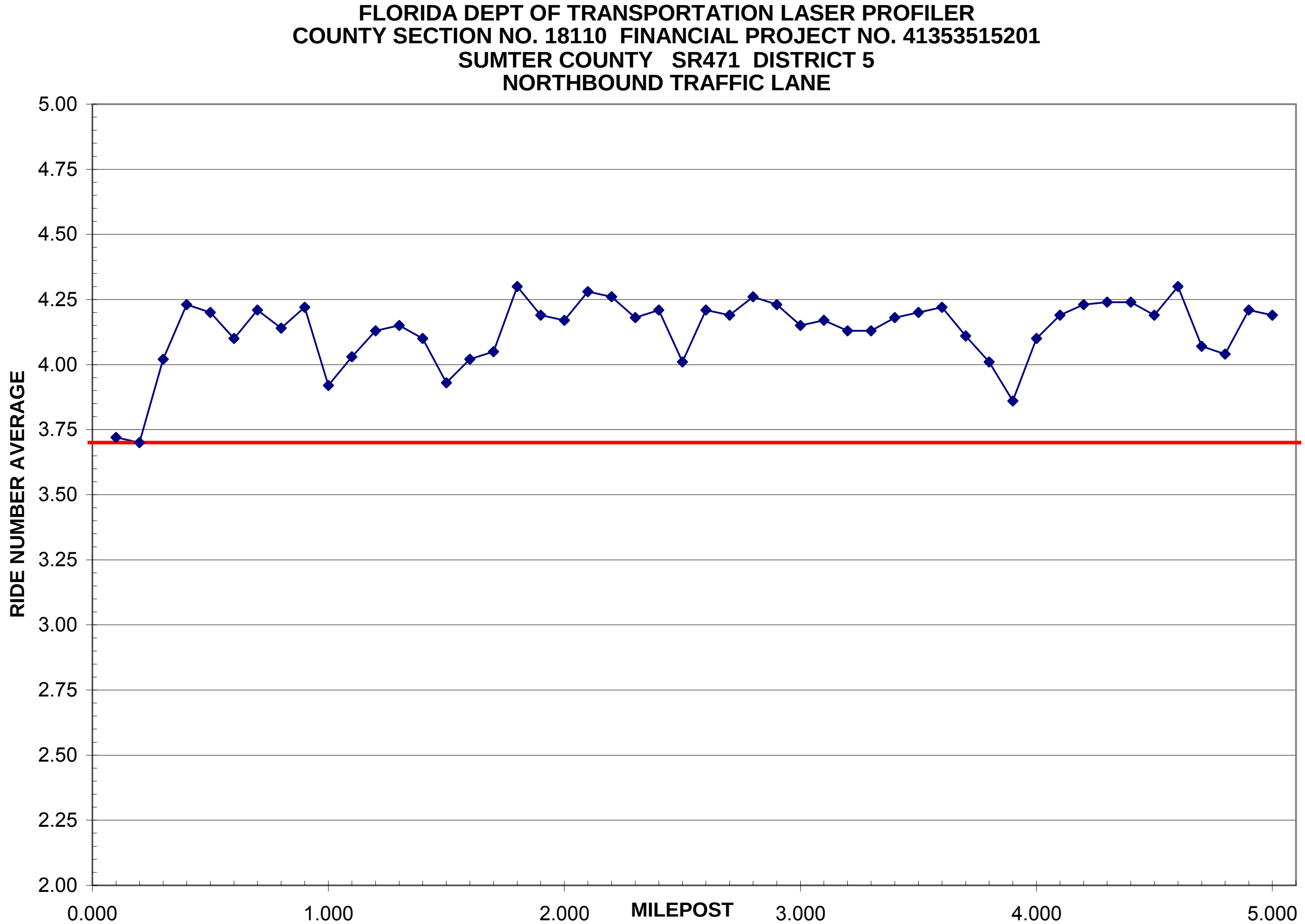
Tests on cores extracted from the roadway indicated that the binder had stiffened due to aging. The cores also indicated that compaction under traffic was responsible for at least a portion of the observed rutting.

5.2 Recommendations

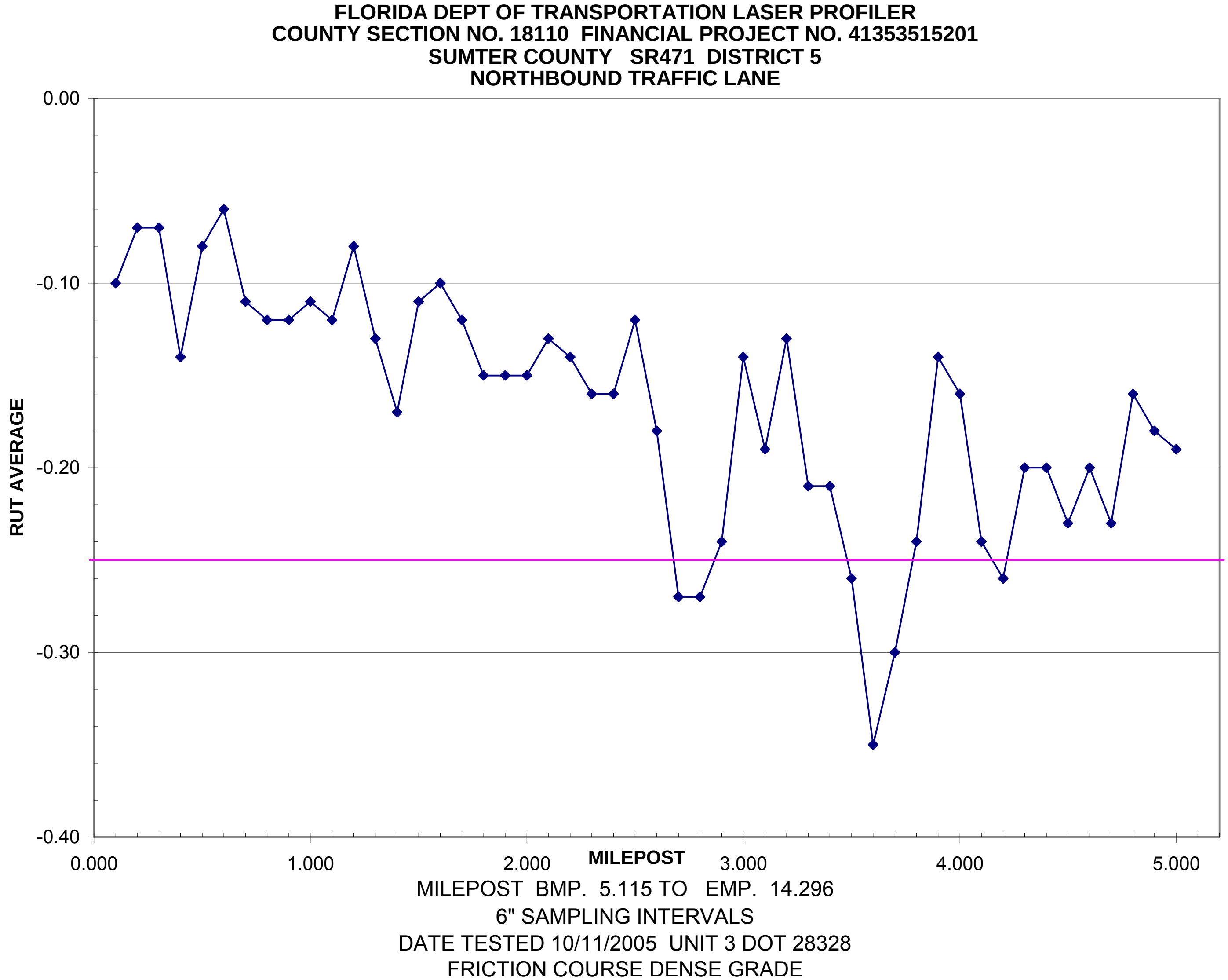
The results of this investigation did not irrefutably determine which layer of the pavement system caused the observed rutting. Therefore, no claims are recommended under the warranty specification.

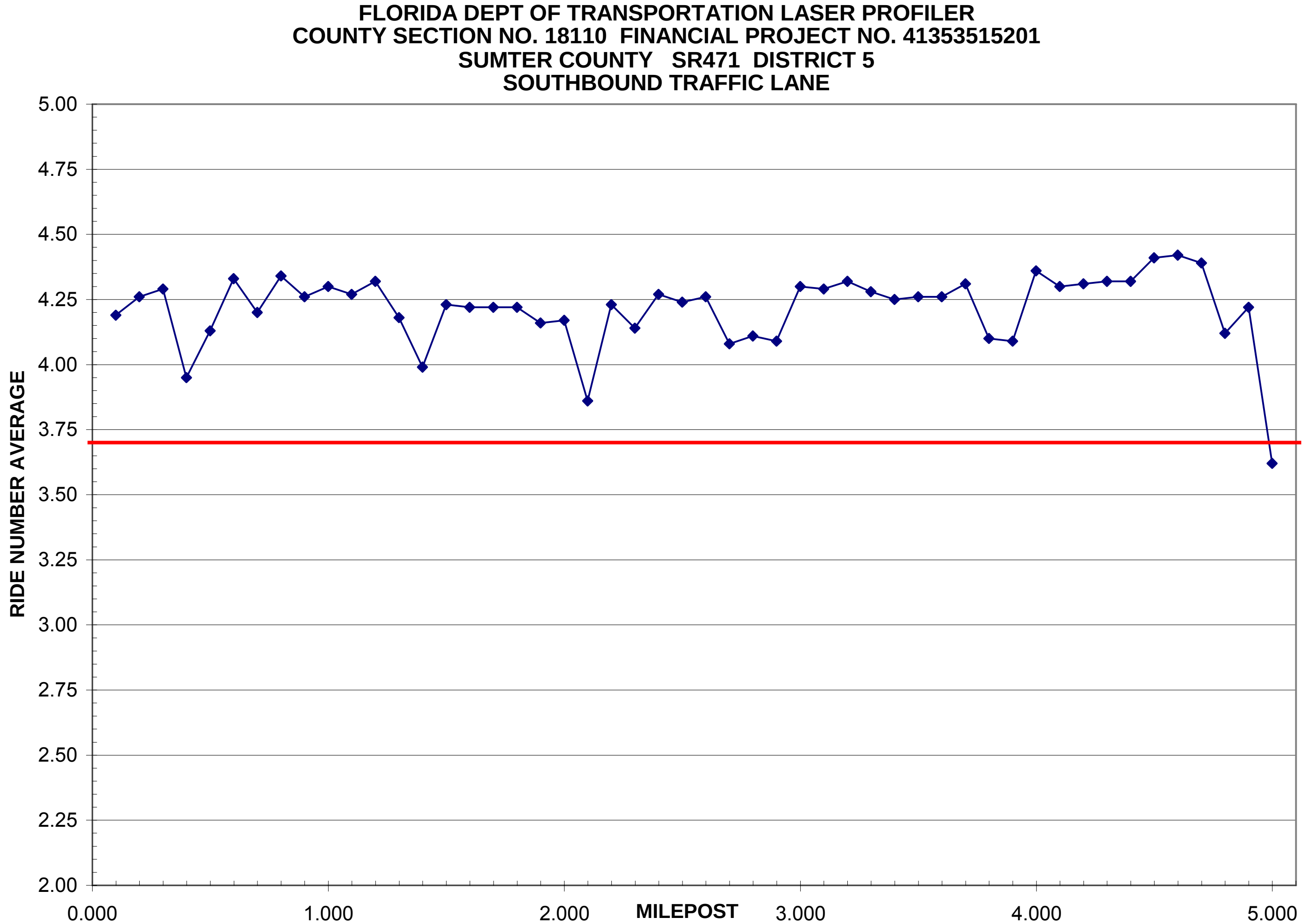
The structural coefficient of the HIPR layer for design was 0.37. Because rutting appears to be occurring in the HIPR layer, it is recommended that the structural coefficient of the HIPR be limited to no more than 0.35 for future projects.

Appendix A: October 2005 Pavement Condition Survey on HIPR Section

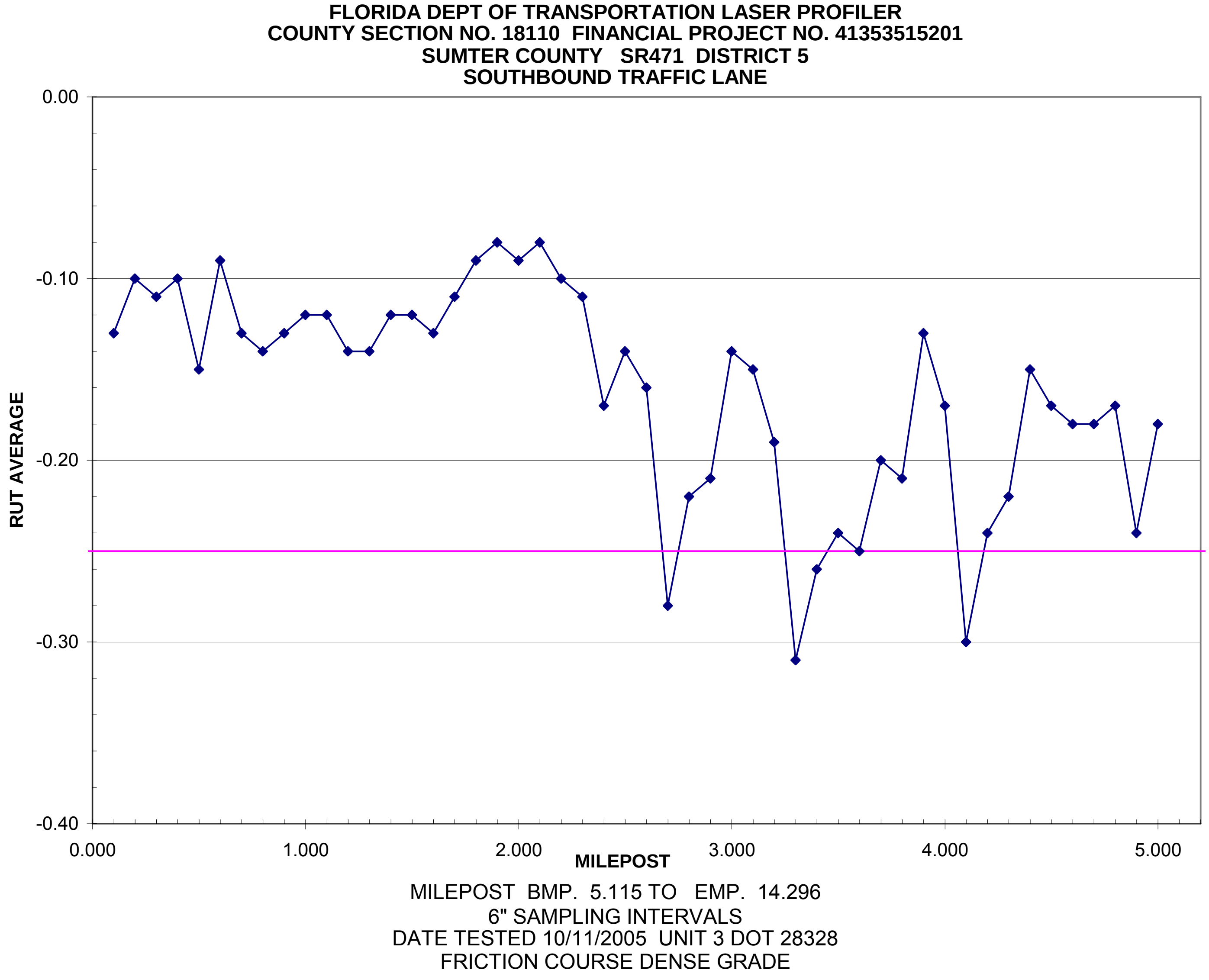


MILEPOST BMP. 0.000 TO EMP. 5.099
6" SAMPLING INTERVALS
DATE TESTED 10/10/2005 UNIT 3 DOT 28328
FRICTION COURSE HIP RECYCLE


FLORIDA DEPT OF TRANSPORTATION LASER PROFILER
COUNTY SECTION NO. 18110 FINANCIAL PROJECT NO. 41353515201
SUMTER COUNTY SR471 DISTRICT 5
NORTHBOUND TRAFFIC LANE
RUT AVERAGE
0.00
-0.10
-0.20
-0.30
-0.40
MILEPOST
0.000
1.000
2.000
3.000
4.000
5.000
MILEPOST BMP. 5.115 TO EMP. 14.296
6" SAMPLING INTERVALS
DATE TESTED 10/11/2005 UNIT 3 DOT 28328
FRICTION COURSE DENSE GRADE

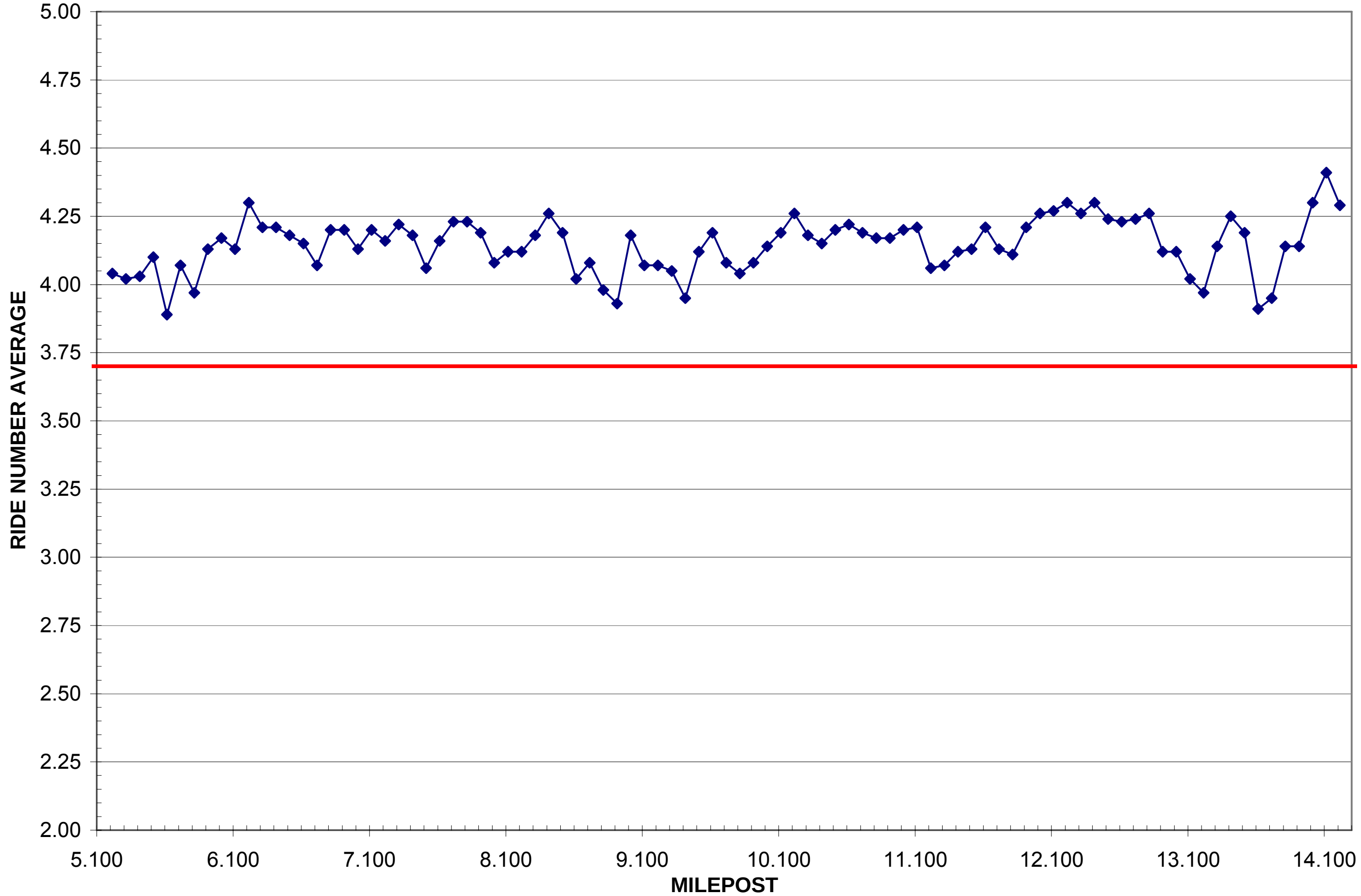


MILEPOST BMP. 0.000 TO EMP. 5.099
6" SAMPLING INTERVALS
DATE TESTED 10/10/2005 UNIT 3 DOT 28328
FRICTION COURSE HIP RECYCLE

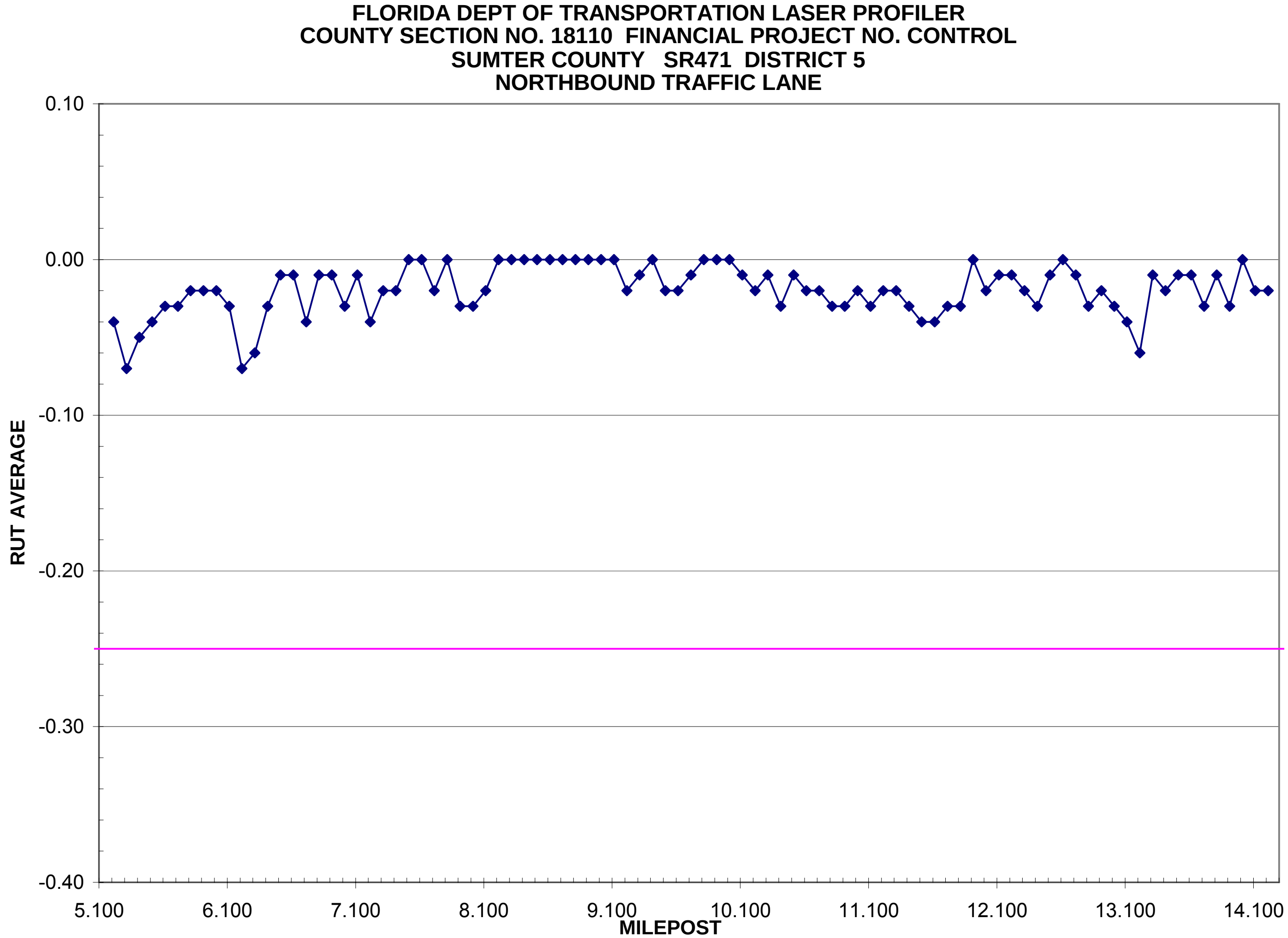

FLORIDA DEPT OF TRANSPORTATION LASER PROFILER
COUNTY SECTION NO. 18110 FINANCIAL PROJECT NO. 41353515201
SUMTER COUNTY SR471 DISTRICT 5
SOUTHBOUND TRAFFIC LANE
RUT AVERAGE
0.00
-0.10
-0.20
-0.30
-0.40
0.000
1.000
2.000
3.000
4.000
5.000
MILEPOST
MILEPOST BMP. 5.115 TO EMP. 14.296
6" SAMPLING INTERVALS
DATE TESTED 10/11/2005 UNIT 3 DOT 28328
FRICTION COURSE DENSE GRADE

Appendix B: October 2005 Pavement Condition Survey on Control Section

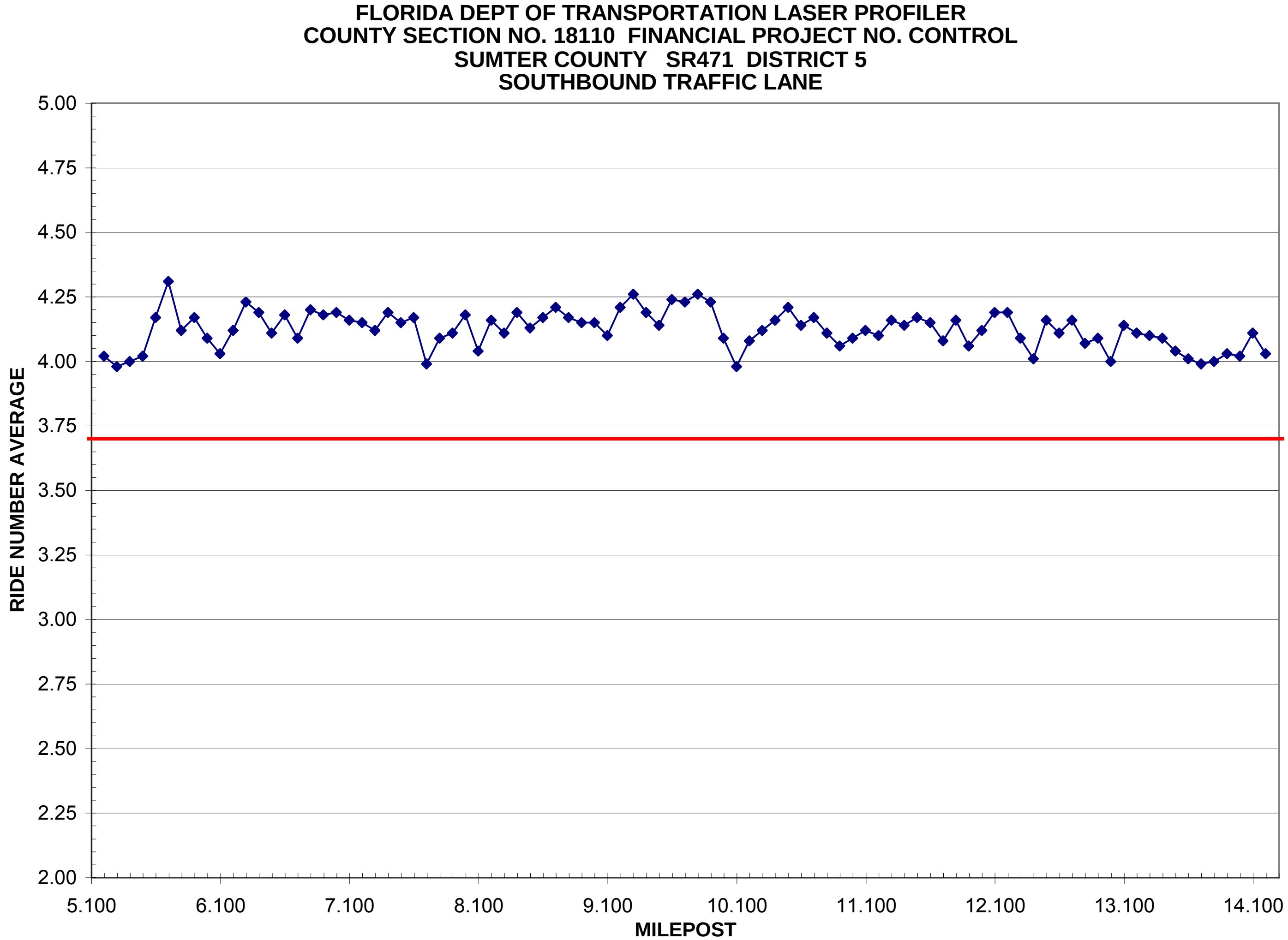
FLORIDA DEPT OF TRANSPORTATION LASER PROFILER
COUNTY SECTION NO. 18110 FINANCIAL PROJECT NO. CONTROL
SUMTER COUNTY SR471 DISTRICT 5
NORTHBOUND TRAFFIC LANE



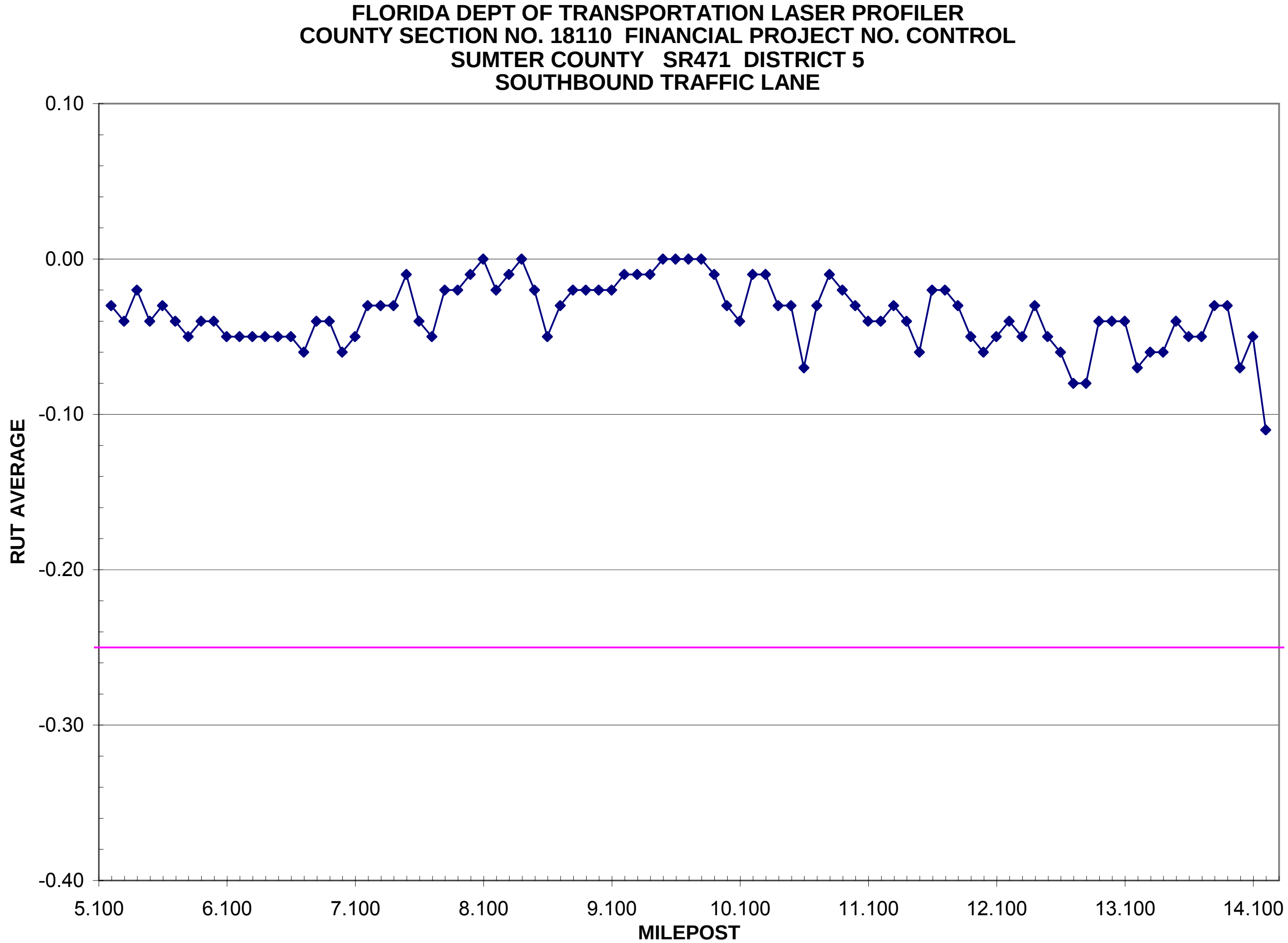
MILEPOST BMP. 5.115 TO EMP. 14.296
6" SAMPLING INTERVALS
DATE TESTED 10/11/2005 UNIT 3 DOT 28328
FRICTION COURSE DENSE GRADE



MILEPOST BMP. 5.115 TO EMP. 14.296
6" SAMPLING INTERVALS
DATE TESTED 10/11/2005 UNIT 3 DOT 28328
FRICTION COURSE DENSE GRADE



MILEPOST BMP. 5.115 TO EMP. 14.296
6" SAMPLING INTERVALS
DATE TESTED 10/11/2005 UNIT 3 DOT 28328
FRICTION COURSE DENSE GRADE



MILEPOST BMP. 5.115 TO EMP. 14.296
6" SAMPLING INTERVALS
DATE TESTED 10/11/2005 UNIT 3 DOT 28328
FRICTION COURSE DENSE GRADE

Appendix C: Northbound FWD Data

MILEPOST	LOAD	D0	D8	D12	D18	D24	D36	D60
0.077	8732	7.69	4.46	2.94	1.95	1.45	1.06	0.69
0.153	8744	11.16	6.38	4.24	2.55	1.76	1.18	0.78
0.256	8859	9.15	5.80	4.01	2.52	1.74	1.19	0.84
0.357	8601	12.56	6.94	4.49	2.63	1.78	1.17	0.79
0.449	8692	11.70	6.40	4.16	2.52	1.77	1.20	0.74
0.545	8712	10.71	6.28	4.13	2.48	1.69	1.10	0.66
0.602	8684	10.64	6.10	4.07	2.40	1.65	1.06	0.67
0.650	8755	9.33	5.20	3.45	2.09	1.41	0.95	0.65
0.751	8644	9.65	5.70	3.93	2.45	1.69	1.06	0.64
0.853	8716	8.49	5.19	3.82	2.50	1.83	1.25	0.86
0.950	8704	9.46	5.28	3.47	2.19	1.62	1.20	0.81
1.054	8728	9.23	5.26	3.46	2.15	1.53	1.05	0.67
1.151	8656	10.89	6.28	4.21	2.72	1.97	1.40	0.91
1.252	8736	9.09	5.27	3.63	2.29	1.66	1.27	0.87
1.356	8608	13.42	7.90	5.22	3.23	2.28	1.63	0.98
1.452	8672	11.79	6.81	4.43	2.63	1.83	1.34	0.99
1.552	8589	12.03	6.59	4.26	2.45	1.66	1.23	0.91
1.651	8668	14.37	8.37	5.05	2.64	1.55	0.84	0.47
1.760	8605	13.48	7.69	4.90	2.71	1.69	1.02	0.57
1.853	8644	12.00	6.94	4.26	2.48	1.81	1.41	0.99
1.952	8644	9.69	5.78	3.85	2.43	1.76	1.24	0.91
2.049	8569	13.43	7.57	4.83	2.88	2.11	1.63	1.24
2.150	8803	12.48	5.83	3.44	2.05	1.61	1.33	0.93
2.247	8680	12.46	6.55	4.11	2.50	1.80	1.31	0.86
2.354	8799	7.76	4.13	2.62	1.64	1.26	1.02	0.74
2.452	8608	14.26	8.03	5.07	2.83	1.84	1.18	0.78
2.548	8509	14.20	8.03	4.97	2.69	1.77	1.24	0.93
2.651	8561	13.58	7.56	4.91	2.85	1.94	1.32	0.80
2.750	8553	14.48	8.52	5.96	4.17	3.31	2.54	1.72
2.848	8676	12.90	8.04	5.59	3.80	2.92	2.17	1.38
2.951	8605	13.30	7.25	4.54	2.62	1.82	1.26	0.83
3.050	8549	15.07	8.98	5.72	3.26	2.00	1.30	0.83
3.149	8616	14.38	9.17	6.29	3.90	2.60	1.58	0.95
3.255	8545	15.97	10.28	7.17	4.33	2.78	1.63	0.91
3.354	8684	14.46	8.51	5.99	4.01	3.04	2.24	1.43
3.447	8513	17.37	9.89	6.53	3.69	2.30	1.43	1.19
3.553	8577	14.70	7.73	4.95	3.12	2.33	1.69	1.07
3.600	8624	13.39	7.30	4.96	3.24	2.33	1.50	0.71
3.647	8589	17.96	10.65	7.24	4.66	3.53	2.51	1.38
3.700	8533	17.72	9.84	6.42	3.96	2.78	1.84	1.05
3.751	8529	16.68	10.18	6.92	4.41	3.14	2.10	1.15
3.850	8585	16.65	10.26	7.23	4.75	3.44	2.28	1.28
3.950	8565	15.29	9.15	6.32	4.03	2.89	1.93	1.19

MILEPOST	LOAD	D0	D8	D12	D18	D24	D36	D60
4.050	8644	13.09	6.82	4.28	2.65	1.93	1.38	0.87
4.152	8664	13.17	7.33	4.88	3.19	2.44	1.78	1.15
4.247	8537	17.50	10.30	6.80	3.98	2.62	1.69	0.92
4.354	8585	15.50	8.31	5.15	2.91	1.92	1.31	0.78
4.455	8783	9.61	6.05	4.27	2.74	2.02	1.46	0.92
4.554	8561	14.63	8.10	5.16	3.02	2.11	1.57	0.98
4.652	8509	14.64	8.09	4.94	2.65	1.73	1.30	0.86
4.751	8660	14.33	8.33	5.36	3.15	2.18	1.47	0.90
4.846	8593	12.86	6.43	3.90	2.31	1.72	1.28	0.85
4.948	8736	9.54	5.89	4.11	2.78	2.15	1.59	1.05
5.048	8557	12.37	8.13	6.07	4.15	2.96	1.83	1.06
5.148	8640	13.78	8.69	5.93	3.80	2.71	1.87	1.23
5.250	8636	15.60	9.17	6.13	3.74	2.60	1.70	1.07
5.355	8680	11.78	7.31	5.22	3.45	2.47	1.67	1.02
5.454	8696	12.65	8.91	6.98	5.31	4.20	2.82	1.44
5.557	8648	10.63	7.74	6.14	4.57	3.46	2.26	1.27
5.655	8744	10.09	6.63	5.28	4.09	3.24	2.26	1.42
5.756	8696	13.42	9.22	7.23	5.45	4.24	2.82	1.37
5.852	8755	12.81	9.05	7.14	5.41	4.19	2.70	1.30
5.951	8736	9.08	6.20	4.94	3.80	3.00	2.02	1.18
6.053	8783	8.62	5.44	4.19	3.02	2.21	1.53	0.86
6.148	8692	13.15	7.30	5.01	3.35	2.41	1.59	0.94
6.250	8668	9.57	5.56	4.19	3.06	2.35	1.61	0.95
6.349	8668	11.52	6.50	4.71	3.36	2.54	1.66	0.90
6.452	8744	9.84	6.60	5.19	3.96	3.09	2.13	1.18
6.551	8823	7.87	4.91	3.66	2.62	1.98	1.30	0.82
6.652	8767	8.19	5.14	3.89	2.90	2.31	1.69	1.15
6.750	8740	12.89	5.88	3.97	2.70	2.08	1.59	1.05
6.852	8799	6.87	4.24	3.16	2.31	1.77	1.30	0.95
6.962	8795	7.25	4.59	3.46	2.46	1.86	1.31	0.89
7.052	8732	7.64	4.94	3.76	2.66	2.01	1.33	0.83
7.154	8708	8.32	5.45	4.22	2.96	2.17	1.41	0.83
7.256	8744	12.17	7.76	5.46	3.75	2.81	1.89	1.04
7.355	8759	10.59	5.74	3.83	2.69	2.07	1.51	1.02
7.449	8736	10.09	5.63	3.81	2.65	1.98	1.40	0.92
7.549	8724	10.26	5.77	3.90	2.55	1.84	1.29	0.90
7.650	8763	10.57	5.75	3.93	2.63	2.01	1.48	0.97
7.756	8763	9.90	5.85	3.94	2.39	1.74	1.20	0.83
7.846	8605	11.22	6.85	4.75	2.97	1.98	1.22	0.81
7.946	8704	9.19	6.46	5.12	3.79	2.82	1.86	1.12
8.052	8652	12.53	7.70	5.43	3.48	2.45	1.59	0.93
8.151	8668	9.24	5.98	4.64	3.39	2.57	1.70	1.09
8.251	8656	9.00	5.48	3.98	2.69	1.91	1.21	0.76
8.351	8660	11.38	6.87	4.70	3.00	2.19	1.54	1.01
8.454	8712	10.83	6.76	4.65	2.97	2.15	1.45	0.89
8.551	8779	10.28	6.18	4.42	2.89	2.06	1.37	0.90

MILEPOST	LOAD	D0	D8	D12	D18	D24	D36	D60
8.648	8684	10.35	5.91	4.20	2.80	2.00	1.33	0.85
8.749	8748	8.73	6.33	4.91	3.52	2.57	1.57	1.05
8.851	8668	10.18	7.05	5.39	3.76	2.74	1.70	1.02
8.948	8771	11.13	7.36	5.08	3.35	2.39	1.61	1.04
9.054	8775	8.39	5.77	4.44	3.16	2.35	1.66	1.17
9.158	8732	8.48	5.30	3.80	2.61	1.85	1.22	0.78
9.258	8732	8.46	5.58	4.22	3.08	2.33	1.69	0.97
9.355	8763	10.31	6.24	4.50	3.03	2.14	1.31	0.78
9.452	8823	8.10	5.17	3.80	2.65	1.94	1.29	0.78
9.551	8835	7.18	4.72	3.51	2.47	1.80	1.22	0.75
9.647	8771	9.44	5.73	4.17	2.82	1.96	1.18	0.72
9.756	8827	6.85	4.59	3.59	2.72	2.10	1.53	1.09
9.852	8767	9.06	5.17	3.64	2.41	1.78	1.28	0.92
9.950	8728	9.05	5.57	3.91	2.61	1.93	1.42	0.94

Appendix D: Southbound FWD Data

MILEPOST	LOAD	D0	D8	D12	D18	D24	D36	D60
0.070	8660	8.52	4.57	2.86	1.78	1.27	0.89	0.57
0.156	8668	10.41	5.76	3.59	2.11	1.43	0.94	0.62
0.255	8652	12.70	7.20	4.46	2.45	1.56	1.09	0.78
0.349	8704	12.80	7.22	4.41	2.40	1.51	1.02	0.66
0.449	8636	12.20	6.66	3.99	1.98	1.18	0.76	0.52
0.551	8605	10.50	6.02	4.06	2.43	1.65	1.09	0.71
0.651	8664	10.69	6.06	3.68	2.03	1.25	0.77	0.53
0.755	8589	12.54	7.24	4.60	2.56	1.57	0.98	0.68
0.850	8744	9.53	5.25	3.36	1.98	1.41	1.09	0.79
0.953	8664	10.32	5.84	3.72	2.22	1.50	0.97	0.58
1.053	8632	10.50	5.70	3.65	2.15	1.46	0.98	0.65
1.154	8664	9.23	5.14	3.43	2.37	1.98	1.61	1.15
1.250	8736	13.06	7.09	4.40	2.48	1.62	1.07	0.67
1.349	8640	13.20	7.75	4.91	2.73	1.67	0.89	0.55
1.452	8537	13.85	7.62	4.76	2.74	1.83	1.35	1.00
1.549	8664	12.15	6.89	4.29	2.42	1.57	1.12	0.91
1.652	8517	14.89	8.39	5.22	2.63	1.33	0.55	0.35
1.750	8593	14.38	8.06	5.03	2.77	1.79	1.18	0.63
1.800	8620	11.84	6.42	3.96	2.36	1.69	1.22	0.87
1.855	8581	12.95	7.61	5.00	3.12	2.26	1.72	1.27
1.900	8708	10.78	6.47	4.26	2.52	1.78	1.30	0.90
1.951	8636	12.49	7.31	5.02	3.33	2.53	1.89	1.32
2.051	8783	11.57	6.46	4.17	2.57	2.00	1.67	1.27
2.151	8740	9.70	5.47	3.53	2.20	1.54	1.12	0.83
2.251	8783	11.28	6.92	4.46	2.65	1.82	1.32	0.83
2.341	8783	8.35	4.80	3.14	2.04	1.49	1.09	0.81
2.451	8553	14.09	7.34	4.26	2.26	1.51	1.08	0.80
2.552	8692	12.54	6.40	3.64	1.92	1.41	1.14	0.86
2.649	8605	16.54	8.94	5.00	2.43	1.57	1.20	0.76
2.748	8581	15.19	8.35	5.40	3.42	2.67	2.15	1.59
2.849	8517	15.38	8.34	5.20	2.98	2.14	1.57	1.04
2.952	8497	17.67	10.17	6.27	3.01	1.58	0.91	0.74
3.051	8668	13.07	7.00	4.10	2.13	1.42	1.05	0.69
3.144	8728	10.88	6.39	4.30	2.69	1.87	1.27	0.78
3.252	8529	17.60	10.56	7.15	4.40	3.11	2.08	1.23
3.348	8537	18.17	10.53	7.22	4.58	3.29	2.31	1.37
3.450	8537	17.54	10.20	6.48	3.75	2.48	1.75	1.43
3.551	8640	12.53	7.29	4.82	2.90	2.07	1.42	0.85
3.649	8533	16.76	10.43	7.26	4.93	3.66	2.48	1.28
3.750	8541	16.60	9.46	6.14	3.72	2.58	1.63	0.81
3.851	8497	14.41	8.61	5.91	3.68	2.59	1.67	0.92
3.948	8700	10.91	5.91	3.58	2.02	1.47	1.12	0.69
4.050	8569	16.11	8.98	5.39	2.85	1.77	1.19	0.81

MILEPOST	LOAD	D0	D8	D12	D18	D24	D36	D60
4.154	8541	16.04	8.94	5.69	3.40	2.36	1.62	0.70
4.200	8608	13.44	7.89	5.40	3.38	2.47	1.73	1.05
4.249	8585	16.50	9.32	5.73	3.17	2.16	1.52	1.00
4.350	8573	16.15	9.20	5.65	3.22	2.21	1.45	0.91
4.449	8597	14.46	8.19	5.24	3.06	2.21	1.68	1.07
4.549	8573	13.34	7.27	4.56	2.51	1.69	1.24	0.89
4.648	8501	17.81	10.07	6.55	3.81	2.57	1.68	1.06
4.749	8628	15.27	8.12	5.07	3.12	2.25	1.65	1.00
4.852	8748	11.78	6.69	4.28	2.65	1.95	1.39	1.01
4.950	8688	8.62	5.13	3.89	2.76	2.09	1.40	0.80
5.050	8636	15.69	10.35	7.70	5.02	3.41	1.96	0.96
5.149	8680	11.21	7.19	5.29	3.56	2.52	1.58	0.89
5.244	8632	11.12	6.76	4.70	3.13	2.24	1.49	0.95
5.347	8652	13.40	7.95	5.10	3.14	2.35	1.55	1.52
5.450	8728	9.27	6.04	4.53	3.25	2.44	1.62	0.97
5.547	8720	9.98	6.83	5.42	4.05	3.15	2.11	1.19
5.650	8728	10.14	6.77	5.31	3.93	3.10	2.07	1.04
5.751	8672	11.43	8.03	6.41	4.99	3.95	2.74	1.52
5.851	8736	9.08	6.30	4.87	3.54	2.76	1.87	1.07
5.951	8847	6.81	4.73	3.90	2.98	2.36	1.65	0.99
6.050	8827	8.20	5.11	4.03	2.95	2.27	1.52	0.93
6.148	8775	9.19	5.24	3.77	2.57	1.92	1.31	1.00
6.250	8839	7.20	4.88	3.97	3.08	2.39	1.60	0.91
6.348	8744	10.23	6.66	5.20	3.77	2.80	1.72	0.75
6.447	8779	8.30	5.56	4.42	3.37	2.66	1.86	1.10
6.550	8763	7.49	4.82	3.63	2.57	1.93	1.28	0.78
6.649	8843	6.55	4.37	3.47	2.63	2.09	1.51	1.00
6.751	8906	5.96	4.05	3.13	2.40	1.94	1.50	0.94
6.849	8831	7.16	4.54	3.40	2.46	1.78	1.28	0.78
6.952	8839	6.28	3.83	2.90	2.01	1.50	1.07	0.69
7.049	8879	5.00	3.33	2.58	1.93	1.52	1.15	0.79
7.152	8875	6.85	4.44	3.43	2.41	1.74	1.13	0.72
7.251	8910	7.43	4.97	3.78	2.67	1.98	1.28	0.70
7.351	8759	8.07	5.67	4.51	3.39	2.59	1.69	0.81
7.447	8755	11.04	7.90	6.27	4.58	3.38	2.08	1.06
7.550	9010	6.95	4.64	3.50	2.44	1.85	1.26	0.70
7.648	8958	6.99	4.53	3.53	2.69	2.07	1.59	1.37
7.747	8883	10.81	6.61	4.62	2.86	1.88	1.06	0.47
7.853	8906	8.83	5.59	4.10	2.78	2.08	1.37	1.00
7.952	8918	8.64	5.91	4.65	3.43	2.65	1.80	1.01
8.049	8906	10.56	6.65	4.89	3.39	2.33	1.48	0.76
8.148	8799	11.36	7.49	5.56	3.80	2.70	1.80	1.05
8.250	8855	9.33	6.01	4.33	2.86	1.91	1.27	1.17
8.353	8863	12.57	7.44	5.16	3.39	2.41	1.50	0.91
8.451	8946	9.66	5.64	3.85	2.40	1.64	1.06	0.71
8.554	8954	9.05	5.35	3.79	2.44	1.74	1.15	0.74

MILEPOST	LOAD	D0	D8	D12	D18	D24	D36	D60
8.754	8910	9.54	6.33	4.57	3.07	2.28	1.39	0.59
8.850	8898	11.84	7.74	5.61	3.73	2.57	1.51	0.64
8.952	9089	8.49	5.84	4.38	2.98	2.08	1.36	0.97
9.048	9022	8.98	6.56	5.24	3.95	3.06	2.04	1.17
9.150	9113	8.79	5.50	4.15	2.89	2.17	1.44	0.93
9.250	8978	10.19	6.59	4.85	3.21	2.29	1.45	1.03
9.352	9045	8.79	5.82	4.29	2.91	1.94	1.17	0.78
9.450	9129	7.54	5.16	3.88	2.65	1.83	1.08	0.76
9.550	9165	7.86	5.31	4.14	2.92	2.18	1.47	0.90
9.650	9133	10.48	6.53	4.65	3.01	2.08	1.31	0.78
9.752	9073	10.56	6.94	5.05	3.29	2.30	1.44	0.98
9.851	9181	8.61	5.44	4.00	2.82	2.10	1.45	0.91
9.950	9212	8.88	5.80	4.43	3.08	2.23	1.47	1.09

Appendix E: SPT Logs

CENTRAL TESTING LABORATORY
ENGINEERING AND MATERIALS TESTING

STANDARD PENETRATION TEST BORING LOG

[illegible] (352) 622-1186

PROJECT NO.:	CLIENT: F-DOT
PROJECT IDENTIFICATION:	
PROJECT LOCATION: SR 471 MP 9.55	
DRILLED BY: Surves / Tim	BORING STARTED ON: 11-18-05
	COMPLETED ON: 11-18-05
BORING NO.: SB-1	SHEET NO.: 1 OF 1
LOCATION OF BORING:	
SPOON DATA: INSIDE DIA.: 1.5	OUTSIDE DIA.: 2.0
HAMMER DATA: DROP: 30"	WEIGHT: 140 CATHEAD
CASING DATA: SIZE:	LENGTH:
ENGINEER: INST. BY:	REV. BY:

DEPTH	N PER 6"	N APRX.	N CONT'S	SAMPLE NO.	% REC.	SOIL TESTS	DESCRIPTION OF SOIL	REMARKS, OBSERVATIONS, SYNOPSIS OF THE TEST
	[illegible]		44	1			0'-2': SAND	
	[illegible]		67					
	[illegible]		53	2			2'-4': SAND	
	[illegible]		94	3			4'-6': SAND	
5	[illegible]		53					
	[illegible]		63	4			6'-8': SAND-clay	
	8 6		14					
	7 6		13	5			8'-10': UR	
	50		50					50 blows-1"
			—					
10	6 5		11	6			10'-12': clay-Rock	
	6 6		12					
	7 8		15	7			12'-14': clay-SAND	
	12 13		25					
15	6 10		16	8			14'-15': clay-SAND	
							Term-15'	

GROUNDWATER TABLE LEVEL: 3' GROUND ELEVATION:

11/17/05
BW

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION
FIELD BORING LOG

FORM 675-030-13
MATERIALS - 10/98

Page 1 of Page 1

Project #: FP #: Boring #: Elevation: Type Equipment: D-50
Bridge #: Station #: Offset: County: Sumter D.O.T.#: 10926
ELEVATION BASED ON BENCH MARK Township South Range East Section
Description: Cont. SPT for pavement evaluation SR 471
Drilled By: Kirkland Logged By: Sturgill Water Table Elevation: Type Hammer: Auto
Date Started: 11/16/05 Date Completed: Boring
Water Table Monitors: Station: Offset: Monitor GSE: Water Table Depth:

(Metric)/(English) SAMPLE FROM	TO	SPT BLOWS			MATERIAL DESCRIPTION	SAMPLES NO.	REC. in.	REC. %	REMARKS
									MilE Post # 1.85
0.0		27			light brown tan Lime				
			25		Rock w/trace sand				
	1.5'			19	moist, V.Dense	1	18	100	
1.5'		17			light gray brown fine				
			22		Sand				
	3.0'			24	moist, Dense	2	15	83	
3.0'		11			light gray fine sand				
			18						
	4.5'			18	moist, Dense	3	14	78	
4.5'		9			light gray fine sand				
			10		w/T silt				
	6.0'			11	moist, Dense	4	16	89	
6.0'		4			light gray fine sand				
			6						water table @ 6.5'
	7.5'			7	wet, Dense	5	14	78	
7.5'		9			light gray brown sand				
			50/3		w/ rock & trace of organics				
	9.0'				wet, Hard	6	10	56	
9.0'									
	10.5'					7			
10.5'									
	12.0'					8			
12.0'									
	13.5'					9			
13.5'									
	15.0'					10			

SHEET ____ OF ____

FORM 697-12
7-72

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

PROJECT NO. ____ NAME SR 471 COUNTY SUMTER DISTRICT 5

LOCATION MP 3.65 TOWNSHIP ____ RANGE ____ SECTION ____

ROAD NUMBER SR 471 SURFACE ELEVATION ____

EQUIPMENT TYPE CENTRAL TESTING RIG NO. ____ BORING NO. ____

DATE STARTED 11/15/05 COMPLETED 11/15/05 DRILLED BY CTL

LOGGED BY CTL BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, CATHEAD

WATER TABLE: 0 HR. 6.0 24 HRS. ____ HRS. ____ CASED, UNCASED, DRILLING MUD, ____

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE

SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ____ SIZE

TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	0	25, 20, 18, 22		*	1			NO BORING LOG GIVEN. SAMPLE INFO TO FOLLOW.
		25, 30, 32, 31			2			
	5	20, 20, 19, 15			3			
		6, 6, 8, 9			4			
		4, 4, 6, 10			5			
	10	4, 5, 6, 6			6			
		2, 2, 2, 3			7			
		2, 3			8			
	15		BT @ 15.0'					
	20							

SR471

STATE OF FLORIDA DEPARTMENT OF TRANSPORTATION

FIELD BORING LOG

FORM 675-030-13 MATERIALS

Page__ of Pages__

Project #: FP #: Boring #: 2 Elevation: Type Equipment:

Bridge #: Station #: MP 4.15 Offset: County: SUMTER D.O.T.#:

ELEVATION BASED ON BENCHMARK Township South Range East Section

Description:

Drilled By: Logged By: Water Table Elevation: Type Hammer:

Date/Time Started: 11/15/05 Date/Time Completed: 11/16/05 Boring

Water Table Monitors: Station: Offset: Monitor GSE: Water Table Depth:

(Metric)(English) SAMPLE FROM	TO	SPT BLOWS			MATERIAL DESCRIPTION	SAMPLES NO.	REC. in.	%	REMARKS
0.0		22			Dark tan brown Lime Rock				Site 2 Mile post 4.15
			25		w/ Some sand.				
	1.5			21	moist, Dense	1	18	100%	
1.5		17			Dark brown fine				
			22		Sand.				
	3.0			24	moist v. Dense	2	15	83	
3.0		10			Dark gray brown fine				
			18		Sand w/ T Silt.				
	4.5			18	moist, Dense	3	15	83	
4.5		5			Dark brown sand				
			4		w/ S. organics				
	6.0			5	wet Loose	4	15	83	
6.0		4			Dark brown sand				
			8		w/ Some silt & organics				
	7.5			12	wet, m.dense	5	12	67	
7.5		3			Dark brown sand w/				
			2		Some silt & organics				
	9.0			10	wet, m.dense	6	6	33	
9.0		2			Dark gray clayey				
			4		Sand to sandy clay				
	10.6			7	wet, stiff	7	18	100	
10.6		4			light gray clay				
			6						
	12.0			8	stiff	8	18	100	
12.0		5			light gray clay				
			8		Trace of sand.				
	13.6			10	v. Stiff	9	18	100	
13.6		2			light gray clay w/				
			4		trace sand				
					stiff	10	12	67	

Appendix F: In-Place Moisture and Density Data

11/15/2005 SR 471 Mile Post 3.65 Northbound Roadway

	GWD	GDD	GM	Can #	Oven Moisture	Oven DD
Base material OWP						
4" Test	133.7	121.4	10.1	121	9.70%	121.9
8" Test	138	125.9	9.6	122	9.20%	126.4
Base Material C/L Lane						
4" Test	127.4	115.5	10.3	11	9.30%	116.6
8" Test	136.8	124.6	9.8	18	10.60%	123.7
Subgrade OWP						
6" Test	123.5	110.5	11.7	31	8.50%	113.8
12" Test	126.7	114	11.1	36	7.70%	117.6
Subgrade IWP						
6" Test	124.2	113.9	9.1	19	7.50%	115.5
12" Test	126.9	116.5	8.9	123	7.50%	118.0
Embankment OWP						
6" Test	120.3	103.9	15.8	34	8.60%	110.8
12" Test	125.8	109.4	14.9	27	7.60%	116.9
Embankment IWP						
6" Test	116	103.7	11.9	133	7.40%	108.0
12" Test	123.5	110.7	11.5	124	6.60%	115.9

11/16/2005 SR 471 Mile Post 4.15 South Bound Roadway

Base material OWP	GWD	GDD	GM	Can #	Oven Moisture	Oven DD
4" Test	123.5	111.5	10.8	143	11.30%	111.0
8" Test	127.8	116.1	10	144	11.90%	114.2
Base Material C/L Lane						
4" Test	132.1	121.1	9.1	134	9.80%	120.3
8" Test	128.8	117.3	9.8	141	11.90%	115.1
Subgrade C/L Lane						
6" Test	129.5	120.2	7.7	138	7.90%	120.0
12" Test	132.8	123.7	7.3	140	8.70%	122.2
Subgrade IWP						
6" Test	127.2	118.5	7.3	135	7.80%	118.0
12" Test	128.7	120	7.2	137	8.90%	118.2
Embankment OWP						
6" Test	129.7	118.9	9.1	146	9.10%	118.9
12" Test	132.4	122	8.5	151	11.00%	119.3
Embankment C/L Lane						
6" Test	127.6	116.9	9.1	128	9.40%	116.6
12" Test	132	121.3	8.8	130	10.80%	119.1

11/17/2005 SR 471 Mile Post 1.85 South Bound Roadway

	GWD	GDD	GM	Can #	Oven Moisture	Oven DD
Base material IWP						
4" Test	129	118	9.3	14	11.10%	116.1
8" Test	131.8	121.1	8.8	22	12.00%	117.7
Base Material OWP						
4" Test	125.9	115.3	9.2	52	10.90%	113.5
8" Test	130.6	120	8.8	127	11.50%	117.1
Subgrade C/L Lane						
6" Test	120.6	115.1	4.8	41	5.60%	114.2
12" Test	121.9	116.4	4.7	124	6.50%	114.5
Subgrade OWP						
6" Test	120.3	114.3	5.2	11	5.80%	113.7
12" Test	123.6	118	4.7	36	6.40%	116.2
Embankment OWP						
6" Test	123.1	114	7.9	12	8.30%	113.7
12" Test	125	116.4	7.4	27	10.00%	113.6
Embankment C/L Lane						
6" Test	119.4	111.7	6.9	18	7.40%	111.2
12" Test	125.4	117.6	6.7	49	10.00%	114.0

11/18/2005 SR 471 Mile Post 0.55 North Bound Roadway

	GWD	GDD	GM	Can #	Oven Moisture	Oven DD
Base material C/L Lane						
4" Test	126.6	115.4	9.7	10	11.10%	114.0
8" Test	129.4	117.6	10	17	11.00%	116.6
Base Material OWP						
4" Test	129	118.4	8.9	121	9.80%	117.5
8" Test	131.5	120.8	8.9	122	10.00%	119.5
Subgrade C/L Lane						
6" Test	114.7	109.1	5.1	164	6.80%	107.4
12" Test	117.4	111.4	5.3	162	5.90%	110.9
Subgrade IWP						
6" Test	119.7	114	5	142	6.20%	112.7
12" Test	120.9	114.7	5.5	161	6.70%	113.3
Embankment OWP						
6" Test	119.2	110.8	7.5	38	7.30%	111.1
12" Test	123.9	116.1	6.8	160	10.10%	112.5
Embankment C/L Lane						
6" Test	120.9	112.7	7.3	148	7.30%	112.7
12" Test	125.1	116.4	7.5	155	9.90%	113.8

Appendix G: DCP Results

MP 0.55 NB - Trench OWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** **(292/DCPI$^{1.12}$)**	**LBR** **(365/DCPI$^{1.12}$)**	**Mr, psi** **(1500CBR)**
0.6	2.0	7	0.205	46	58	69,188
2.0	5.0	26	0.115	88	110	131,922
5.0	8.0	28	0.107	96	119	143,338
0.6	8.0	59	0.126	80	100	119,482
8.0	22.0	86	0.163	59	74	88,996
22.0	30.0	73	0.110	93	116	139,176

MP 0.55 NB - Trench MWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** **(292/DCPI$^{1.12}$)**	**LBR** **(365/DCPI$^{1.12}$)**	**Mr, psi** **(1500CBR)**
0.7	1.9	5	0.240	39	48	57,893
1.9	5.0	25	0.122	83	103	123,759
5.0	7.9	27	0.110	92	115	138,547
0.7	7.9	55	0.131	76	95	113,829
7.9	22.0	68	0.207	45	57	68,219
22.0	22.2	2	0.063	174	217	260,378

MP 0.55 NB - Core IWP-1						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** **(292/DCPI$^{1.12}$)**	**LBR** **(365/DCPI$^{1.12}$)**	**Mr, psi** **(1500CBR)**
0.4	2.0	18	0.087	119	149	179,090
2.0	5.0	35	0.087	120	150	180,404
5.0	8.0	32	0.092	112	141	168,723
0.4	8.0	83	0.091	114	142	170,945
8.0	21.9	99	0.141	70	88	105,094
21.9	30.0	73	0.110	92	115	138,137

MP 0.55 NB - Core IWP-2						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** ($292/DCPI^{1.12}$)	**LBR** ($365/DCPI^{1.12}$)	**Mr, psi** (1500CBR)
0.4	2.0	16	0.098	105	131	156,957
2.0	5.0	44	0.068	160	200	239,407
5.0	8.1	39	0.080	132	165	198,410
0.4	8.1	97	0.079	134	167	200,889
8.1	22.0	118	0.118	85	107	128,115
22.0	28.3	52	0.121	83	104	124,786

MP 0.55 NB - Core MWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** ($292/DCPI^{1.12}$)	**LBR** ($365/DCPI^{1.12}$)	**Mr, psi** (1500CBR)
0.3	2.0	15	0.115	88	110	132,452
2.0	5.0	33	0.093	112	140	167,791
5.0	8.0	31	0.094	110	138	165,068
0.3	8.0	77	0.100	103	129	154,302
8.0	22.1	95	0.148	66	83	99,067
22.1	30.0	68	0.116	87	108	130,174

MP 0.55 NB - Core OWP-1						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** ($292/DCPI^{1.12}$)	**LBR** ($365/DCPI^{1.12}$)	**Mr, psi** (1500CBR)
0.5	2.0	19	0.080	132	165	197,804
2.0	5.0	37	0.080	132	165	198,514
5.0	8.0	42	0.072	148	186	222,738
0.5	8.0	96	0.078	136	169	203,353
8.0	21.9	122	0.114	89	111	132,797
21.9	23.8	14	0.134	74	92	110,897

MP 0.55 NB - Core OWP-2						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** (292/DCPI$^{1.12}$)	**LBR** (365/DCPI$^{1.12}$)	**Mr, psi** (1500CBR)
0.4	2.0	19	0.089	118	147	176,722
2.0	5.0	38	0.079	134	167	200,446
5.0	7.9	32	0.091	115	144	172,227
0.4	7.9	87	0.087	120	150	179,721
7.9	22.0	115	0.122	82	103	123,230
22.0	28.1	61	0.100	103	129	154,632

MP 1.85 SB - Trench OWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.9	2.0	10	0.102	101	126	150,803
2.0	5.0	33	0.094	110	138	165,618
5.0	7.9	21	0.138	72	90	107,453
0.9	7.9	62	0.113	90	112	134,272
7.9	22.0	76	0.184	52	65	77,712
22.0	29.1	84	0.085	123	154	184,447

MP 1.85 SB - Core IWP-1						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.6	2.0	7	0.199	47	59	71,180
2.0	5.0	30	0.098	105	131	156,957
5.0	8.1	29	0.107	96	119	143,306
0.6	8.1	64	0.116	87	108	130,175
8.1	21.9	136	0.102	100	126	150,628
21.9	30.0	95	0.085	124	155	185,541

MP 1.85 SB - Core IWP-2						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.6	2.0	8	0.172	56	70	83,865
2.0	5.0	41	0.074	144	179	215,378
5.0	8.1	27	0.113	89	112	134,017
0.6	8.1	74	0.101	102	127	152,338
8.1	21.9	99	0.140	70	88	105,701
21.9	30.0	89	0.091	114	143	171,612

MP 1.85 SB - Core MWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.5	2.0	12	0.128	78	97	116,689
2.0	5.0	35	0.086	121	151	181,598
5.0	8.0	37	0.080	132	165	198,514
0.5	8.0	82	0.092	113	142	169,989
8.0	22.0	113	0.124	81	101	121,004
22.0	30.0	75	0.107	95	119	143,095

MP 1.85 SB - Core OWP-1						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.5	2.0	10	0.147	67	84	100,352
2.0	5.0	33	0.091	114	143	171,149
5.0	8.0	38	0.081	130	163	195,233
0.5	8.0	79	0.096	108	135	162,174
8.0	22.1	98	0.143	69	86	103,164
22.1	29.9	51	0.154	63	79	95,040

MP 1.85 SB - Core OWP-2						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.5	1.9	10	0.138	72	90	107,676
1.9	5.0	34	0.090	116	145	173,494
5.0	8.0	34	0.088	118	147	176,971
0.5	8.0	76	0.098	105	132	157,803
8.0	22.0	131	0.107	95	119	142,586
22.0	30.1	52	0.155	63	79	94,710

MP 3.65 NB - Trench OWP						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR ($292/DCPI^{1.12}$)	LBR ($365/DCPI^{1.12}$)	Mr, psi (1500CBR)
0.7	2.1	8	0.176	54	68	81,742
2.1	5.0	24	0.122	82	103	123,263
5.0	8.0	31	0.096	108	135	161,885
0.7	8.0	61	0.120	84	105	125,924
8.0	15.0	56	0.126	79	99	118,803
15.0	29.9	159	0.093	111	139	166,338

MP 3.65 NB - Trench IWP						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR ($292/DCPI^{1.12}$)	LBR ($365/DCPI^{1.12}$)	Mr, psi (1500CBR)
0.6	2.1	6	0.240	39	48	57,844
2.1	5.0	23	0.128	78	97	116,557
5.0	8.1	44	0.069	156	195	234,537
0.6	8.1	71	0.104	98	122	146,801
8.1	22.0	111	0.125	80	100	119,608
22.0	29.9	90	0.089	118	147	176,797

MP 3.65 NB - Core IWP-1						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR ($292/DCPI^{1.12}$)	LBR ($365/DCPI^{1.12}$)	Mr, psi (1500CBR)
0.1	2.0	15	0.128	78	98	117,368
2.0	5.0	37	0.081	130	162	194,478
5.0	8.0	40	0.076	140	174	209,376
0.1	8.0	90	0.089	118	147	176,797
8.0	15.1	60	0.118	86	107	128,263
15.1	29.1	131	0.107	95	119	143,153

MP 3.65 NB - Core IWP-2						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR ($292/DCPI^{1.12}$)	LBR ($365/DCPI^{1.12}$)	Mr, psi (1500CBR)
0.5	2.1	8	0.194	49	61	73,550
2.1	5.0	38	0.076	139	174	208,860
5.0	8.0	34	0.088	118	147	176,903
0.5	8.0	78	0.096	108	135	162,210
8.0	15.0	78	0.090	116	145	174,083
15.0	19.5	47	0.096	107	134	161,074

MP 3.65 NB - Core MWP						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR ($292/DCPI^{1.12}$)	LBR ($365/DCPI^{1.12}$)	Mr, psi (1500CBR)
0.6	2.0	7	0.198	48	60	71,789
2.0	5.0	30	0.102	100	126	150,692
5.0	8.1	32	0.095	109	136	163,077
0.6	8.1	67	0.112	91	113	136,070
8.1	15.0	57	0.122	82	103	123,596
15.0	30.0	142	0.106	97	121	145,003

MP 3.65 NB - Core OWP-1						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR ($292/DCPI^{1.12}$)	LBR ($365/DCPI^{1.12}$)	Mr, psi (1500CBR)
0.0	2.0	21	0.094	111	138	165,772
2.0	5.0	41	0.073	145	182	218,170
5.0	8.0	38	0.078	135	169	203,129
0.0	8.0	98	0.081	130	162	194,989
8.0	15.0	59	0.119	84	106	126,601
15.0	30.0	150	0.100	103	129	154,604

MP 3.65 NB - Core OWP-2						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR** (292/DCPI$^{1.12}$)	**LBR** (365/DCPI$^{1.12}$)	**Mr, psi** (1500CBR)
0.5	2.0	14	0.109	93	116	139,488
2.0	5.0	48	0.062	177	221	265,700
5.0	8.0	51	0.059	186	232	278,588
0.5	8.0	111	0.067	160	200	239,509
8.0	15.0	67	0.105	97	122	145,978
15.0	30.0	152	0.098	105	131	157,129

MP 4.15 SB - Trench OWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.8	1.9	5	0.224	42	52	62,585
1.9	5.1	14	0.228	41	51	61,357
5.1	8.0	19	0.153	64	80	95,734
0.8	8.0	36	0.200	47	59	70,792
8.0	22.1	94	0.150	65	81	97,687
22.1	30.0	62	0.127	79	99	118,425

MP 4.15 SB - Trench IWP						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.0	1.9	6	0.306	29	37	44,019
1.9	5.0	18	0.174	55	69	82,837
5.0	8.0	27	0.110	92	115	138,448
0.0	8.0	49	0.162	60	75	89,740
8.0	20.0	86	0.140	71	88	106,191
20.0	28.8	79	0.111	91	114	136,789

MP 4.15 SB - Core IWP-1						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.7	2.0	5	0.246	38	47	56,285
2.0	5.0	25	0.120	84	105	126,009
5.0	7.9	39	0.076	139	174	208,743
0.7	7.9	67	0.107	95	119	142,270
7.9	20.0	110	0.109	93	116	139,739
20.0	29.9	103	0.097	107	133	159,758

MP 4.15 SB - Core IWP-2						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI1.12)	LBR (365/DCPI1.12)	Mr, psi (1500CBR)
0.6	2.0	6	0.235	39	49	59,180
2.0	5.0	26	0.115	88	110	132,225
5.0	8.0	41	0.074	144	180	215,874
0.6	8.0	71	0.105	98	122	146,558
8.0	20.0	108	0.111	91	114	137,014
20.0	30.0	135	0.074	144	181	216,635

MP 4.15 SB - Core MWP						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI1.12)	LBR (365/DCPI1.12)	Mr, psi (1500CBR)
0.5	2.1	13	0.122	82	103	123,641
2.1	5.0	32	0.093	111	139	166,577
5.0	8.0	35	0.085	124	155	185,414
0.5	8.0	78	0.097	107	133	160,190
8.0	20.0	81	0.148	66	83	99,111
20.0	30.0	118	0.084	124	155	186,271

MP 4.15 SB - Core OWP-1						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI1.12)	LBR (365/DCPI1.12)	Mr, psi (1500CBR)
0.5	2.0	10	0.146	67	84	101,083
2.0	5.0	23	0.133	75	93	112,071
5.0	8.0	33	0.092	113	142	170,131
0.5	8.0	64	0.118	86	107	128,358
8.0	20.0	86	0.140	71	88	106,162
20.0	30.0	77	0.129	77	96	115,624

MP 4.15 SB - Core OWP-2						
Actual Initial Depth, in	**Actual Ending Depth, in**	**No. of Blows**	**DCPI, in/blow**	**CBR (292/DCPI1.12)**	**LBR (365/DCPI1.12)**	**Mr, psi (1500CBR)**
0.4	2.1	10	0.170	57	71	85,101
2.1	4.9	20	0.142	69	87	103,890
4.9	8.1	23	0.135	73	92	109,828
0.4	8.1	51	0.150	65	81	97,780
8.1	20.0	78	0.153	64	80	95,583
20.0	28.6	74	0.116	87	109	130,783

MP 6.50 SB - IWP-1						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI$^{1.12}$)	LBR (365/DCPI$^{1.12}$)	Mr, psi (1500CBR)
0.6	3.0	24	0.100	102	128	153,553
3.0	6.0	40	0.074	143	179	215,190
6.0	9.0	35	0.087	120	150	180,365
0.6	9.0	97	0.087	120	151	180,625
9.0	21.0	98	0.122	82	103	123,431
21.0	28.7	105	0.074	144	180	216,033

MP 6.50 SB - IWP-2						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI$^{1.12}$)	LBR (365/DCPI$^{1.12}$)	Mr, psi (1500CBR)
0.5	3.0	13	0.189	50	63	75,369
3.0	6.0	42	0.071	150	188	225,734
6.0	9.0	39	0.078	136	170	203,604
0.5	9.0	92	0.092	112	141	168,604
9.0	21.0	99	0.121	83	104	124,631
21.0	29.5	113	0.075	142	177	212,264

MP 6.50 SB - MWP						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI$^{1.12}$)	LBR (365/DCPI$^{1.12}$)	Mr, psi (1500CBR)
0.5	3.0	26	0.095	108	135	162,475
3.0	6.2	25	0.130	77	96	115,250
6.2	9.0	19	0.148	66	83	99,579
0.5	9.0	68	0.125	80	100	119,610
9.0	21.0	89	0.134	74	92	110,807
21.0	29.7	112	0.078	136	170	203,823

MP 6.50 SB - OWP-1						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI$^{1.12}$)	LBR (365/DCPI$^{1.12}$)	Mr, psi (1500CBR)
0.0	3.1	17	0.178	54	67	80,873
3.1	6.0	37	0.080	132	165	198,554
6.0	9.0	28	0.107	95	119	142,375
0.0	9.0	80	0.112	90	113	135,414
9.0	20.9	78	0.153	64	80	95,912
20.9	30.0	89	0.102	101	126	151,560

MP 6.50 SB - OWP-2						
Actual Initial Depth, in	Actual Ending Depth, in	No. of Blows	DCPI, in/blow	CBR (292/DCPI$^{1.12}$)	LBR (365/DCPI$^{1.12}$)	Mr, psi (1500CBR)
0.1	3.0	29	0.101	102	128	153,243
3.0	6.0	39	0.078	136	170	203,604
6.0	9.1	28	0.109	94	117	140,479
0.1	9.1	94	0.096	108	135	161,854
9.1	21.0	90	0.133	75	93	111,823
21.0	29.0	90	0.089	117	147	176,247