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Effects of Subsurface Drainage on Pavement Performance

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REPORT 583

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Effects of Subsurface Drainage on Pavement Performance

Analysis of the SPS-1 and SPS-2 Field Sections

TRANSPORTATION RESEARCH BOARD
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 583

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Pavement Design, Management, and Performance

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TRANSPORTATION RESEARCH BOARD

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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

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FOREWORD

By Edward T. Harrigan
Staff Officer
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This report evaluates the effects of subsurface drainage features on pavement performance through a program of inspection and testing of the subsurface drainage features present in the Long-Term Pavement Performance (LTPP) SPS-1 and SPS-2 field sections. The report will be of particular interest to engineers in the public and private sectors with responsibility for the design, construction, and rehabilitation of highway pavements.

NCHRP Project 1-34, "Performance of Subsurface Pavement Drainage," was completed in 1998. Its objective was to evaluate the effectiveness of new and retrofitted subsurface pavement drainage systems—including permeable base and associated edge drains and traditional dense-graded bases with and without edge drains—for hot-mix asphalt (HMA) and portland cement concrete (PCC) pavements. Pavement sections from the LTPP SPS-1 (flexible HMA pavement) and SPS-2 (rigid PCC pavement) experiments were not included because they were not of sufficient age at the time the project was underway.

Under NCHRP Project 1-34C, "Effects of Subsurface Drainage on Performance of Asphalt and Concrete Pavements," which was completed in 2003, data from the LTPP SPS-1 and SPS-2 experiments were analyzed to evaluate how the presence of subsurface drainage affected long-term pavement performance. For HMA pavements, measures of cracking and International Roughness Index (IRI) were best when undrained dense-graded asphalt-treated bases were present compared to either undrained dense-graded aggregate bases or drained permeable asphalt-treated bases. For PCC pavements, measures of cracking and IRI were best when drained permeable asphalt-treated bases were present compared to either undrained dense-graded aggregate bases or undrained lean concrete bases.

In the project reported here, evaluation of the LTPP SPS-1 and SPS-2 pavement sections was extended to include comprehensive field inspection and flow testing of the pavement drainage systems as well as a detailed deflection analysis based on data available from Release 19 (January 2005) of the LTPP database.

These tests and analyses did not identify any aspect of the behavior or performance of the HMA and PCC pavement structures in the SPS-1 and SPS-2 experiments that could be shown to have been improved by the presence of subsurface pavement drainage. Instead, the measures of pavement behavior and performance analyzed for these pavements—namely, deflection response, roughness, rutting, faulting, and cracking—were found to be influenced by the stiffness, rather than the drainability, of the base layers. Overall, the best-performing HMA pavements in the SPS-1 experiment were those with the stiffest bases (incorporating a dense-graded asphalt-treated base layer), whether drained or undrained. The best-performing PCC pavements in the SPS-2 experiments were those with bases that were neither too weak (untreated aggregate) nor too stiff (lean concrete). These include the sections with drained permeable asphalt-treated base, but also the sections with undrained HMA base and cement-aggregate-mixture base.

This final report includes a detailed description of the field inspections, available data, and analysis procedures; a discussion of the research results and their limitations; a summary of the key findings; and three supporting appendixes:

- Appendix A: Test Section Layout Diagrams,
- Appendix B: Permeability Calculations from Field Measurements, and
- Appendix C: Data Used in Regression Analyses.

CONTENTS

CHAPTER 1

Introduction

Background

Subsurface drainage systems are commonly believed to be beneficial to the performance of both asphalt concrete (AC) and portland cement concrete (PCC) pavements. Over at least the past 80 years, pavement engineers have observed that excessive water in pavement structures can accelerate rutting, fatigue cracking, and roughness in AC pavements and faulting, fatigue cracking, D-cracking, reactive aggregate distress, and roughness in PCC pavements. The use of subsurface drainage systems has been widely advocated as a way to combat the detrimental effects of water in pavement structures. Such drainage systems include not just granular bases, but also open-graded granular or treated layers and longitudinal edgedrains and outlets. Guidance on the design and construction of subsurface drainage systems is readily available (*1–10*).

Information that convincingly demonstrates the benefits of subsurface drainage systems on pavement performance and pavement life is, however, less readily available. Elfino et al. point out that some studies have shown better performance in drained pavements than in undrained pavements, while other studies have found no difference in performance (*9*). The *Guide for Mechanistic-Empirical Design of New and Rehabilitated Pavement Structures* sums up the situation in this way:

> The current state of the art is such that conclusive remarks regarding the effectiveness of pavement subsurface drainage or the need for subsurface drainage are not possible. (*10*)

The reasons often mentioned for why subsurface pavement drainage systems do not always yield improvements in performance include inadequate design, improper construction, and inadequate maintenance. If, however, these were the only reasons, then they could be countered by—and improvements in pavement performance and pavement life could be consistently achieved by—adequate design, proper construction, and adequate maintenance.

Yet there are at least two other reasons why drained pavements do not consistently perform better than undrained pavements. First, subsurface drainage systems are sometimes used in *locations* where they are not needed (e.g., places with low amounts of rainfall or with subgrade soils that have sufficient natural drainage characteristics so that water rarely, if ever, collects in the constructed pavement layers long enough to contribute to any damage).

Second, subsurface drainage systems are sometimes used in *pavements* where they are not needed, such as pavements with other design features (such as thickness or dowels) that make them unlikely to develop the types of damage that would be exacerbated by excess water.

In recent years, many state highway agencies have become less enthused about subsurface pavement drainage because of concerns about construction difficulties, the need to conduct frequent maintenance of edgedrains and their outlets, and scant evidence of performance benefits that justify the costs of drainage system installation and maintenance.

NCHRP 1-34 Drainage Studies

Between 1995 and 1998, researchers involved in NCHRP Project 1-34, Performance of Subsurface Pavement Drainage, evaluated the effectiveness of subsurface drainage systems in AC and PCC pavements (*11*). The findings from that study were based on relatively small sets of paired pavement sections with and without subsurface drainage. Pavement sections from the Long-Term Pavement Performance (LTPP) Studies' SPS-1 (Strategic Study of Structural Factors for Flexible Pavements) and SPS-2 (Strategic Study of Structural Factors for Rigid Pavements) experiments were not included in the NCHRP study because they were not of sufficient age at the time. In addition, the field data collection effort for Project 1-34 did not include an assessment of which subdrainage systems were functioning and which were not.

Under NCHRP Project 1-34B, completed in 1999, the Project 1-34 findings were reviewed, and a research plan was developed for further evaluating the effects of subsurface drainage on AC and PCC pavement performance, using data from the SPS-1 and SPS-2 experiments (*12*). A preliminary analysis of the data from the SPS-1 and SPS-2 experiments was conducted according to that research plan under NCHRP Project 1-34C, completed in 2003 (*13*).

The SPS-1 experiment consists of AC pavement test sections with three undrained base types (dense-graded aggregate, asphalt-treated base, and asphalt-treated base over dense-graded aggregate) and two drained base types (permeable asphalt-treated base over aggregate and asphalt-treated base over permeable asphalt-treated base). The SPS-2 experiment consists of PCC pavement test sections with two undrained base types (dense-graded aggregate and lean concrete base) and one drained base type (permeable asphalt-treated base). In the SPS-1 and the SPS-2 experiments, the sections with a permeable asphalt-treated base layer have longitudinal edgedrains and outlets. The main SPS-1 and SPS-2 experiments include no pavement sections with open-graded base layers that are "daylighted"—that is, that drain directly out to the fore slope.

During the course of Project 1-34C, FHWA, with NCHRP support, contracted for the video inspection of edgedrains at the SPS-1 and SPS-2 sites, and the results of those inspections were used in Project 1-34C. Project 1-34C demonstrated the feasibility of applying appropriate statistical tests to the SPS-1 and SPS-2 performance data to assess the influence of such factors as the presence of subsurface drainage, despite some limitations in the SPS-1 and SPS-2 experiments that pose obstacles to their analysis. The findings from Project 1-34C were, however, considered preliminary because they were based on data collected only through mid-2001 and because the effects of truck traffic, climate, structural capacity, and subdrainage system functioning were not examined in depth.

This project (1-34D) was conducted as a follow-up to Project 1-34C and makes use of

- More recent performance data (LTPP data Release 19.0, January 2005),
- Analysis of deflection data (to assess the relative structural contributions of different base types), and
- Subdrainage system flow time measurements (to assess the functioning of the subsurface drainage systems).

Research Objectives

The objectives of this project were as follows:

1. Resolve the discrepancies between the as-designed and as-constructed drainage designs of the SPS-1 and SPS-2 test sections.
2. Resolve other discrepancies in the as-designed versus as-constructed conditions, such as whether or not fabric filters were used to separate permeable asphalt-treated base layers from subgrade materials.
3. Develop a method for quantitative testing of the functioning of subdrains in SPS-1 and SPS-2 test sections.
4. Conduct testing of subdrainage functioning in SPS-1 and SPS-2 test sections.
5. Use the results of the subdrainage testing together with the video inspection results obtained earlier to achieve a more complete and quantitative assessment of the functioning of subdrains in the test sections.
6. Analyze the deflection data from the SPS-1 and SPS-2 experiments for the purpose of quantifying differences in structural capacity among sections of different base types and thickness designs.
7. Incorporate data from the Minnesota Road Research Project (MnRoad) and Wisconsin Department of Transportation (DOT) drainage studies into the analysis.
8. Expand on the performance analysis conducted in NCHRP Project 1-34C, in light of the findings from the subdrainage testing and structural analysis, as well as other information.
9. Based on the results of the testing and analyses conducted, report on the quantifiable effects of subsurface drainage on the performance of AC and PCC pavements.

Research Approach

Observations from the video inspections of subdrains in the SPS-1 and SPS-2 sections with permeable asphalt-treated bases suggest that some discrepancies exist between the as-designed and as-constructed drainage systems. These discrepancies were reported to the LTPP program in a data analysis/operations feedback report, and the responses from the LTPP regional support centers were included in an earlier report (*13*).

Information in the LTPP database suggests that inconsistencies exist among the different SPS-1 and SPS-2 sites with respect to the presence of filter fabric below the permeable asphalt-treated base layers. These inconsistencies were also reported to the LTPP program, and some clarifications were received from the LTPP regional support centers (*13*).

For this study, a method for measuring the time of flow of water through the drained SPS-1 and SPS-2 test sections was developed. Pilot testing was conducted on a drained highway pavement in Wisconsin and at the Arkansas SPS-1 and SPS-2 sites. As a result of the pilot testing, some adjustments were made to the test procedure, and drainage flow time testing was subsequently conducted at all of the remaining SPS-1 and SPS-2 sites, as well as at the MnRoad site.

In the SPS-1 and SPS-2 experiments, two of the experimental factors—base type and subdrainage—are confounded.

This was perhaps unavoidable, but it complicates the analysis of the performance of the SPS-1 and SPS-2 test sections. The confounding of these two experimental factors makes it difficult to ascertain how much any differences in performance between drained and undrained test sections are due to the presence or absence of a functioning subdrainage system, versus differences in base stiffness.

To address this issue, this study included an analysis of the nondestructive deflection test data for every SPS-1 and SPS-2 test section for every date that the sections were tested. The primary goal of the deflection testing was to assess the relative structural contributions of different types of bases. The results of the deflection analyses are presented in this report.

The effects of the base type/subdrainage factor on roughness, cracking, and rutting in the SPS-1 pavement sections and on roughness, cracking, and faulting in the SPS-2 pavement sections were analyzed.

Details about the construction, materials testing, and data availability for the SPS-1 and SPS-2 experiments are available in the LTPP database (www.ltpp-products.com) and in the following reports:

- *Structural Factors for Flexible Pavements—Initial Evaluation of the SPS-1 Experiment* (*14*),
- *Structural Factors for Jointed Plain Concrete Pavements: SPS-2 —Initial Evaluation and Analysis* (*15*), and
- *LTPP Data Analysis: Influence of Design and Construction Features on the Response and Performance of New Flexible and Rigid Pavements* (*16*).

The first two of these reports also present some preliminary findings concerning the performance of the SPS-1 and SPS-2 test sections, based on information available in Release 10 of the LTPP database (January 2000). The third report presents the findings of performance analyses conducted using information available in Release 17 of the LTPP database (January 2004).

Organization of this Report

The research conducted for this project is described in the following sequence:

- Chapter 1—Introduction,
- Chapter 2—Description of the SPS-1 and SPS-2 Experiments,
- Chapter 3—Field Testing of Drainage Systems,
- Chapter 4—Deflection Analysis of SPS-1 and SPS-2 Designs,
- Chapter 5—Roughness and Distress in SPS-1 Flexible and SPS-2 Rigid Pavements, and
- Chapter 6—Conclusions and Recommendations.

CHAPTER 2

Description of the SPS-1 and SPS-2 Experiments

Design of SPS-1 and SPS-2 Experiments

The SPS-1 experiment was designed to assess the influence of the following factors on the performance of AC pavements:

- AC thickness,
- Base type,
- Base thickness,
- Subdrainage,
- Climate,
- Subgrade, and
- Truck traffic level.

The original experimental design and research plan for SPS-1 is described in a Strategic Highway Research Program (SHRP) report (*17*). The design factorial for the SPS-1 experiment is shown in Table 1. The first two digits of the number shown within each cell signify the SPS experiment (in this case, SPS-1); the last two digits signify the test section number of each design.

The originally intended site factorial for the SPS-1 experiment is shown in Table 2. The states listed in the upper row for each subgrade type are those that built designs 0101 through 0112. The states listed in the lower row for each subgrade type are those that built designs 0113 through 0124.

In the wet-freeze-fine subgrade cells, two pairs of states are listed; each state was to build a set of the 12 designs, so as to create "replicates" of the designs. These are not, however, replicates in the true sense of the word, as the sites are not identical in terms of truck traffic or climate.

The Texas site, originally listed in the dry-nonfreeze-coarse subgrade cell, was found to have a fine subgrade; consequently, it was recategorized as a dry-nonfreeze-fine site, as shown in the actual site factorial (Table 3).

The pavement designs corresponding to designs 0101 through 0112 are shown in Table 4; those for designs 0113 through 0124 are shown in Table 5.

The SPS-2 experiment was designed to assess the influence of the following factors on the performance of jointed PCC pavements:

- PCC thickness,
- Concrete flexural strength,
- Base type,
- Lane width,
- Subdrainage,
- Climate,
- Subgrade, and
- Truck traffic level.

The original experimental design and research plan for SPS-2 are described in a SHRP report (*18*). The design factorial for the SPS-2 experiment is shown in Table 6. The first two digits of the number within each cell in Table 6 signify the SPS-2 experiment, and the last two digits signify the test section design.

The site factorial for the SPS-2 experiment is shown in Table 7. The upper row corresponding to each subgrade type lists the states that built designs 0201 through 0212; the pavement designs constructed at these sites are shown in Table 8. The bottom row associated with each subgrade type in the table lists the states that built designs 0213 through 0224; the corresponding pavement designs are shown in Table 9.

Several of the state DOTs also constructed supplemental test sections to evaluate design features or materials typically used in the state or that were of interest for future use. A total of 32 supplemental test sections were built at SPS-1 sites; 40 supplemental sections were built at SPS-2 sites.

SPS-1 and SPS-2 Locations

The locations of the SPS-1 sites and the SPS-2 sites are shown in Figures 1 and 2, and location details for the SPS-1 and SPS-2 sites are given in Tables 10 and 11. A comparison

Table 1. SPS-1 design factorial.

		Drainage				
		No			Yes	
		Base Type				
Total Base Thickness (in.)	Surface Thickness (in.)	Dense-Graded Aggregate	Asphalt-Treated Base	Asphalt-Treated Base over Dense-Graded Aggregate	Permeable Asphalt-Treated Base over Aggregate	Asphalt-Treated Base over Permeable Asphalt-Treated Base
8	4	0113	0103	0105	0107	0122
	7	0101	0115	0117	0119	0110
12	4	0102	0116	0118	0120	0111
	7	0114	0104	0106	0108	0123
16	4				0121	0112
	7				0109	0124

Table 2. Intended SPS-1 site factorial.

	Wet		Dry	
	Freeze	Nonfreeze	Freeze	Nonfreeze
Fine subgrade	IA, OH	AL	KS	NM
	VA, MI	LA	NE	OK
Coarse subgrade	DE	FL	NV	TX
	WI	AR	MT	AZ

Table 3. Actual SPS-1 site factorial.

	Wet		Dry	
	Freeze	Nonfreeze	Freeze	Nonfreeze
Fine subgrade	IA, OH	AL	KS	NM
	VA, MI	LA	NE	OK, TX
Coarse subgrade	DE	FL	NV	
	WI	AR	MT	AZ

Table 4. Core SPS-1 test sections built at the Alabama, Delaware, Florida, Iowa, Kansas, Nevada, New Mexico, and Ohio sites.

		Drainage				
		No			Yes	
		Base Type				
Total Base Thickness (in.)	Surface Thickness (in.)	Dense-Graded Aggregate	Asphalt-Treated Base	Asphalt-Treated Base over Dense-Graded Aggregate	Permeable Asphalt-Treated Base over Aggregate	Asphalt-Treated Base over Permeable Asphalt-Treated Base
8	4		0103	0105	0107	
	7	0101				0110
12	4	0102				0111
	7		0104	0106	0108	
16	4					0112
	7				0109	

Table 5. Core SPS-1 test sections built at the Arizona, Arkansas, Louisiana, Michigan, Montana, Nebraska, Oklahoma, Texas, Virginia, and Wisconsin sites.

		Drainage				
		No			Yes	
		Base Type				
Total Base Thickness (in.)	Surface Thickness (in.)	Dense-Graded Aggregate	Asphalt-Treated Base	Asphalt-Treated Base over Dense-Graded Aggregate	Permeable Asphalt-Treated Base over Aggregate	Asphalt-Treated Base over Permeable Asphalt-Treated Base
8	4	0113				0122
	7		0115	0117	0119	
12	4		0116	0118	0120	
	7	0114				0123
16	4				0121	
	7					0124

Table 6. SPS-2 design factorial.

			Drainage		
			No		Yes
			Base type		
Slab Thickness (in.)	Flexural Strength (psi)	Lane Width (ft)	Aggregate	Lean Concrete Base	Permeable Asphalt-Treated Base
8	550	12	0201	0205	0209
		14	0213	0217	0221
	900	12	0214	0218	0222
		14	0202	0206	0210
11	550	12	0215	0219	0223
		14	0203	0207	0211
	900	12	0204	0208	0212
		14	0216	0220	0224

Table 7. SPS-2 site factorial.

	Wet		Dry	
	Freeze	Nonfreeze	Freeze	Nonfreeze
Fine subgrade	OH, KS	NC		
	MI, IA, ND	AR		
Coarse subgrade	DE		NV, WA	CA
	WI		CO	AZ

Table 8. Core SPS-2 test sections built at California, Delaware, Kansas, Nevada, North Carolina, Ohio, and Washington sites.

			Drainage		
			No		Yes
			Base type		
Slab Thickness (in.)	Flexural Strength (psi)	Lane Width (ft)	Aggregate	Lean Concrete Base	Permeable Asphalt-Treated Base
8	550	12	0201	0205	0209
		14			
	900	12			
		14	0202	0206	0210
11	550	12			
		14	0203	0207	0211
	900	12	0204	0208	0212
		14			

Table 9. Core SPS-2 test sections built at Arizona, Arkansas, Colorado, Iowa, Michigan, North Dakota, and Wisconsin sites.

			Drainage		
			No		Yes
			Base type		
Slab Thickness (in.)	Flexural Strength (psi)	Lane Width (ft)	Aggregate	Lean Concrete Base	Permeable Asphalt-Treated Base
8	550	12			
		14	0213	0217	0221
	900	12	0214	0218	0222
		14			
11	550	12	0215	0219	0223
		14			
	900	12			
		14	0216	0220	0224

Figure 1. SPS-1 (flexible pavement) sites.

Figure 2. SPS-2 (rigid pavement) sites.

Table 10. SPS-1 location data.

SHRP ID	State	County or Parish	Nearby City or Town	Route	Latitude	Longitude
010100	AL	Lee	Opelika	US 280	32.61	85.25
040100	AZ	Mohave	Kingman	US 93	35.39	114.26
050100	AR	Craighead	Jonesboro	US 63	35.72	90.58
100100	DE	Sussex	Ellendale	US 113	38.79	75.44
120100	FL	Palm Beach	Coral Springs	US 27	26.54	80.69
190100	IA	Lee	Burlington	US 61	40.70	91.25
200100	KS	Kiowa	Greensburg	US 54	37.60	99.25
220100	LA	Calcasieu	Lake Charles	US 171	30.33	93.20
260100	MI	Clinton	Lansing	US 27	42.99	84.52
300100	MT	Cascade	Great Falls	I-15	47.41	111.53
310100	NE	Thayer	Hebron	US 81	40.07	97.62
320100	NV	Lander	Battle Mountain	I-80	40.69	117.01
350100	NM	Doña Ana	Las Cruces	I-25	32.68	107.07
390100	OH	Delaware	Delaware	US 23	40.43	83.06
400100	OK	Comanche	Lawton	US 62	34.64	98.66
480100	TX	Hidalgo	McAllen	US 281	26.74	98.11
510100	VA	Pittsylvania	Danville	US 29	36.66	79.37
550100	WI	Marathon	Wausau	SR 29	44.87	89.29

Table 11. SPS-2 location data.

SHRP ID	State	County or Parish	Nearby City or Town	Route	Latitude (deg)	Longitude (deg)
040200	AZ	Maricopa	Phoenix	I-10	33.45	112.74
050200	AR	Saline	Benton	I-30	34.54	92.68
060200	CA	Merced	Turlock	SR 99	37.42	120.77
080200	CO	Adams	Denver	I-76	39.97	104.79
100200	DE	Sussex	Ellendale	US 113	38.87	75.44
190200	IA	Polk	Des Moines	US 65	41.65	93.47
200200	KS	Dickenson	Salina	I-70	38.97	97.09
260200	MI	Monroe	Toledo, Ohio	US 23	41.75	83.70
320200	NV	Lander	Battle Mountain	I-80	40.72	117.04
370200	NC	Davidson	Lexington	US 52	35.87	80.27
380200	ND	Cass	Fargo	I-94	46.88	97.17
390200	OH	Delaware	Delaware	US 23	40.43	83.08
530200	WA	Adams	Ritzville	US 395	47.06	118.42
550200	WI	Marathon	Wausau	SR 29	44.83	89.23

of Figures 1 and 2 shows that the sites in the two experiments are comparably distributed in the eastern, midwestern, and western regions of the country; in the southeastern region, however, there are four SPS-1 sites but no SPS-2 sites.

SPS-1 and SPS-2 Climates

The average annual precipitation and the average annual temperature for each of the SPS-1 and SPS-2 sites are shown in Tables 12 and 13, respectively. This information was obtained from "virtual weather station" statistics in the LTPP database, which represent distance-weighted averages from as many as five operating weather stations in the vicinity of each site. The distribution of the SPS-1 and SPS-2 sites with respect to average annual precipitation and temperature is illustrated in Figure 3.

The Thornthwaite moisture index can be used to describe a location's climate in a way that reflects both precipitation and temperature (*19*). This index is calculated as a function of the difference between the average monthly precipitation and the potential evapotranspiration in each month of the year, with evapotranspiration being a function of the average monthly temperature, the number of days in the month, and the length of the day (the number of hours between sunrise and sunset) in the middle of each month. The Thornthwaite moisture index values calculated for the

Table 12. Average annual precipitation and temperature levels for SPS-1 sites.

State	State Code	Latitude (degrees)	Longitude (degrees)	Average Annual Precipitation (in.)	Average Annual Temperature (°F)
AL	01	32.61	85.25	51.5	63.2
AZ	04	35.39	114.26	8.1	66.5
AR	05	35.72	90.58	48.1	60.1
DE	10	38.79	75.44	45.3	55.6
FL	12	26.33	80.69	52.5	73.5
IA	19	40.70	91.25	39.2	52.0
KS	20	37.60	99.25	25.0	55.1
LA	22	30.33	93.20	59.8	68.0
MI	26	42.99	84.52	31.7	47.8
MT	30	47.41	111.53	14.2	44.8
NE	31	40.07	97.62	29.5	52.5
NV	32	40.69	117.01	9.0	49.7
NM	35	32.68	107.07	10.6	60.4
OH	39	40.43	83.06	38.3	50.2
OK	40	34.64	98.66	30.7	61.7
TX	48	26.74	98.11	22.1	54.9
VA	51	36.66	79.37	44.2	57.5
WI	55	44.87	89.29	32.1	42.6

Table 13. Average annual precipitation and temperature levels for SPS-2 sites.

State	State Code	Latitude (deg)	Longitude (deg)	Average Annual Precipitation (in.)	Average Annual Temperature (°F)
AZ	04	33.45	112.74	7.6	71.4
AR	05	34.54	92.68	53.0	61.7
CA	06	37.42	120.77	11.9	61.8
CO	08	39.97	104.79	14.7	49.7
DE	10	38.87	75.44	45.4	55.7
IA	19	41.65	93.47	33.1	48.9
KS	20	38.97	97.09	31.9	54.9
MI	26	41.75	83.70	33.0	49.9
NV	32	40.72	117.04	8.9	49.7
NC	37	35.87	80.27	44.2	58.6
ND	38	46.88	97.17	22.3	41.3
OH	39	40.43	83.06	38.3	50.2
WA	53	47.06	118.42	10.8	49.1
WI	55	44.83	89.23	32.1	42.7

SPS-1 and SPS-2 sites are shown in Tables 14 and 15, listed from most arid (negative numbers) to most humid (positive numbers).

In Figure 3, the SPS-1 and SPS-2 sites whose precipitation and temperature levels plot in the upper left-hand corner (high average annual temperature and low average annual precipitation) are those with the lowest Thornthwaite moisture index values. The Arizona SPS-2 site is the most arid of all of the sites, with a moisture deficit (potential evapotranspiration exceeding precipitation) in every month of the year, and a Thornthwaite moisture index of -51. The average monthly precipitation and average monthly minimum,

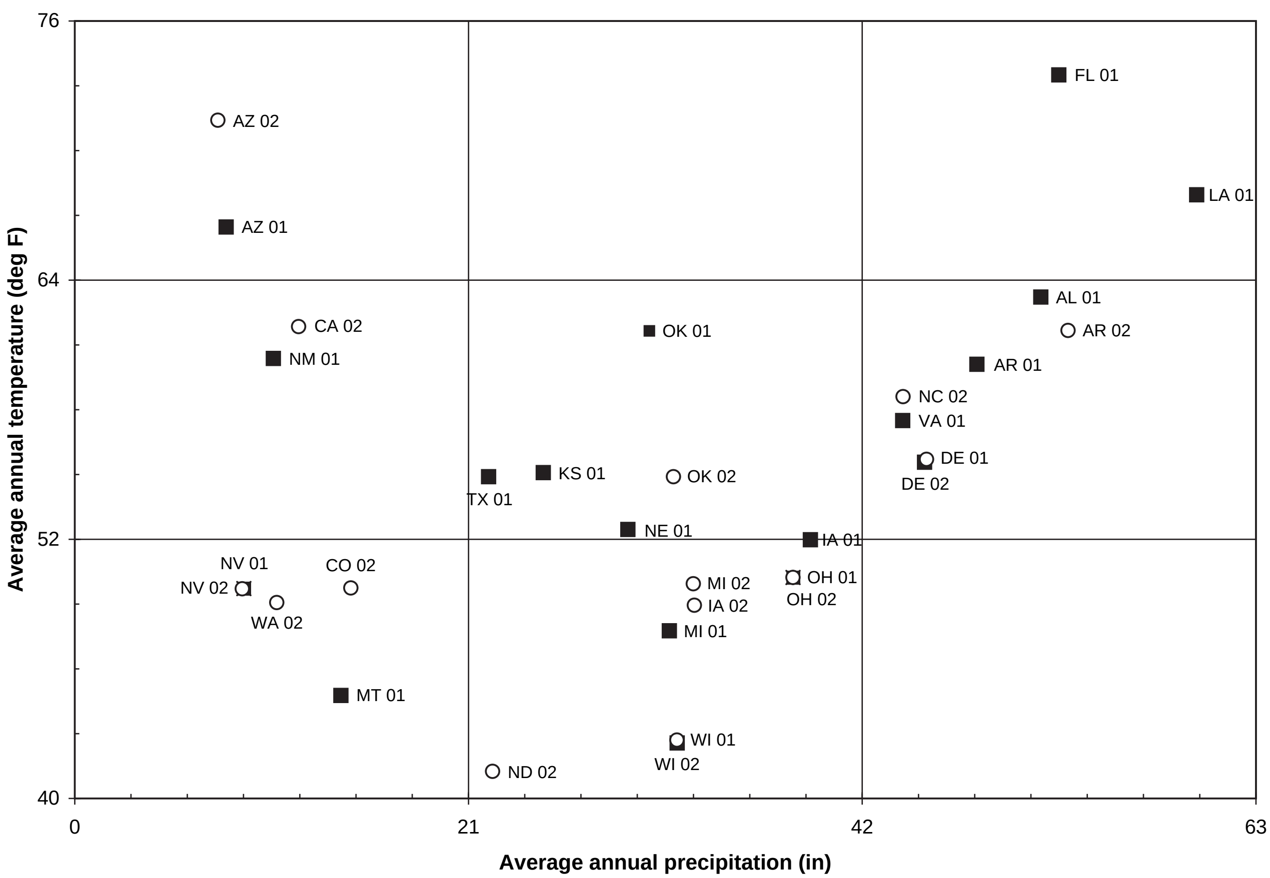

Figure 3. Distribution of average annual precipitation and temperature at SPS-1 and SPS-2 sites.

Table 14. Thornthwaite moisture index (TMI) values for SPS-1 sites.

State	State Code	TMI
AZ	04	-48
NM	35	-39
NV	32	-23
OK	40	-2
KS	20	3
FL	12	3
TX	48	4
MT	30	13
NE	31	23
LA	22	38
AL	01	51
AR	05	56
VA	51	62
IA	19	64
MI	26	73
DE	10	79
OH	39	87
WI	55	106

mean, and maximum temperatures at the Arizona SPS-2 site are shown in Figure 4.

By comparison, the site where the Nevada SPS-1 and SPS-2 test sections are located receives only slightly more precipitation than the Arizona SPS-2 site, but it has a higher Thornthwaite moisture index (-23). The Nevada site has a moisture surplus in 6 months of the year and a moisture deficit in the other 6 months. At 4,500 ft above sea level, the Nevada site has much lower temperatures than the Arizona SPS-2 site, which sits at 1,100 ft above sea level. The average monthly precipitation and the average monthly minimum, mean, and maximum temperatures at the Nevada SPS-1 and SPS-2 site are plotted in Figure 5.

Table 15. Thornthwaite moisture index (TMI) values for SPS-2 sites.

State	State Code	TMI
AZ	04	-51
CA	06	-32
NV	32	-23
WA	53	-10
CO	08	-5
KS	20	21
ND	38	36
IA	19	53
NC	37	56
AR	05	61
MI	26	61
DE	10	78
OH	39	87
WI	55	105

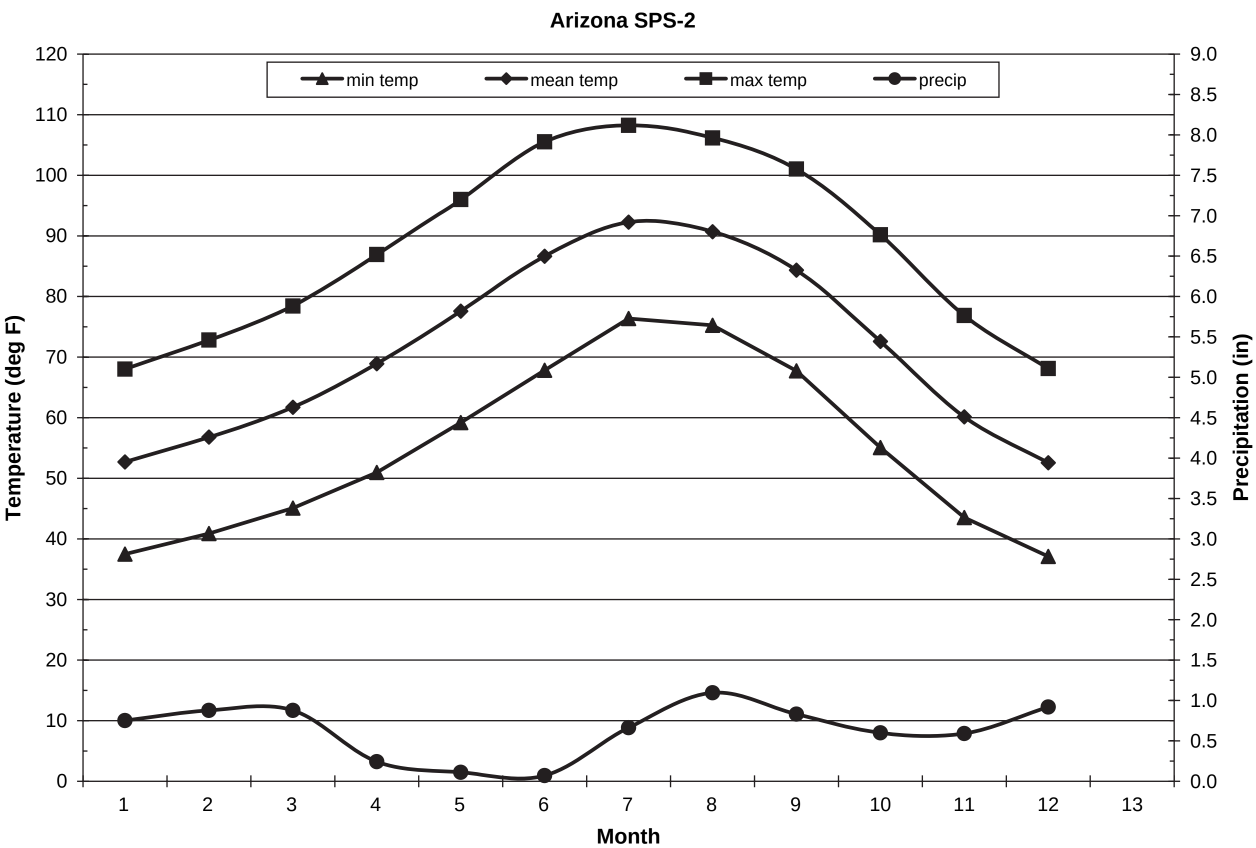

Figure 4. Monthly average precipitation and high, mean, and low temperatures at the Arizona SPS-2 site.

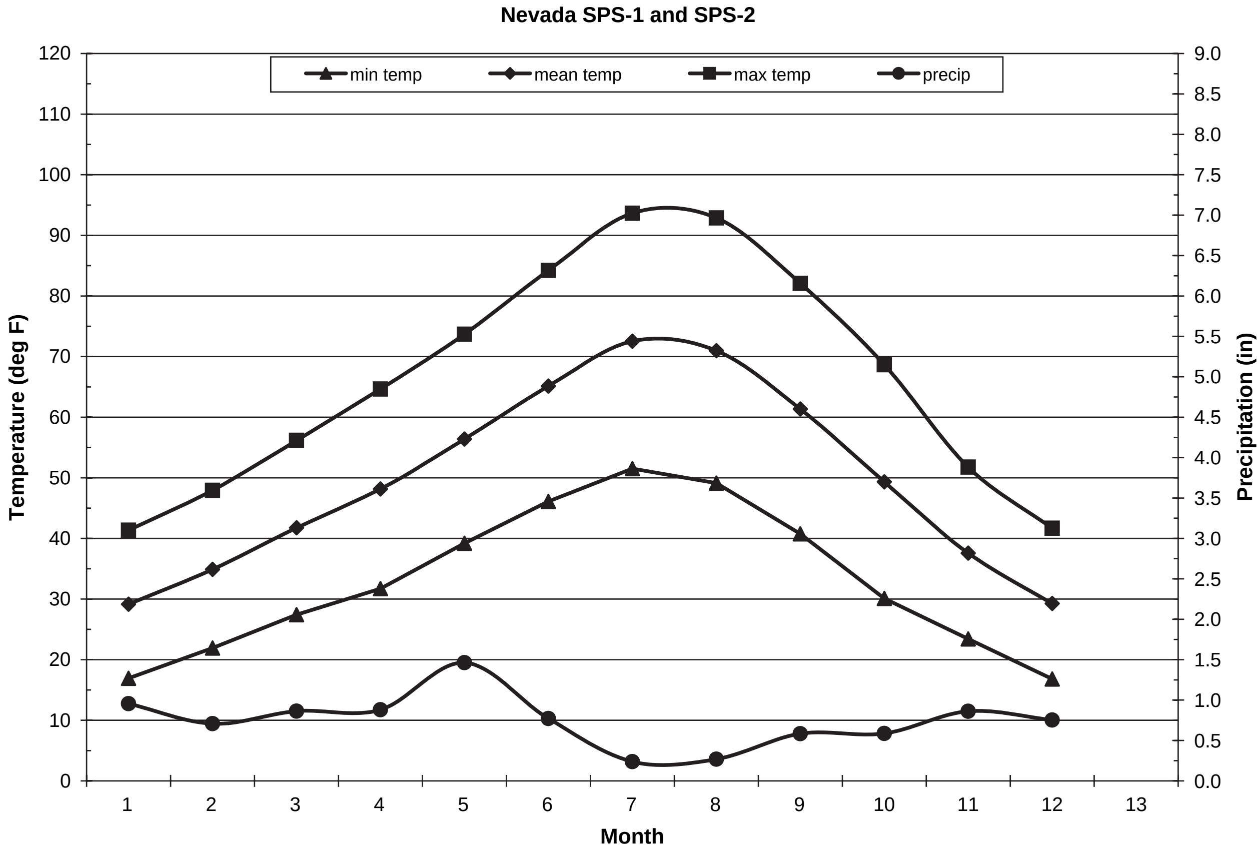

Figure 5. Monthly average precipitation and high, mean, and low temperatures at the Nevada SPS-1 and SPS-2 site.

In general, the Thornthwaite moisture index values at the SPS-1 and SPS-2 sites increase with increasing average annual precipitation and decreasing average annual temperature, as shown as a diagonal line downward and to the right across the plot in Figure 3. The site with the highest Thornthwaite moisture index value is not the one with the highest average annual precipitation (Louisiana SPS-1), but rather the site closest to the lower right-hand corner of the plot (the Wisconsin SPS-1 and SPS-2 test sections). Although there are several other sites that receive more precipitation, the combination of moderate precipitation and low temperatures at the Wisconsin site results in a moisture surplus in 11 of 12 months of the year and a Thornthwaite moisture index of 105. A plot of the average monthly precipitation and average monthly minimum, mean, and maximum temperatures at the Wisconsin SPS-1 and SPS-2 site is shown in Figure 6.

In the design of a pavement subsurface drainage system, a location's precipitation is typically characterized by a design rainfall (also called a design storm), which is the amount of rainfall expected with a selected frequency and duration. The frequency (also called the return period) is the likelihood of that event occurring in any given year. A 100-year storm, for example, is an event that has a 1% chance of occurrence in any given year. A 1-year rainfall is considered a once-a-year event—that is, with a 100% chance of occurrence in any given year. Thus a 1-year, 1-hour rainfall is an amount of rainfall that, at a particular location, lasts 1 hour and occurs, on average, once a year. A 2-year, 1-hour rainfall is an amount of rainfall that lasts 1 hour and occurs, on average, once every 2 years.

As shown in Figure 7, there is an evident, albeit nonlinear, correlation between average annual precipitation and the 1-year, 1-hour rainfall for nearly all of the sites. The exceptions are the three SPS-1 sites closest to the Gulf Coast (Texas, Louisiana, and Florida), for which the correlation curve seems to be shifted upward (higher 1-year, 1-hour rainfall at those sites than for noncoastal sites with similar levels of average annual precipitation).

In the FHWA report *Highway Subdrainage Design*, Moulton cited Cedergren as having recommended 1-year, 1-hour precipitation rates as the basis for computing infiltration rates into pavement structures (*1, 20*). The contour map that Cedergren recommended for this purpose was from the 1961 *Rainfall Frequency Atlas of the United States* (*21*), which has been superseded in part by other reports (*22-24*).

In contrast, the reference manual for the National Highway Institute's training course on pavement subsurface drainage design says that "a storm of 2-year frequency and 1-hour

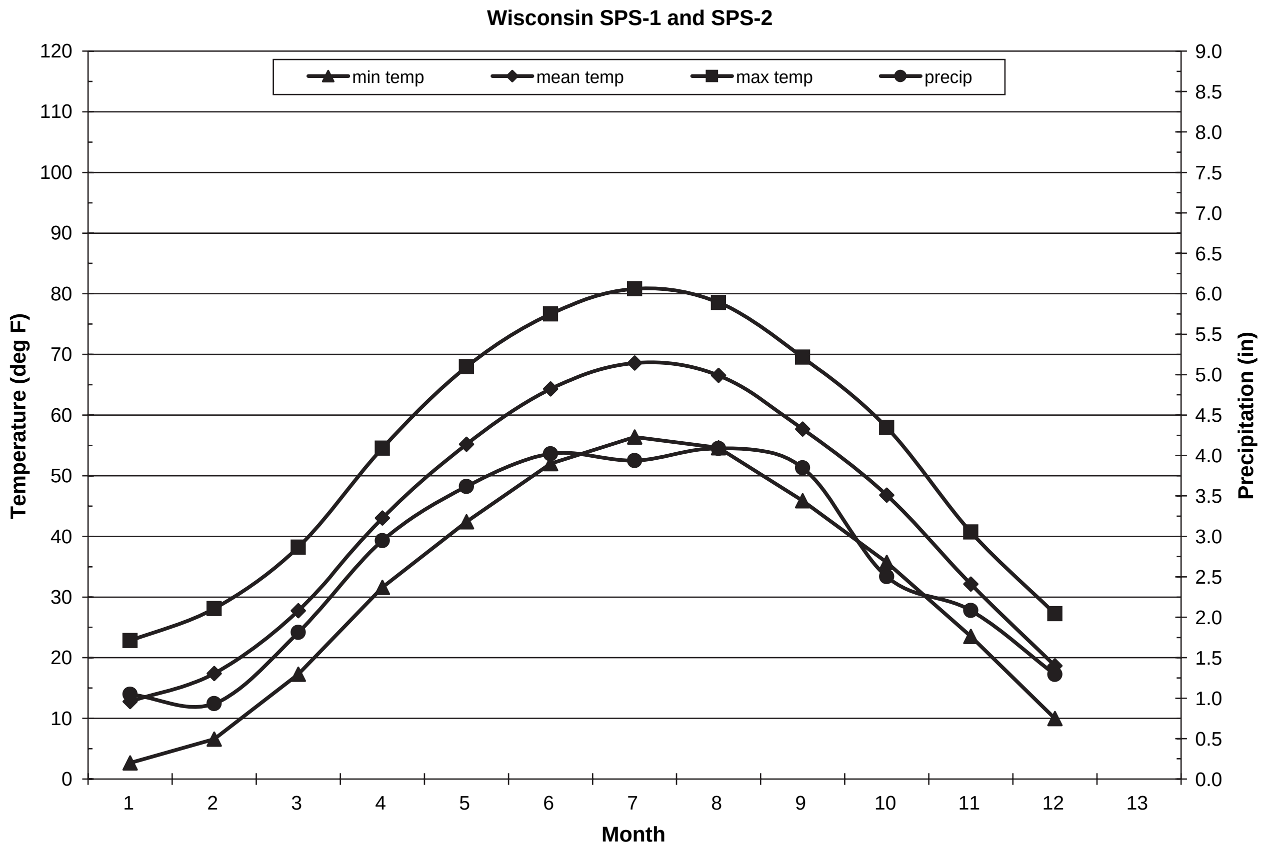

Figure 6. Monthly average precipitation and high, mean, and low temperatures at the Wisconsin SPS-1 and SPS-2 site.

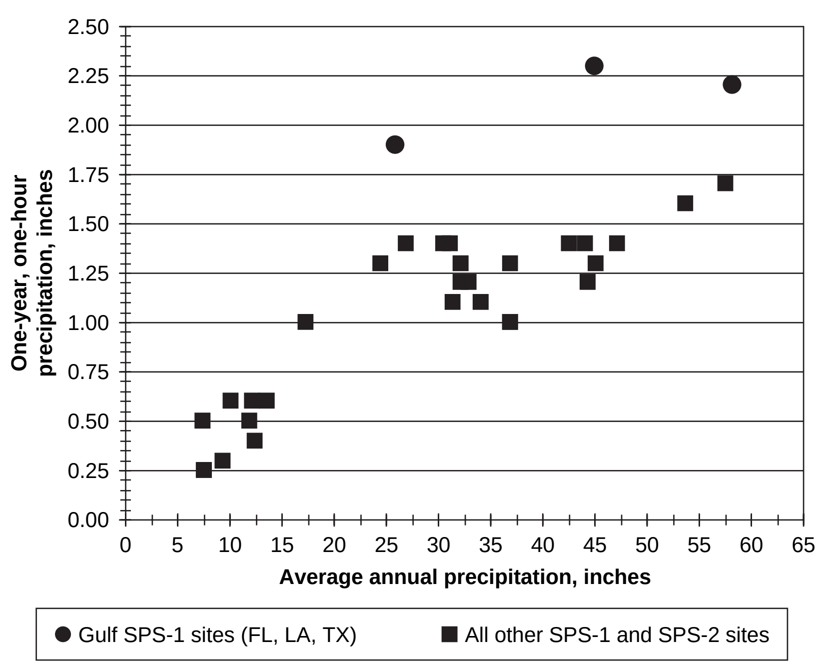

Figure 7. One-year, 1-hour precipitation rate versus average annual precipitation for SPS-1 and SPS-2 sites.

duration is typically used in design to determine the amount of rainfall that will be available to infiltrate the pavement" (*8*).

In any case, if the 1-year, 1-hour precipitation amount or the 2-year, 1-hour precipitation amount is known for a given location, it is not difficult to determine the other amount using the contour maps in the publications mentioned above. In addition, precipitation frequency data for weather stations in some states are accessible in electronic form. For example, there are Web sites that, once you enter the latitude and longitude for any point within one of those states, will provide precipitation levels for a range of durations and frequencies. Such precipitation data was collected for the eight SPS-1 and SPS-2 sites located within those states; the results are presented in Tables 16 and 17 and Figure 8. There is a strong curvilinear correlation between the 1-year, 1-hour precipitation levels and the 2-year, 1-hour precipitation levels.

There is no right answer as to which rainfall frequency is most appropriate for use in pavement subsurface drainage design. What is important is that an agency pick a design rainfall, use it consistently in design, and then document the design rainfall used, along with other details of the drainage system design.

Table 16. One-year and 2-year 1-hour rainfalls for SPS-1 sites.

State	State Code	One-Year, 1-hour Rainfall (in./h)	Two-Year, 1-Hour Rainfall (in./h)
AL	01	1.7	
AZ	04	0.5	0.8
AR	05	1.4	
DE	10	1.4	
FL	12	2.3	
IA	19	1.3	
KS	20	1.3	
LA	22	2.2	
MI	26	1.1	
MT	30	0.4	
NE	31	1.4	
NV	32	0.25	0.32
NM	35	0.6	0.85
OH	39	1.0	1.32
OK	40	1.4	
TX	48	1.9	
VA	51	1.2	1.48
WI	55	1.2	

Table 17. One-year and 2-year 1-hour rainfalls for SPS-2 sites.

State	State Code	One-Year, 1-Hour Rainfall (in./h)	Two-Year, 1-Hour Rainfall (in./h)
AZ	04	0.6	0.79
AR	05	1.6	
CA	06	0.5	
CO	08	0.6	
DE	10	1.4	
IA	19	1.3	
KS	20	1.4	
MI	26	1.1	
NV	32	0.25	0.32
NC	37	1.3	1.60
ND	38	1.0	
OH	39	1.0	1.32
WA	53	0.3	
WI	55	1.2	

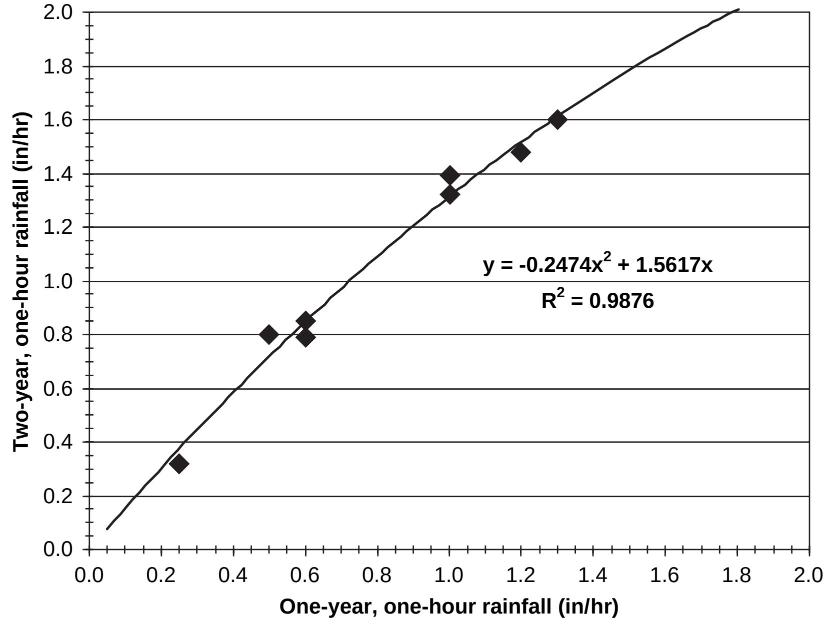

Figure 8. One-year, 1-hour precipitation versus 2-year, 1-hour precipitation for SPS-1 and SPS-2 sites.

Test Section Layouts and Pavement Structures

The station limits, layer thicknesses, and material types for each of the SPS-1 and SPS-2 test sections were extracted from the SPS_PROJECT_STATIONS and TST_L05B tables in the LTPP database. The thicknesses in the TST_L05B table represent the LTPP regional support centers' best estimates of the as-built layer thicknesses and materials.

Layout diagrams were developed to display the stationing of the test sections at each site, identify the sections to be drained, show the locations of edgedrain outlets where video inspection had been done, and indicate the material types and thicknesses of the pavement layers. For the SPS-2 sites, the layout diagrams also indicate which sections were built with widened slabs and show the design concrete strength. The SPS-1 and SPS-2 layout diagrams are included in Appendix A.

For the purposes of analyzing deflections measured at the SPS-1 and SPS-2 sites, the layer materials used in the different test sections were categorized in the following groups:

Group	Description
AC	Asphalt concrete (the combined thickness of all lifts)
PCC	Portland cement concrete
AGG1	Unbound aggregate layer directly beneath AC or PCC layer
LCB	Lean concrete base
ATB	Dense-graded asphalt-treated base
PATB	Permeable asphalt-treated base
HMAC	Hot-mix asphalt concrete base
AGG2	Unbound aggregate layer beneath a treated base layer
CAM	Cement-aggregate mixture

These groups were then used in the layout diagrams to indicate the composition of the pavement layers.

In most cases in the SPS-1 experiment, the AC layer is the combined thickness of lifts of dense-graded asphalt concrete (material code 1 in the LTPP database). In some cases, (Arizona 040160, all of the Delaware SPS-1 sections, and all of the New Mexico SPS-1 sections), the top layer is an open-graded asphalt friction course (material code 2).

In all cases in the SPS-2 experiment, the PCC layer is jointed plain concrete pavement (JPCP, material code 4). The Arizona SPS-1 site has one supplemental section (040160) with a JPCP surface layer, and another supplemental section (040163) with a roller-compacted concrete layer (material code 20, "other") and an open-graded asphalt friction course.

Materials categorized in this study as AGG1 are unbound granular materials directly beneath the AC or PCC layer; they are typically identified in the LTPP database as crushed stone (303) or crushed gravel (304). The materials categorized as AGG2 are unbound granular materials or gravel-soil mixtures beneath a treated base layer. For this analysis, the material types listed in the LTPP database that were placed in the AGG2 group include "soil-aggregate mixture, predominantly fine-grained" (307), "soil-aggregate mixture, predominantly coarse-grained" (308), and a number of soils with a gravel or sand component. For backcalculation purposes, some judgment was applied in distinguishing between a granular material considered as a layer in the pavement structure versus a granular material considered as part of the foundation and/or a filter layer intended to block fines from infiltrating a permeable base.

Although the LTPP database may identify eight or nine different layer materials (including multiple AC lifts and multiple granular subbase and select fill materials) above the subgrade for a given section, for the purposes of this study the SPS-1 test sections were analyzed as either one, two, or three layers above the subgrade.

The SPS-1 sections fall into one of the following five groups:

- AC Group A—AC alone or AC over aggregate (AGG1),
- AC Group B—AC over asphalt-treated base (ATB),
- AC Group C—AC over asphalt-treated base (ATB) over aggregate (AGG2),
- AC Group D—AC over permeable asphalt-treated base (PATB) over aggregate (AGG2), and
- AC Group E—AC over asphalt-treated base (ATB) over permeable asphalt-treated base (PATB)

The SPS-2 sections were analyzed as two layers above the subgrade, and all but a few fell into one of the following three groups:

- PCC Group A—PCC over dense-graded aggregate,
- PCC Group B—PCC over lean concrete base, and
- PCC Group C—PCC over permeable asphalt-treated base.

The SPS-2 sections that did not fall into one of the three PCC groups included the following:

- Supplemental sections where the base layer is identified in the database as hot-mix asphalt concrete (material code 319): Arizona 040266, 040267, and 040268; Nevada 320259; and Washington 530259.
- Supplemental sections where the base layer is identified as an asphalt-treated mixture (material code 321): North Carolina 370259 and 370260.
- Supplemental sections where the base layer is identified as a cement-aggregate mixture (material code 331): Kansas 200259, Ohio 390261 and 390262, and Wisconsin 550261.
- A supplemental section where the concrete slab was constructed on the subgrade: Colorado 080259.

The layer thicknesses shown in the layout diagrams were obtained from the TST_L05B table in Release 19 of the LTPP database. It should be noted that there are quite a few minor differences (sometimes one or two tenths of an inch, but in a few cases up to a half of an inch) between the layer thicknesses reported in Release 19 and those reported in earlier releases.

Soils at the SPS-1, SPS-2, and MnRoad Sites

Information on the natural drainage characteristics of the soils was obtained, in most cases, from county soil reports published by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS). For a few of the SPS-1 and SPS-2 sites for which a printed copy of the county soil report could not be obtained, information on the soils at the sites' locations was requested from a state or local NRCS office or the county's agricultural extension office.

For several of the SPS-1 and SPS-2 sites, the most recent county soil report had been published prior to the construction not only of those test sections, but also of any roadway along that alignment. This made it difficult to identify the predominant soil type at the test sections. Latitudinal and longitudinal data, as well as geographical features such as rivers and streams, are in those cases especially useful in attempting to pinpoint the location of an SPS-1 or SPS-2 site on the map sheets in the county soil reports.

The drainage class (also called the natural drainage class) of a soil describes the frequency and duration of periods of saturation or partial saturation in the absence of artificial (fabricated) drains or irrigation. Drainage classes are, however, primarily defined for agricultural purposes, which explains why, for example, very rapid water movement through the soil is classified as "excessive," when from a pavement engineering perspective the more rapidly water moves through the soil, the better. There are seven drainage classes defined in the *Soil Survey Manual*:

> Excessively drained—Water is removed very rapidly. The occurrence of internal free water commonly is very rare or very deep. The soils are commonly coarse-textured and have very high hydraulic conductivity or are very shallow.
>
> Somewhat excessively drained—Water is removed from the soil rapidly. Internal free water occurrence commonly is very rare or very deep. The soils are commonly coarse-textured and have high saturated hydraulic conductivity or are very shallow.
>
> Well drained—Water is removed from the soil readily but not rapidly. Internal free water occurrence commonly is deep or very deep; annual duration is not specified. Water is available to plants throughout most of the growing season in humid regions. Wetness does not inhibit growth of roots for significant periods during most growing seasons. The soils are mainly free of the deep to redoximorphic features that are related to wetness.
>
> Moderately well drained—Water is removed from the soil somewhat slowly during some periods of the year. Internal free water occurrence commonly is moderately deep and transitory through permanent. The soils are wet for only a short time within the rooting depth during the growing season, but long enough that most mesophytic crops are affected. They commonly have a moderately low or lower saturated hydraulic conductivity in a layer within the upper 1 m, periodically receive high rainfall, or both.

Somewhat poorly drained—Water is removed slowly so that the soil is wet at a shallow depth for significant periods during the growing season. The occurrence of internal free water commonly is shallow to moderately deep and transitory to permanent. Wetness markedly restricts the growth of mesophytic crops, unless artificial drainage is provided. The soils commonly have one or more of the following characteristics: low or very low saturated hydraulic conductivity, a high water table, additional water from seepage, or nearly continuous rainfall.

Poorly drained—Water is removed so slowly that the soil is wet at shallow depths periodically during the growing season or remains wet for long periods. The occurrence of internal free water is shallow or very shallow and common or persistent. Free water is commonly at or near the surface long enough during the growing season so that most mesophytic crops cannot be grown, unless the soil is artificially drained. The soil, however, is not continuously wet directly below plow-depth. Free water at shallow depth is usually present. This water table is commonly the result of low or very low saturated hydraulic conductivity of nearly continuous rainfall, or of a combination of these.

Very poorly drained—Water is removed from the soil so slowly that free water remains at or very near the ground surface during much of the growing season. The occurrence of internal free water is very shallow and persistent or permanent. Unless the soil is artificially drained, most mesophytic crops cannot be grown. The soils are commonly level or depressed and frequently ponded. If rainfall is high or nearly continuous, slope gradients may be greater. (*25*)

A second means of classifying soil drainage characteristics is by hydrologic soil group, which indicates the estimated runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups, according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

Group A—Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B—Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C—Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D—Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanently high water table, soils that have a claypan at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission. (*25*)

Three dual hydrologic groups—A/D, B/D, and C/D—are also recognized for those wet soils that can be adequately drained. The first letter applies to the drained condition, the second to the undrained. Only soils that are rated D in their natural condition can be assigned to a dual group, and then only if drainage is feasible and practical.

Brief descriptions of the drainage characteristics of the predominant type or types of soil at most of the SPS-1 and SPS-2 site locations are given below. The sites are listed alphabetically by state. The descriptions are based on information obtained from county soil reports and from soil series available on the Internet, as well as other sources (*26-29*). It is apparent that at some of the SPS-1 and SPS-2 sites, water that enters pavement structures is likely to be able to drain downward through the natural subgrade, while at other sites, where it is not likely to drain downward, a subdrainage system would be needed to allow the water to drain laterally.

Alabama SPS-1: Appling sandy loam, with slopes ranging from 1% to 6%. This soil is an SM or SM-SC in the Unified Soil Classification System (ASTM D-2498) and an A-2 in the AASHTO Soil Classification System (AASHTO M-145). It is in hydrologic Group B. The Appling series consists of very deep, well drained, moderately permeable soils, on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed in residuum weathered from felsic igneous and metamorphic rocks. Appling sandy loam is a soil low in natural fertility and organic content. Its natural vegetation is forest, and where it has been cleared it is used for pasture and crops. Photos of the Alabama SPS-1 site and of some soil that has accumulated at an outlet in one of the drained test sections are shown in Figures 9, 10, and 11.

The taxonomic classification of Appling soils is as fine, kaolinitic, thermic Typic Kanhapludults. *Fine* refers to the soil texture, *kaolinitic* refers to the mineralogical composition being predominantly clay, and *thermic* indicates that the

Figure 9. Alabama SPS-1 site.

Figure 10. Water and soil at drainage outlet at Alabama SPS-1 site.

mean annual soil temperature is between 15°C and 22°C and that the mean winter and mean summer soil temperatures differ by less than 5°C. These soils are typical of the udult (humid) suborder of ultisols found throughout much of the southeastern United States (see Figures 12 and 13).

Arizona SPS-1: Milkweed-Quartermaster-Buckndoe complex, with slopes ranging from 2% to 20%. This is a mix of about 50% Milkweed series soils, 30% Quartermaster series soils, 15% Buckndoe series soils, and 5% other soils. Milkweed, Quartermaster, and Buckndoe soils are classified as GP, GM-GC, GP-GM, or GM in the unified system and as A-1 or A-2 in the AASHTO system. Milkweed and Quartermaster soils are classified in hydrologic Group C; Buckndoe soils are in Group B. A photo of the Arizona SPS-1 site is shown in Figure 14.

Figure 11. Soil accumulation in drainage outlet at Alabama SPS-1 site.

All three series in this complex are well drained soils, formed on fan terraces of plateaus at elevations of 4,600 to 5,500 ft. The Milkweed, Quartermaster, and Buckndoe series are shallow, moderately deep, and deep, respectively, to hardpan. Milkweed and Buckndoe soils are derived predominantly from sedimentary and igneous rocks; Quartermaster soils are derived predominantly from limestone and basalt. These soils make for grazeable woodland, firewood production, and wildlife habitat.

The taxonomic classifications of the three soils are similar. All are inceptisols, which are “young,” that is, only mildly weathered. The distribution of the major suborders of inceptisols in the United States is shown in Figure 15. Milkweed soils are classified as loamy-skeletal, mixed, superactive, mesic, shallow Petrocalcic Calciustepts. *Loamy-skeletal* refers to the soil texture, *mixed* refers to the mineralogical composition, and *superactive* refers to the cation exchange capacity of the clay component. *Mesic* indicates that the mean annual soil temperature is between 8°C and 15°C and that the mean winter and mean summer soil temperatures differ by more than 5°C.

Petrocalcic Calciustepts are soils with a cemented calcium carbonate horizon. Quartermaster soils are classified as fine-loamy, mixed, superactive, mesic Aridic (dry) Calciustepts. Buckndoe soils are classified as loamy-skeletal, mixed, superactive, mesic Aridic Calciustepts. Note that Calciustepts, being a fairly minor suborder of inceptisols, are not shown in Figure 15. They are found mainly on the Great Plains of the United States, as well as in the intermountain valleys of the western states.

Arizona SPS-2: Perryville-Rillito complex, with slopes ranging from 0% to 3%, and Gunsight-Pinal complex, with 1% to 10% slopes. These are very deep, well drained to somewhat excessively drained soils, formed on alluvial fans and terraces. Perryville, Rillito, and Gunsight soils are in hydrologic Group B; Pinal soils are in hydrologic Group D. A photo of the Arizona SPS-2 site is shown in Figure 16.

The taxonomic classifications of these soils identify them as hyperthermic (mean annual soil temperature greater than 22°C and mean winter and mean summer soil temperatures different by more than 5°C). The predominant Perryville, Rillito, and Gunsight soils are Haplocalcids, meaning that they are typical of calcid (carbonate) aridisols, the desert soils found in much of the southwestern United States, as shown in Figure 17.

Arkansas SPS-1: Dundee fine sandy loam. This soil is an ML or CL-ML in the Unified Soil Classification System and an A-4 in the AASHTO system. It is in hydrologic Group C. The Dundee series consists of very deep, somewhat poorly drained soils that formed in loamy alluvium. These soils are level to gently sloping soils on natural levees and low terraces along former channels of the Mississippi River and its tributaries in

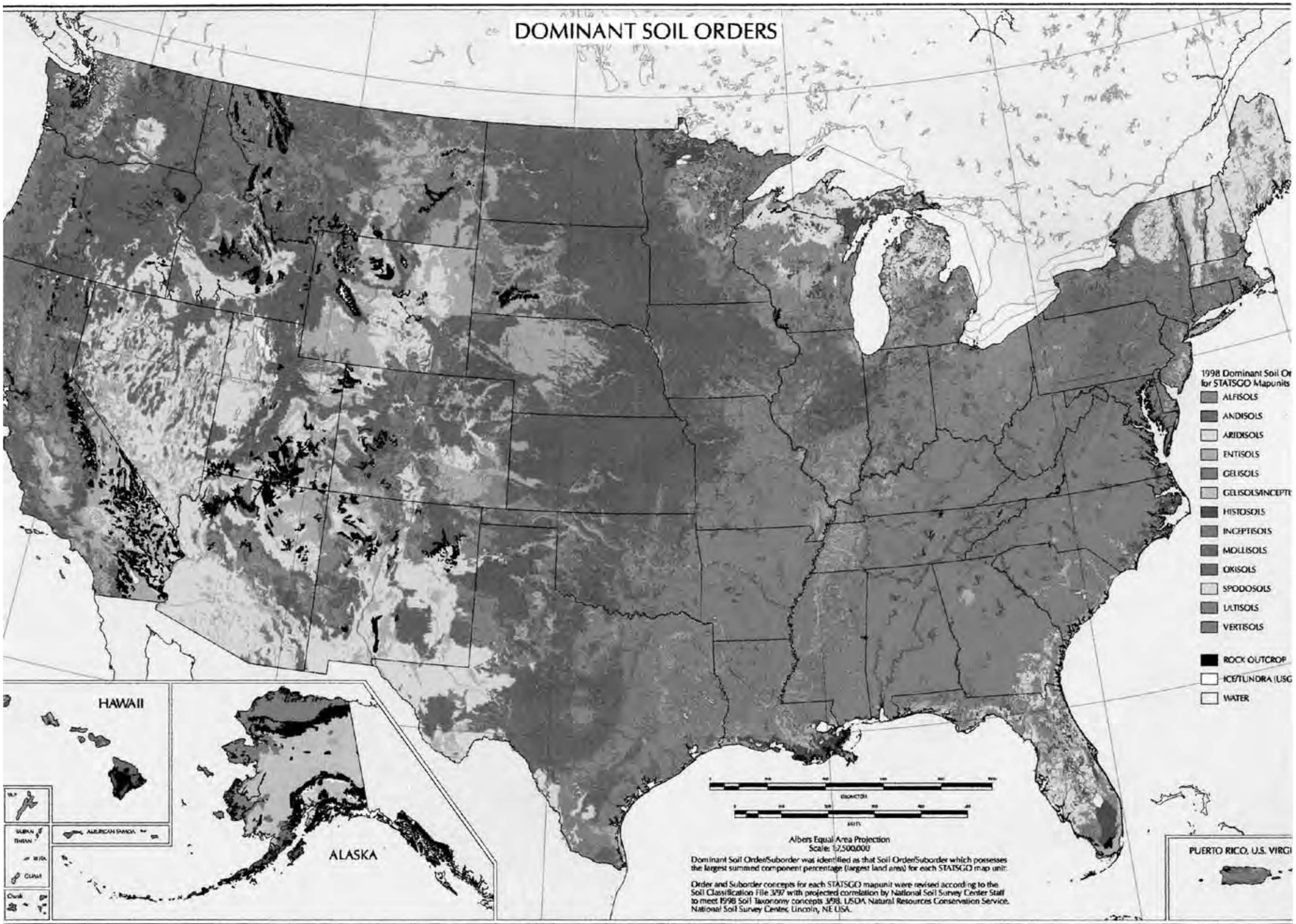

Figure 12. Dominant soil orders of the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

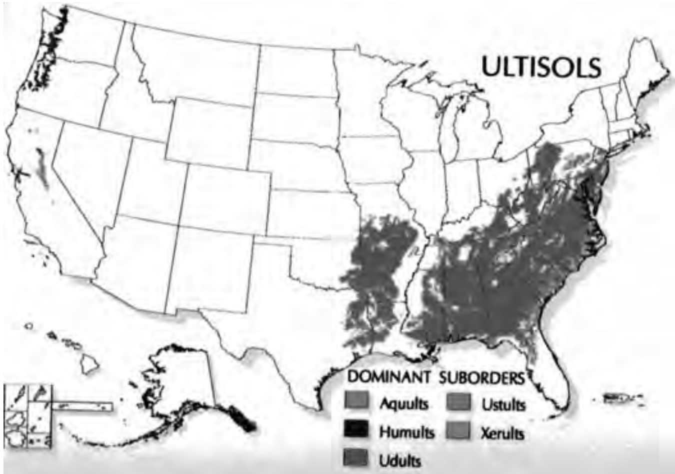

Figure 13. Distribution of ultisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

Figure 14. Arizona SPS-1 site.

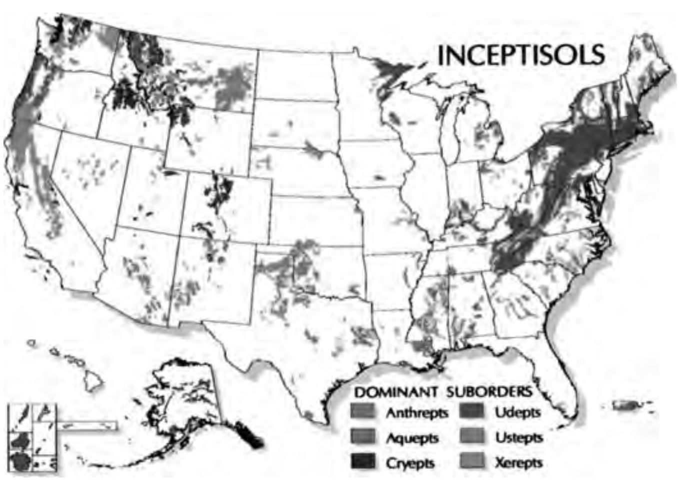

Figure 15. Distribution of inceptisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

Figure 16. Arizona SPS-2 site.

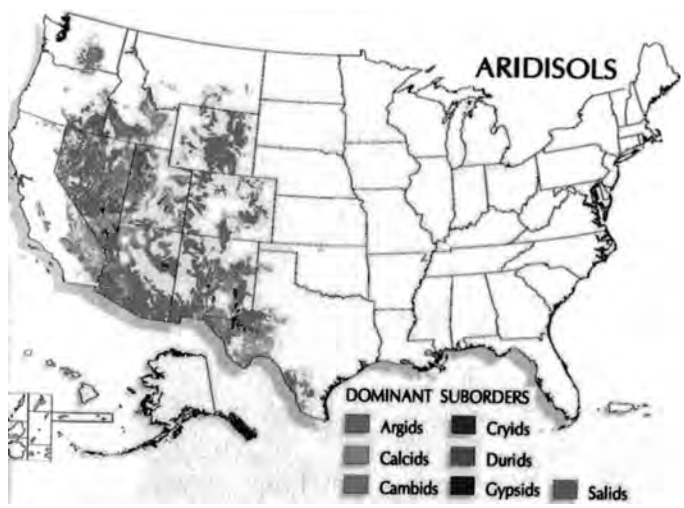

Figure 17. Distribution of aridisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

the southern Mississippi Valley. Dundee fine sandy loams have slopes of less than 1% and a shallow water table in the winter and spring. The typical crop grown in this soil is cotton. A photo from the Arkansas SPS-1 site is shown in Figure 18.

The taxonomic classification of Dundee soils are as fine-silty, mixed, active, thermic Typic Endoaqualfs. The endo- prefix indicates that these soils tend to be saturated. These soils belong to the aqualf (wet) suborder of alfisols—the fertile but poorly draining soils that are commonly found in a broad swath from the Great Lakes region, down through the Mississippi Valley all the way to the Gulf of Mexico, as shown in Figure 19.

Arkansas SPS-2: Savannah-Urban land complex, with 3% to 8% slopes. This soil is an SM or ML in the unified system and an A-2 or A-4 in the AASHTO system. It is in hydrologic Group C. The Savannah series consists of moderately well drained, moderately slowly permeable soils with a fragipan (a dense, brittle layer). A water table is perched above the fragipan at a depth of 1.5 to 3.0 ft below the surface during wet seasons (January to March). Savannah soils are formed in loamy marine or fluvial terrace deposits. They are on uplands and terraces that range from nearly level to moderately steep. The natural vegetation of Savannah soils is mixed hardwoods and pines; as the photos in Figures 20 and 21 show, the vicinity of the Arkansas SPS-2 site is forested.

Perhaps the most striking thing about the Arkansas SPS-2 site, from the standpoint of drainage as an experimental pavement design factor, is how steep and variable the longitudinal slopes are. This is evident in the photos in Figures 20 and 21.

The taxonomic classification of Savannah soils is as fine-loamy, siliceous (sandy), semiactive, thermic Typic Fragiudults. The fragi- prefix refers to the presence of a fragipan. Like the soil at the Alabama SPS-1 site, the soil at the Arkansas SPS-2 sites belongs to the udult (humid) suborder of ultisols, found throughout much of the southeastern United States (see Figure 13).

Colorado SPS-2: Vona loamy sand, 1% to 3% slopes. This soil is an SM in the unified system and an A-2 or A-4 in the

Figure 18. Arkansas SPS-1 site.

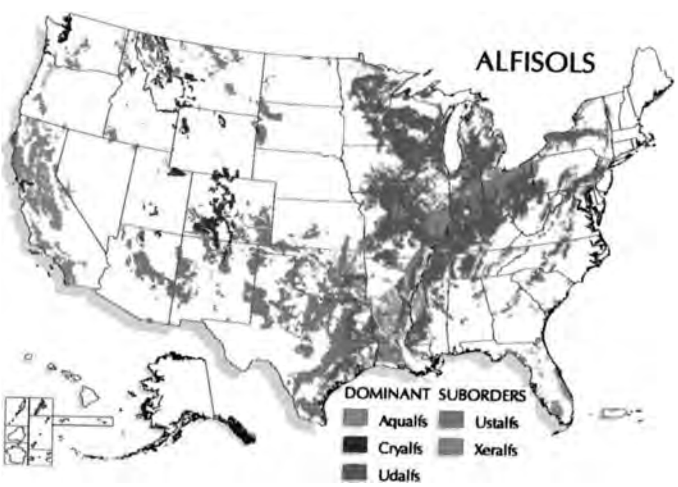

Figure 19. Distribution of alfisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

Figure 20. Arkansas SPS-2 site.

Figure 21. Arkansas SPS-2 site.

AASHTO system. The Vona series consists of very deep, well to somewhat excessively drained, moderately rapid and rapidly permeable soils that formed in eolian or partly wind-reworked alluvial materials. Vona soils are found on hills, ridges, plains, and uplands and are frequently parallel to major river channels. These soils are used for grazing cattle and for irrigated and drought-tolerant crops.

The taxonomic classification of Vona soils is as coarse-loamy, mixed, superactive, mesic Aridic Haplustalfs. *Mixed* refers to their mineralogical content, *superactive* refers to the cation exchange capacity of the clay component, and *mesic* indicates that the mean annual soil temperature is between 8°C and 15°C and that the mean winter and mean summer soil temperatures differ by more than 5°C. Aridic Haplustalfs are among the drier soils of the ustalf (dry) suborder of alfisols (see Figure 19).

Delaware SPS-1: Pocomoke sandy loam. This soil is an SM in the unified system and an A-2 or A-4 in the AASHTO system. The Pocomoke series consists of very deep, very poorly drained soils, formed in sandy sediments, mostly of marine origin, on low-lying terraces of the Atlantic and Gulf Coastal Plains. Slopes range from 0% to 2%. The water table is seasonally at or near the surface, and it remains at this level for long periods of time unless the soil is artificially drained. The flatness of the Delaware SPS-1 site is evident in Figure 22.

The taxonomic classification of Pocomoke soils is as coarse-loamy, siliceous, active, thermic Typic Umbraquults. The umbra- prefix indicates that the A horizon (the top 10 in. or so) is dark in color, due to the organic matter present. Aquults are aquic (wet) ultisols (see Figure 13).

Delaware SPS-2: Sassafras sandy loam, with 0% to 2% slopes. The Delaware SPS-2 site is located very near the Delaware SPS-1 site, but its soil is of a different type, with better drainage characteristics. The textures of the two soils are similar: like Pocomoke sandy loam, Sassafras sandy loam is an SM or ML in the unified system and an A-2 or A-4 in the AASHTO system. One key difference is that the depth to the seasonal high water table is greater than 5 ft for the Sassafras soil at the SPS-2 site, but 0 ft for the Pocomoke soil at the SPS-1 site. So while the SPS-1 site's soil is classified as very poorly drained, the SPS-2 site's soil is classified as well drained. A photo of the Delaware SPS-2 site is shown in Figure 23.

The taxonomic classification of Sassafras soils is as fine-loamy, siliceous, semiactive, mesic Typic Hapludults. This is similar to the classification of the Pocomoke soils at the SPS-1 site. One curious difference is that the SPS-1 site's soil is classified as belonging to the thermic temperature regime (mean annual temperature of 15°C to 22°C), while the SPS-2 site's soil is classified as belonging to the mesic regime (mean annual temperature of 8°C to 15°C). In fact, as shown in Tables 12 and 13, the two sites have nearly the same mean annual temperature (about 13°C), as one would expect, considering how close they are to each other. So while one soil series might more typically be found in the thermic regime and the other in the mesic regime, in this particular instance, these two locations both meet the definition of the thermic regime.

Florida SPS-1: Pahokee muck. This is classified as a Pt in the Unified Soil Classification System; there is no corresponding class in the AASHTO system. It is in the A/D dual hydrologic class. Pahokee soils, which occupy the central and southern parts of the Everglades, are nearly level, very poorly drained organic soils that are 36 to 51 in. thick over limestone. Typically, they have a surface layer of black muck, over a black and dark reddish brown muck, resting on hard limestone. Pahokee mucks are formed in organic deposits of freshwater marshes. In natural areas the water table is at or above the surface for much of the year; in other areas the water table is controlled by artificial means.

Figure 22. Delaware SPS-1 site.

Figure 23. Delaware SPS-2 site.

The taxonomic classification of Pahokee soils is as euic, hyperthermic Lithic Haplosaprists. *Euic* indicates a high base content. The hyperthermic soil moisture regime has a mean annual soil temperature greater than 22°C and a difference of more than 5°C between the mean summer and mean winter soil temperatures. *Lithic* means that the soils are near stone. They belong to the saprist (unrecognizable fibers) suborder of histosols, organic soils found in wetlands (see Figure 24).

Iowa SPS-1: Fayette silt loam, 2% to 5% slopes. This soil is a CL or CL-ML soil in the Unified Soil Classification System and an A-4 or A-6 in the AASHTO system. It is in hydrologic Group B. The Fayette series consists of very deep, well drained, moderately permeable soils, formed in loess. These soils are on convex crests, interfluves and side slopes on uplands, and on treads and risers on high stream terraces. The seasonal high water table is more than 6 ft deep. The taxonomic classification of Fayette silt loam is fine-silty, mixed, superactive, mesic Typic Hapludalfs, of the alfisol order (see Figure 19). The Iowa SPS-1 site is shown in Figure 25.

Kansas SPS-1: Naron fine sandy loam, 1% to 3% slopes. This soil is an SM, SM-SC, ML, or CL-ML in the Unified Soil Classification System and A-2 or A-4 in the AASHTO system. It is in hydrologic Group B. The seasonal high water table is more than 6 ft deep. The Naron series consists of very deep, well drained, moderately permeable soils that formed in loamy eolian sediments. These soils are on dunes on terraces in river valleys of the Great Bend Sand Plains.

The taxonomic classification of Naron soils is as fine-loamy, mixed, superactive, mesic Udic Argiustolls. The argi-prefix refers to the presence of a clay horizon. These soils belong to the ustic (intermittently dry during the summer) suborder of mollisols—the dark, soft, grassland soils that cover much of the Great Plains, as well as much of Iowa and northern and central Illinois (Figure 26). The Kansas SPS-1 site is shown in Figure 27.

Figure 25. Iowa SPS-1 site.

Kansas SPS-2: Hobbs silt loam, channeled, and Clime-Sogn complex, with 5% to 20% slopes. The Kansas SPS-2 site is shown in Figure 28.

Hobbs silt loam is a CL or CL-ML in the Unified Soil Classification System and an A-4 or A-6 in the AASHTO system. It is in hydrologic Group B. The seasonal water table is more than 6 ft deep. The Hobbs series consists of very deep, well drained, moderately permeable soils that formed in stratified, silty alluvium. These soils are on flood plains, foot slopes, and alluvial fans. The Hobbs silt loam soil is deep, nearly level soil with entrenched stream channels along intermittent drainageways. This soil is mostly used for rangeland and wildlife areas.

Figure 24. Distribution of histosols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

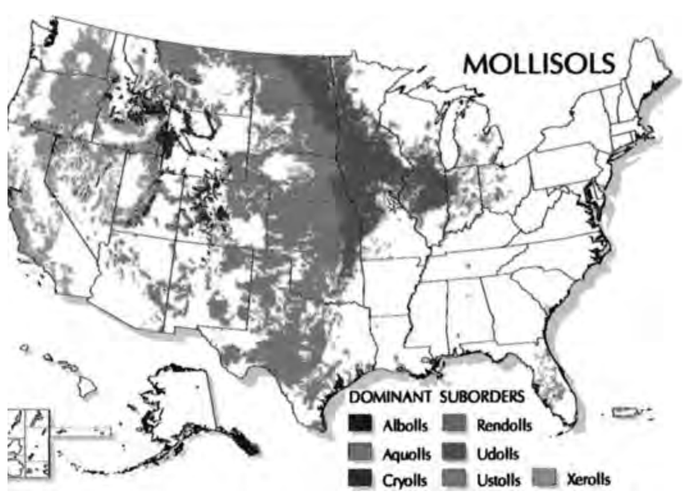

Figure 26. Distribution of mollisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

Figure 27. Kansas SPS-1 site.

The taxonomic classification of Hobbs soils is as fine-silty, mixed, superactive, nonacid, mesic Mollic Ustifluvents. *Mollic* refers to a soft, dark, highly organic surface layer. The usti- prefix refers to intermittent dryness in summer. These soils belong to the fluvent (formed from alluvial deposits) suborder of entisols—a category that encompasses a wide range of "new" soils with little in common other than the near or total lack of soil profile development (Figure 29).

The Clime-Sogn complex consists of well drained and somewhat excessively drained soils, some moderately deep (Clime) and some shallow (Sogn), on uplands. The complex is 50% to 80% Clime soils and 10% to 30% Sogn soils. These soils are best suited for rangeland; they have poor potential for cropland.

The Clime series consists of moderately deep, well drained, slowly permeable soils on uplands, formed in residuum from calcareous clayey shale. Clime is in the CL or CH class in the Unified Soil Classification System and an A-7 or A-6 in the AASHTO system. It is in hydrologic Group C. The taxonomic classification of the Clime series is as fine, mixed, active, mesic Udorthentic Haplustolls. *Udorthentic* refers to the characteristics of the surface layer (that is, resembling udic entisols such as relatively steep slopes of exposed loess or shale). Clime soils belong to the ustic (dry in summer) suborder of mollisols (see Figure 26).

Figure 28. Kansas SPS-2 site.

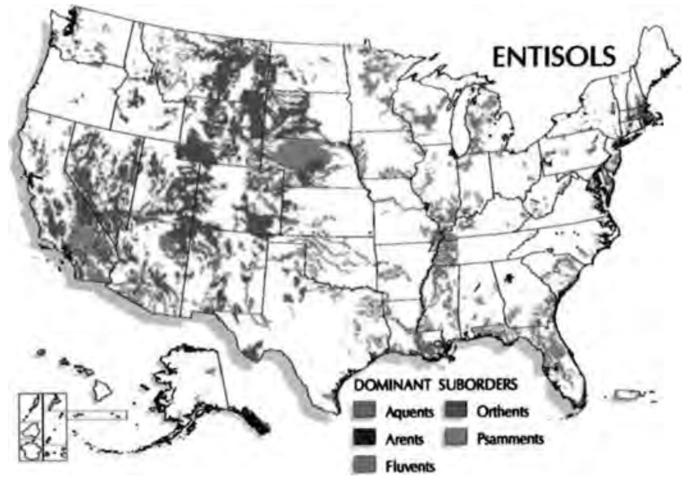

Figure 29. Distribution of entisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

The Sogn series consists of shallow and very shallow, somewhat excessively drained, soils that formed in uplands from residuum weathered from limestone. Sogn is in the CL class in the unified system and in the A-7 or A-6 class in the AASHTO system. It is in hydrologic Group D. The taxonomic classification of Sogn is as loamy, mixed, superactive, mesic Lithic Haplustolls. *Lithic* means near stone. Like the Clime soils that share this complex, Sogn soils are in the ustic suborder of mollisols (see Figure 26).

Louisiana SPS-1: Brimstone silt loam. This soil is a CL-ML or CL in the Unified Soil Classification System and an A-4 or A-6 in the AASHTO system. It is in hydrologic Group D. The Brimstone series consists of deep, poorly drained, slowly permeable soils that are high in exchangeable sodium. They formed in loamy sediments on low Late Pleistocene terraces. These soils are on broad flats at intermediate elevations. Slopes range from 0% to 1%. Water runs off the surface slowly and stands in low places for short periods after a heavy rain. The surface layer remains wet for long periods after a heavy rain. The seasonal high water table fluctuates between the surface and a depth of 1.5 ft from December through April. This type of soil is well suited for cultivating crops such as rice and soybeans and moderately well suited for pasture, although both cultivated crops and pasture plants require drainage to survive in this soil. The Louisiana SPS-1 site is shown in Figure 30.

Figure 30. Louisiana SPS-1 site.

Figure 31. Michigan SPS-1 site.

The taxonomic classification of Brimstone soils is as fine-silty, siliceous, superactive, thermic Glossic Natraqualfs. *Glossic* refers to the tongued interlayering of the horizons. The natr- prefix refers to the presence of a natric horizon (a layer of silicate clay with more than 15% exchangeable sodium ions). These soils belong to the aquic (wet) suborder of alfisols (see Figure 19).

Michigan SPS-1: Capac loam, with 0% to 4% slopes. This soil is an ML or CL in the Unified Soil Classification System and an A-4 in the AASHTO system. The Capac series consists of very deep, somewhat poorly drained, moderately slowly permeable soils that formed in loam or clay loam calcareous till. These soils are on moraines and till plains of the Wisconsinian glaciation and typically have slopes ranging from 0% to 6%. The taxonomic class of Capac soils is fine-loamy, mixed, active, mesic Aquic Glossudalfs. The gloss- prefix in the name means that the soil horizons are tongued, or interlacing. Glossudalfs are in the udalf (moist) suborder of alfisols (see Figure 19). The Michigan SPS-1 site is shown in Figure 31.

Michigan SPS-2: Pewamo clay loam. This soil is a CL in the Unified Soil Classification System and an A-6 or A-7 in the AASHTO system. It is in the C/D dual hydrologic class. The water table is near or above the surface in winter and spring. The Pewamo series consists of very deep, very poorly drained soils formed in till on moraines and lake plains. Permeability is moderately slow. This soil is found in low areas and depressions and is subject to frequent ponding. Figure 32 is a photo from the Michigan SPS-2 site, showing a pond alongside the roadway. The surface of the water in the pond appeared to be at a level not very different from the surface of the pavement.

The taxonomic classification of Pewamo soils is as fine, mixed, active, mesic Typic Argiaquolls. The argi- prefix refers to the presence of a clay horizon. They are in the aquic (wet) suborder of mollisols (see Figure 26).

Montana SPS-1: Virgelle-Absher complex, with slopes ranging from 0% to 3%. This soil is about 55% Virgelle loamy fine sand and 30% Absher clay loam. The Virgelle sand occupies the smooth slopes and convex areas, and the Absher soil occupies shallow depressions. A photo of the Montana SPS-1 site is shown in Figure 33.

The Virgelle series consists of very deep, well drained soils that formed mainly in alluvium or eolian. These soils are on stream terraces and till plains at elevations of 3,300 to 3,600 ft. These soils are suitable for crops such as wheat and for rangeland or pastureland. This soil is an SM in the unified system and an A-2 in the AASHTO system. It is in hydrologic Group C. The seasonal high water table is more than 6 ft below the surface.

The taxonomic classification of Virgelle soils is as clayey, mixed over smectitic, frigid Entic Haplustolls. *Smectite* is the name used for clays that used to be called montmorillonite.

Figure 32. Michigan SPS-2 site.

Figure 33. Montana SPS-1 site.

Figure 34. MnRoad site.

Frigid refers to the soil moisture regime (mean annual soil temperature between 0°C and 8°C, and greater than 5°C difference between the mean winter and mean summer soil temperature). These soils belong to the ustic (intermittently dry) suborder of mollisols (see Figure 26).

The Absher series consists of very deep, well, and moderately well drained soils that formed in till, glaciofluvial deposits, and alluvium derived from many sources of geologic materials. These soils are on alluvial fans, stream terraces, drainageways, sedimentary plains, and till plains. This soil is a CL in the unified system and an A-6 or A-7 in the AASHTO system. It is in hydrologic Group D. The seasonal high water table is more than 6 ft below the surface.

The taxonomic classification of the Absher series is as fine, smectitic, frigid, leptic Torrertic Natrustalfs. Torrertic refers to a surface horizon with vertical cracks indicative of shrink-swell behavior. The natr- prefix refers to the presence of a natric horizon. These soils belong to the ustalf (dry) suborder of alfisols (see Figure 19).

MnRoad: Hayden loam, with slopes ranging from 2% to 6%, and Dundas and Ames silt loams with 0% to 3% slopes. The MnRoad site is shown in Figure 34, and a diagram from the county soil report, showing the drainage characteristics of the major soil series of Wright County, Minnesota, is shown in Figure 35. Some of the MnRoad test sections are located in areas of fairly flat or mild slopes, with the pavement surface higher than the surrounding ground, while other test sections are located in low areas between hills, with the surrounding ground higher than the pavement surface or with ponded water alongside the roadway at almost the level of the pavement surface. In general, this variability in terrain makes the MnRoad site seem less suited for the study of subsurface drainage than for the study of other pavement design factors.

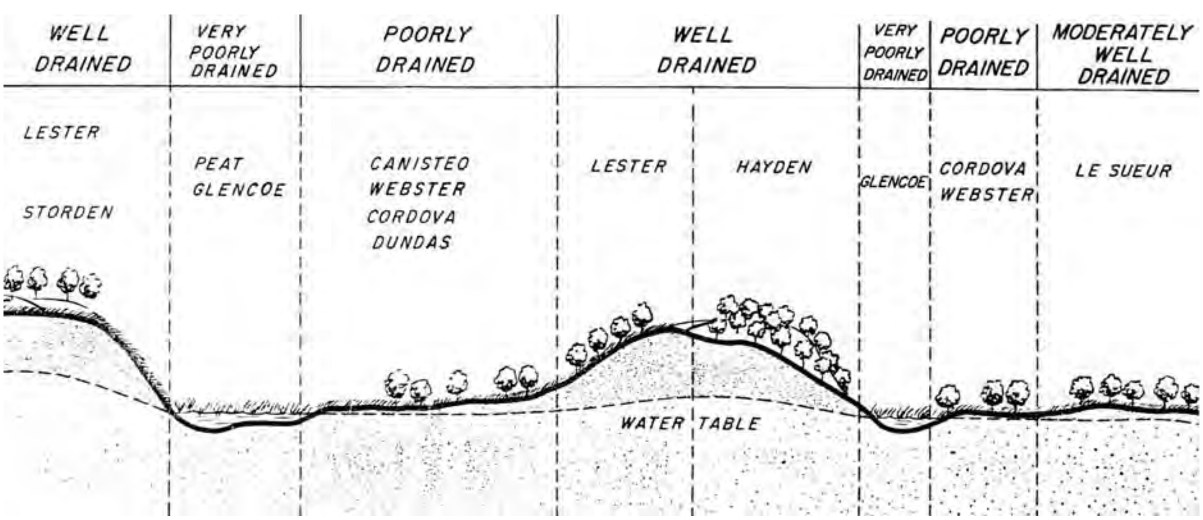

Figure 35. Major soils series in Wright County, Minnesota.

Hayden loam is an ML-CL in the unified system and an A-6 in the AASHTO system. The Hayden series consists of deep, well drained, moderately permeable soils that formed in calcareous loamy glacial till on glacial moraines and till plains. In general, the slopes are gently undulating but irregular, and small areas of poorly drained soils are found in depressions between the slopes. The taxonomic classification of Hayden soils is as fine-loamy, mixed, superactive, mesic Glossic Hapludalfs. They belong to the udalf (moist) suborder of alfisols (see Figure 19).

The Dundas and Ames silt loam map unit is more than 60% Dundas soils. Dundas silt loam is an MH or OH in the unified system and an A-5 in the AASHTO system. The Dundas series consists of very deep, nearly level, poorly drained soils that formed in loamy calcareous till on moraines. They formed mostly in friable calcareous, glacial till of the late Wisconsin stage. These soils have moderately low saturated hydraulic conductivity. Dundas and Ames are fair to good for crops and good for pasture; wetness is, however, a problem because water moves slowly through these soils even with artificial drainage.

The taxonomic classification of Dundas soils is as fine-loamy, mixed, superactive, mesic Mollic Endoaqualfs. Mollic refers to a mollic (soft, dark, organic) surface layer. The endo- prefix indicates that these soils tend to be saturated. These soils belong to the aqualf (wet) suborder of alfisols (see Figure 19).

Nebraska SPS-1: Geary silty clay loam, with 3% to 7% slopes, eroded; and Hastings silty clay loam, 3% to 7% slopes, eroded. The Geary silty clay loam is on ridge crests and gently side slopes. It is a CL in the unified system and an A-6 in the AASHTO system. The Hastings soils, which occur at higher elevations than the Geary soils, are CL or CH in the unified system and an A-6 or A-7 in the AASHTO system. The main concerns about Geary and Hastings soils, with respect to their suitability for a highway location, are their high to very high susceptibility to frost action and their erodibility.

The Geary series consists of very deep, well drained, moderately or moderately slowly permeable soils that formed in loess. These soils are on uplands. The taxonomic classification of Geary soils is as fine-silty, mixed, superactive, mesic Udic Argiustolls. The argi- prefix refers to the presence of a clay horizon. These soils belong to the ustoll (intermittently dry) suborder of mollisols (see Figure 26).

The Hastings series consists of very deep, well drained soils on uplands. They formed in silty loess. Permeability is moderately slow. The taxonomic classification of Hastings soils is as fine, smectitic, mesic Udic Argiustolls. Like the Geary soils, they belong to the ustoll (intermittently dry) suborder of mollisols (see Figure 26).

North Carolina SPS-2: Cecil sandy loam, with slopes ranging from 2% to 8%. Soils in the Cecil series are very deep, well drained, moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock. They formed in residuum weathered from felsic, igneous, and high-grade metamorphic rocks. They are well drained, with medium to rapid runoff, medium internal drainage, moderate permeability, and low shrink-swell potential. The seasonal high water table is below 6 ft. Cecil soils are found throughout the Piedmont area of Alabama, Georgia, North Carolina, South Carolina, and Virginia.

The taxonomic classification of Cecil soils is as fine, kaolinitic, thermic Typic Kanhapludults. (Note that this is the same taxonomic classification as at the Alabama SPS-1 site.) *Kaolinitic* indicates that the subsoil is clayey. *Thermic* indicates that the mean annual soil temperature is between 15°C and 22°C and that the mean winter and mean summer soil temperatures differ by less than 5°C. These soils are typical of the udult (humid) suborder of ultisols, found throughout much of the southeastern United States (see Figure 13).

North Dakota SPS-2: Fargo silty clay. This soil is a CH in the unified system and an A-7-6 in the AASHTO system. It is in hydrologic Group D. The seasonal high water table is 0 to 3 ft below the surface. The Fargo series consists of very deep, poorly drained and very poorly drained, slowly permeable soils that formed in calcareous, clayey lacustrine sediments. These soils are on glacial lake plains, floodplains, and gently sloping side slopes of streams within glacial lake plains. Slopes range from 0% to 6%. A system of legal drains, section lines, road ditches, and field drains remove surface water from most Fargo soils.

The taxonomic classification of Fargo soils is as fine, smectitic, frigid Typic Epiaquerts. The epi- prefix indicates the presence of a perched water table. These soils are in the aquert (wet) suborder of vertisols, which consist of shrinking and swelling clay soils. As shown in Figure 36, vertisols are found in fairly few places in the United States. The greatest concentrations of dry vertisols are in eastern Texas and western South Dakota. The greatest concentrations of wet vertisols are along the lower Mississippi River and along the border of North Dakota with Minnesota, where, unfortunately, the North Dakota SPS-2 site is located.

Oklahoma SPS-1: Foard-Hinkle complex, with 1% to 3% slopes. This is a mix of Foard silt loam and Hinkle silt loam. The Oklahoma SPS-1 site is shown in Figure 37.

Both the Foard and the Hinkle series consist of very deep, well drained, very slowly permeable soils that formed in material weathered from old alluvium of granitic outwash. Both are nearly level to gently sloping soils on broad summits and shoulder slopes of terrace pediments in the Central Rolling Red Plains and the Wichita Mountains. The taxonomic classification of both Foard and Hinkle soils is fine, smectitic, thermic Vertic Natrustolls. *Vertic* indicates the presence of a surface layer with shrink-swell potential. The natr- prefix refers to the presence of natric horizon. These soils are of the ustoll (dry) suborder of mollisols (see Figure 26.)

Texas SPS-1: Nueces-Sarita complex, with 0% to 3% slopes. A photo of the Texas SPS-1 site is shown in Figure 38. Both Nueces and Sarita soils are very deep, well drained, moderately

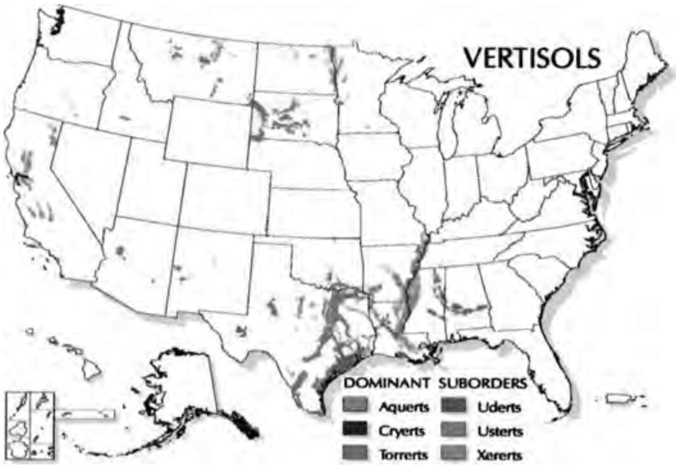

Figure 36. Distribution of vertisols in the United States. SOURCE: U.S. Department of Agriculture, Natural Resources Conservation Service.

rapidly permeable soils, formed in sandy eolian materials overlying loamy sediments. These soils are on gently undulating sandy eolian plains associated with vegetated dunes on the Sandsheet Prairie of the South Texas Coastal Plain.

The taxonomic classification of Nueces soils is as loamy, mixed, superactive, hyperthermic Arenic Paleustalfs. *Arenic* refers to the presence of a sandy horizon. The pale- prefix refers to old development. The taxonomic classification of Sarita soils is as loamy, mixed, active, hyperthermic Grossarenic Paleustalfs. Both Nueces and Sarita soils are in the ustalf (dry) suborder of alfisols (see Figure 19).

Virginia SPS-1: Appling sandy loam, with 7% to 15% slopes. Other than the steeper slopes, this is the same soil as at the Alabama SPS-1 site and it has the same taxonomic classification (fine, kaolinitic, thermic Typic Kanhapludults) as the Cecil sandy loam at the North Carolina SPS-2 site. A photo of the Virginia SPS-1 site is shown in Figure 39.

Figure 37. Oklahoma SPS-1 site.

Figure 38. Texas SPS-1 site.

Washington SPS-2: Ritzville silt loam. The Ritzville series consists of very deep and deep to duripan, well drained, moderately permeable soils formed in loess. Ritzville soils are located on uplands, including plateaus, benches, and canyon side slopes. Elevations range from 800 to 3,000 ft, and slopes range from 0% to 70%. These soils formed in loess. They have a small amount (less than 20%) of volcanic ash in the surface layer. These soils are in a semiarid climate with cool, moist winters and warm, dry summers. A photo of the Washington SPS-2 site is shown in Figure 40. The taxonomic classification of Ritzville soils is coarse-silty, mixed, superactive, mesic Calcidic Haploxerolls. These soils belong to the xeroll (dry summers, moist winters) suborder of mollisols (see Figure 26).

Wisconsin SPS-1: Kennan sandy loam, with 8% to 30% slopes, and Seelyeville muck. Kennan soils are gently sloping to steep and are well drained. They are formed in sandy loam or loamy sand glacial till, and they are found on the tops and

Figure 39. Virginia SPS-1 site.

Figure 40. Washington SPS-2 site.

sides of knolls, hills, and ridges on terminal and recessional moraines. They are classified as SM, SM-SC, ML, or CL-ML in the unified system and as A-2, A-4, or A-1 in the AASHTO system. The taxonomic classification of Kennan soils is as coarse-loamy, mixed, superactive, frigid Haplic Glossudalfs. The gloss- prefix in the name means that the soil horizons are tongued, or interlacing. Glossudalfs are in the udalf (moist) suborder of alfisols—the fertile but poorly draining soils that are commonly found in the Great Lakes and Mississippi Valley regions (see Figure 19).

The Seelyeville series consists of very deep, very poorly drained soils that formed in organic materials more than 51 in. thick. These soils are on glacial outwash plains, valley trains, flood plains, glacial lake plains and glacial moraines. Seelyeville soil is a PT in the Unified Soil Classification System and an A-8 in the AASHTO system. The taxonomic classification is euic, frigid Typic Haplosaprists. *Euic* signifies that the soil is organic and has a pH of 4.5 or more. Seelyeville soils belong to the saprist (unrecognizable fibers) suborder of histosols—organic soils found in wetlands (see Figure 24).

Wisconsin SPS-2: Rosholt silt-loam, Scott Lake silt loam, and Oesterle loam, all with slopes ranging from 0% to 2%. The Rosholt series consists of very deep, well drained soils that are moderately deep to sandy outwash. These soils formed mostly in loamy alluvial deposits and are underlain by stratified sandy outwash. They are classified as SM, SM-SC, ML, or CL-ML in the unified system and as A-2, A-4, or A-1 in the AASHTO system. The taxonomic classification of Rosholt soil is as a coarse-loamy, mixed, superactive, frigid Haplic Glossudalf (which is the same taxonomic classification as the Kennan soil at the nearby Wisconsin SPS-1 site).

Scott Lake soils are moderately well drained and are found on broad flats adjacent to lower depressions. They are classified as ML, CL-ML, SM, or SM-SC in the unified system and as A-4 in the AASHTO system. Their taxonomic classification is coarse-loamy, mixed, superactive, frigid Oxyaquic Glossudalfs. The moisture regime of this soil is indicated by the suborder name oxyaquic, meaning oxygenated water.

The Oesterle series consists of very deep, somewhat poorly drained soils that are moderately deep to underlying sandy outwash. They formed dominantly in loamy alluvium underlain by sandy outwash on outwash plains, valley trains, stream terraces, glacial lake plains, and outwash areas on moraines. They are classified as CL-ML, SM-SC, CL, or SC in the unified system and as A-4 in the AASHTO system. Their taxonomic classification is coarse-loamy, mixed, superactive, frigid Aquic Glossudalfs.

Traffic at the SPS-1 and SPS-2 Sites

The 18-kip equivalent single-axle load (ESAL) levels at the SPS-1 and SPS-2 sites were determined by extracting ESAL estimates from the TRF_MON_EST_ESAL table and axle load distributions from the TRF_MONITOR_AXLE_DISTRIBUTION table in the LTPP database.

Axle load distribution data were available for 12 of the 18 SPS-1 sites and 11 of the 14 SPS-2 sites. Data were not available for the SPS-1 sites in Alabama, Louisiana, Montana, Oklahoma, Texas, and Wisconsin, nor were data available for the SPS-2 sites in California, North Dakota, and Wisconsin.

ESALs were calculated for the years in which axle load distribution data were available, using the number of axles reported in each load range in the distribution, and load equivalency factors calculated as a function of structural number (in turn calculated from as-built layer thicknesses and typical structural coefficients for layer materials) or slab thickness. Average annual ESALs for the site were calculated using the annual ESAL estimates for the different test sections at the site. The average annual ESAL estimates for each site were then used to calculate accumulated ESAL estimates from the date the section was opened to traffic to each of several dates when distress and profile measurements were taken. The monitoring dates used were those on which measurements were obtained for most or all of the test sections at the site.

Estimated accumulated ESALs are plotted for each of the SPS-1 sites with available traffic data in Figure 41 and for each of the SPS-2 sites in Figure 42. The different scales on the vertical axes of the two figures should be noted. In general, the SPS-2 sites have carried more truck traffic than have the SPS-1 sites; more than half of the SPS-2 sites have carried more truck traffic than the two most heavily trafficked SPS-1 sites.

Because so many of the SPS-1 sites are located on lower volume roads (compared with the SPS-2 sites), extrapolating the findings from this study, or any study involving SPS-1 and SPS-2 data, to higher accumulated ESAL levels will be less reliable for the SPS-1 sites than for the SPS-2 sites.

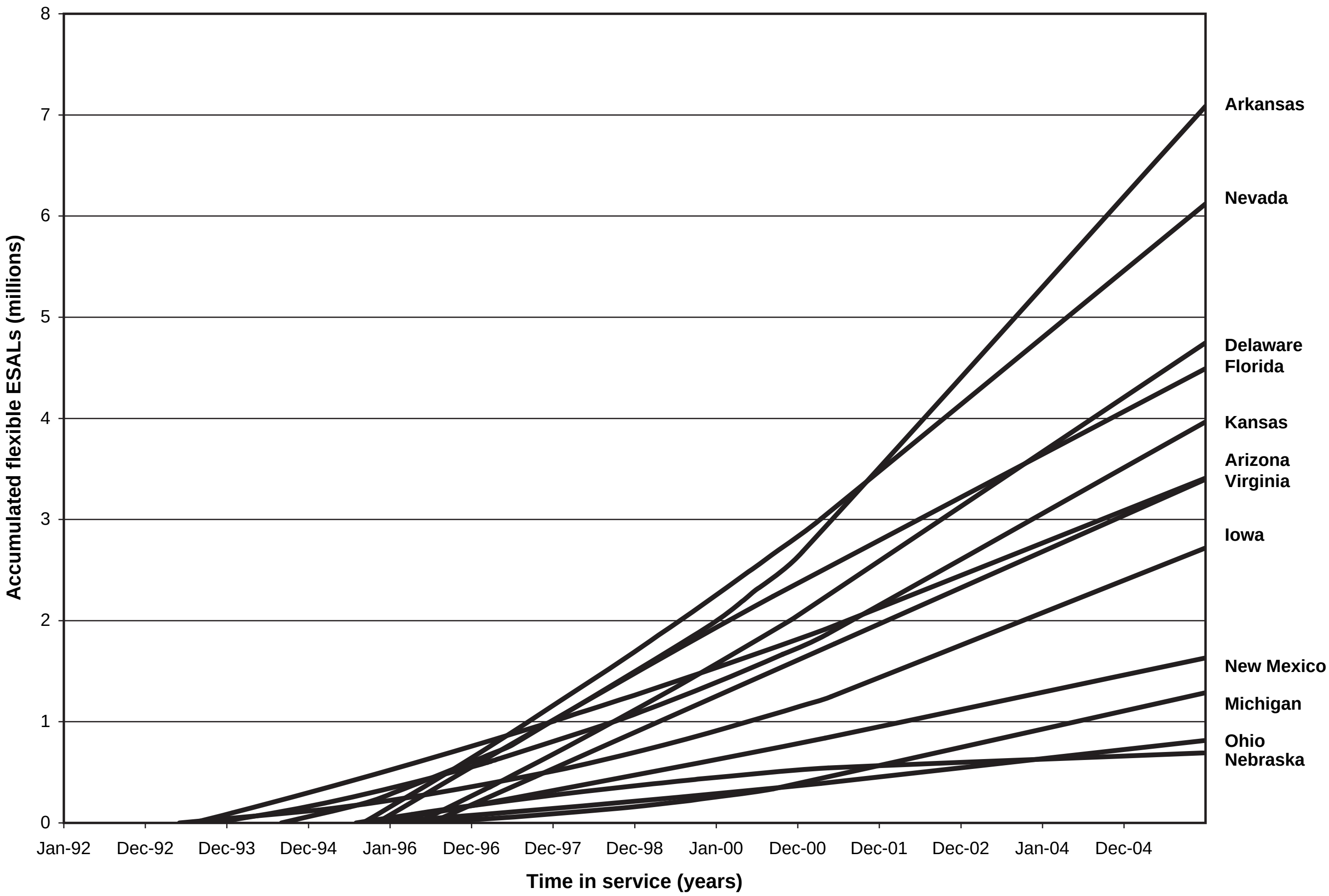

Figure 41. Estimated accumulated ESALs for SPS-1 sites with traffic data available.

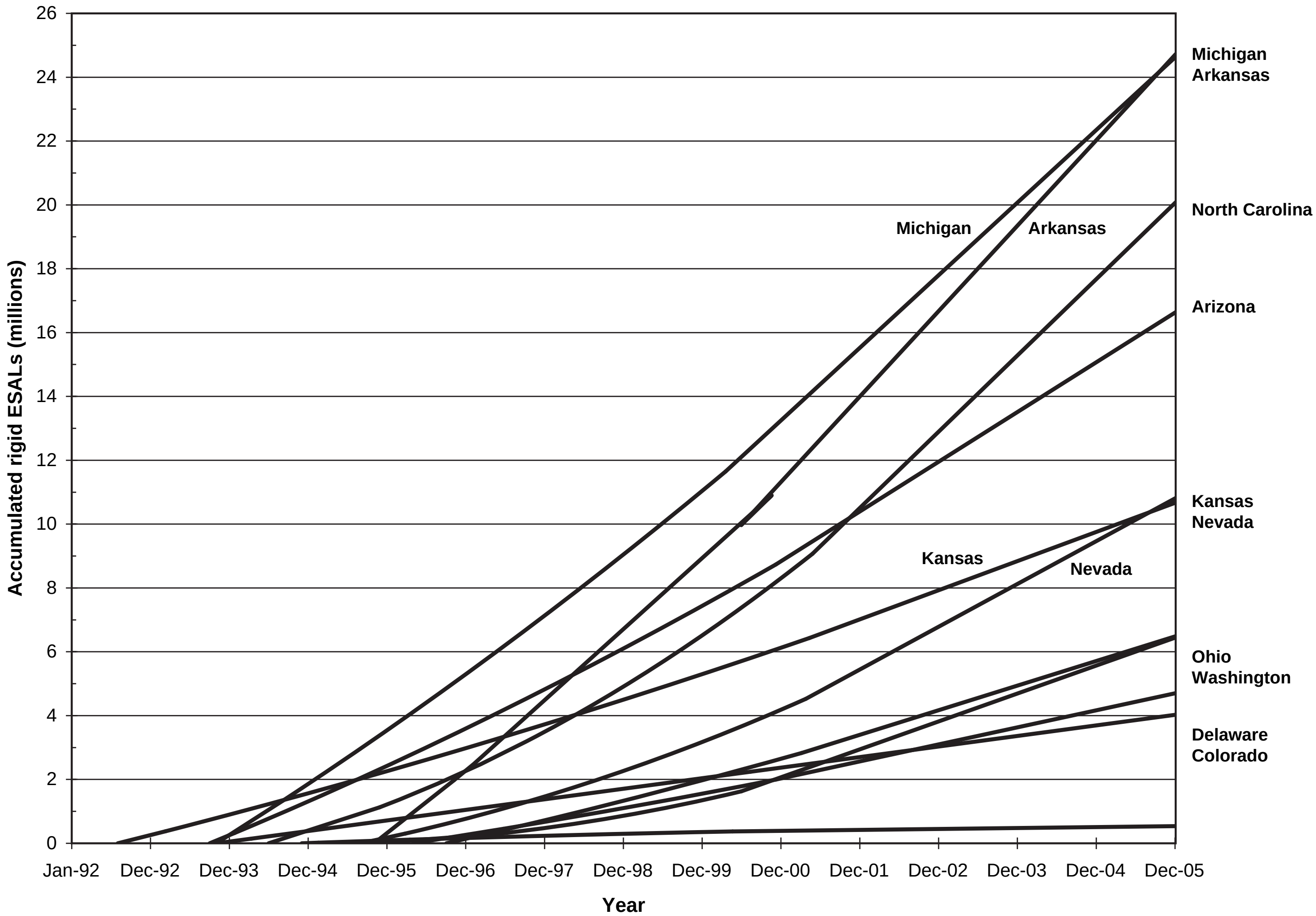

Figure 42. Estimated accumulated ESALs for SPS-2 sites with traffic data available.

CHAPTER 3

Field Testing of Drainage Systems

Field Testing Procedure

Pilot testing of the procedure and equipment developed for determining the flow rate of water through the subsurface drainage systems in the SPS-1 and SPS-2 sites was conducted at the SPS-1 and SPS-2 sites in Arkansas and at other, non-LTPP sites in Wisconsin. Based on that testing, some improvements were made to the procedure before flow rate testing was conducted at the remaining SPS-1 and SPS-2 sites. The testing procedure took at most 1 hour per test section, or a maximum of 6 hours at SPS-1 sites and a maximum of 4 hours at SPS-2 sites.

To accommodate the testing, the state DOT either set up a moving traffic control operation or closed a full outer lane. The testing procedure is described below.

Locating and Clearing the Outlets

For each of the drained test sections (the six sections with permeable asphalt-treated base layers and edgedrain/outlet systems at each SPS-1 site, and the four sections with permeable asphalt-treated base layers and edgedrain/outlet systems at each SPS-2 site), the drainage outlets were located. The results from the video inspections conducted earlier were helpful in locating the outlets. In addition, state DOT staff and regional LTPP center representatives knowledgeable about the construction of the test sections were often on site to assist with locating the outlets.

At many of the sites, the outlet headwalls were unmarked and obscured by tall vegetation (see Figures 43 through 46, for example). At some sites, the outlet headwalls were also completely covered by dirt, gravel, and other vegetation that had to be dug out with hand tools (see Figures 47 through 51). In one case, a metal detector had to be used to find the outlets. Even when the outlet headwall was visible and fairly clear, it was often necessary to use hand tools to clear dirt and debris out of the first foot or so of the outlet.

Measuring Longitudinal Grade

Because no coring was permitted within the test sections, coring was done in the transition sections just outside the test section limits. In some cases, it was evident which of the test section ends was higher than the outlet to be tested, but for those pavements with almost no longitudinal grade, it was necessary to determine which test section end was higher. The longitudinal grade was measured using a carpenter's level with a digital display (Figure 52).

Coring

A core was cut through the pavement surface down to the top of the permeable base layer. The as-constructed layer thickness information (see Appendix A) was consulted to determine the depth of coring necessary to reach the top of the PATB layer. At some locations, it was not possible to remove all of the hot-mix asphalt (HMA) material above the permeable asphalt-treated base because of the HMA's considerable thickness. At those locations, the coring was advanced through the top of the permeable asphalt-treated base, so that water could flow down into the base during the testing. The coring was conducted by the state DOT (Figure 53) in all but one case; when one DOT was unable to provide a coring rig and operator, the consultant rented the necessary equipment and conducted the coring (Figure 54).

Other Measurements

Because coring had to be conducted outside the limits of the test section, but the locations of the drainage outlets inside the limits of the test sections were not consistent from site to site, it was necessary to obtain a variety of distance and elevation measurements that could be used to later calculate the length of the flow path. A measuring wheel was used to

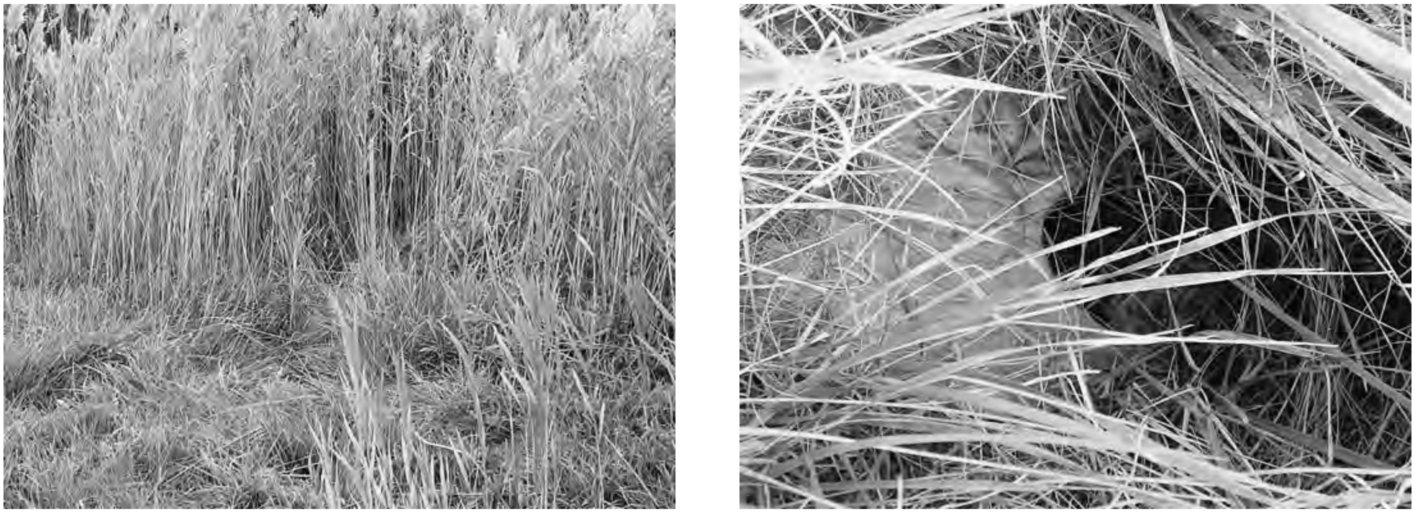

Figure 43. View from shoulder and close-up view of overgrown drainage outlet, Michigan SPS-2.

Figure 44. View from shoulder and close up view of overgrown drainage outlet, Kansas SPS-2.

Figure 45. View from shoulder and close-up view of overgrown drainage outlet, Iowa SPS-2.

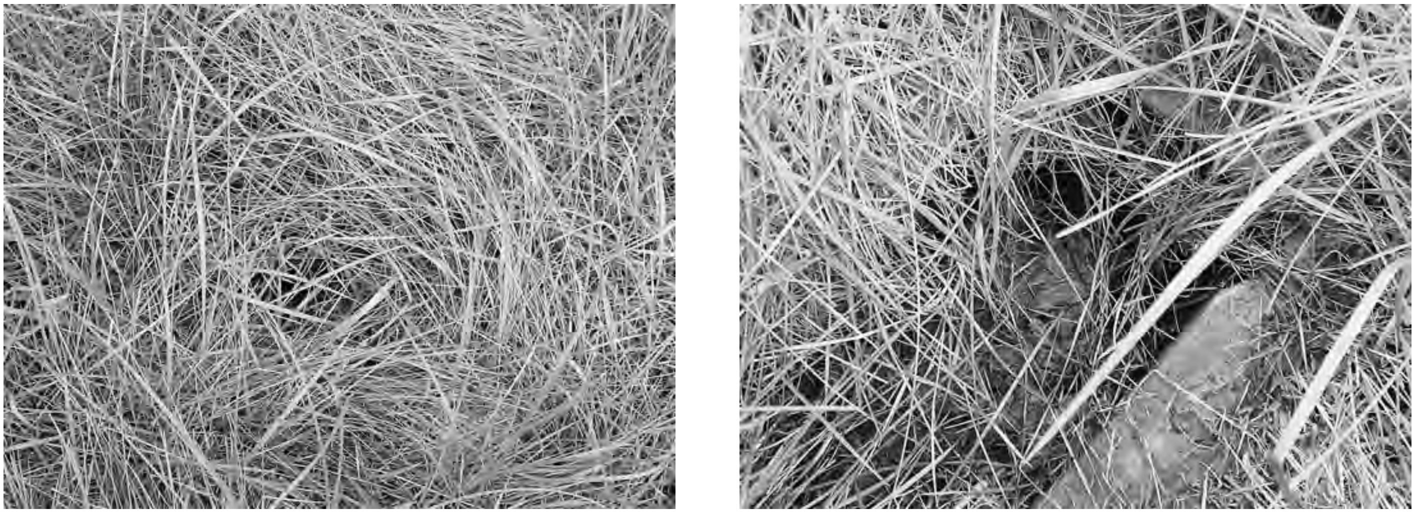

Figure 46. View from above and close-up view of overgrown drainage outlet, Delaware SPS-2.

measure the transverse distance from the core hole to the edge of the pavement, the longitudinal distance from the core hole to the drainage outlet, and the transverse distance from the edge of the pavement to the drainage outlet (Figure 55). A rod and a laser level were used to measure the elevation of the surface of the pavement next to the core hole, the top of the permeable asphalt-treated base layer in the core hole, the edge of the pavement at the core hole station, the edge of the pavement at the drainage outlet station, and the inside bottom edge of the drainage outlet pipe (Figure 56). The digital level was used to measure transverse and longitudinal slopes. Each core was photographed, and its thickness was measured (Figures 57 and 58).

Figure 47. Clearing drainage outlet, Texas SPS-1.

Measuring Inflow and Outflow

The major pieces of equipment needed for the testing are shown in Figure 59. Water was run from a water truck provided by the DOT, through a hose to a water pump, then through a flow meter (Figure 60), and finally into the core hole (Figures 61 and 62). The flow meter's screen can display either

Figure 48. Clearing drainage outlet, Texas SPS-1.

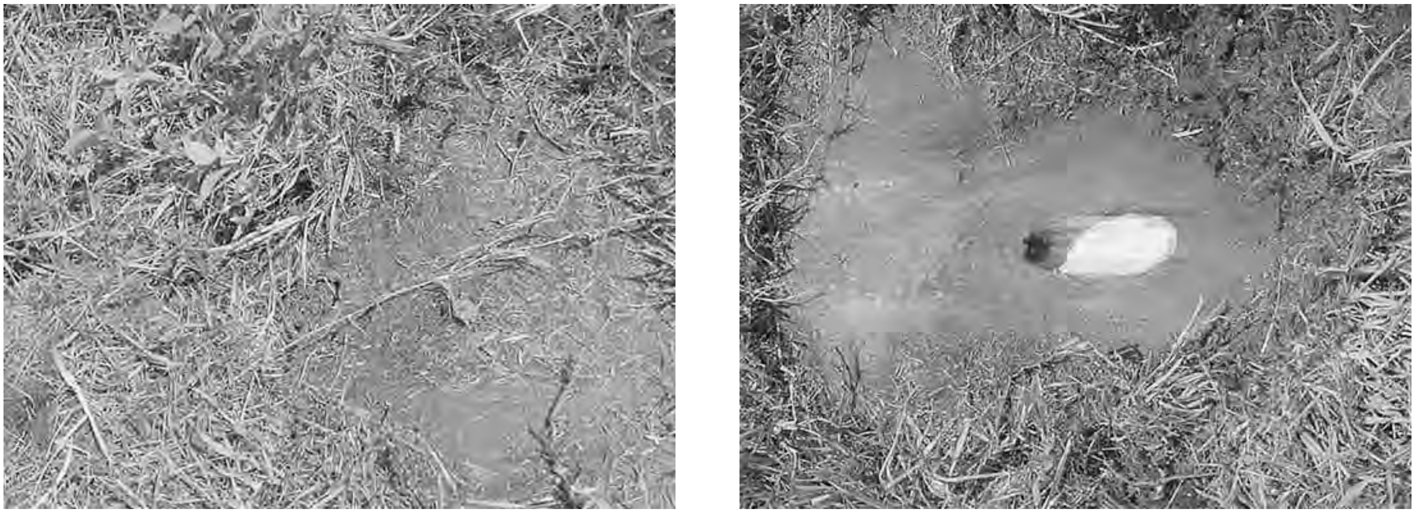

Figure 49. Drainage outlet before and after being uncovered, Florida SPS-1.

Figure 50. Dual outlets, one cleared for testing, one packed with dirt and stone, Nevada SPS-1.

the total volume of water used, in gallons, or the rate of water flow, in gallons per minute. The water pump was powered by a car battery. The water pump was not needed in those cases where the water head from the truck was sufficient to achieve maximum measurable flow through the flow meter or maximum inflow capacity of the permeable asphalt-treated base.

Normally the tests were conducted by first adjusting the flow rate to the maximum that the permeable asphalt-treated base could accommodate without water spilling out of the top of the core hole. The maximum inflow rate was recorded, and the flow rate was then reduced to a steady-state rate of 8 gal/min. If the maximum inflow capacity of the base was less than 8 gal/min, the inflow rate was set to a value that would maintain the water level in the core hole just below the pavement surface.

Water was allowed to flow into the base until it was observed flowing out of the nearest downstream outlet (Figure 63); this usually took at least several minutes. Once free flow through

Figure 51. Dual outlets, one cleared, one blocked by dirt and stone, Nevada SPS-2.

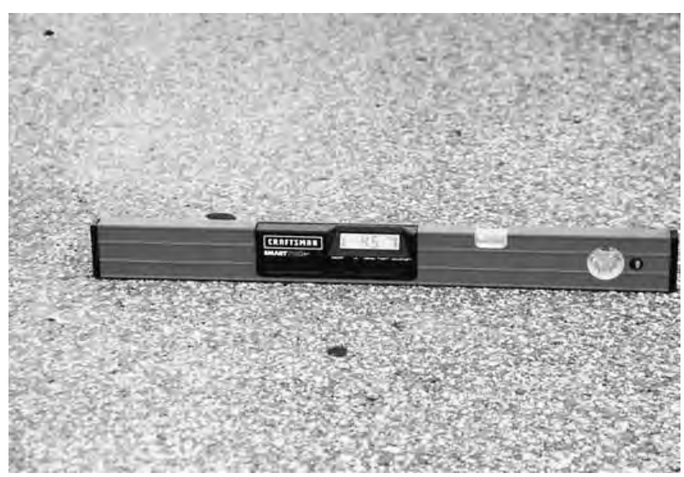

Figure 52. Digital level for measuring transverse and longitudinal grades.

Figure 53. Coring by state DOT personnel, Arkansas SPS-1.

Figure 54. Rented coring rig, Nevada SPS-1.

the drainage system was established, a tracer dye was added to the inflowing water. In the pilot test, liquid soap had been used to attempt to measure the time to free flow (Figure 64), but a tracer dye was found to produce more clearly visible results (Figure 65). A stopwatch was used to measure the time to when outflow was first observed, the time to when tracer dye outflow was observed, and the time to when inflow was stopped.

Patching Core Holes

The core holes were patched by the research team, using similar materials, or were, at the state DOT's discretion, left to be patched by the state's own crews.

Photos from the pilot tests at the Arkansas SPS-2 site provide vivid evidence of a drain that functioned not only during the testing, but also prior to the testing. What appears to be soft mud at the end of the drainage outlet in Figure 66 is, in fact, a hardened buildup of residue from drainage flows that occurred before the pilot test. Figure 67 shows the damage to nearby vegetation that appears to be due to this outflow. The SPS-2 test sections at this site were not built directly on the subgrade or prepared fill, but rather on top of an old concrete pavement that had been rubblized. Leaching of chemicals from this old rubblized concrete layer may be the cause of the vegetation damage seen in Figure 67.

Drainage Flow Calculations

The following general equation is used to determine the rate of flow through a porous medium:

$$Q = k\,i\,A$$

where

Q = rate of flow through cross-sectional area (length/time),
k = hydraulic conductivity of medium (length/time),
i = hydraulic gradient (elevation head difference/length), and
A = cross-sectional area ($length^2$).

Figure 55. Measuring distances between core hole and drainage outlet.

Figure 56. Rod and level measurement of elevation of bottom of drainage outlet pipe at headwall.

Figure 57. Measuring thickness of AC lifts above PATB from core.

Figure 58. Measuring thickness of PCC above PATB from core.

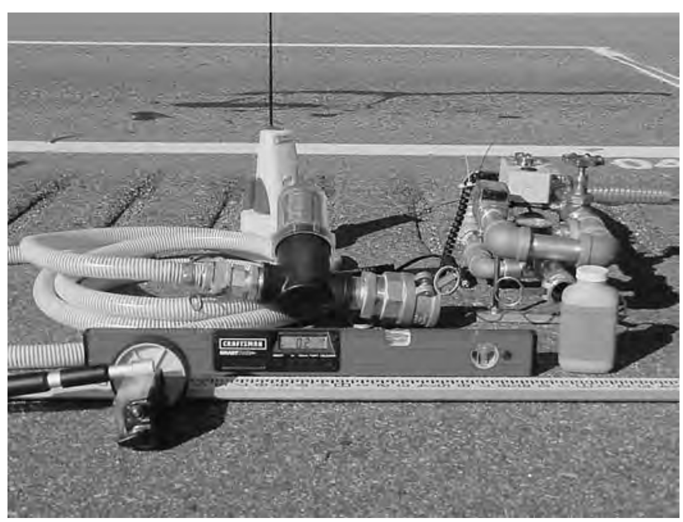

Figure 59. Equipment for flow time testing.

Figure 60. Flow meter.

Figure 61. Water truck, connecting hose, flow meter, car battery, and tracer dye.

Figure 62. Water inflow from flow meter to PATB.

Figure 63. Free flow is established when clear water flows out of drain.

Figure 64. Bubbles from liquid soap used in pilot testing to attempt to measure time to free flow.

Figure 65. Flow time measured from introduction to outflow of tracer dye.

This equation can be rearranged as follows to solve for the hydraulic conductivity, k, as a function of a known flow rate, hydraulic gradient, and area:

$k = Q / i A$

For this study, the variables in the above equation are defined as follows (and illustrated in Figures 68 and 69):

k = estimated hydraulic conductivity of PATB (ft/day)
Q = maximum inflow rate measured during field tests (measured in gal/min, converted to cu ft/day)
i = hydraulic gradient measured in field ($\Delta h / L$)
h = elevation head difference measured in field
= (1 − 2) + 3 + 4
where
1 = elevation measured at pavement edge (ft),
2 = elevation measured at top of pavement at core hole (ft)
3 = pavement thickness above PATB (ft), and
4 = thickness of PATB (ft).
L = flow length (ft)—the distance measured from core hole to pavement edge
A = cross-sectional area of flow (sq ft)—the thickness of PATB (ft) × assumed width of flow plume through PATB (ft).

The above equations are based on transverse flow (a longitudinal grade of 0%). As the longitudinal grade increases above 0%, both the hydraulic gradient and the flow length increase. The proportional increase is the same in both, however, making the above equation valid for any longitudinal gradient.

An example of these calculations is provided below, using the measurements from the test at one of the drainage outlets at the Alabama SPS-1 site.

Date:	08/18/03
SHRP site ID:	010107
Core hole test station:	0 - 68
GPS coordinates:	N 32° 36.344'
	W 85° 15.027'
Cross slope (%):	1.2

Figure 66. Dual outlets, one flowing, and hardened buildup of past outflow residue, believed to be due to rubblizing of old concrete pavement under test sections, Arkansas SPS-2.

Figure 67. Vegetation near drainage outlet appears damaged, possibly due to chemicals leached from old rubblized concrete layer, Arkansas SPS-2.

Longitudinal grade (%):	0.8
Distance measures (ft)	
Core to edge:	5.7
Core to outlet:	80.0
Edge to outlet:	21.0
Elevation readings (ft)	
Top of pavement at core:	1.58
Top of PATB after coring:	1.96
Edge of pavement:	1.67
Edge at outlet:	2.50
Outlet:	5.92
Infiltration measures	
Steady-state infiltration rate (gal/min):	6
Time to first outflow (min:sec):	13:58
Cumulative inflow to tracer input (gal):	15 @ 2:33
Time to tracer outflow (min:sec):	13:58
Maximum inflow rate (gal/min):	6

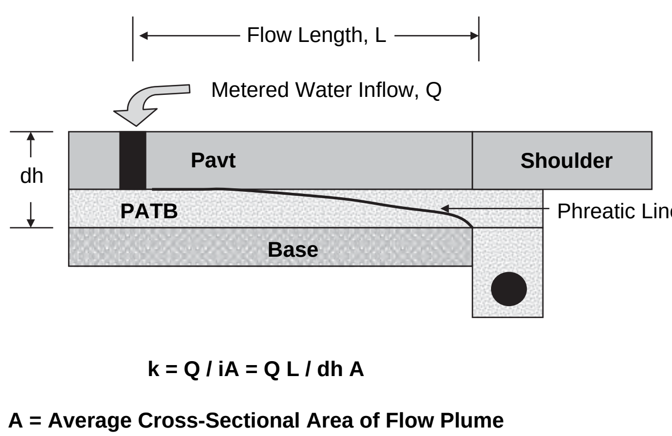

Figure 68. Illustration of parameters used in determining in-place base permeability.

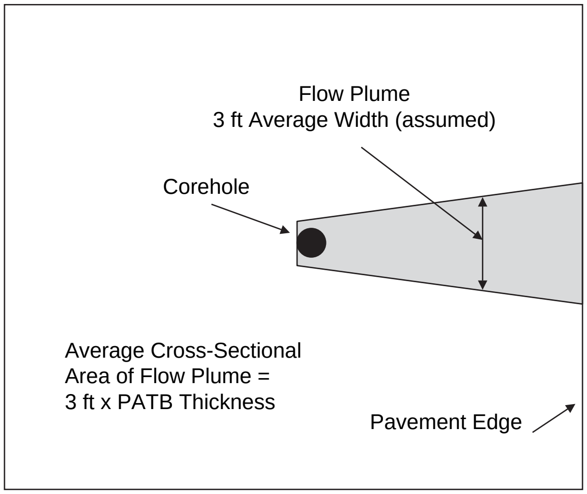

Figure 69. Illustration of plume of water from core hole to pavement edge.

Water inflow stopped (gal):	83
Cross slope (elevation measures) (%)	1.5
Longitudinal grade (elevation measures) (%)	1.0
Thickness of pavement above PATB (elevation measures) (ft):	0.38
Thickness of pavement above PATB (elevation measures) (in.):	4.5
Thickness of pavement above PATB (LTPP database) (ft):	0.38
Thickness of pavement above PATB (LTPP database) (in.):	4.6
Thickness of PATB (LTPP database) (ft)	0.30
Thickness of PATB (LTPP database) (in.)	3.6
Hpavt (ft):	0.38
Hpatb (ft):	0.30
Q (cu ft/day):	1,154
Δh (ft):	0.76

Table 18. Summary of permeability calculations from field testing data.

SHRP ID	State	Subgrade drainage class	Drainage system permeability (ft/day)
SPS-1			
010100	Alabama	Well drained	11,257
040100	Arizona	Well drained	No outflow
050100	Arkansas	Somewhat poorly drained	Not calculated
100100	Delaware	Very poorly drained	11,245
120100	Florida	Very poorly drained	10.056
190100	Iowa	Well drained	10,140
200100	Kansas	Well drained	5,712
220100	Louisiana	Poorly drained	8,841
260100	Michigan	Somewhat poorly drained	8,528
300100	Montana	Well drained	11,437
310100	Nebraska	Well drained	Not tested
320100	Nevada	–	6,058
350100	New Mexico	–	17,545
390100	Ohio	–	No outflow
400100	Oklahoma	Well drained	9,199
480100	Texas	Well drained	6,224
510100	Virginia	Well drained	7,987
550100	Wisconsin	–	13,289
SPS-2			
040200	Arizona	Well to somewhat excessively drained	15,966
050200	Arkansas	Moderately well drained	Not calculated
060200	California	–	8,803
080200	Colorado	Well to somewhat excessively drained	14,270
100200	Delaware	Well drained	9,981
190200	Iowa	–	9,809
200200	Kansas	Well drained	12,225
260200	Michigan	Very poorly drained	10,581
320200	Nevada	–	9,275
370200	North Carolina	Well drained	15,291
380200	North Dakota	Poorly drained	10,172
390200	Ohio	–	9,539
530200	Washington	Well drained	32,656
550200	Wisconsin	–	15,697
MN/Road	Minnesota	Mix of well and poorly drained	11,239

L (ft):	5.7
i (ft/ft):	0.13
Assumed width of flow plume (ft):	3
A (sq ft):	0.9
k (ft/day):	9,583

Although the result obtained appears reasonable, since it falls within the expected range for a permeable asphalt-treated base, it should be noted that there is at least one limitation to this approach to calculating the in-place permeability of the base. The actual value obtained for the permeability, *k*, is a function of the assumed width of the flow plume. In the above example, a flow plume width of 3 ft was assumed; for the purposes of comparison with other test results obtained, a width of 3 ft was assumed for all of the outlets tested in this study. But there is really no way of knowing what the true flow plume width was for the particular core hole test considered in the example, nor what it is for other tests at other locations. Had a width of 4 ft been assumed, the calculated *k* would have been reduced to 7,187 ft; on the other hand, had a width of 2.5 ft been assumed, the calculated *k* would have been 11,499 ft. The calculated *k* can be changed by thousands of feet per day simply by varying the value assumed for the width of the flow plume.

This suggests that it is best not to place too much importance on the actual values of the permeability values calculated using the procedure outlined above. They are more meaningful as indicators of the functioning of the subdrainage system.

When no outflow occurs, on the other hand, this might or might not be due to a malfunctioning of the subdrainage system. If water fails to flow out of just one of several outlets at a site, for example, this suggests some localized problem in the system, such as a blockage in the longitudinal pipe. But if water fails to flow out of all of the outlets at a site, this suggests that the water introduced into the permeable base flowed downward into the subgrade.

Field Testing Results

The measurements obtained in the field testing and the permeability values calculated from these field measurements are shown in Appendix B (Tables B-1 through through B-17 for the SPS-1 sites, Tables B-18 through B-31 for the SPS-2 sites, and Table B-32 for the MnRoad site). The results of the field testing of the subdrainage systems at the SPS-1 and SPS-2 sites and the MnRoad site are summarized in Table 18.

CHAPTER 4

Deflection Analysis of SPS-1 and SPS-2 Designs

Deflection Data Processing

The following data items were extracted from the LTPP database for use in the deflection analysis of the SPS-1 and SPS-2 test sections:

- Testing date and time,
- Test location (position on pavement),
- Applied loads,
- Deflection sensor configurations,
- Peak deflection data, and
- Air and pavement surface temperature measurements.

Basin Checks

Each line of deflection data in the LTPP database has a number that identifies the configuration of the deflection sensors. Those sensor configuration numbers were used to retrieve the deflection sensor positions and match them to the deflections. The following checks were then applied:

- Nondecreasing basin check. Deflection should be greatest at the center of the load plate and steadily decrease at increasing distance from the load plate. A small percentage of deflection basins did not pass this check, and they were not used in the analysis.
- Four-sensor configuration check. If a deflection basin had sensors located at 0 in., 12 in., 24 in., and 36 in. from the center of the load plate, it was usable in equations relying on the commonly used four-sensor AREA calculation. This was almost always true in this study.
- SHRP configuration check. If a basin had sensors located at 0 in., 8 in., 12 in., 18 in., 24 in., 36 in., and 60 in. from the center of the load plate, it was usable in equations relying on the seven-sensor LTPP AREA calculation.
- Approach and leave load transfer checks. For the PCC pavements in the SPS-2 experiment, load transfer measurements labeled in the database as having been measured at the J4 position (load plate on the approach side of the joint) were considered valid only if the sensor configuration showed that the basin did indeed have sensors at 0 in. and 12 in. from the center of the load plate. This was true for all but two of the tens of thousands of J4 basins in the database. Similarly, load transfer measurements labeled in the database as having been measured at the J5 position (load plate on the leave side of the joint) were only considered valid if the sensor configuration showed that the basin did indeed have sensors at –12 in. and 0 in. from the center of the load plate, and if it could be determined which of the deflection sensors normally located in front of the center load plate had been moved to the –12 position. Usually it was the number 2, 4, or 9 sensor (normally located at 8 in., 18 in., or 60 in., respectively, in front of the center of the load plate) that had been moved to the –12 position for the J5 measurements. Whichever one of these sensors was found to have been at the –12 position was used along with the deflection at the 0 position (under the load plate) to calculate the leave-side load transfer.

In-Pavement Temperatures

During deflection testing of an LTPP pavement section on any given day, the temperatures in the AC or PCC surface layer are also measured. Temperatures measured near the surface, at or near the middepth, and near the bottom of the AC or PCC surface layer are stored, along with the depths and times at which these temperatures were measured, in the LTPP database tables MON_DEFL_TEMP_VALUES and MON_DEFL_TEMP_DEPTHS. Those data were extracted from the database for each SPS-1 and SPS-2 section.

For both the SPS-1 and SPS-2 sections, the temperature measured at the second recorded depth was taken as the middepth temperature, and regression equations were developed for middepth temperature as a function of time of day for all of the nearly 1,400 SPS-1 deflection testing dates and all of the nearly 1,100 SPS-2 deflection testing dates. These regression equations were used with the extracted deflection data to assign an AC or PCC middepth temperature to every deflection basin measured. In addition, the temperatures measured near the tops and bottoms of the concrete slabs in the SPS-2 sections were used to extrapolate temperatures at the tops and bottoms of the slabs, and a linear temperature gradient was calculated as the bottom temperature minus the top temperature. Regression equations were then developed for temperature gradient as a function of time of day for all of the SPS-1 deflection testing dates.

Analysis of SPS-1 Asphalt Pavement Deflections

A two-layer analysis procedure was used to determine the in-place elastic modulus of the subgrade and the elastic modulus of the pavement structure (all layers combined) above the subgrade, using deflections measured at load levels nearest to 9,000 lb and normalized to 9,000 lb. This pavement modulus was calculated as a function of the actual total thickness of all layers above the subgrade, in the manner of the asphalt pavement deflection analysis procedure in the AASHTO *Guide for Design of Pavement Structures* (*30*).

For the purpose of comparing the relative structural capacities of the pavement sections at each site, the actual total thickness and the backcalculated pavement modulus were used to calculate an equivalent pavement thickness for a fixed AC modulus of 500,000 psi. The actual magnitudes of in-place subgrade modulus and pavement modulus calculated in this way might very well differ from the moduli that would be obtained from different backcalculation algorithms. Nonetheless, this approach was considered a reasonable way to consistently treat all of the deflection data from the SPS-1 test sections; it was also considered to be a realistic approach, considering the huge amount of deflection data collected on these sections over 13 years.

As was shown in Table 1 in Chapter 2, the SPS-1 pavement structures fall into the following five categories by base type and drainage design:

- Undrained:
  - Group A—AC alone or AC over aggregate (AGG)
  - Group B—AC over asphalt-treated base (ATB)
  - Group C—AC over asphalt-treated base (ATB) over aggregate (AGG)
- Drained:
  - Group D—AC over permeable asphalt-treated base (PATB) over aggregate (AGG)
  - Group E—AC over asphalt-treated base (ATB) over permeable asphalt-treated base (PATB)

Tables 4 and 5 (Chapter 2) illustrate the specific pairwise comparisons that can be made to assess the effects of base type and drainage on pavement performance in the SPS-1 experiment, all other things being equal (location, subgrade soil, climate, traffic, age, construction, and base and surface layer thicknesses). For example, at the eight sites where test section designs 0101 through 0112 were built, sections 0101 and 0110 are a pair in that they have almost all factors in common, including total base thickness and AC surface thickness; the sole difference is that section 0101 has an undrained dense-graded aggregate base with a design thickness of 7 in., while section 0110 has a base composed of a dense-graded asphalt-treated layer over a drained permeable asphalt-treated layer, with a combined design thickness of 7 in.

Analysis of the SPS-1 deflection data reveals that the different types of base materials used result in very different backcalculated pavement stiffnesses (or equivalently, effective pavement thicknesses). The results from deflections measured in the first year of service are shown in Table 19. Also shown in Table 19 are the design AC surface thickness, the design base thickness, and the total design thickness for each of the 24 test section designs.

Four sets of test section pairs at the SPS-1 sites can be used to compare the backcalculated effective pavement thicknesses in the undrained Group A (AGG) with the those in the drained Group E (ATB over PATB). These test section pairs are shown in Figures 70 (0101 versus 0110), 71 (0102 versus 0111), Figure 72 (0113 versus 0122), and Figure 73 (0114 versus 0123).

It is clear from those four figures that, despite the design AC surface and total base thicknesses, along with all other experimental design factors, being equal for each of the pairs, the backcalculated effective pavement thicknesses are, in nearly every case, greater for the sections with the base composed of ATB over drained PATB than for the undrained sections with undrained dense-graded aggregate base. As shown in Table 19, the average backcalculated effective thicknesses of the matching undrained AGG and drained ATB/PATB test sections are 9.6 in, versus 11.7 in. (see Figure 70), 8.2 in. versus 14.6 in. (see Figure 71), 6.9 in. versus 12.3 in. (see Figure 72), and 11.3 in. versus 20.3 in. (see Figure 73).

Yet the backcalculation analysis shows just the opposite result when the other group of undrained test sections is compared with its two corresponding groups of drained test sections. Four sets of three test sections apiece at the SPS-1 sites can be used to compare the backcalculated effective pavement thicknesses in the undrained Group B (ATB) and Group C (ATB over AGG) with the those in the drained Group D (PATB). These sets of test sections and are shown Figure 74 (0103 and 0105 versus 0107), Figure 75 (0104 and 0106 versus 0108), Figure 76 (0115 and 0117 versus 0119), and Figure 77 (0116 and 0118 versus 0120).

Table 19. First-year backcalculated effective pavement thicknesses and design thicknesses for SPS-1 test sections.

	Backcalculated Effective Pavement Thickness by Experimental Design Test Section																							
State	0101	0102	0103	0104	0105	0106	0107	0108	0109	0110	0111	0112	0113	0114	0115	0116	0117	0118	0119	0120	0121	0122	0123	0124
AL	9.1	6.9	10.6	20.8	8.0	20.8	7.2	12.0	15.2	11.8	12.5	17.5												
DE	9.1	9.0	14.6	22.7	10.1	20.9	8.1	14.1	18.3	16.5	18.9	24.4												
FL	11.2	10.7	13.4	21.7	9.4	18.8	8.2	15.2	21.5	13.5	14.6	22.5												
IA	8.9	7.4	9.3	24.8	6.6	21.7	5.3	11.0	12.2	9.0	9.4	20.7												
KS	12.5	10.1	10.0	18.0	7.8	16.9	6.8	13.0	14.6	13.2	16.6	22.0												
NV	10.2	7.5	7.5	17.4	6.7	16.1	7.0	12.0	14.4	11.5	24.1	14.3												
NM	8.5	8.3	8.0	11.6	6.1	9.6	7.9	11.6	12.8	8.1	8.1	10.1												
OH	7.7	5.9	7.8	18.3	6.7	16.1	5.7	12.2	13.8	9.8	13.0	17.6												
AZ													7.2	12.1	19.0	19.5	16.0	15.7	12.3	10.8	13.4	12.5	20.4	26.9
AR													6.9	10.7	16.7	19.2	12.1	15.3	12.1	10.1	11.5	10.9	17.7	20.3
LA													8.6	14.0	16.5	18.0	13.5	12.3	14.9	12.2	14.3	11.1	16.4	21.2
MI															19.2	18.0	13.4	14.2		8.4	10.7		22.6	28.3
MT													4.8	9.0	23.3	25.8	18.2	20.9	16.0	11.6	13.7	14.6	25.9	33.0
NE													5.0	6.5	9.1	12.2	8.3	10.9	8.1	8.2	9.4	7.8	13.4	15.9
OK													7.1	14.3	24.7	21.9	16.8	17.3	16.1	13.1	13.1	17.3	25.7	31.0
TX													9.8	15.9	19.2	19.6	13.4	16.6	15.4	14.8	15.9	13.1	20.6	27.0
VA													5.3	9.5	21.7	24.2	14.5	16.2	14.5	10.8	12.3	14.9	22.9	27.7
WI													7.7	9.8	14.0	10.9	12.0	11.4	9.1	8.4	11.7	8.7	17.3	20.1
Average (in.)	9.6	8.2	10.1	19.4	7.7	17.6	7.0	12.6	15.4	11.7	14.6	18.6	6.9	11.3	18.3	18.9	13.8	15.1	13.2	10.8	12.6	12.3	20.3	25.1
AC design thickness (in.)	7	4	4	7	4	7	4	7	7	7	4	4	4	7	7	4	7	4	7	4	4	4	7	7
Total base design thickness (in.)	8	12	8	12	8	12	8	12	16	8	12	16	8	12	8	12	8	12	8	12	16	8	12	16
Total design thickness (in.)	15	16	12	19	12	19	12	19	23	15	16	20	12	19	15	16	15	16	15	16	20	12	19	23

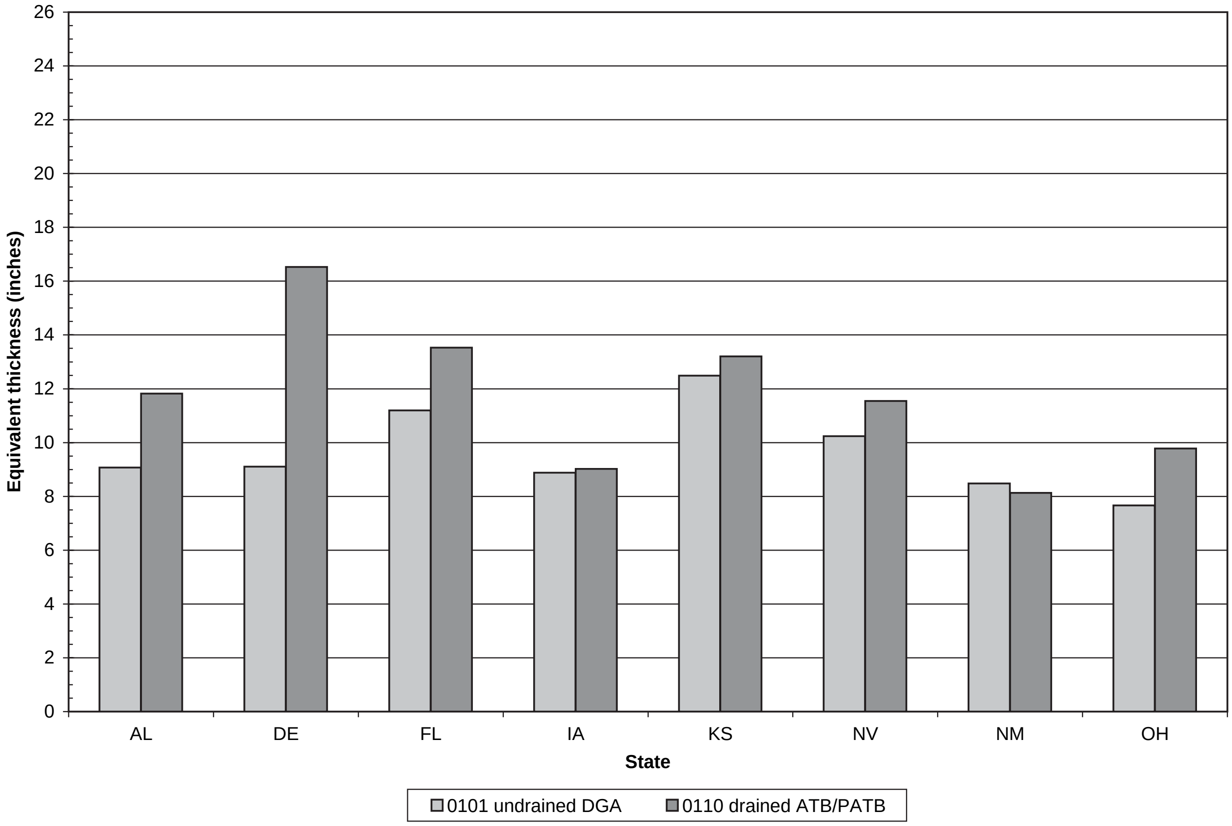

Figure 70. Backcalculated effective pavement thickness, undrained aggregate base (0101) versus drained ATB/PATB (0110).

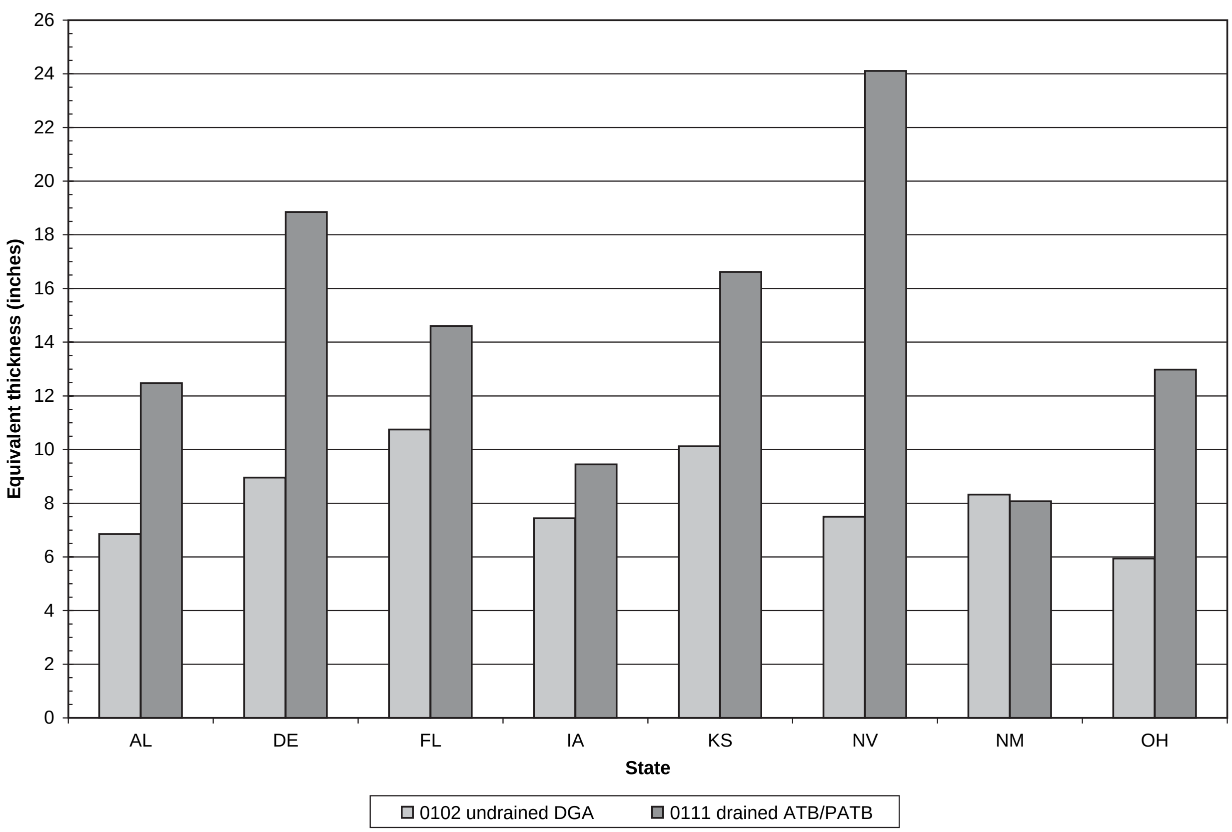

Figure 71. Backcalculated effective pavement thickness, undrained aggregate base (0102) versus drained ATB/PATB (0111).

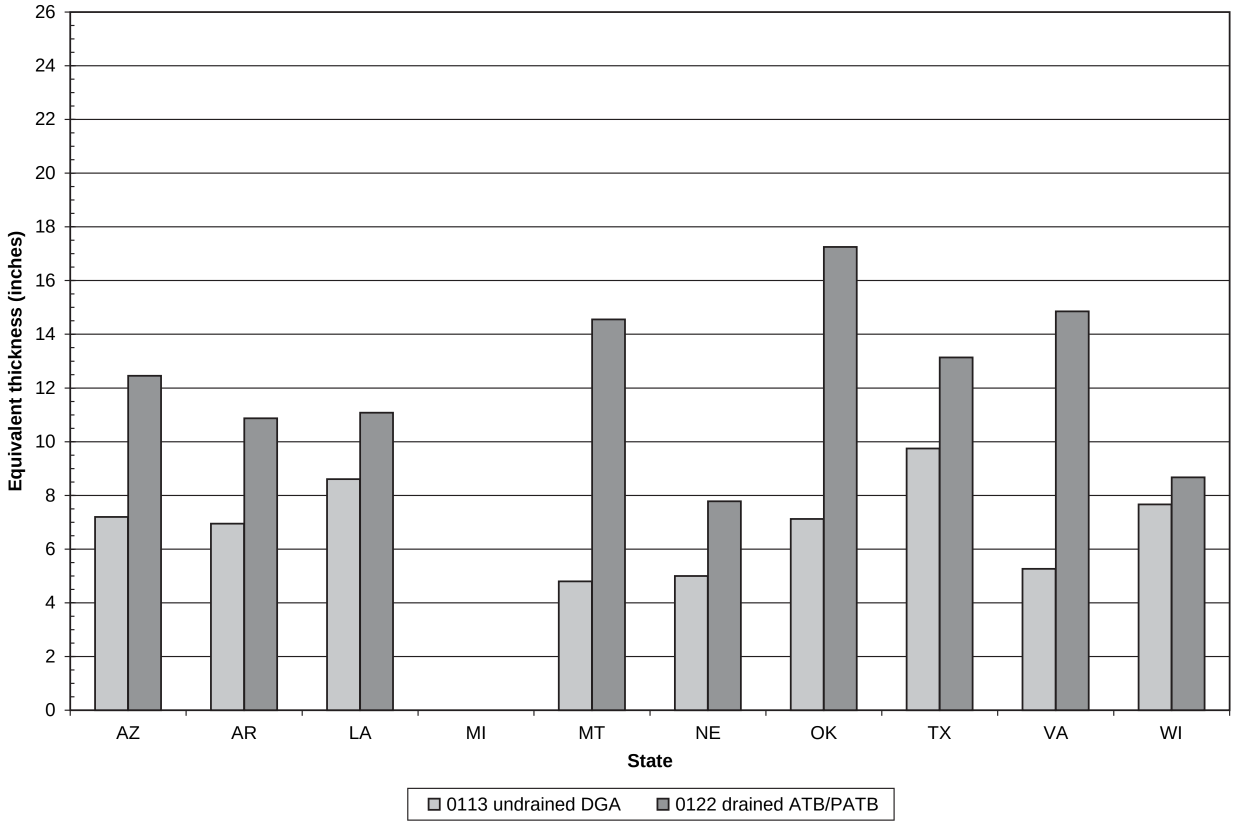

Figure 72. Backcalculated effective pavement thickness, undrained aggregate base (0113) versus drained ATB/PATB (0122).

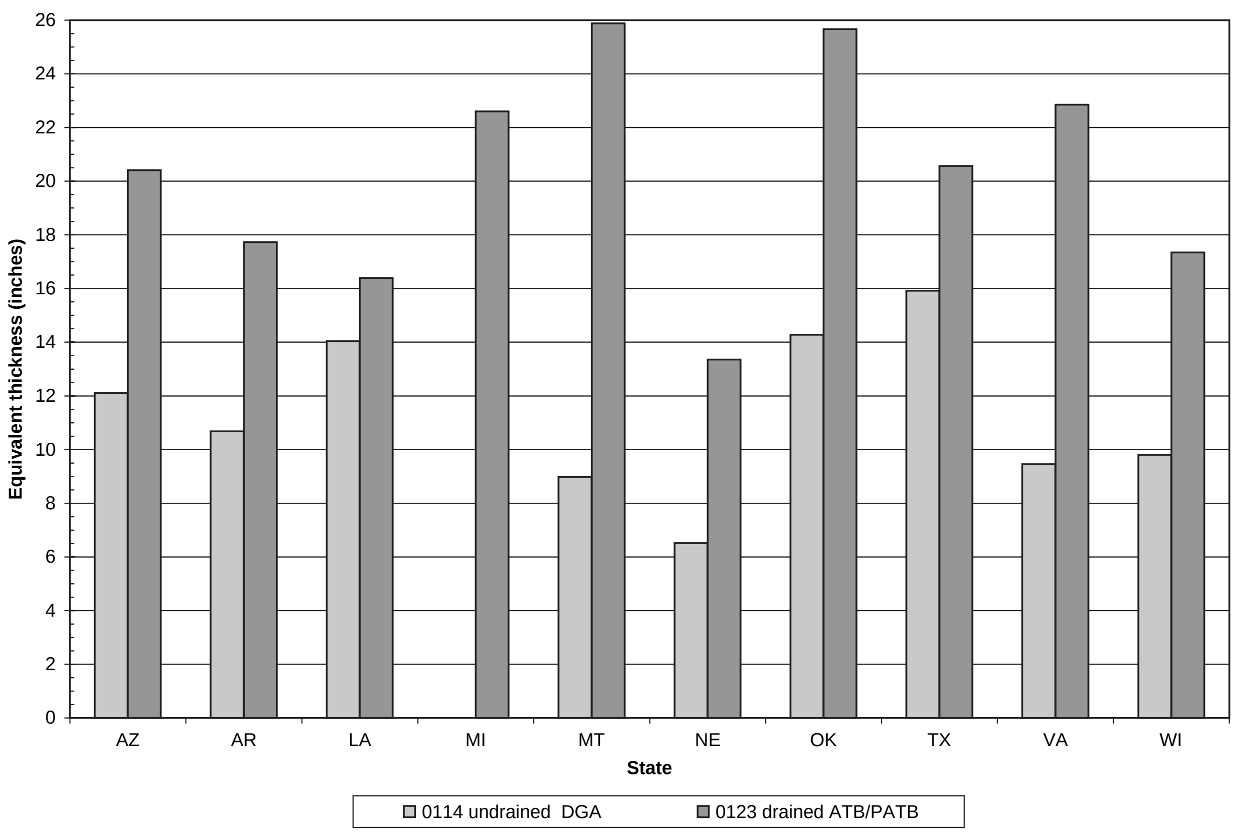

Figure 73. Backcalculated effective pavement thickness, undrained aggregate base (0114) versus drained ATB/PATB (0123).

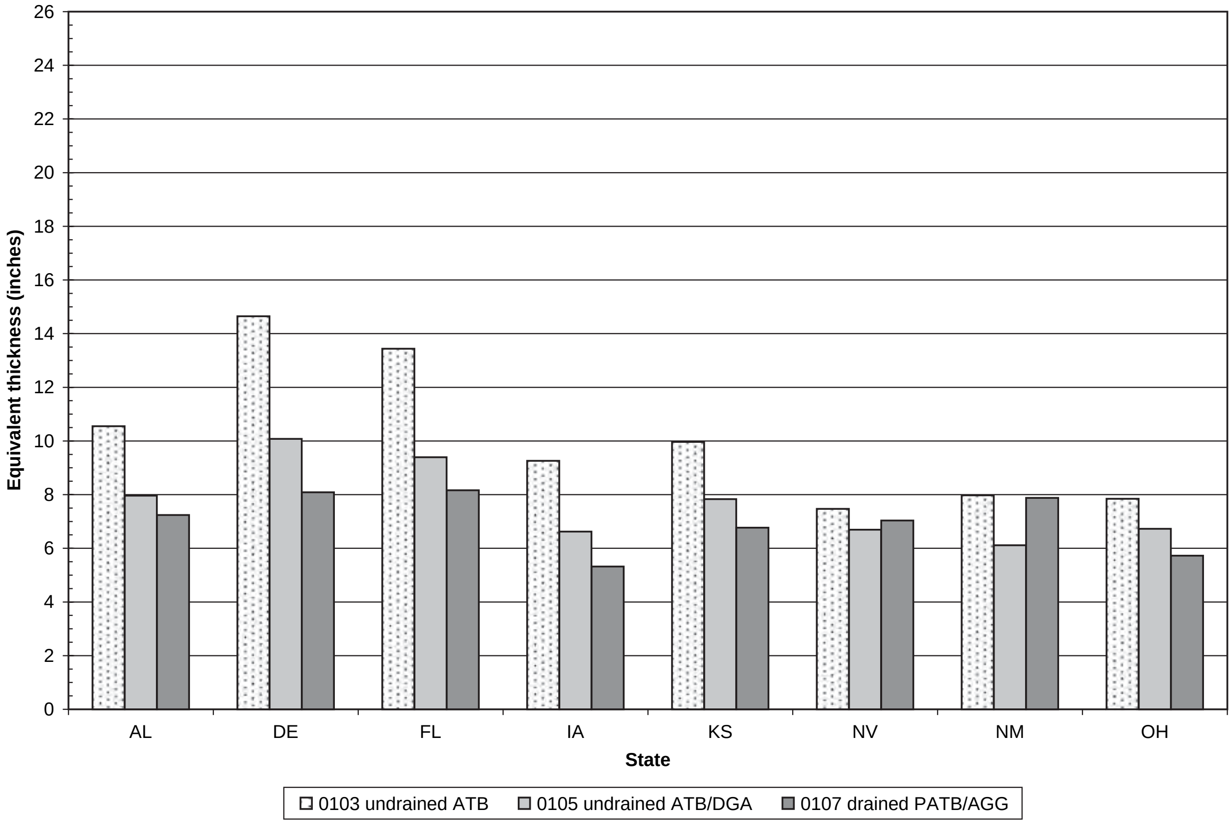

Figure 74. Backcalculated effective pavement thickness, undrained ATB (0103) and undrained ATB/AGG (0105) versus drained PATB/AGG (0107).

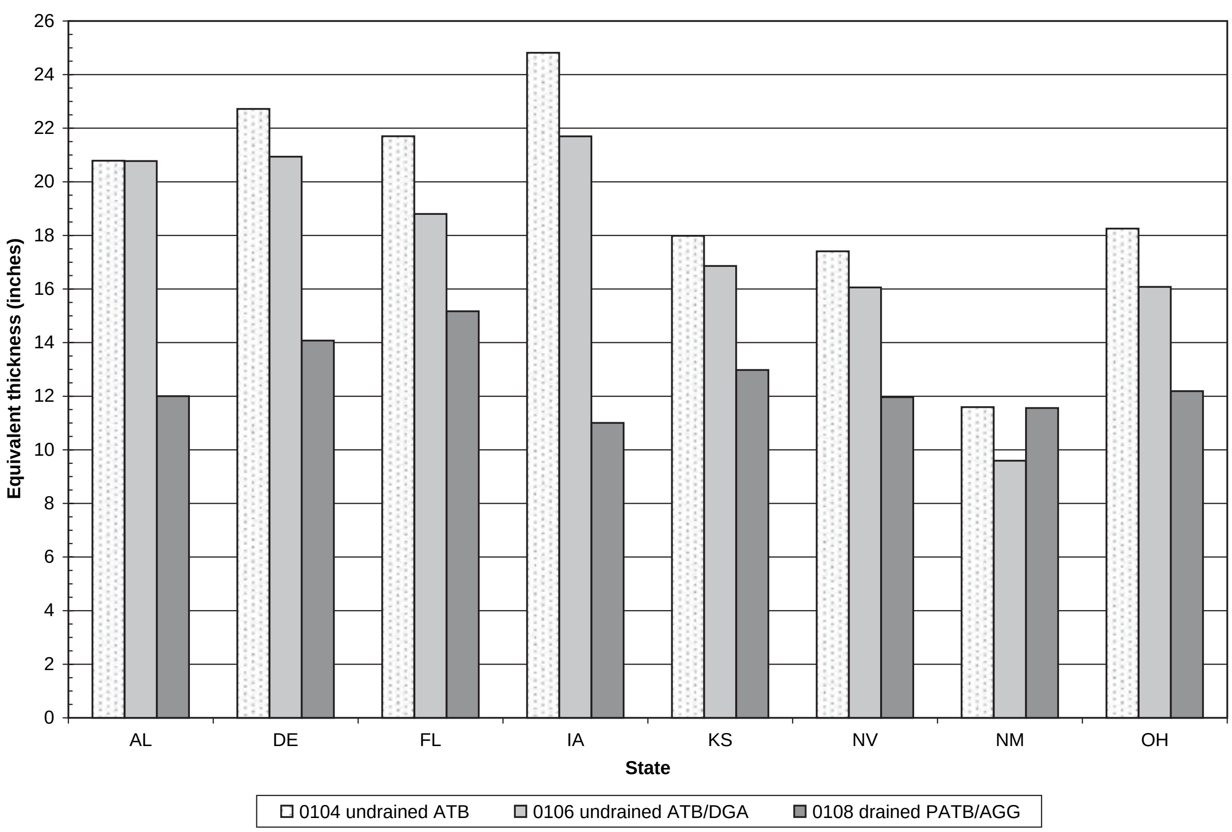

Figure 75. Backcalculated effective pavement thickness, undrained ATB (0104) and undrained ATB/AGG (0106) versus drained PATB/AGG (0108).

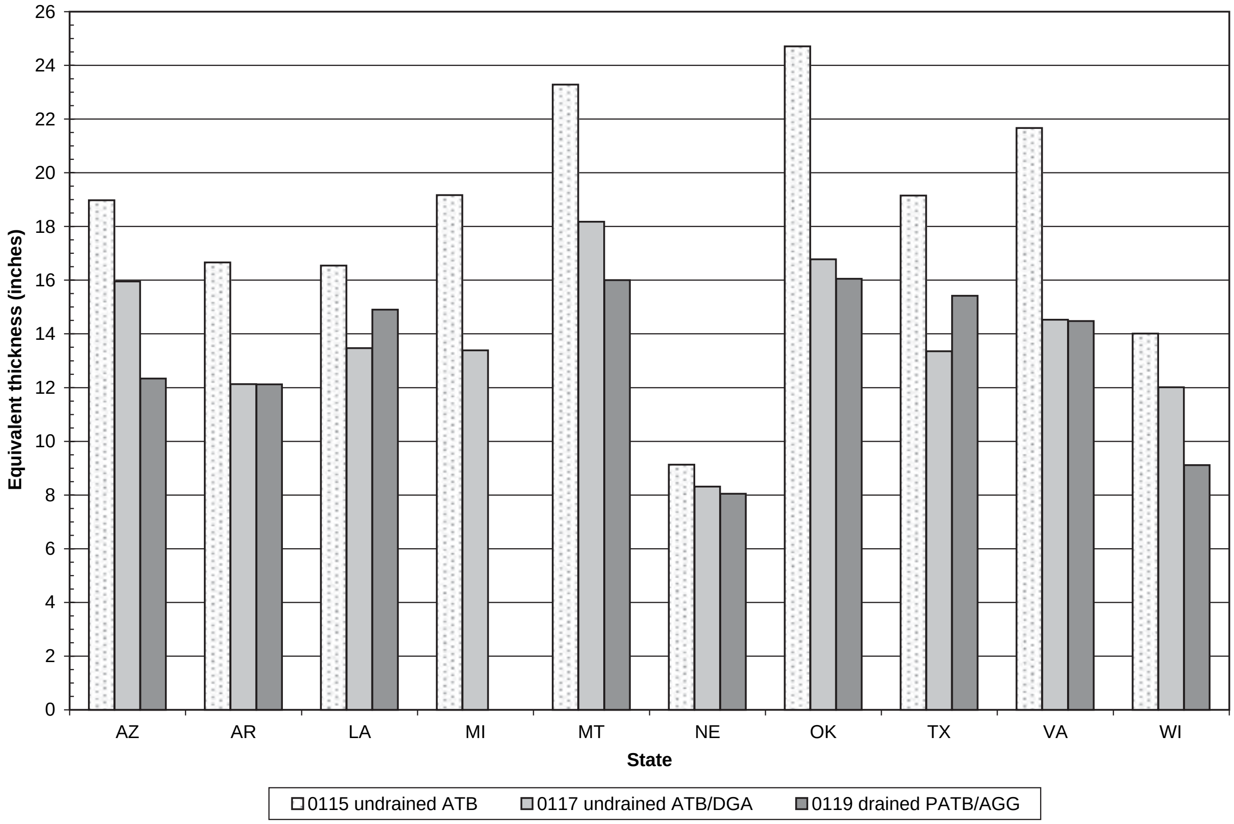

Figure 76. ***Backcalculated effective pavement thickness, undrained ATB (0115) and undrained ATB/AGG (0117) versus drained PATB/AGG (0119).***

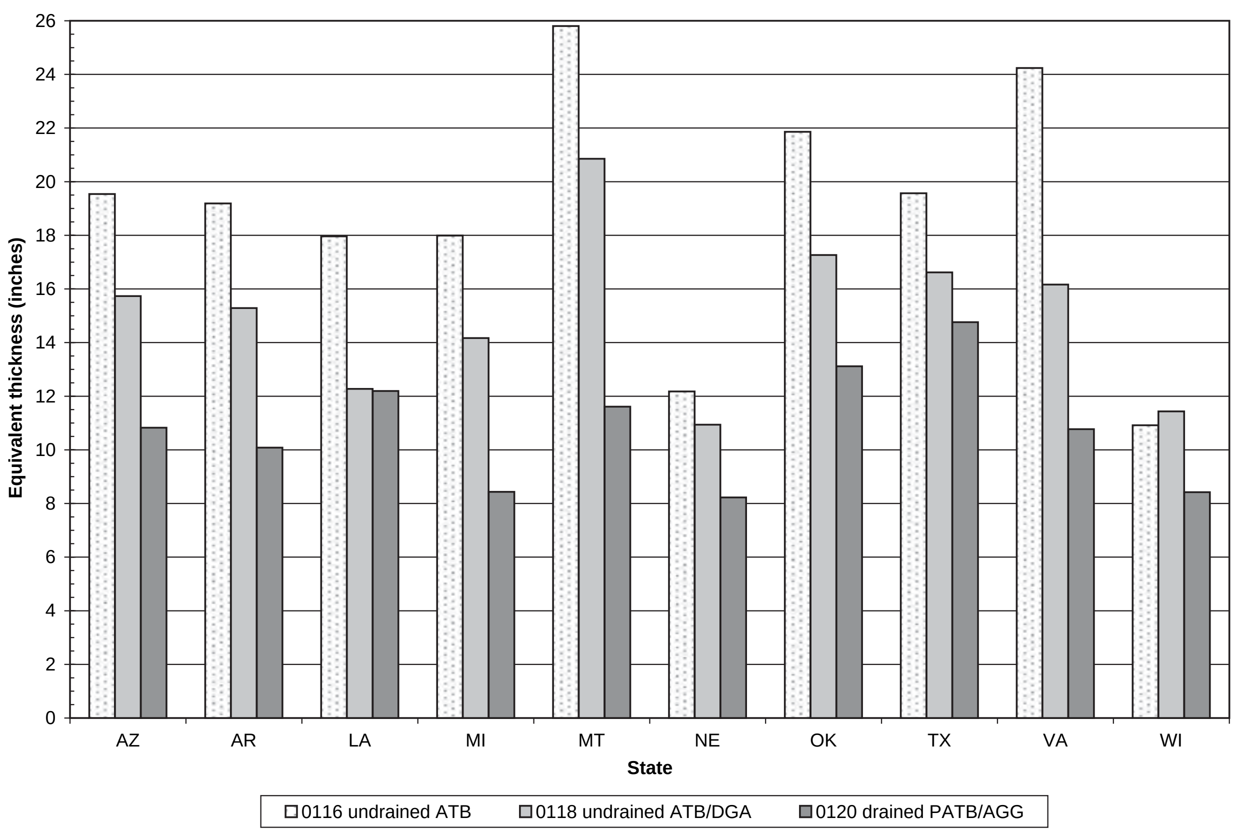

Figure 77. ***Backcalculated effective pavement thickness, undrained ATB (0116) and undrained ATB/AGG (0118) versus drained PATB/AGG (0120).***

Despite the design AC surface thickness, total base thickness, and all other experimental factors being equal for each set of test sections compared in those four figures, in nearly every case it is the pavements with dense-graded asphalt-treated base that have the greatest backcalculated effective pavement thickness. In every case, the pavement section with drained permeable asphalt-treated base over aggregate (PATB/AGG, Group D) has a backcalculated effective pavement thickness equal to or less than (in most cases considerably less than) the effective pavement thickness of the asphalt-treated base section of otherwise equal design.

In most cases, the undrained Group C sections, with dense-graded asphalt-treated base over aggregate, have backcalculated effective pavement thicknesses between those of those other two groups. As shown in Table 19, in the first set of test section designs compared (see Figure 74), the average backcalculated thickness of the matching undrained ATB, undrained ATB/AGG, and drained PATB/AGG pavement test sections are 10.1 in., 7.7 in., and 7.0 in., respectively. Similarly, in the second set, (see Figure 75), the averages are 19.4 in., 17.6 in., and 12.6 in., respectively. In the third group (see Figure 76), the averages are 18.3 in., 13.8 in., and 13.2 in., respectively, and in the fourth group (see Figure 77), the averages are 18.9 in., 15.1 in., and 10.8 in., respectively.

These results are not surprising. It makes sense that, all other things being equal, the weakest pavement sections would be those with the untreated aggregate bases, that the strongest pavements would be those with the dense-graded asphalt-treated bases, and that the pavement sections with bases made up of combinations of asphalt-treated aggregate, permeable asphalt-treated aggregate, and untreated aggregate would fall between those two in terms of pavement stiffness.

The distress and roughness characteristics of the different test sections in the SPS-1 experiment are assessed with respect to the base type/subdrainage groups in the next chapter of this report. Although it is impossible to completely separate the confounded effects of these two experimental factors, the deflection results and the distress/roughness results considered together suggest which of these two factors predominates. If pavement stiffness is more important, then the sections with ATB base will perform the best, the sections with AGG base will perform the worst, and the sections with combinations of PATB, ATB, and AGG will perform someplace in between. If, on the other hand, drainage is more important, then the sections with PATB will perform the best, and the sections with undrained ATB and AGG will perform the worst.

The comparisons described above are based on an analysis of deflections measured in the first year of service for each of the SPS-1 sites. It is worth asking how the stiffness of the different types of pavement sections might have changed over time and whether any changes that occurred were different for the undrained pavement sections than for the drained pavement sections.

The temperature-adjusted, effective full-depth AC pavement thicknesses for the SPS-1 test sections, backcalculated from deflections measured in the most recent year of deflection data analyzed, are shown in Table 20. Also shown in Table 20 are the design AC surface thickness, the design base thickness, and the total design thickness for each of the 24 test section designs. As shown in Figure 78, while the actual values of the backcalculated effective thicknesses are different from the first year to the last year of data analyzed, there does not appear to be any systematic shift in effective thickness for either the undrained or the drained pavement design groups.

The average difference (last year minus first year) in backcalculated effective thickness is in every case positive: 0.7 in., 0.4 in., 0.4 in., 1.2 in., and 1.5 in. for Groups A, B, C, D, and E, respectively. In paired *t*-tests, no statistical significance was detected for the differences in four of the five groups (A, B, C, and E) at the 95% confidence level; in the fifth group (D), a slight statistical significance to the difference was detected at the 95% confidence level. Given that the actual magnitude of the average difference for Group D is less than the average difference for Group E, the statistical significance detected for Group D can be explained by the fact that the variance of the differences in Group D is smaller than the variance of the differences in Group E.

The backcalculated subgrade modulus values for the SPS-1 test sections were subjected to the same analysis. The average backcalculated subgrade modulus in the first year was 46 ksi in Group A, 48 ksi in Group B, 44 ksi in Group C, 44 ksi in Group D, and 43 ksi in Group E. The average difference (last year minus first year) in backcalculated subgrade modulus was in every case negative: –10 ksi, –9 ksi, –11 ksi, –10 ksi, and –8 ksi for Groups A, B, C, D, and E, respectively. However, given the wide range of differences in every group between subgrade modulus in the first year and in the last year, none of the differences was found to be statistically significant in paired *t*-tests at the 95% confidence level.

The analysis results described above suggest that the changes noted in the deflection response of the SPS-1 test sections (that is, mostly insignificant increases in effective pavement thickness—a reflection of pavement stiffness—and insignificant decreases in subgrade stiffness) were no different for the undrained pavement sections than for the drained pavement sections.

Table 20. Last-year backcalculated effective pavement thicknesses and design thicknesses for SPS-1 test sections.

	Backcalculated Effective Pavement Thickness by Experimental Design Test Section																							
State	0101	0102	0103	0104	0105	0106	0107	0108	0109	0110	0111	0112	0113	0114	0115	0116	0117	0118	0119	0120	0121	0122	0123	0124
AL	12.3	6.4	17.0	26.0	11.8	25.4	7.0	22.4	19.6	20.4	20.7	26.8												
DE	7.9	8.5	9.5	16.2	7.7	15.2	6.3	10.5	14.8	11.5	13.5	16.5												
FL	11.9	11.6	15.0	22.8	10.4	21.6	9.8	16.5	21.5	16.7	17.7	21.2												
IA	14.7	10.7	17.8	26.1	11.9	24.9	14.5	14.9	22.4	22.8	22.9	33.4												
KS	7.8	7.9	7.6	16.0	5.7	13.7	5.5	10.6	11.7	11.7	11.9	15.7												
NV	13.0	7.8	15.6	29.1	14.5	24.7	8.9	19.7	21.6	20.1	22.2	29.7												
NM	11.8	8.8	13.9	19.6	9.4	20.9	10.7	16.2	17.7	14.7	14.7	18.5												
OH	7.5	5.5	9.1	14.9	4.7	12.8	0.0	10.4	13.5	12.6	13.7	19.1												
AZ													6.5	13.3	19.6	21.4	17.1	16.3	12.9	10.1	12.8	13.3	18.7	26.2
AR													9.9	13.2	16.3	25.2	12.6	17.8	15.4	12.8	13.6	19.9	29.0	31.8
LA													0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MI													0.0	0.0	17.8	22.7	14.4	8.2	5.3	8.3	25.5	31.5	8.8	0.0
MT													2.9	9.8	13.8	12.8	11.2	12.1	11.2	8.9	10.7	8.2	13.9	18.3
NE													6.4	8.2	7.6	10.6	7.0	8.8	8.3	7.8	10.2	7.0	12.7	15.5
OK													5.9	12.2	14.9	13.4	9.6	12.2	13.5	11.9	11.8	15.1	21.1	24.1
TX													9.7	14.3	20.6	22.0	16.0	16.8	12.4	12.9	14.6	16.2	22.1	25.7
VA													5.7	13.2	13.8	16.3	13.7	14.6	13.5	9.9	12.1	13.0	19.5	21.3
WI													8.3	14.4	20.1	22.4	15.5	20.5	12.5	11.6	13.9	16.6	24.0	29.5
Average (in.)	10.9	8.4	13.2	21.3	9.5	19.9	7.8	15.2	17.8	16.3	17.2	22.6	5.5	9.9	14.5	16.7	11.7	12.7	10.5	9.4	12.5	14.1	17.0	19.2
AC design thickness (in.)	7	4	4	7	4	7	4	7	7	7	4	4	4	7	7	4	7	4	7	4	4	4	7	7
Total base design thickness (in.)	8	12	8	12	8	12	8	12	16	8	12	16	8	12	8	12	8	12	8	12	16	8	12	16
Total design thickness (in.)	15	16	12	19	12	19	12	19	23	15	16	20	12	19	15	16	15	16	15	16	20	12	19	23

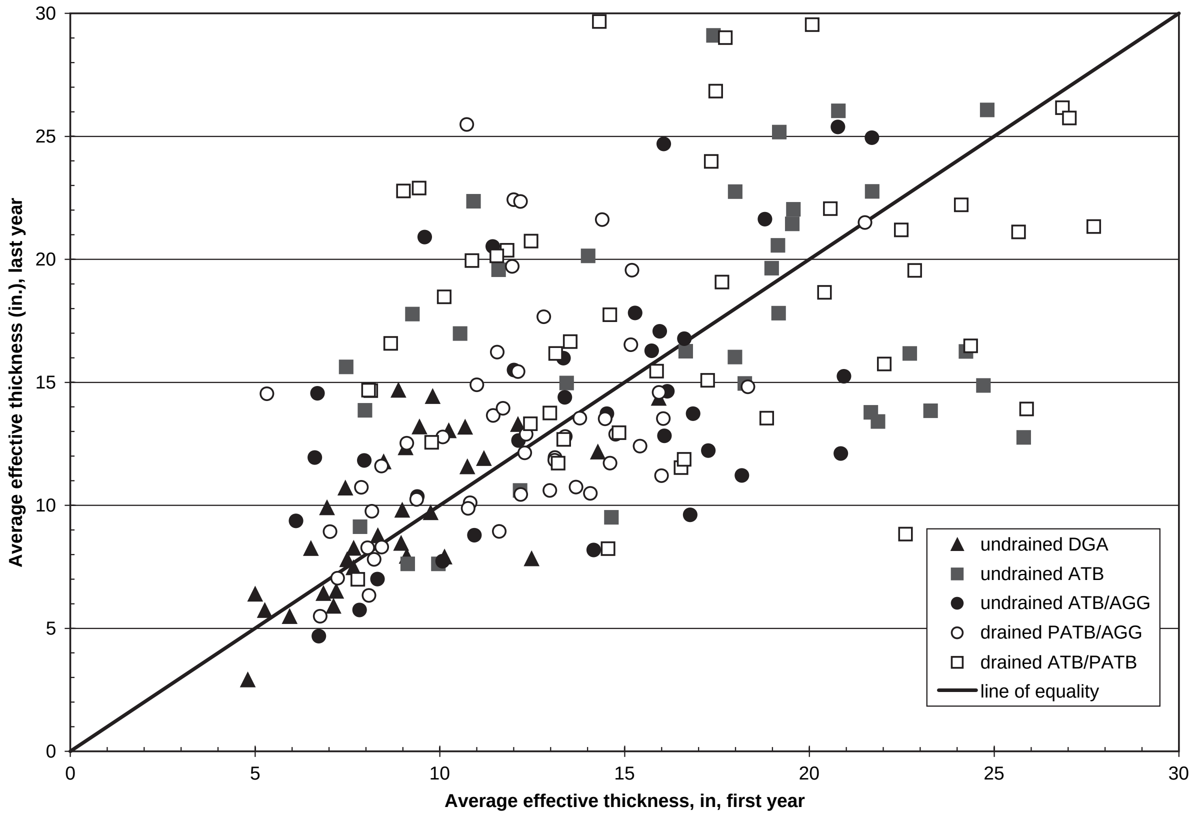

Figure 78. First-year versus last-year average backcalculated effective pavement thickness, by base type.

Analysis of SPS-2 Concrete Pavement Deflections

Effective Thickness of SPS-2 PCC Pavement Structures

A two-layer analysis procedure was used to determine the in-place *k* value of the subgrade and the elastic modulus of the pavement structure (all layers combined) above the subgrade, using deflections measured at load levels nearest to 9,000 lb and normalized to 9,000 lb. This pavement modulus was calculated in the manner of the PCC pavement deflection analysis procedure in the 1998 supplement to the AASHTO guide (namely, an AREA-based solution for the pavement's radius of relative stiffness, with corrections to the radius of relative stiffness and maximum deflection as a function of slab length and width) (*31*).

To compare the relative structural capacities of the different types of pavements at any given site, the actual total thickness and the backcalculated pavement modulus were used to calculate an equivalent pavement thickness for a fixed PCC modulus of 5,000,000 psi. This approach was considered a reasonable way to consistently treat all of the deflection data from the SPS-2 test sections so as to allow relative comparisons of the pavement structures, and it was also considered to be a realistic approach, considering the huge amount of deflection data collected on these sections over 13 years.

As shown in Table 6 (Chapter 2), the SPS-2 pavement structures fall into the following three categories by base type and drainage design:

- Undrained:
  - Group A—PCC over aggregate (AGG)
  - Group B—PCC over lean concrete base (LCB)
- Drained:
  - Group C—PCC over permeable asphalt-treated base (PATB)

Tables 8 and 9 (Chapter 2) illustrated the specific pairwise comparisons that can be made to assess the effects of base type and drainage on pavement performance in the SPS-2 experiment, all other things being equal (location, subgrade soil, climate, traffic, age, construction, slab thickness, design flexural strength, and lane width). For example, at the seven sites where test section designs 0201 through 0212 were built, Sections 0201 and 0209 are a pair, as are Sections 0205 and 0209.

Analysis of the SPS-2 deflection data reveals that the different types of base material used result in differences in the backcalculated pavement stiffness (or equivalently, effective pavement thickness). The effective PCC pavement thicknesses from deflections measured in the first year of service are shown in Table 21. Also shown in Table 21 are the design

Table 21. First-year backcalculated effective pavement thicknesses and experimental factors for SPS-2 test sections.

	Backcalculated Effective Pavement Thickness by Experimental Design Test Section																							
State	0201	0202	0203	0204	0205	0206	0207	0208	0209	0210	0211	0212	0213	0214	0215	0216	0217	0218	0219	0220	0221	0222	0223	0224
CA	15.2	16.2	17.0	17.4	20.7	15.2	19.6	23.1	13.2	13.9	13.6	15.2												
DE	16.1	17.1	18.4	18.1	19.1	24.4	23.0	21.7	15.3	14.9	16.9	16.7												
KS	15.0	15.9	17.7	18.5	27.4	21.5	28.5	23.9	15.5	14.8	17.7	16.4												
NV	13.8	7.6	14.3	16.5	21.7	17.7	21.4	23.3	11.5	11.1	12.7													
NC	19.1	18.9	17.3	19.0	23.9	21.5	23.4	22.8	15.2	15.0	15.1	16.2												
OH	15.4	15.5	16.8	19.3	15.9	17.0	16.1	17.2	13.8	13.5	15.2	16.6												
WA	14.4	15.1	16.2	16.5	18.0	16.0	18.6	16.2	12.5	12.9	14.1	14.1												
AZ													14.9	16.7	16.9	18.0	20.5	20.8	16.7	17.8	14.6	13.6	15.6	17.0
AR													22.4	20.1	20.8	22.0	22.0	22.2	22.0	23.4	15.2	14.2	15.3	17.7
CO													13.7	13.4	16.4	18.5	16.4	15.1	19.9	16.6	12.1	14.4	14.7	15.1
IA													15.9	14.9	17.3	18.0	21.4	18.7	20.4	21.1	12.1	24.3	15.1	16.8
MI													15.0	15.1	17.4	17.4	20.7	17.3	21.1	16.7	14.0	14.3	16.1	15.9
ND													16.9	18.5	18.6	19.4	27.8	21.0	24.5	19.8	15.0	14.9	16.5	17.1
WI													16.3	16.9	15.7	18.5	24.1	22.2	22.1	27.0	13.0	14.2	14.6	15.7
Average (in.)	15.6	15.2	16.8	17.9	21.0	19.1	21.5	21.2	13.9	13.7	15.0	15.9	16.4	16.5	17.6	18.8	21.8	19.6	21.0	20.3	13.7	15.7	15.4	16.5
Design PCC slab thickness (in.)	8	8	11	11	8	8	11	11	8	8	11	11	8	8	11	11	8	8	11	11	8	8	11	11
Design PCC flexural strength (psi)	550	900	550	900	550	900	550	900	550	900	550	900	550	900	550	900	550	900	550	900	550	900	550	900
Lane width (ft)	12	14	14	12	12	14	14	12	12	14	14	12	14	12	12	14	14	12	12	14	14	12	12	14

PCC slab thickness, the design PCC flexural strength, and the lane width for each of the 24 test section designs.

Eight sets of three test sections apiece can be used to compare the backcalculated effective pavement thicknesses in the undrained Group A (AGG) and Group B (LCB) with those in the drained Group C (PATB). These sets are shown in Figure 79 (0201 and 0205 versus 0209), Figure 80 (0202 and 0206 versus 0210), Figure 81 (0203 and 0207 versus 0211), Figure 82 (0204 and 0208 versus 0212), Figure 83 (0213 and 0217 versus 0221), Figure 84 (0214 and 0218 versus 0222), Figure 85 (0215 and 0219 versus 0233), and Figure 86 (0216 and 0220 versus 0224).

One observation that arises from examination of these figures is that, surprisingly, the effective thickness of the pavement sections built with undrained, untreated, dense-graded aggregate base is not much different from, and in fact is in most cases slightly greater than, the effective thickness of the otherwise equivalent pavement sections built with drained permeable asphalt-treated base. This suggests that at most of the SPS-2 sites, the permeable asphalt-treated base in the drained sections is not any stiffer than the untreated aggregate in the undrained aggregate sections, nor is the permeable asphalt-treated base contributing to bending resistance of the concrete slab through friction and bond at the slab/base interface. The notable exception is the permeable asphalt-treated base section 0222 at the Iowa SPS-2 site (see Figure 84).

Not surprisingly, the effective thickness of the pavement sections built with undrained lean concrete base is, in most cases, greater than the effective thickness of the otherwise equivalent pavement sections built with undrained aggregate or drained permeable asphalt-treated base. This suggests that the lean concrete base at most of the SPS-2 sites is considerably more rigid than the aggregate and permeable asphalt-treated base materials or is contributing to bending resistance of the concrete slab through friction and bond at the slab/base interface.

The average differences in effective pavement thickness between the first year and the last year of deflection data analyzed are small (–0.4 in., 1.9 in., and 0.2 in. for Groups A, B, and C, respectively), and not statistically significant at the 95% confidence level for any of the three groups. The backcalculated subgrade *k* values were subjected to the same analysis, and the average difference between the first and the last year (–15 psi/in., –45 psi/in., and 8 psi/in. for Groups A, B, and C, respectively) was not statistically significant at the 95% confidence level for any of the three groups.

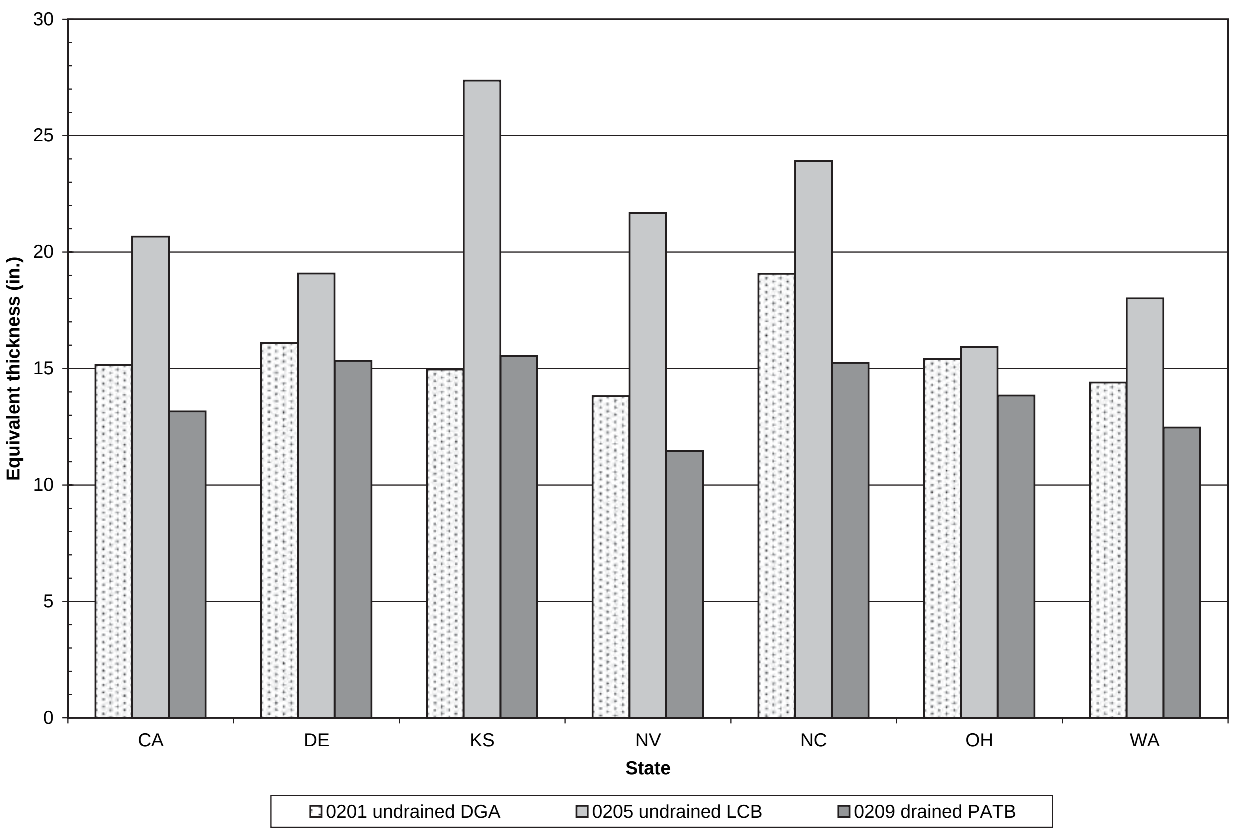

Figure 79. Backcalculated effective pavement thickness, undrained AGG (0201) and undrained LCB (0205) versus drained PATB (0209).

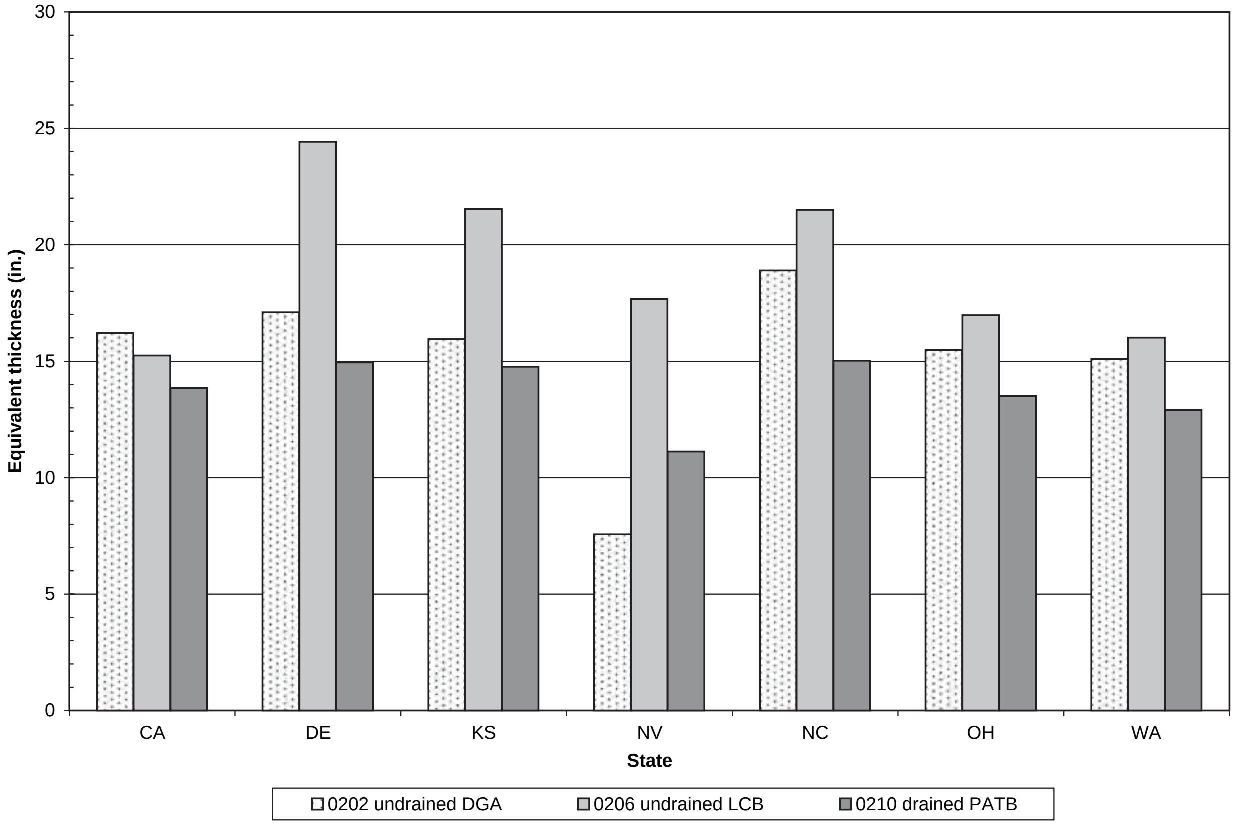

Figure 80. Backcalculated effective pavement thickness, undrained AGG (0202) and undrained LCB (0206) versus drained PATB (0210).

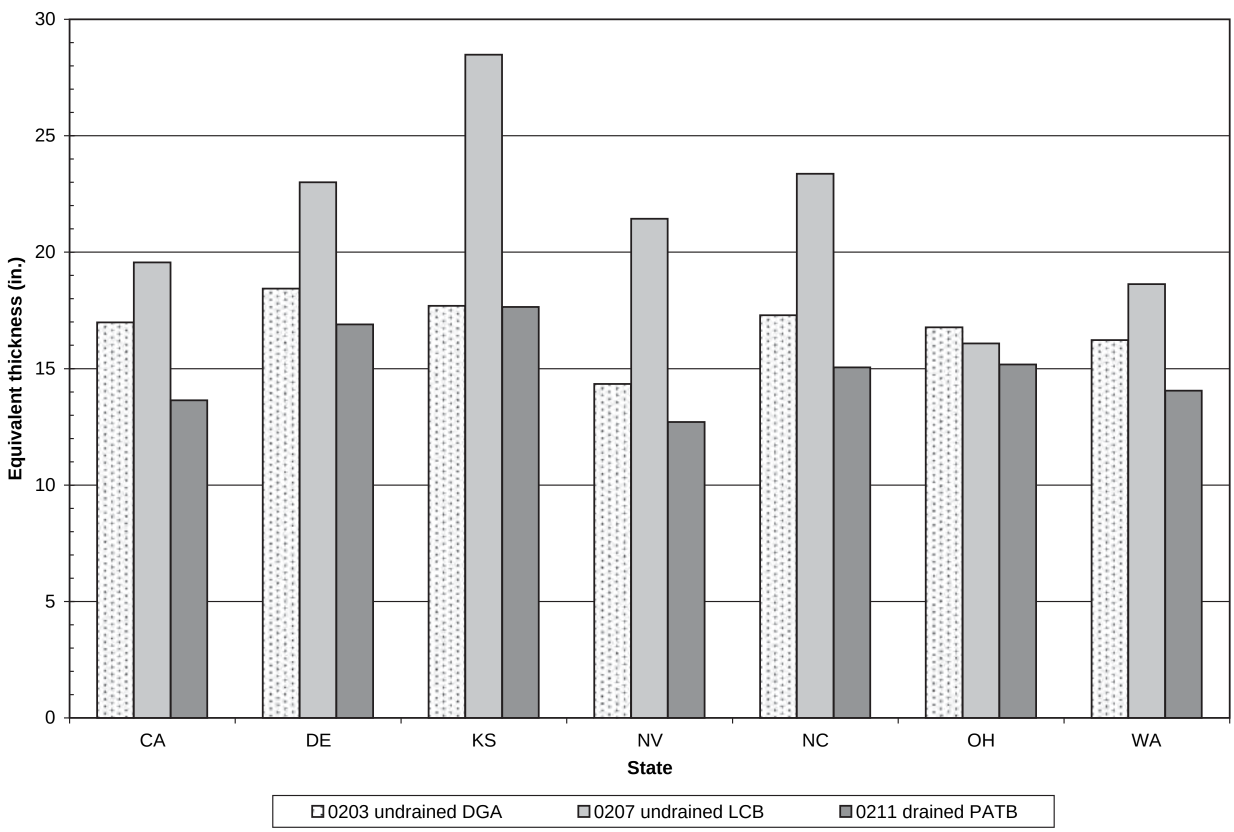

Figure 81. Backcalculated effective pavement thickness, undrained AGG (0203) and undrained LCB (0207) versus drained PATB (0211).

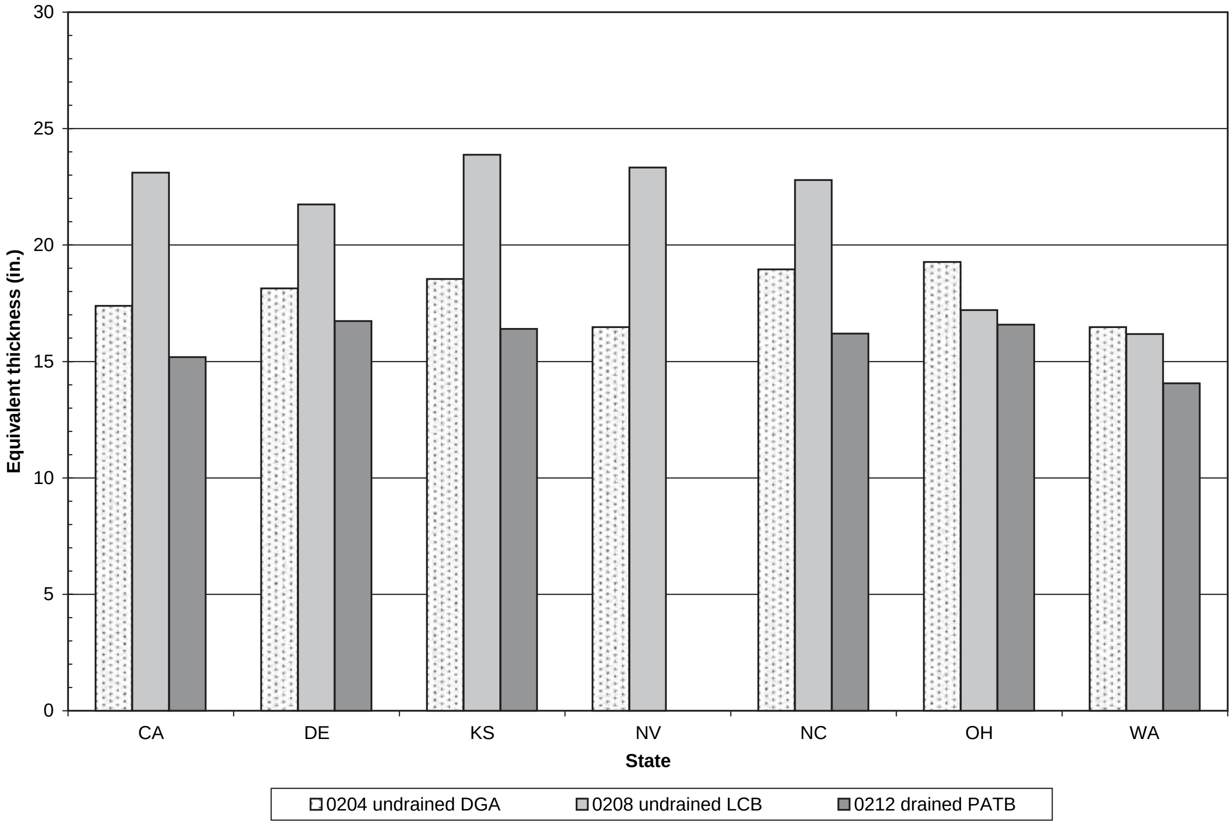

Figure 82. Backcalculated effective pavement thickness, undrained AGG (0204) and undrained LCB (0208) versus drained PATB (0212).

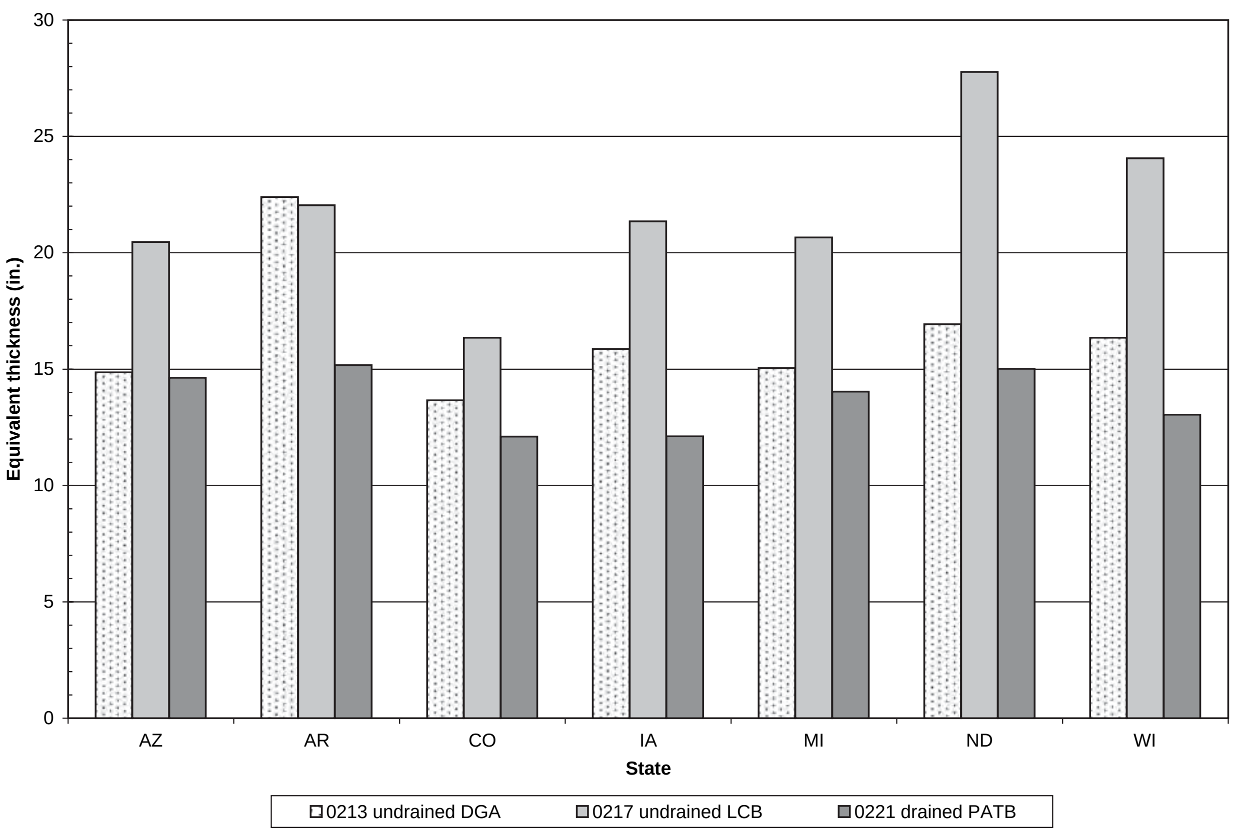

Figure 83. Backcalculated effective pavement thickness, undrained AGG (0213) and undrained LCB (0217) versus drained PATB (0221).

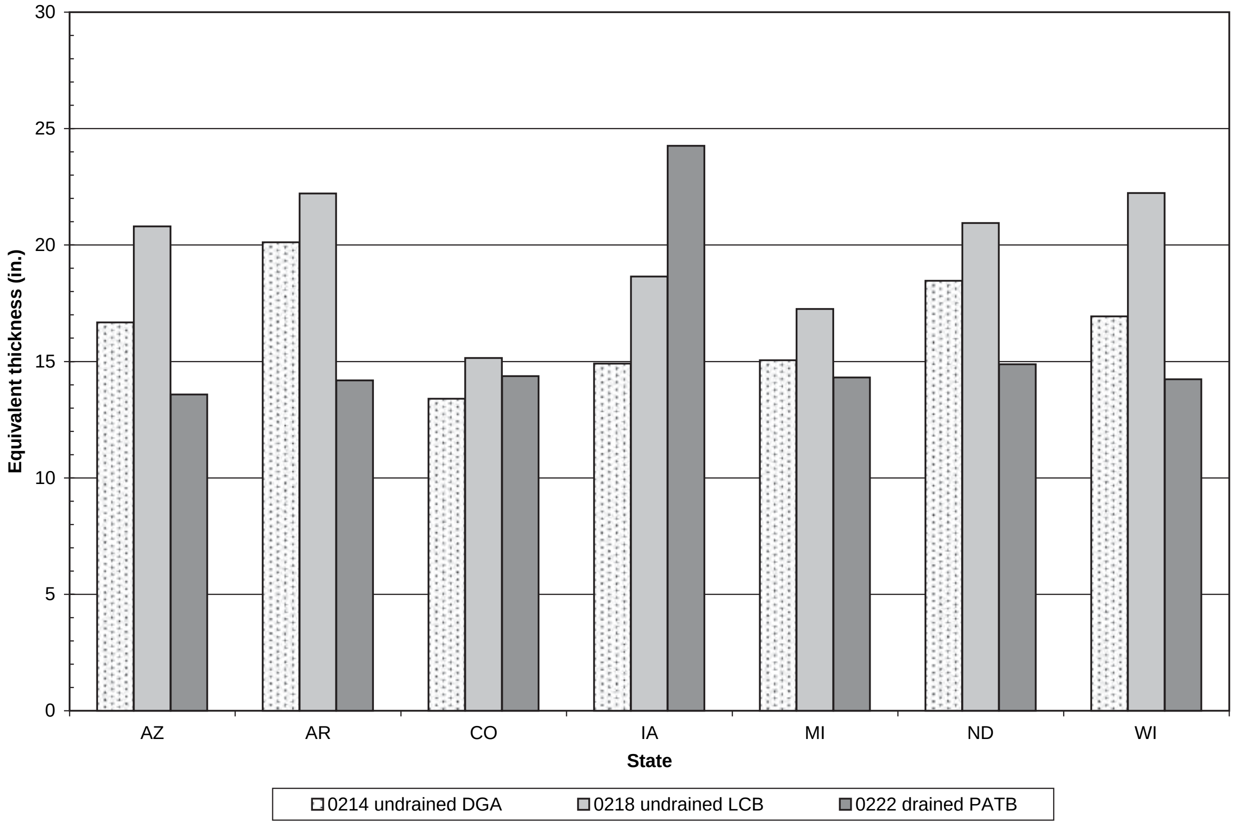

Figure 84. Backcalculated effective pavement thickness, undrained AGG (0214) and undrained LCB (0218) versus drained PATB (0222).

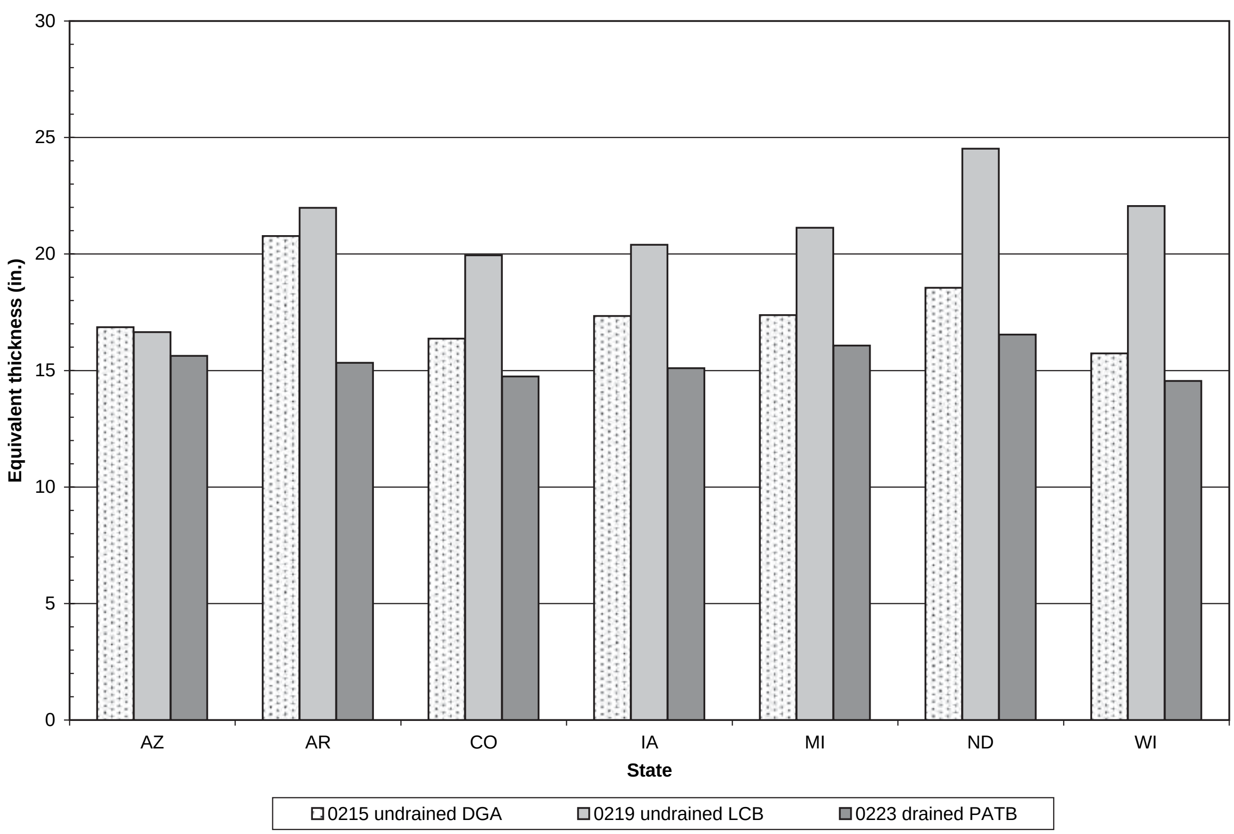

Figure 85. Backcalculated effective pavement thickness, undrained AGG (0215) and undrained LCB (0219) versus drained PATB (0223).

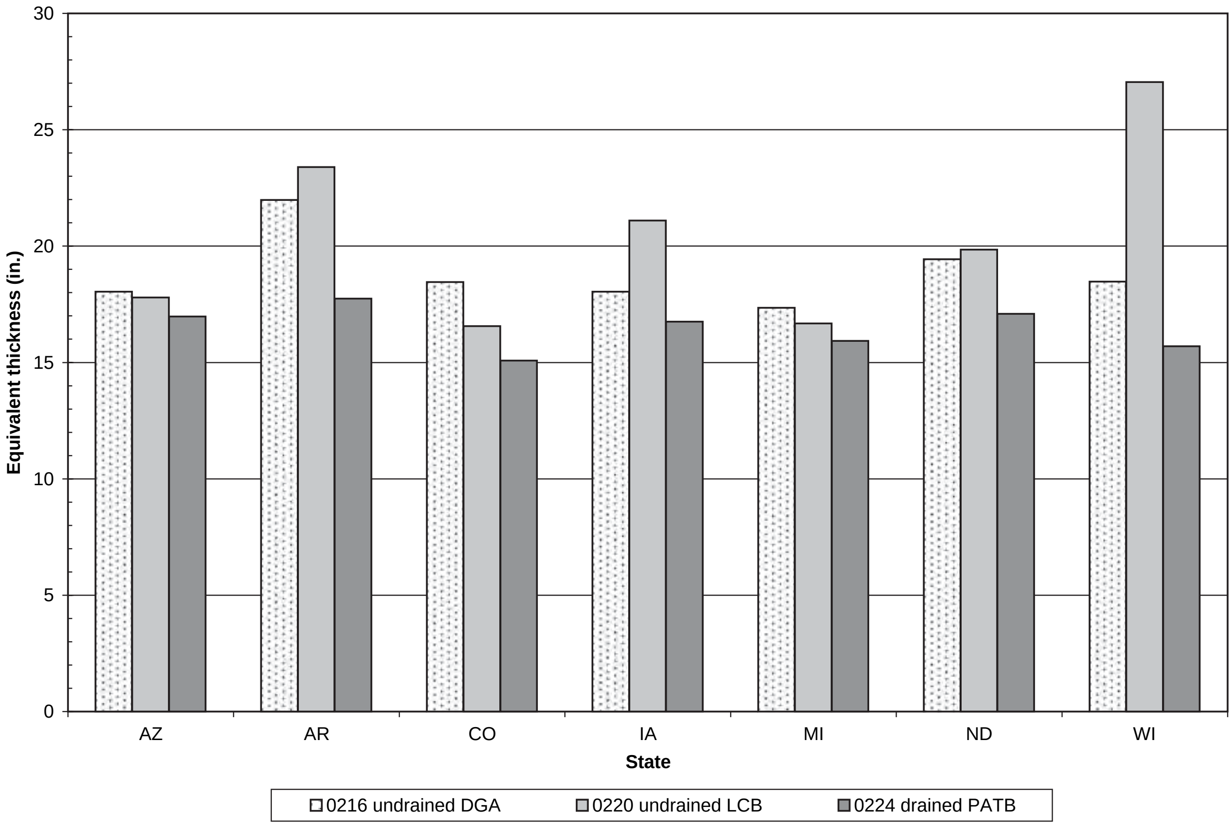

Figure 86. Backcalculated effective pavement thickness, undrained AGG (0216) and undrained LCB (0220) versus drained PATB (0224).

Approach versus Leave Joint Load Transfer

It is commonly believed that load transfer values calculated from deflections measured when the falling weight deflectometer (FWD) load plate is on the leave side of the joint tend to be lower than load transfer values calculated from deflections measured when the FWD load plate is on the approach side of the joint. The rationale for this belief is that support under the slab on the leave side of the joint is expected to be weaker, according to the classical description of the mechanism of pumping at transverse joints. In a recent analysis of a large set of load transfer measurements from the LTPP database, however, just the opposite was found: in the vast majority of cases, load transfers computed from leave-side deflection tests were higher than load transfers computed from approach-side deflection tests (*31*).

The same was found to be true in this study, in which the entire set of deflection data (from construction to late 2003) from all SPS-2 sections was analyzed. The differences between approach-side load transfer measurements (in LTPP deflection testing parlance, the J4 pass) and the leave-side load transfer measurements (the J5 pass) are illustrated in Figure 87. It should be kept in mind that overlapping of points in the vicinity of the mean difference can give the visual impression that there are more outliers than there really are. In fact, in the SPS-2 data analyzed in this study, about 75% of all differences between leave- and approach-load transfer were within ±10%.

Nonetheless, a paired *t*-test analysis of the more than 10,000 joint-by-joint pairs of approach and leave load transfer values indicates that the mean difference between the leave load transfer and approach load transfer is 2.7% (leave minus approach) and that this difference is statistically significant at the 95% confidence level. The horizontal best-fit line through the data shown in Figure 87 suggests that the magnitude of the difference between leave load transfer and approach load transfer is not sensitive to temperature (which in turn suggests that the difference is unrelated to the size of the joint opening).

Load Transfer by Base Type and Drainage

Comparisons of joint load transfer among the three different base type/drainage groups in the SPS-2 experiment are difficult because of the variation that is introduced by temperature differences. The load transfer data for the three main base type/drainage treatments (undrained aggregate, undrained lean concrete base, and drained permeable asphalt-treated

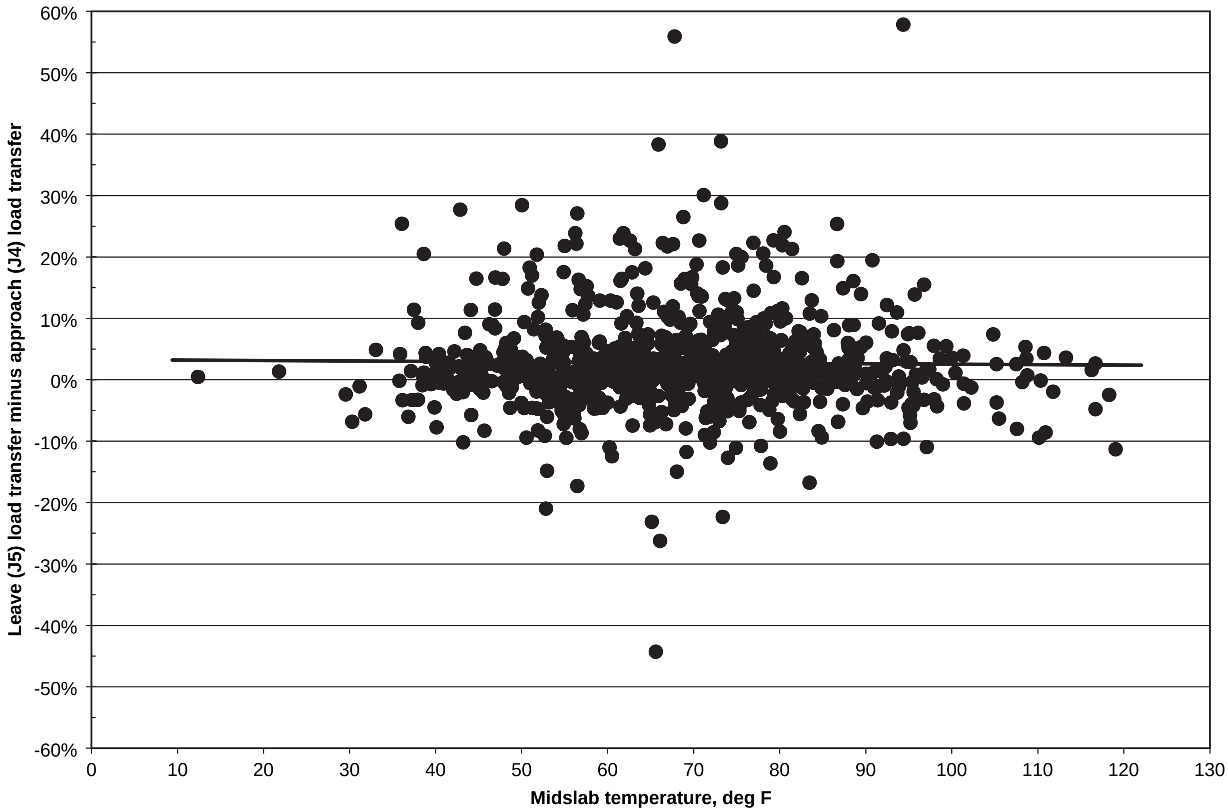

Figure 87. Leave-side minus approach-side load transfer, SPS-2 test section averages.

base) are so scattered that they do not display any clear trends (such as the S-shaped curves that one might expect) with respect to temperature. This makes it difficult to compare load transfer measurements made on different test sections at a given site, even if measured on the same day.

It is possible, however, to confirm that the load transfer data for the SPS-2 test sections with the three different base type/drainage treatments of interest were measured over temperature ranges that are essentially the same in their mean and in their distribution, as shown in Figure 88. This provides some reassurance of the validity of the comparison, shown in Figure 89, of the cumulative frequency distributions of leave load transfers from the first year of deflection testing. The undrained AGG treatment, with the curve farthest to the right for most of the plot (that is, with the lowest cumulative percentage of joints with load transfer at or below any given load transfer level), exhibits the best initial load transfer. The second best is the drained PATB treatment, and the worst of the three is the undrained LCB.

This would seem to run counter to the reasonable expectation that the stiffer the base material, the better the support provided to the joint when loaded. A possible explanation for the seemingly counterintuitive results is that comparisons of deflection load transfer can be misleading if differences in the magnitude of deflection are not taken into consideration. For example, if two sides of one joint deflect 8 mils and 10 mils, respectively, while two sides of another joint deflect 2 mils and 4 mils, the first joint will have a calculated load transfer of 80% while the second joint will have a calculated load transfer of only 50%. Nonetheless, the second of the two joints is the one that is more resistant to bending and thus less likely to develop load-related distress at the joint.

The cumulative frequency distributions of leave load transfer from the latest year of deflection testing at each SPS-2 site are shown in Figure 90. At higher load transfer levels, the cumulative frequency distributions are similar for each of the treatments. At lower load transfer levels, the undrained LCB and undrained AGG distributions are fairly similar, but the drained PATB distribution has shifted farther to the left than either of the other two (highest percentage of joints with load transfer at or below any given load transfer level below 80%). Some caution should be exercised in interpreting this figure, since a given differential deflection can result in lower calculated load transfer at lower deflection magnitudes than at higher deflection magnitudes. Nonetheless, in comparing Figures 89 and 90, it is evident that all three of the treatment types exhibit a leftward (worsening) shift in their load transfer cumulative frequency distributions in the range of 50% to 80% load transfer, and that the PATB curve has shifted farther to the left than the curves of the other two treatments.

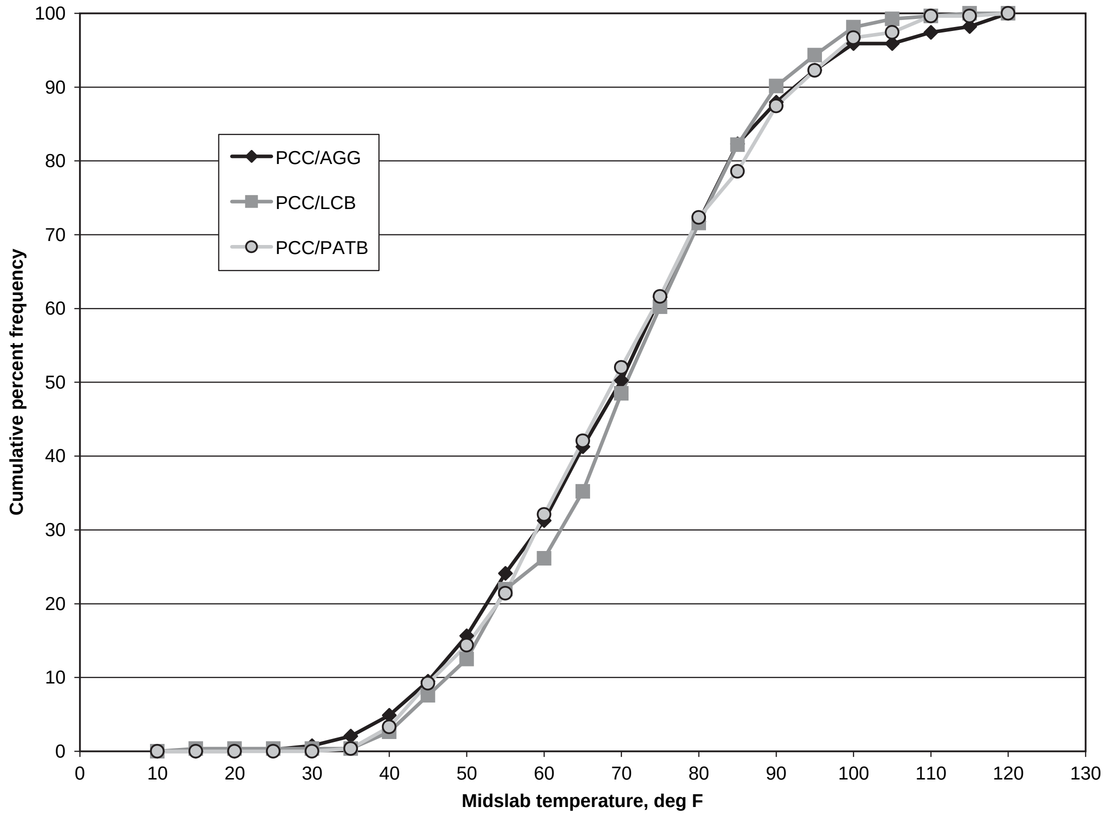

Figure 88. Cumulative frequency distributions of temperatures corresponding to SPS-2 load transfer measurements.

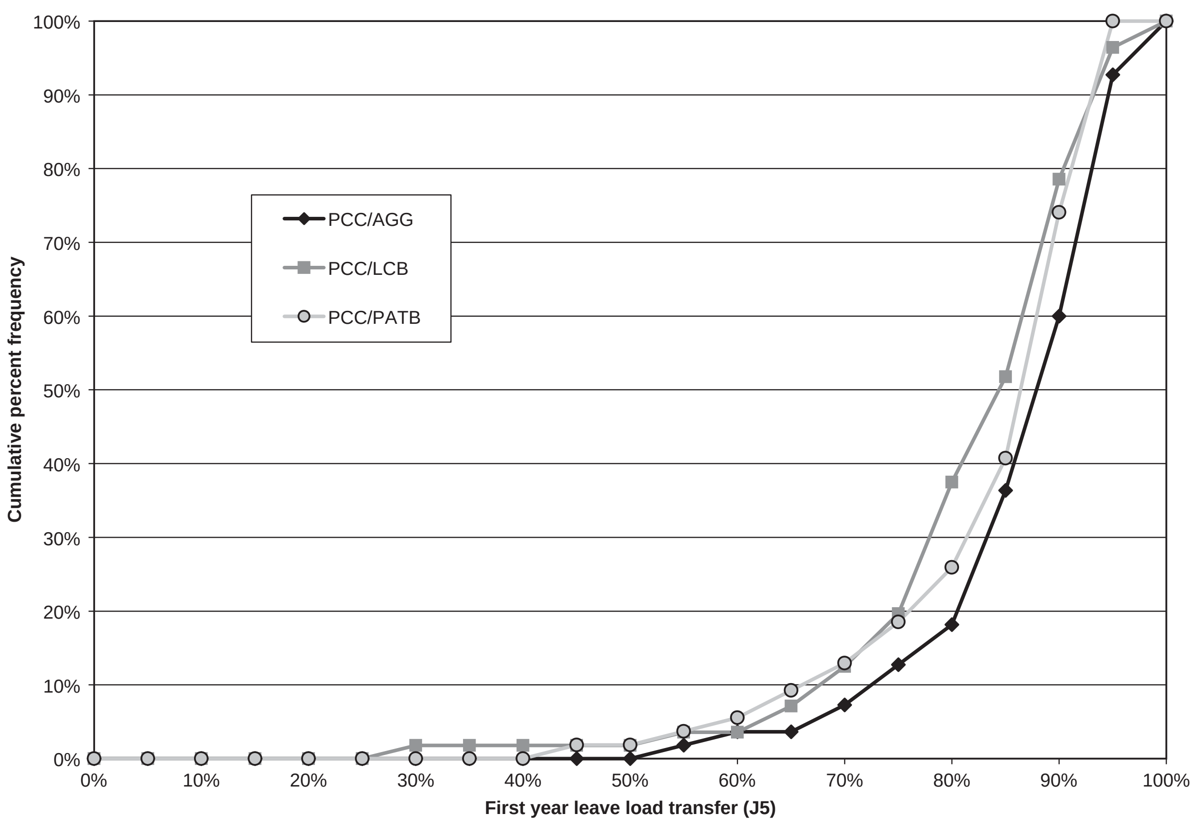

Figure 89. Cumulative frequency distribution of leave load transfers from first year of deflection testing at SPS-2 sites.

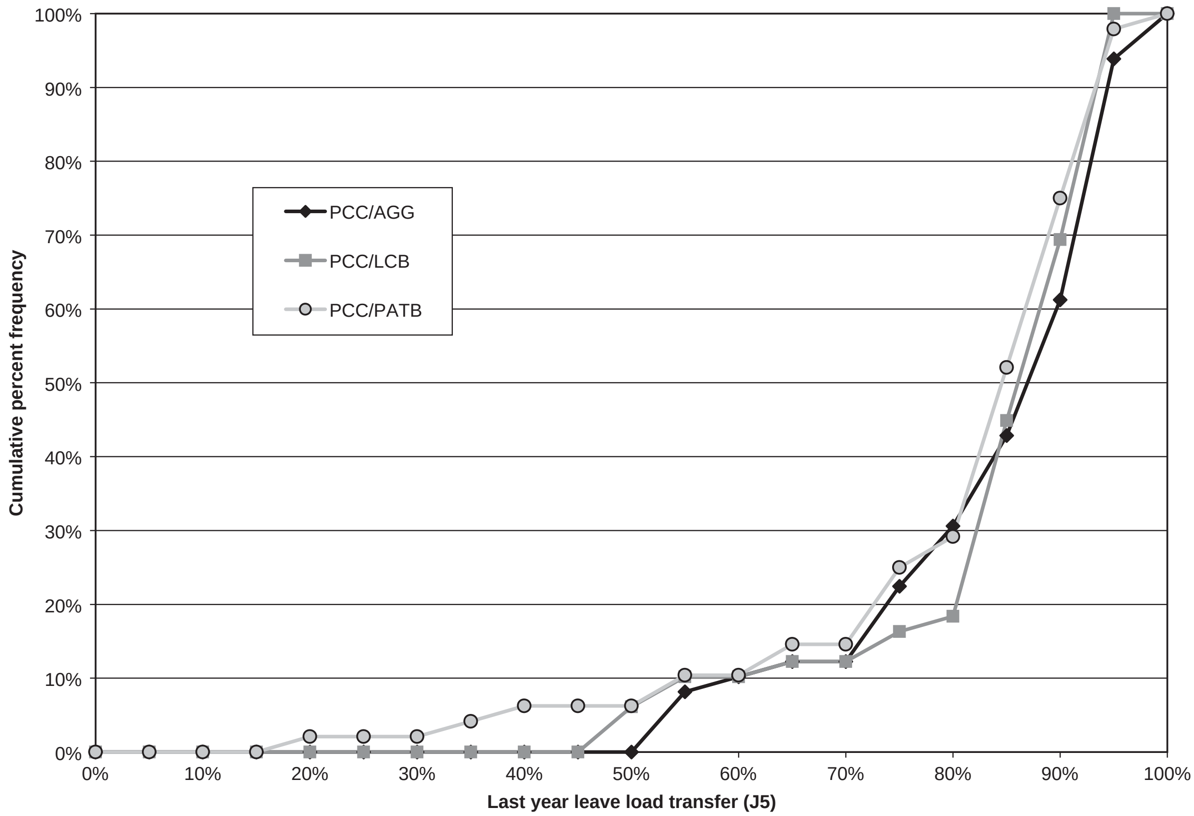

Figure 90. Cumulative frequency distribution of leave load transfers from last year of deflection testing at SPS-2 sites.

To keep these observations in perspective, however, it should be remembered that all of the joints in the core experimental sections (1 through 24) in the SPS-2 experiment are dowelled, and that after being in service for several years—and in some cases for more than 10 years—only a small percentage of joints associated with any of the treatments are exhibiting poor load transfer. There is, in short, nothing dramatically different among these treatments in terms of load transfer, either in the first year or in the most recent year of field testing.

CHAPTER 5

Roughness and Distress in SPS-1 Flexible and SPS-2 Rigid Pavements

Performance Data Analysis Approach

The effects of several factors, including the experimental design factors, on the development of roughness and distress in SPS-1 flexible and SPS-2 rigid pavements are examined in this chapter. The SPS-1 experimental design factors include

- AC thickness,
- Base thickness,
- Base type,
- Subdrainage,
- Climate,
- Subgrade, and
- Traffic.

For SPS-2 pavements, the experimental factors include

- PCC thickness,
- Concrete flexural strength,
- Base type,
- Slab width,
- Subdrainage,
- Climate,
- Subgrade, and
- Traffic.

The last three factors listed for each pavement type (climate, subgrade, and traffic) are those that would be expected to be most useful in explaining differences in observed performance among pavements of similar design at different locations. The other factors listed are those that would be expected to be most useful in explaining differences in observed performance among different test sections at a given site.

The main goal of this study is to assess the effects of subdrainage on the performance of the pavements in the SPS-1 and SPS-2 experiments. The previous phase of this research demonstrated the feasibility of making this assessment by comparing distress and roughness between drained and undrained pairs of test sections at each site (*13*). For example, referring back to the SPS-1 experimental design matrix presented in Chapter 2 (Tables 4 and 5), the relative effects of undrained dense aggregate base and drained permeable asphalt-treated base may be assessed by comparing distress and roughness in the following test section pairs at each site:

- 0101 versus 0110,
- 0102 versus 0111,
- 0113 versus 0122, and
- 0114 versus 0123.

In each of these four pairs, the design AC surface thickness and the design base thickness are the same, and the subgrade, traffic, and climate are the same at each site. Thus, analyzing all of the relevant pairs at all of the SPS-1 sites using paired difference *t*-tests blocks the effects of these other factors and detects any significant differences in performance that can be attributed to some sections having undrained dense aggregate base and others having permeable asphalt-treated base.

There are some limitations to this pairwise comparison approach to analysis of the performance data. One limitation is that treating some factors as qualitative rather than quantitative variables (for example, using design layer thicknesses rather than as-constructed thicknesses) masks the contribution of variation in these factors to the overall variation in observed performance.

Another limitation is that blocking out the effects of factors that differ by site (climate, subgrade, and traffic) focuses the analysis only on the one experimental factor analyzed (the base/drainage factor) and precludes assessment of the potential effects of climate, subgrade, and traffic. Blocking for these other factors does not, as some believe, confuse the analysis of the factor of interest by failing to take their influence into account; rather, it clarifies the analysis by taking their influence into account in the appropriate manner. This does mean, however, that an analysis of this nature only has something to say about the statistical significance of the one factor analyzed. It cannot yield quantitative conclusions about the relative statistical significance of the other factors in the experiment.

Another obstacle exists that no choice of statistical test can overcome—namely, the base type and subdrainage factors are confounded in both the SPS-1 experiment and the SPS-2 experiment. So while it is possible to test for statistically significant differences in performance between, for example, sections with undrained dense aggregate base and otherwise equivalent sections with permeable asphalt-treated base, it is not possible to determine, on the basis of a statistical test, whether any such differences in performance are due to the two different base types or to the two different drainage situations.

The larger question, however, is how much does the base/drainage factor of the SPS-1 and SPS-2 experimental designs influence performance, compared with other experimental factors and site features? If the base/drainage factor has a strong influence on the performance of the different pavement sections at the SPS-1 and SPS-2 sites, it then becomes necessary to consider the results of the statistical tests of the performance data together with the results of the deflection analysis, flow time testing, and assessment of the natural drainage characteristics of the subgrade soil to make some judgments about how much the stiffness of the base seems to be the influential aspect of that experimental design factor, versus how much the quality of base drainage seems to be the influential aspect. If, on the other hand, the base/drainage factor does not have a strong influence on the performance of the different pavement sections at the SPS-1 and SPS-2 sites, then it becomes much less important to try to determine whether base stiffness or the quality of drainage is the key aspect of that experimental design factor.

To assess the relative importance of the base/drainage factor, compared with the other design and site factors in the SPS-1 and SPS-2 experiments, the available performance (roughness and distress) data were analyzed using an approach that does not rely on test section pair comparisons alone, but rather examines the effects of all of the experimental factors together. This approach employs regression analysis to detect which of the factors involved are significant. Regression analysis also overcomes the other limitation to pairwise comparison mentioned earlier. It allows qualitative and quantitative variables to be considered together, which permits quantitative consideration of factors such as layer thickness, subgrade stiffness, climate, and traffic level. This reduces the "noise" due to section-to-section and site-to-site variations in these factors, which might otherwise mask the contribution of variation in these factors to the overall variation in observed performance.

Although testing for significance of factor effects applies statistical tests to the linear regression of performance differences with respect to each of the factors, it does not imply a presumption that those relationships are better described by linear, rather than nonlinear, regression. The question of interest is not what is the nature (linear or nonlinear) of the relationship of the factors to the observations, but whether any relationship exists at all between the factors and the observations. Linear regression is a tool for detection of significant factor effects that should be the first step in model building—the step that identifies which variables should be included in any kind of prediction model subsequently developed. The next step in the model-building process, which is beyond the scope of this study, would be to identify the model form that yields the best prediction of the observed performance measure as a function of the factors that have been found to be significant.

Regression Model for Assessing Effects of SPS-1 Experimental Factors

The following regression model was used to assess the significance of subdrainage and other SPS-1 experimental factors to the development of pavement roughness and distress:

$$Y = a_0 + a_1\,\text{YFIRST} + a_2\,\text{HAC} + a_3\,\text{HB} + a_4\,\text{B1} + a_5\,\text{B2} + a_6\,\text{B3} + a_7\,\text{B4}\,\{+\,a_8\,\text{DRN}\,\} + a_9\,\text{TMP} + a_{10}\,\text{PRECIP} + a_{11}\,\text{ESUB} + a_{12}\,\text{HEQUIV} + a_{13}\,\text{CESAL} + a_{14}\,\text{TIME}$$

where

- Y = latest available measurement of performance measure of interest (distress or international roughness index [IRI]), or change in performance measure;
- YFIRST = first available measurement of performance measure of interest;
- HAC = as-constructed AC surface thickness (in.);
- HB = total thickness of as-constructed base and subbase, if any (in.);
- B1 to B4 = SPS-1 base type variables (defined below);
- DRN = 1 if drained, 0 if not drained;
- TMP = average annual temperature (°F);
- PRECIP = average annual precipitation (in.);
- TMI = Thornthwaite moisture index;
- ESUB = backcalculated subgrade modulus (psi) (see Chapter 4);
- HEQUIV = backcalculated equivalent pavement thickness (in.) (see Chapter 4); and
- CESAL = accumulated 18-kip ESALs from date of opening to traffic to date of Y measurement.

The four SPS-1 base type variables (B1 to B4) are dummy variables that identify which of the SPS-1 experiment's five base types is present. The values assigned to each of the base variables, as well as to the DRN variable, for each of the five base types are shown in Table 22. Note that the value of DRN can always be determined from the values of B1, B2, B3, and B4. The DRN variable and the base type variables are redundant. The DRN variable thus cannot be considered in the regression analysis together with the base type variables, as the regression analysis cannot be run correctly if collinearity is introduced. The DRN variable in the regression model form above is for illustrative purposes only and is thus shown in braces. The DRN variable was not used in the regression analysis; instead, the four base type variables were used.

The design, climate, and backcalculation results used in the regression analyses of the SPS-1 performance data are shown by test section in Table C-1 in Appendix C. The data used are shown in Table C-2. The accumulated ESAL and age data used are shown in Table C-3.

Regression Model for Assessing Effects of SPS-2 Experimental Factors

The following regression model was used to assess the significance of subdrainage and other SPS-2 experimental factors to the development of pavement roughness and distress:

$$Y = b_0 + b_1\,\text{HPCC} + b_2\,\text{HIGH} + b_3\,\text{WIDE} + b_4\,\text{B1} + b_5\,\text{B2}$$
$$\{+\,b_6\,\text{DRN}\,\}$$
$$+\,b_7\,\text{TMP} + b_8\,\text{PRECIP} + b_9\,K + b_{10}\,\text{CESAL}$$
$$+\,b_{11}\,\text{YFIRST} + b_{12}\,\text{BAR} + b_{13}\,\text{AC}$$

where

Y = latest available measurement of performance measure of interest (distress or IRI), or change in performance measure;
HPCC = as-constructed concrete slab thickness (in.);
HIGH = 1 if design 28-day concrete strength = 900 psi, and 0 if design 28-day concrete strength = 550 psi;
WIDE = 1 if outer slab constructed 14 ft wide and 0 if outer slab constructed 12 ft wide;
B1, B2 = the SPS-2 base type variables;
B3, B4, B5 = 0-1 variables for base types in supplemental SPS-2 test sections (HMAC, none, or CAM, respectively);
DRN = 1 if drained, 0 if not drained;
TMP = average annual temperature (°F);
PRECIP = average annual precipitation (in.);
K = estimated static k value from backcalculation (psi/in.);
CESAL = accumulated 18-kip ESALs from date of opening to traffic to date of Y measurement; and
YFIRST = first available Y measurement.

The AC variable is used for two supplemental test sections at the Arizona SPS-2 site:

AC = 1 if pavement type is AC and 0 if pavement type is PCC.

The BAR variable is used to identify supplemental test sections without dowels at the Arizona, North Dakota, and Washington SPS-2 sites:

BAR = 1 if PCC pavement is dowelled and 0 if undowelled.

The two base variables B1 and B2 are dummy variables that identify which of the SPS-2 experiment's three base types is present. The values assigned to each of the base variables, as well as to the DRN variable, for each of the three base types, are shown in Table 23. As with the DRN and the base type variables in the SPS-1 experiment, the B1 and B2 base type variables in the SPS-2 experiment indicate the value of, and are redundant with, the DRN variable.

There are, however, several supplemental sections in the SPS-2 experiment with a base type other than one of the three base types in the main experiment. There are some sections with a hot-mix asphalt concrete base, one section with no

Table 22. Values of base and drainage variables in the SPS-1 performance regression equation.

Base Type	B1	B2	B3	B4	DRN
Dense-graded aggregate	0	0	0	0	0
Asphalt-treated base	1	0	0	0	0
Asphalt-treated base over dense-graded aggregate subbase	0	1	0	0	0
Permeable asphalt-treated base over aggregate subbase	0	0	1	0	1
Asphalt-treated base over permeable asphalt-treated subbase	0	0	0	1	1

Table 23. Values of base and drainage variables in the SPS-2 performance regression equation.

Base Type	B1	B2	DRN
Dense-graded aggregate	0	0	0
Lean concrete base	1	0	0
Permeable asphalt-treated base	0	1	1

base at all, and some sections with a cement-aggregate mixture base. The presence of one of these three base types is indicated by a value of 1 for the base variable B3, B4, or B5. Not to include these three supplemental base type variables would erroneously suggest that a section for which B1 = 0 and B2 = 0 had the third type of base in the main experiment (the undrained dense-graded aggregate). Since the type of drainage is not generally known with a great degree of confidence for the supplemental test sections, no value (neither 0 nor 1) is assigned to the DRN variable for those sections.

The design, climate, and backcalculation results used in the regression analyses of the SPS-2 performance data are shown by test section in Table C-4 in Appendix C. The performance data used are shown in Table C-5. The accumulated ESAL and age data used are shown in Table C-6.

Selection of IRI Data for Analysis

Roughness in the SPS-1 and SPS-2 pavement sections was analyzed using IRI data extracted from the MON_PROFILE_MASTER table in the LTPP database. The IRI is a roughness parameter obtained from a mathematical model applied to a measured profile. The model simulates a quarter-car (one-wheel) system traveling at 80 km/h. The IRI value is the cumulative vertical movement of the suspension of the quarter-car system, divided by the traveled distance.

The MON_PROFILE_MASTER table reports three IRI values for each profile run: the left wheelpath IRI, the right wheelpath IRI, and the average of the two values. One decision that must be made in the analysis of IRI data is which of these three IRI values to use. If there is no significant difference between left wheelpath and right wheelpath IRI, then they can be presumed to be samples from the same population. If this is the case, it does not matter which value (the left wheelpath, the right wheelpath, or the average) is used. If, on the other hand, there is a significant difference between left wheelpath and right wheelpath IRI, that means that the two are samples from different populations, and one of the two should be selected and used consistently in the analysis. In this case, the average of the two values is not a better indicator of the true IRI than either one of them, nor even as good an indicator as either one of them.

To assess this, left and right wheelpath IRI values were compared in paired difference *t*-tests using the results from all of the profile runs conducted on SPS-1 and SPS-2 test sections from the date of their construction through 2004. The results, shown in Table 24, indicate that the left and right wheelpath IRI values are significantly different in both the SPS-1 and SPS-2 data sets. The mean right wheelpath IRI was greater than the mean left wheelpath IRI in both cases; the right wheelpath IRI was thus selected for use in further analyses for this study.

For each profile measurement date, the mean right wheelpath IRI was calculated from the right wheelpath IRI values from all of the profile runs on that day (usually five runs, but sometimes as few as one or as many as 15). These mean right wheelpath IRI values were used in the regression analysis.

Table 24. Tests of significant difference between left and right wheelpath IRI.

	SPS-1		SPS-2	
	Left Wheelpath	Right Wheelpath	Left Wheelpath	Right Wheelpath
Mean IRI (m/km)	0.958	0.992	1.350	1.401
Mean difference	0.034		0.051	
Standard deviation s_D	0.208		0.253	
n	9879		9954	
Calculated *t*	16.05		20.05	
$t_{0.025, n-1}$	1.96		1.96	
Significant difference?	yes		yes	

Fluctuations in IRI not Due to Pavement Deterioration

The expectation is that IRI will tend to increase over time, as the pavement deteriorates. IRI does not, however, always increase steadily over time. Sometimes the IRI of a test section is lower than that measured at the same test section a year earlier, a month earlier, or even a day earlier. There are several reasons why IRI might decrease from one testing date to the next, including the following:

- Rehabilitation or maintenance between testing dates;
- Seasonal variation;
- Measurement in different paths;
- Different starting locations;
- Spikes in the data caused by reflection of light from the white paint stripe at the start of a test section; and
- Problems with the profilometer electronics, sensors, or distance measurement (*32*).

It is not necessarily true, however, that an IRI decrease, or an IRI increase for that matter, always has a physical explanation. Some portion of the variation seen in IRI data is random variation—that is, some fluctuations in IRI, both upward and downward, are not significantly different from no change at all.

Initial IRI Values

Examination of the first available IRI values for the SPS-1 and SPS-2 test sections reveals a surprisingly large disparity between the two experiments in these initial (or early) levels. This is illustrated by the cumulative frequency distributions shown in Figure 91. The mean first IRI for the SPS-1 test sections was 0.88 m/km, while the mean first IRI for the SPS-2 test sections was 1.30 m/km.

This disparity cannot be attributed to the first SPS-1 IRI values being obtained from profile runs conducted sooner after the pavement was opened to traffic than were the SPS-2 IRI values. As Figure 92 shows, there is not much difference in the cumulative frequency distributions of time from the date of opening to traffic to the date of the first available IRI data. Indeed, Figure 92 shows that the first IRI values after the pavement was opened to traffic tended to be obtained sooner

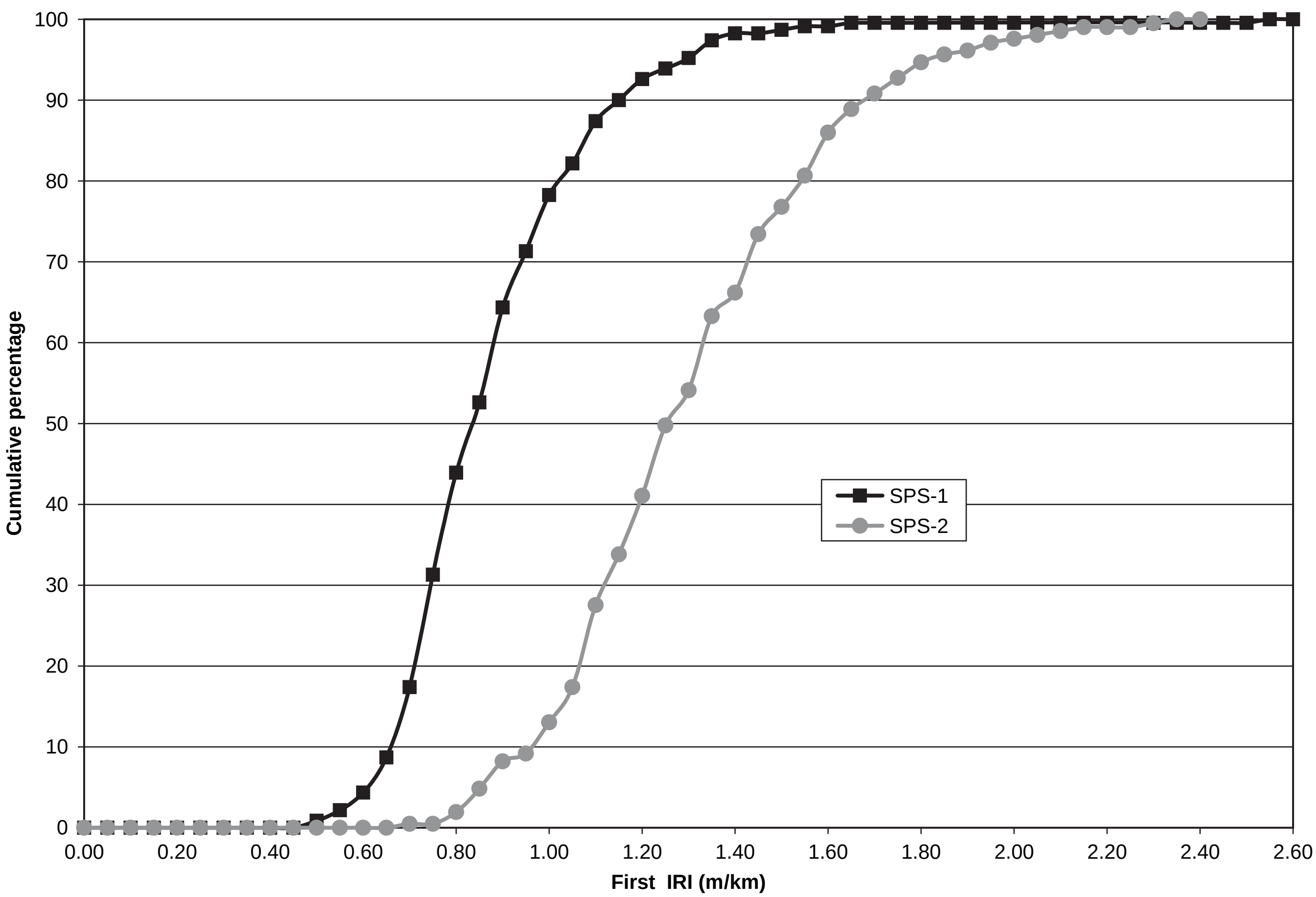

Figure 91. Cumulative frequency distributions of first IRI of SPS-1 and SPS-2 test sections.

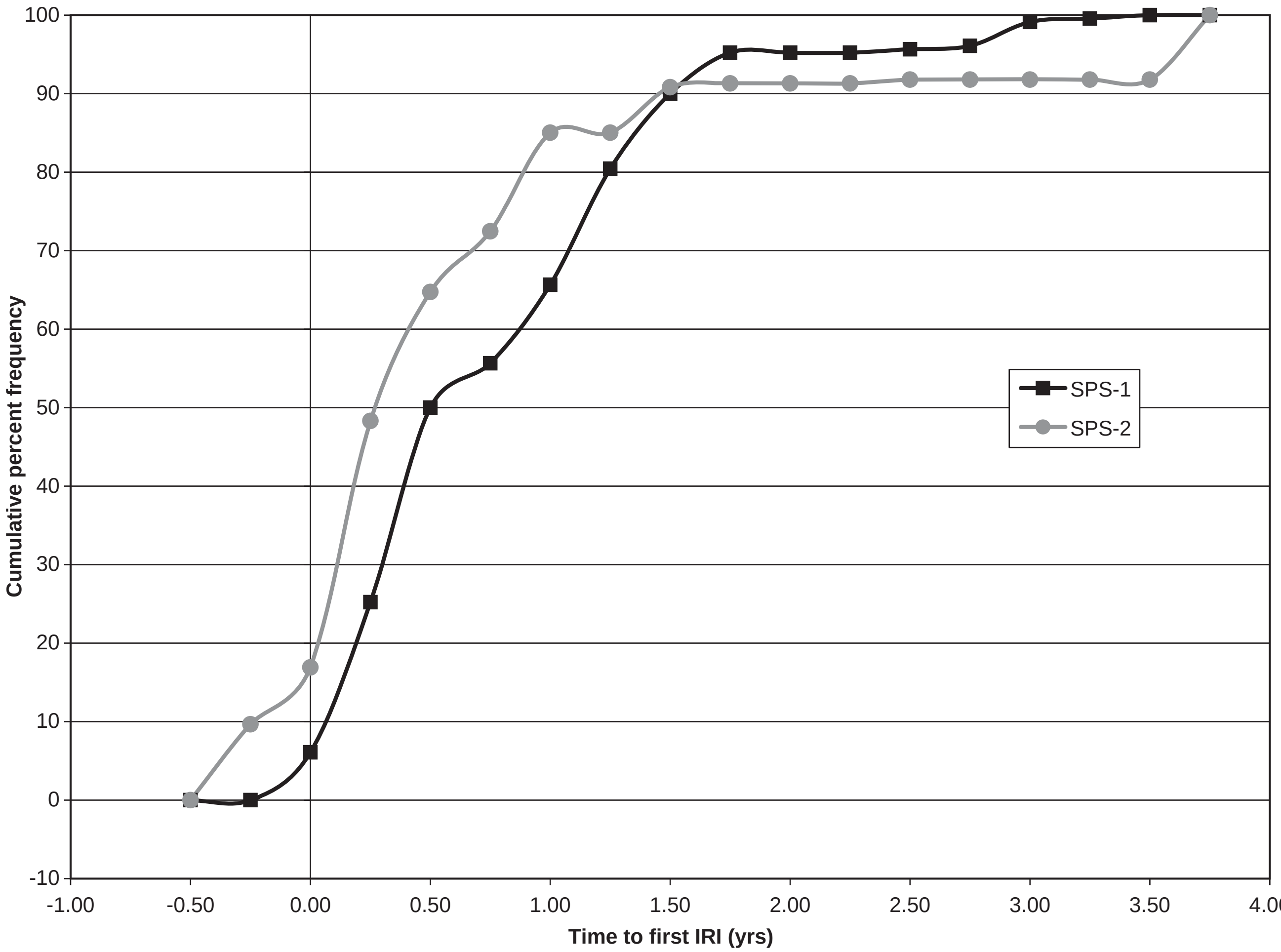

Figure 92. Cumulative frequency distributions of time from date of opening to traffic to date of profile run corresponding to first available IRI values, for SPS-1 and SPS-2 test sections.

from SPS-2 sections than from SPS-1 sections. Figures 91 and 92 together indicate that, in general, better initial smoothness levels were obtained in the construction of the SPS-1 test sections than in the SPS-2 test sections. The same might not necessarily be true, however, of more conventional paving (as opposed to the 500-ft test sections of varying design, as in the SPS-1 and SPS-2 experiments).

Regression Analysis of Factors Affecting IRI In SPS-1 Flexible Pavements

The regression models presented previously were used to determine which of the various experimental design factors and site factors in the SPS-1 and SPS-2 experiments have had a significant effect on roughness development.

The relative contributions of the SPS-1 factors to the r^2 of the regression model for latest observed IRI are summarized in Table 25. The factor most significant to the last observed IRI was initial IRI, which alone contributes 26% of the 38% total r^2 possible when all other factors are included in the regression. The latest observed IRI values of the SPS-1 test sections were more strongly related to the initial IRI values than to all of the other factors combined.

The latest IRI values of the SPS-1 test sections are plotted against the initial IRI values in Figure 93, along with the linear

Table 25. Significance of SPS-1 regression variables to last IRI.

Independent Variable	Combined r^2 with this variable added
FIRST_IRI	0.26
TIME_LAST_IRI	0.30
H_EQUIV	0.31
TMI	0.33
PRECIP	0.34
ESUB	0.35
B2	0.35
B3	0.36
B4	0.37
HB	0.37
CESAL_LAST_IRI	0.38
TMP	0.38
HAC	0.38
B1	0.38

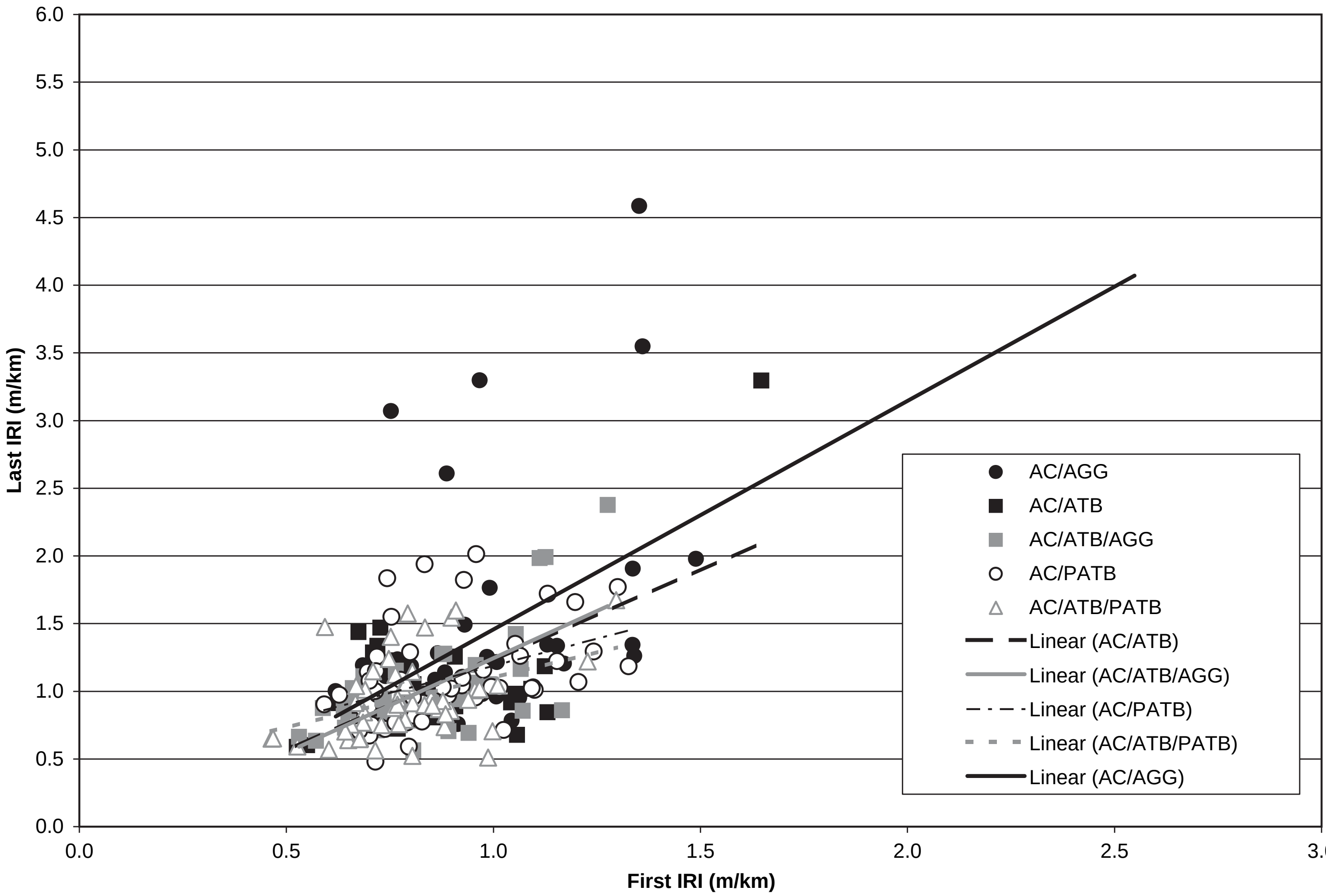

Figure 93. Linear correlations of latest IRI to initial IRI for SPS-1 pavement sections.

trend line for last IRI versus initial IRI for each base type. It is not surprising that the pavement sections that are rougher soon after construction would also be rougher at a later point in time. What is surprising is that the roughness at the later point in time would be more strongly correlated to the initial roughness than to any and all of the other experimental design factors.

The next most influential factor in the regression for last IRI was the time to the measurement of the last IRI (that is, the age of the pavement section). This is also as one would expect, although it might surprise some to see that accumulated ESALs are much lower on the list of variables, in order of contribution to r^2, than age. In fact, both age and accumulated ESALs were about equally well correlated (about 10%) to last IRI when analyzed independently. Because age and accumulated ESALs are themselves fairly strongly correlated, once either of these two terms is in the regression model, the addition of the second one does not do much to improve r^2.

Similarly, the backcalculated equivalent thickness of the pavement structure was more significant in the regression for last IRI than was either AC surface thickness or base thickness, both of which are reflected in the backcalculated equivalent thickness. Not surprisingly, once this variable is in the model, the AC surface thickness and base thickness terms do not add anything to r^2.

After initial IRI and age, the next most influential factors in the regression for last IRI were the backcalculated equivalent thickness of the pavement structure, the Thornthwaite moisture index, and the average annual precipitation. Those five factors account for 34% of the 38% total r^2 possible. The base type/drainage factors, together with all other factors, increase r^2 by only 4%.

The cumulative frequency distributions of last IRI for the five different base type/drainage combinations in the SPS-1 experiment are shown in Figure 94. There is an evident separation between the three groups of pavements that have an asphalt-treated base layer (undrained AC/ATB, undrained AC/ATB/DGA, and drained AC/ATB/PATB) and the two groups of pavements that do not have an asphalt-treated base layer (undrained AC/AGG and drained AC/PATB/AGG). It is reasonable to conclude from this, along with the finding concerning the significance of backcalculated equivalent thickness to the regression, that whatever fairly minor effect the base type/drainage factor had on last IRI was due

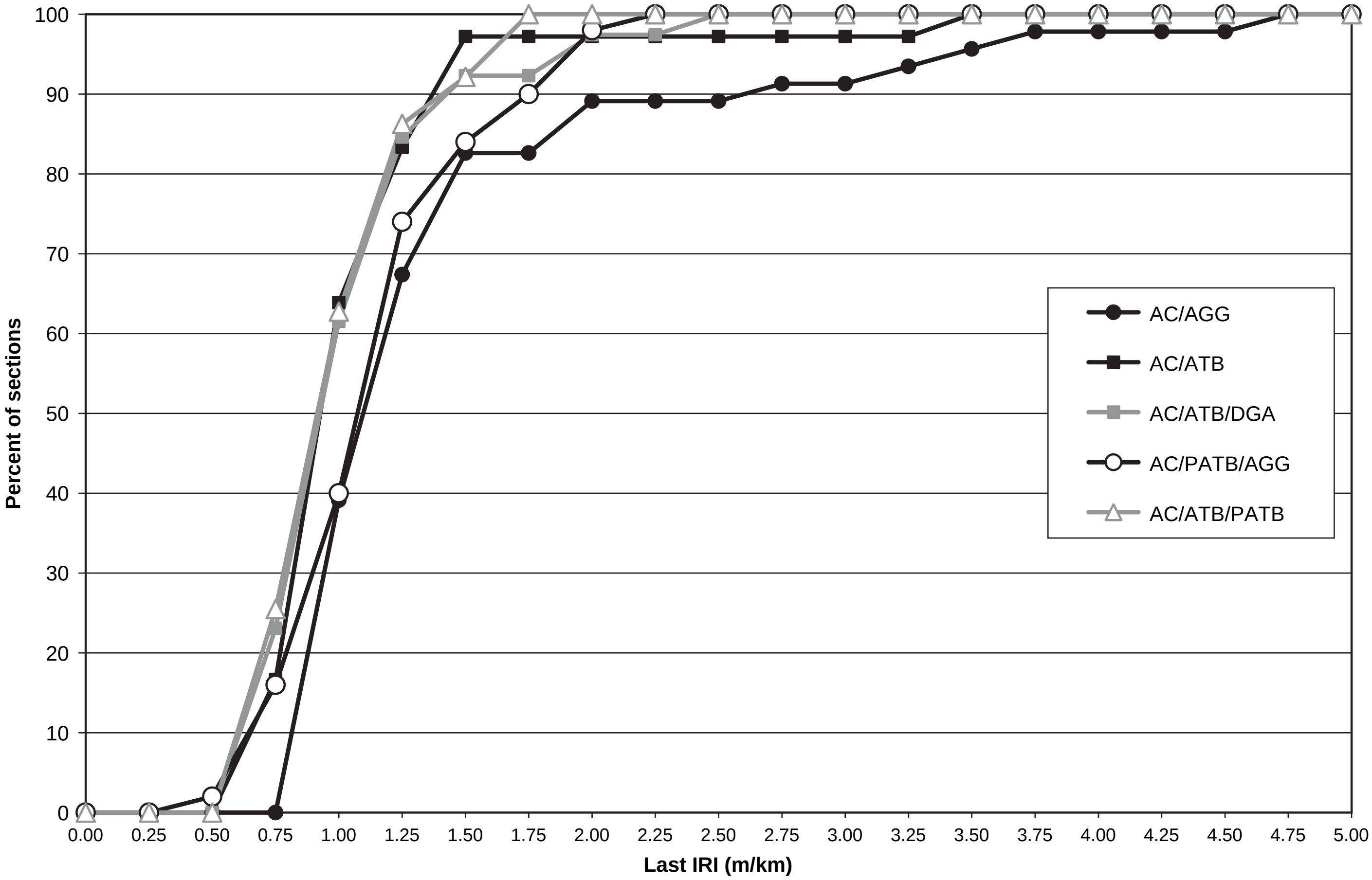

Figure 94. Cumulative frequency distributions of last IRI for SPS-1 pavement sections.

to differences in base stiffness and not differences in drainage.

The relative contributions of the SPS-1 factors to the r^2 of the regression model for change in IRI (latest minus initial) are summarized in Table 26. The four most influential variables were age, equivalent thickness, Thornthwaite moisture index, and precipitation. Initial IRI contributed very little to the regression for change in IRI over time. This finding, together with the finding mentioned above concerning the effect of initial IRI on latest observed IRI, indicates that for the SPS-1 experiment, those pavements that were rougher initially were, not surprisingly, rougher later, but not because they increased in roughness at a faster rate. This is illustrated in Figure 95, in which change in IRI is plotted against initial IRI. For some base types, there is a slight upward trend, while for others there is a slight downward trend; the overall trend, indicated by the regression line and equation shown, is a slightly negative slope that is not significantly different from zero.

Table 26. Significance of SPS-1 regression variables to change in IRI.

Independent Variable	Combined r^2 with this variable added
TIME_DELTA_IRI	0.05
H_EQUIV	0.08
TMI	0.10
PRECIP	0.11
TMP	0.12
FIRST_IRI	0.12
HB	0.12
B4	0.13
B3	0.13
B2	0.13
CESAL_DELTA_IRI	0.14
ESUB	0.14
HAC	0.14
B1	0.14

The cumulative frequency distributions of change in IRI for the five different base type/drainage combinations in the SPS-1 experiment are shown in Figure 96. Again, the three groups of pavements with an asphalt-treated base layer (undrained AC/ATB, undrained AC/ATB/DGA, and drained AC/ATB/PATB) exhibit smaller changes in IRI than the two groups of pavements that do not have an asphalt-treated base layer (undrained AC/AGG and drained AC/PATB/AGG). However, the difference between the two sets of distributions is fairly small, at least in the vicinity of the medians (50th percentiles) of the distributions. The separation of the AC/AGG distribution curve from those of the other four groups at

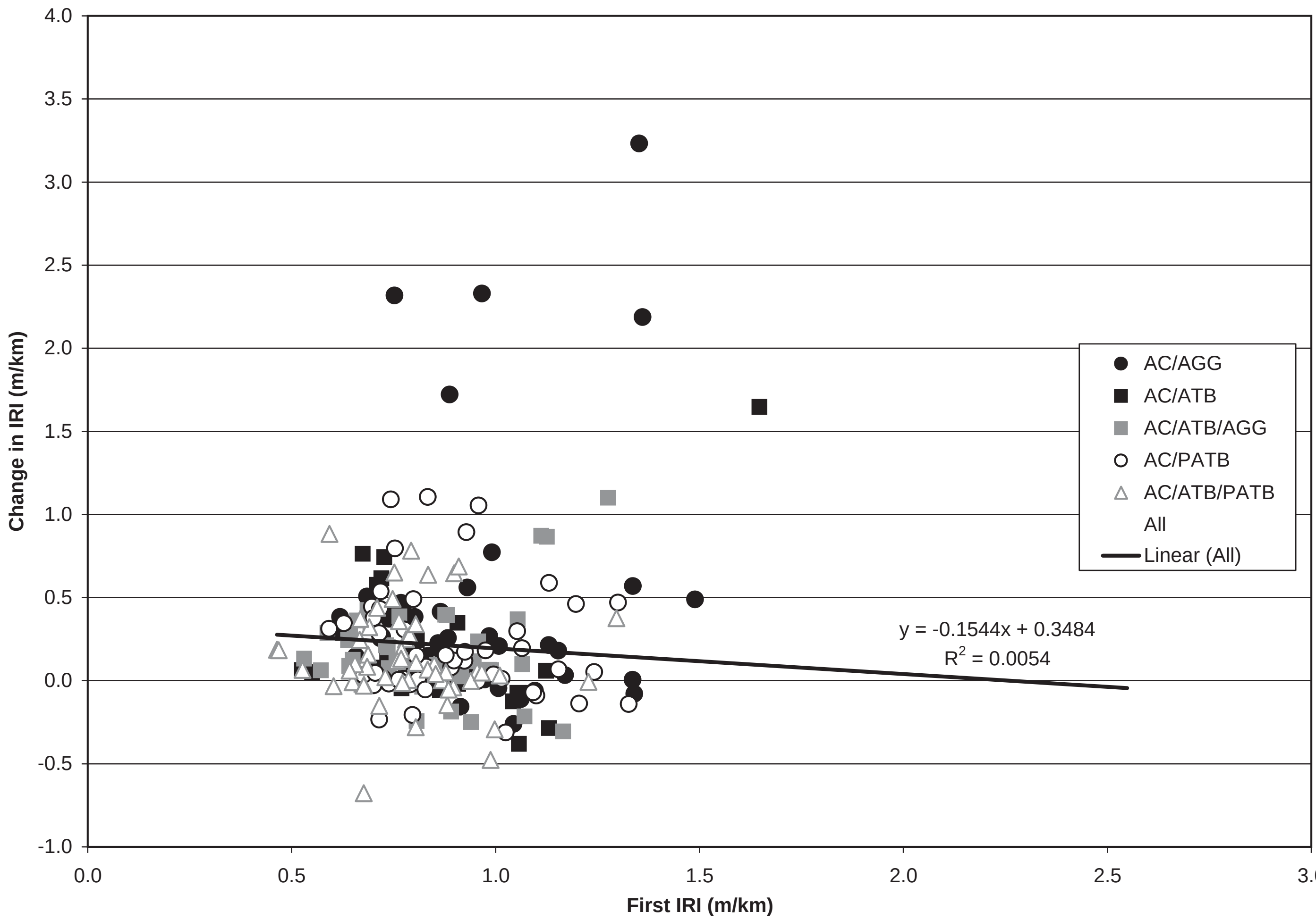

Figure 95. Linear correlation of change in IRI to initial IRI for SPS-1 pavement sections.

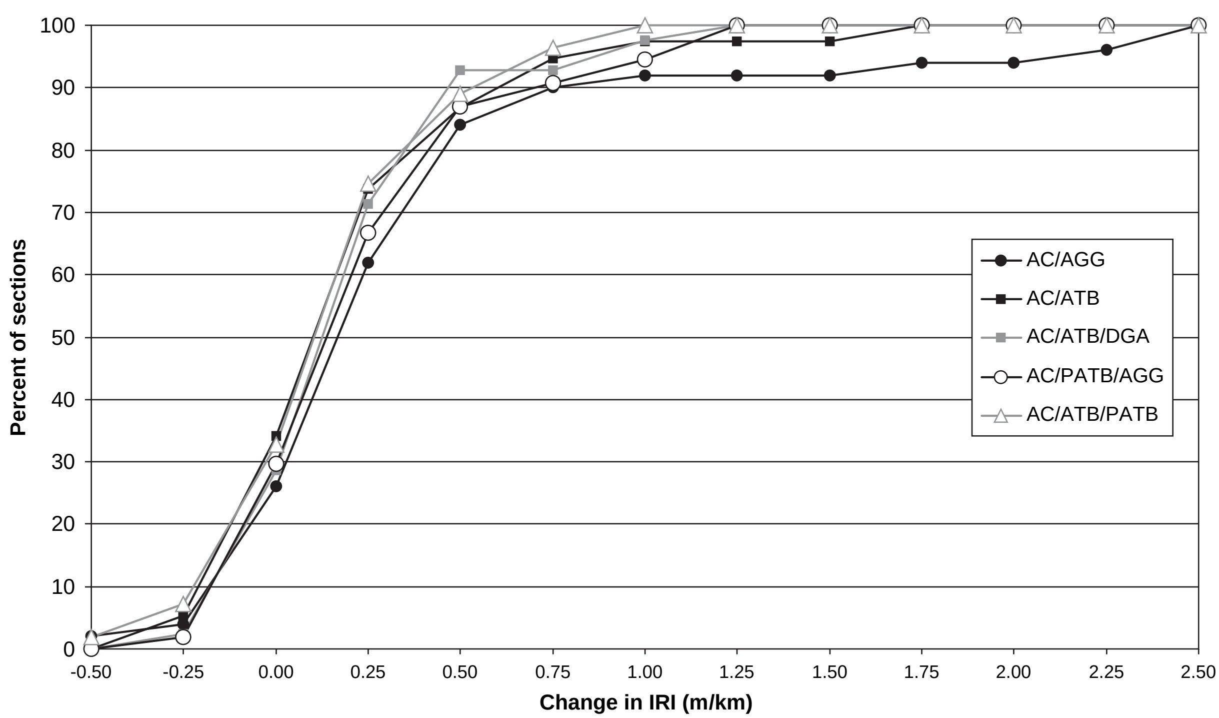

Figure 96. Cumulative frequency distributions of change in IRI for SPS-1 pavement sections.

higher cumulative percentage levels indicates that the largest changes in IRI tended to occur in this group, and this is confirmed by Figure 95 as well.

The small differences in median change in IRI raise the question of whether different rates of change in IRI over time in service are entirely responsible for the differences seen in last IRI for the different groups. The cumulative frequency distributions of the initial IRI values were examined, and as Figure 97 shows, the pavement sections without ATB (undrained AG/AGG and drained AC/PATB/AGG sections) tended to have higher initial IRI values than the pavement sections with ATB (undrained AC/ATB, undrained AC/ATB/DGA, and drained AC/ATB/PATB).

It is thus reasonable to conclude that whatever fairly minor effect the base type/drainage factor has had on the latest observed IRI values and rates of change in IRI over time for the SPS-1 pavement sections has been due to differences in base stiffness, not differences in drainage. Furthermore, the differences in IRI by base type are not entirely due to different rates of change in IRI over the time that the pavement sections have been in service, because there is evidence that the pavements with weaker bases (lower backcalculated effective thickness) also tended to be rougher initially.

Regression Analysis of Factors Affecting Rutting in SPS-1 Flexible Pavements

The relative contributions of the SPS-1 factors to the r^2 of the regression model for rutting are summarized in Table 27. Age was by far the most significant factor in the regression, contributing 25% to the total possible r^2 of 51%. However, the correlation of age to rutting in the SPS-1 data is not as positive a correlation as one would expect. As Figure 98 shows, there is actually a negative correlation between change in rutting (latest measurement minus first measurement) and age for three of the base groups (AC/AGG, AC/ATB, and AC/PATB) and essentially no correlation for the other two groups (AC/ATB/PATB and AC/ATB/AGG). The negative correlations for the first three groups are due to some pavement sections with unusually high rutting at a young age (less than 6 years). The greater consistency of rutting values in pavement sections older than 6 years suggests that aside from some pavement sections that developed unusually high rutting at a young age, the majority of the SPS-1 pavement sections do not appear to have started to develop increased rutting with increasing age (or with accumulated traffic).

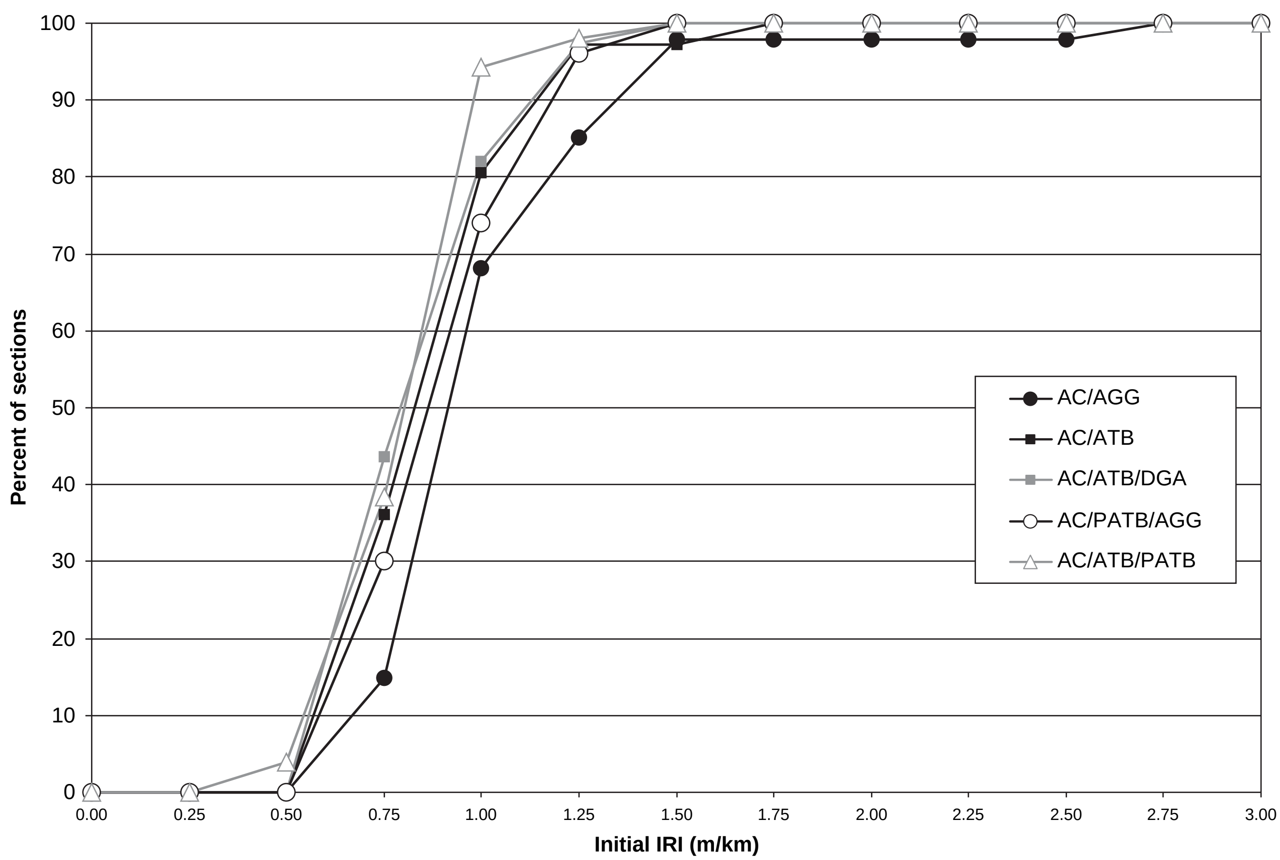

Figure 97. Cumulative frequency distribution of initial IRI for SPS-1 pavement sections.

Table 27. Significance of SPS-1 regression variables to rutting.

Independent Variable	Combined r^2 with this variable added
TIME_LAST_RUT	0.25
H_EQUIV	0.35
TMP	0.38
ESUB	0.41
TMI	0.43
PRECIP	0.46
HB	0.48
B3	0.49
CESAL_LAST_RUT	0.50
B2	0.50
B4	0.51
HAC	0.51
B1	0.51

The backcalculated equivalent thickness of the pavement structure was the second most influential factor in the regression for rutting, raising the r^2 by another 10%. Rutting values are plotted against the backcalculated equivalent thicknesses of the SPS-1 pavement sections in Figure 99. Note that the handful of pavement sections with unusually high rutting levels all had fairly low backcalculated equivalent thicknesses, and most of them were AC over undrained aggregate base. Figure 99 illustrates the different ranges in backcalculated equivalent thickness for different base types (the AC/AGG and AC/PATB sections having lower equivalent thicknesses than the AC/ATB, AC/ATB/PATB, and AC/ATB/AGG sections) and that pavement sections with higher equivalent thicknesses tend to have less rutting.

The cumulative frequency distributions of rutting for the five different base type/drainage combinations in the SPS-1 experiment are shown in Figure 100. Four of the five groups have very similar distributions; the one that is noticeably different is the undrained AC/AGG section, which had a larger percentage of sections with unusually high rutting values. Recall, however, from Figure 98 that most of these unusually high rutting values were measured on younger pavement sections. These higher rutting values were not anomalies observed at any one particular SPS-1 site: the sites with one or more sections with 12 mm or more of rutting were located in Kansas, Nebraska, Ohio, and Virginia.

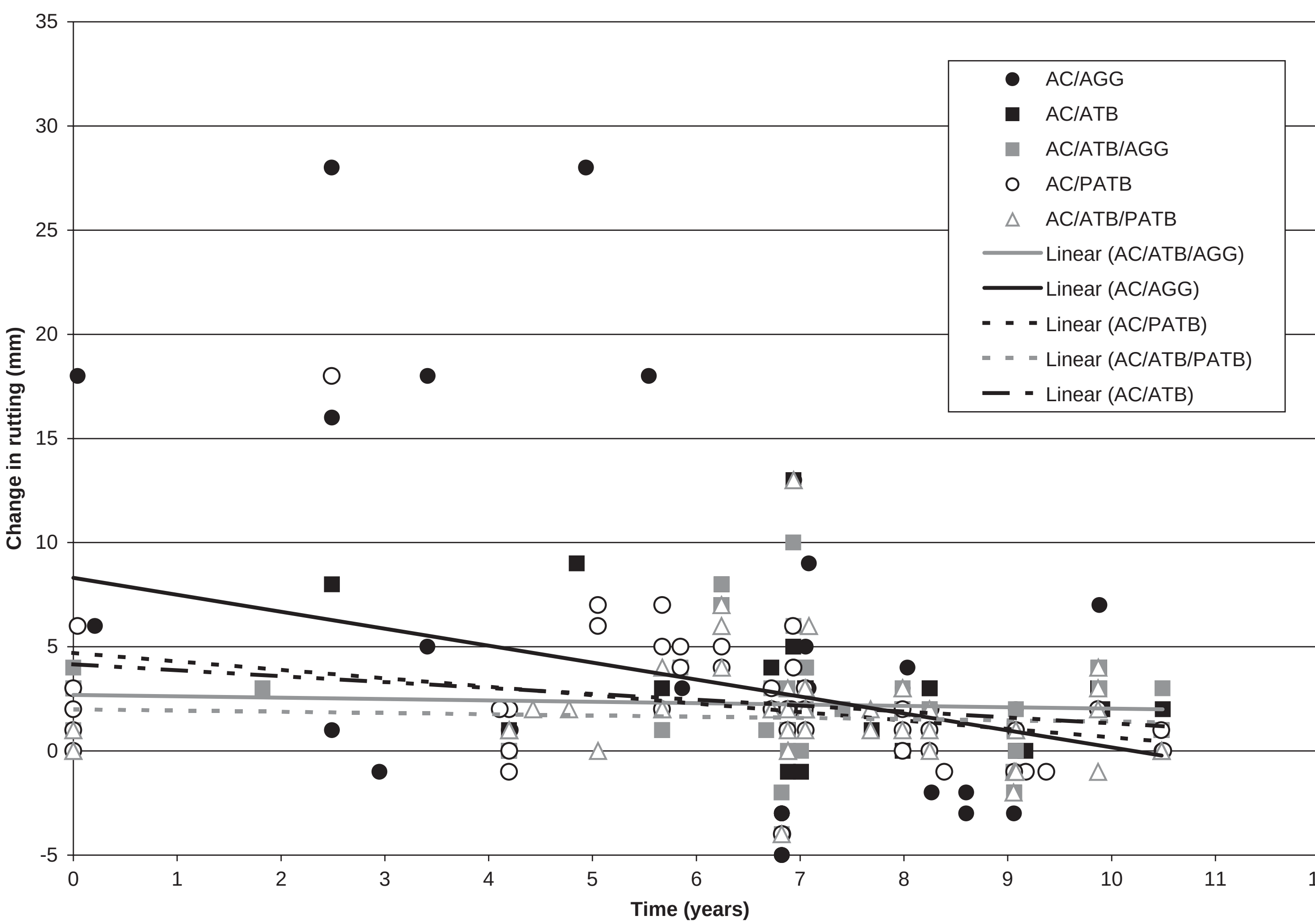

Figure 98. Change in rutting versus age for SPS-1 pavement sections.

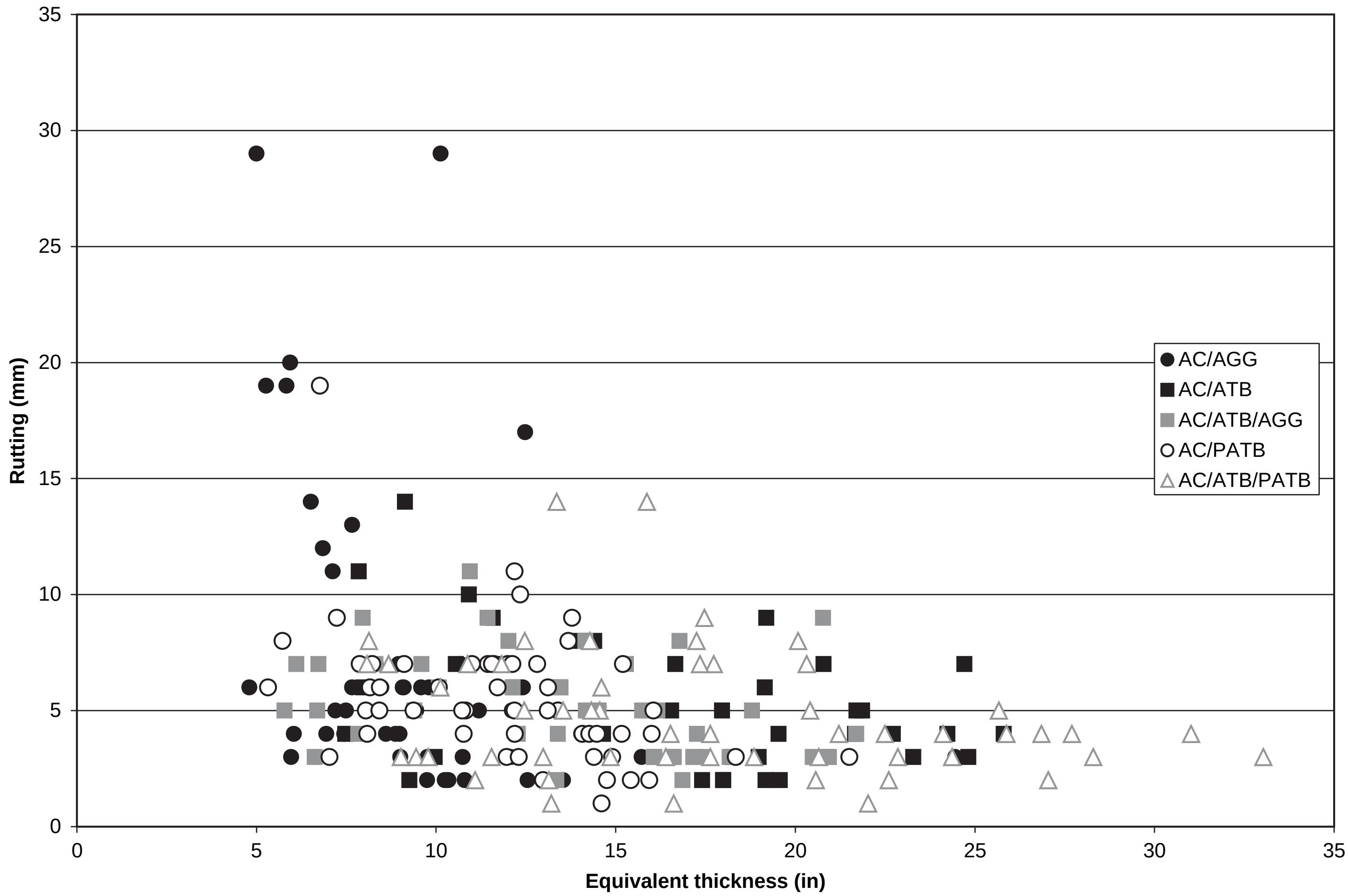

Figure 99. Rutting versus backcalculated equivalent thickness for SPS-1 pavement sections.

Average annual temperature, backcalculated subgrade modulus, Thornthwaite moisture index, and average annual precipitation were the next most influential factors in the regression for rutting. The base type/drainage factors, together with the remaining factors considered (accumulated ESALs, base thickness, and AC surface thickness, all of which are correlated to other factors already in the model), add only 3% to the total r^2.

Since backcalculated equivalent thickness was an influential factor in the regression for rutting, but the base type/drainage factors were not, it is reasonable to conclude that it is the stiffness of the base, not the presence or absence of drainage, that was responsible for whatever role the different base types played in the development of rutting in the SPS-1 pavement sections. This is reinforced by the similarity of the cumulative frequency distributions for rutting among the undrained AC/ATB and AC/ATB/DGA sections and the drained AC/PATB/AGG and AC/ATB/PATB sections. The weakest sections (undrained AC/AGG) were the ones most likely to exhibit more rutting after just a few years in service.

Regression Analysis of Factors Affecting Cracking in SPS-1 Flexible Pavements

The relative contributions of the SPS-1 factors to the $r^2$of the regression model for cracking are summarized in Table 28. The most influential variable was the Thornthwaite moisture index, contributing 19% to the 44% total possible r^2. The positive correlation between cracking and Thornthwaite moisture index is illustrated in Figure 101. Recall that a low Thornthwaite moisture index results from a combination of high temperatures and low precipitation, while a high Thornthwaite moisture index results from a combination of low temperatures and high precipitation.

The next most influential variables were, in decreasing order of importance, the other climatic variables (average annual temperature and average annual precipitation), accumulated ESALs and pavement age, subgrade modulus, equivalent thickness, base type/drainage variables, and surface and base thickness. The relatively minor effects of these factors may be due to the fact that most of the SPS-1 sections

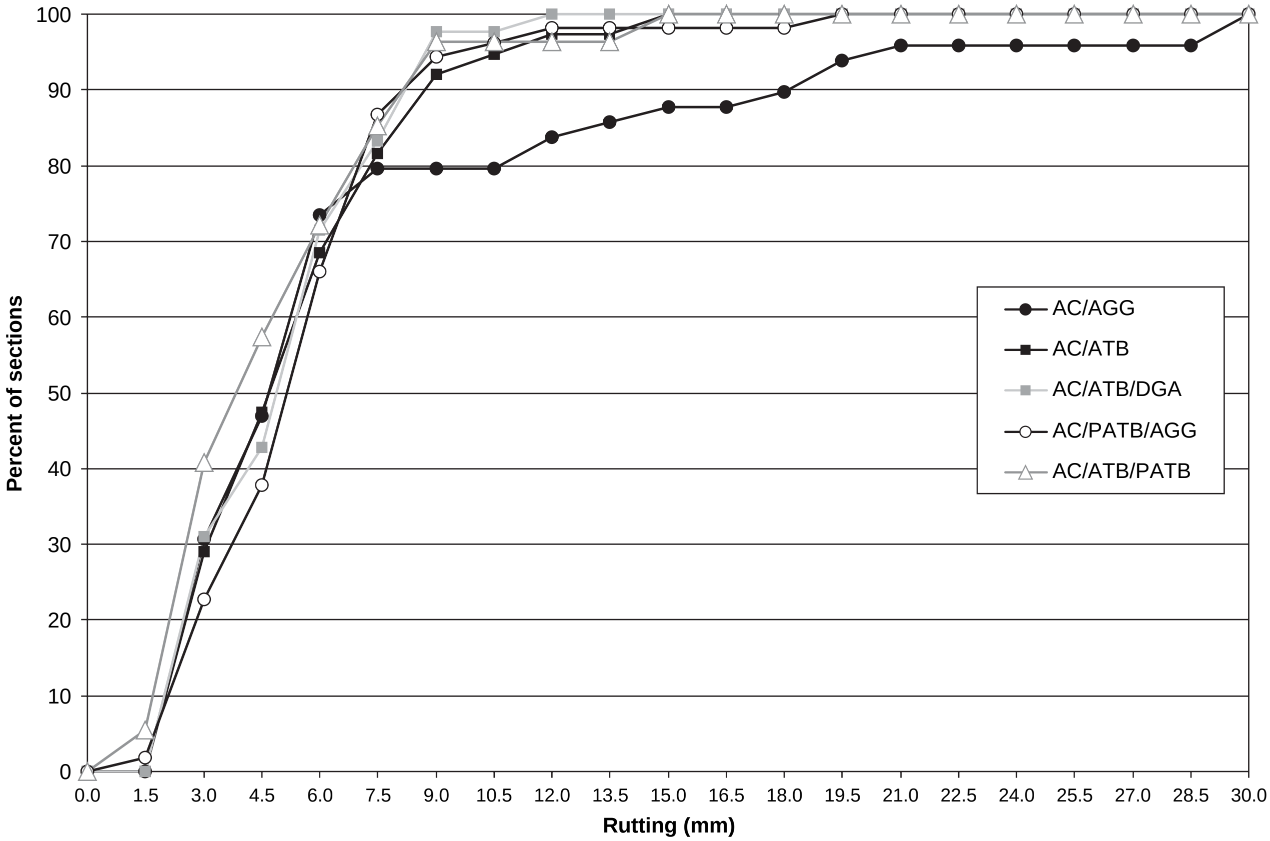

Figure 100. Cumulative frequency distributions of rutting for SPS-1 pavement sections.

have not yet developed much cracking, which is probably because of the relatively low truck traffic levels at most of the SPS-1 sites.

The cumulative frequency distributions of cracking for the five different base type/drainage combinations in the SPS-1 experiment are shown in Figure 102. Roughly half of the sections in each group have no cracking. As with the IRI and rutting frequency distributions shown earlier, the weaker pavement sections (undrained AC/AGG group and drained AC/PATB/AGG) have more cracking than the stronger pavement sections. These findings suggest that whatever minor effect the base type/drainage factor has had on cracking in the SPS-1 pavement sections, it has been due to differences in base stiffness rather than differences in drainage.

Table 28. Significance of SPS-1 regression variables to cracking.

Independent Variable	Combined r^2 with this variable added
TMI	0.19
TMP	0.21
PRECIP	0.30
CESAL_LAST_CRACK	0.33
TIME_LAST_CRACK	0.36
ESUB	0.39
H_EQUIV	0.40
B4	0.41
B1	0.41
B3	0.42
HAC	0.44
HB	0.44
B2	0.44

Regression Analysis of Factors Affecting IRI in SPS-2 Rigid Pavements

The relative contributions of the SPS-2 factors to the r^2 of the regression model for latest observed IRI are summarized in Table 29. As was the case for the SPS-1 pavements, the most influential variable was initial IRI. For the SPS-2 pavements, however, its influence was not as strong, contributing 11% to the total possible r^2 of 41% (compared with contributing 26% of the total 38% r^2 for the SPS-1 pavements). The latest IRI values of the SPS-2 test sections are plotted against the initial IRI values in Figure 103, along with the linear trend line for last IRI versus initial IRI for each base type.

The next most influential variables in the regression for last IRI were age, backcalculated k value, the base type variable B2 (indicating the presence or absence of a permeable

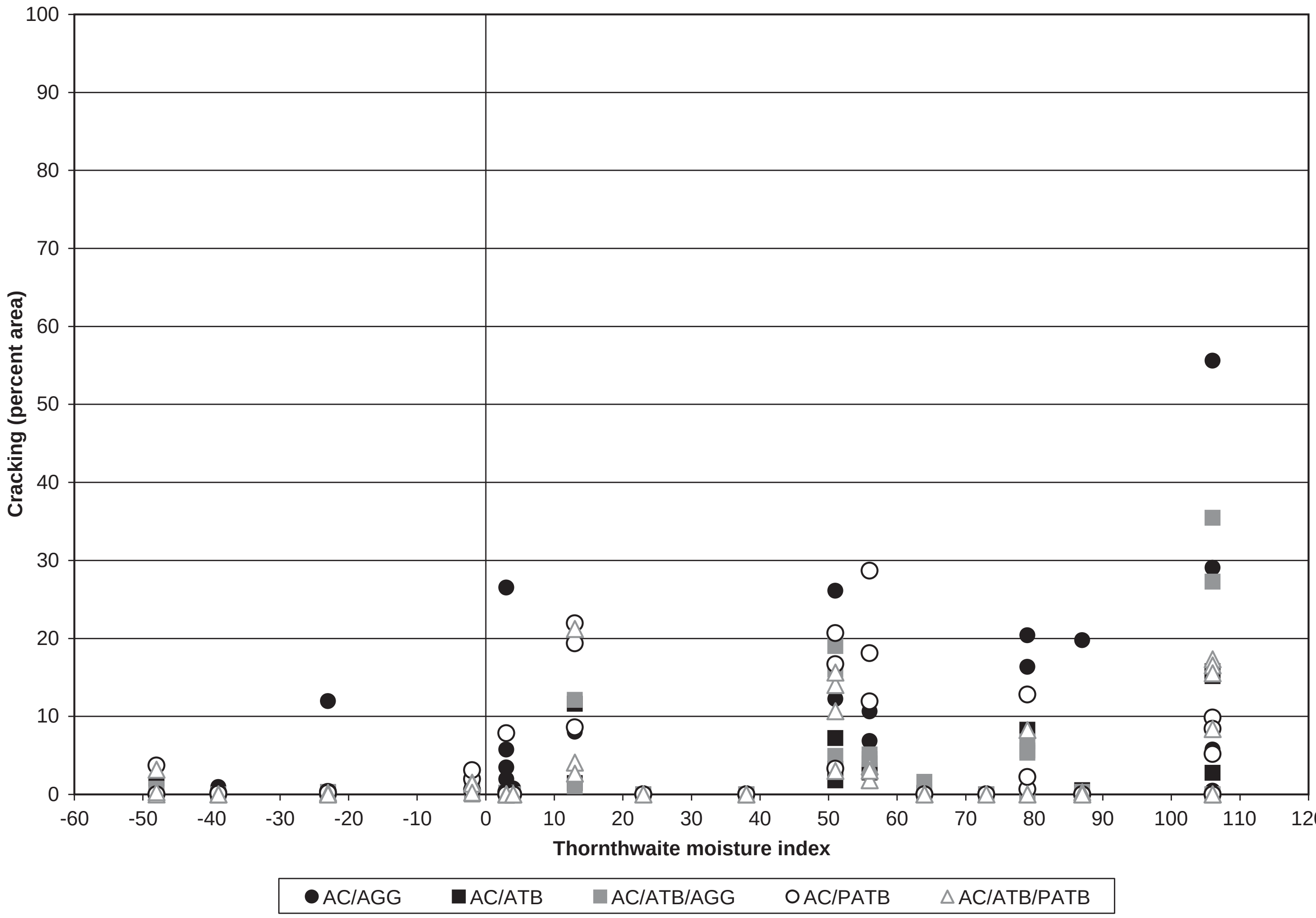

Figure 101. Cracking versus Thornthwaite moisture index for SPS-1 pavement sections.

asphalt-treated base), accumulated ESALs, Thornthwaite moisture index, temperature, and the BAR variable (indicating the presence or absence of dowel bars). The other base type variables, along with slab width, concrete strength, as-built slab thickness, backcalculated equivalent slab thickness, and precipitation, contributed very little to the regression. The cumulative frequency distribution of last IRI for the different base type/drainage combinations in the SPS-2 experiment is shown in Figure 104. The solid lines shown indicate the three types of drainage in the main SPS-2 experiment: undrained aggregate, undrained lean concrete base, and drained permeable asphalt-treated base. The dotted lines show the distributions for two base types (both presumably undrained) found in some supplemental sections—HMAC (there are seven of these) and CAM (four of these). No distributions are shown for two other situations represented by supplemental SPS-2 sections—one section with a concrete slab on grade, without any base (at the Colorado SPS-2 site), and two sections of asphalt concrete over aggregate base (at the Arizona SPS-2 site).

The cumulative frequency distributions in Figure 104 indicate that the SPS-2 sections with undrained aggregate bases tend to have the highest IRI values, followed by the sections with the undrained LCB sections and then by the drained PATB sections. The similarity of the distributions for the two undrained base types compared with the PATB distribution explains why the base type variable for PATB was the most significant variable in the regression. The distribution for undrained HMAC base is between that of the drained PATB and the undrained LCB and AGG distributions, and the undrained CAM distribution is even better (lower IRI values) than that of the drained PATB. Nonetheless, it might not be wise to put too much weight on the findings for the HMAC base and CAM base types, as there are few sections with these base types in the SPS-2 experiment.

It is more difficult to determine for the SPS-2 experiment than for the SPS-1 experiment if what distinguishes the drained base sections from the undrained base sections is due to differences in stiffness of the base or to differences in drainage. In the case of flexible pavements, increased base stiffness is expected to increase overall structural capacity and thus improve performance. If pavements with drained asphalt-treated base perform better than pavements with

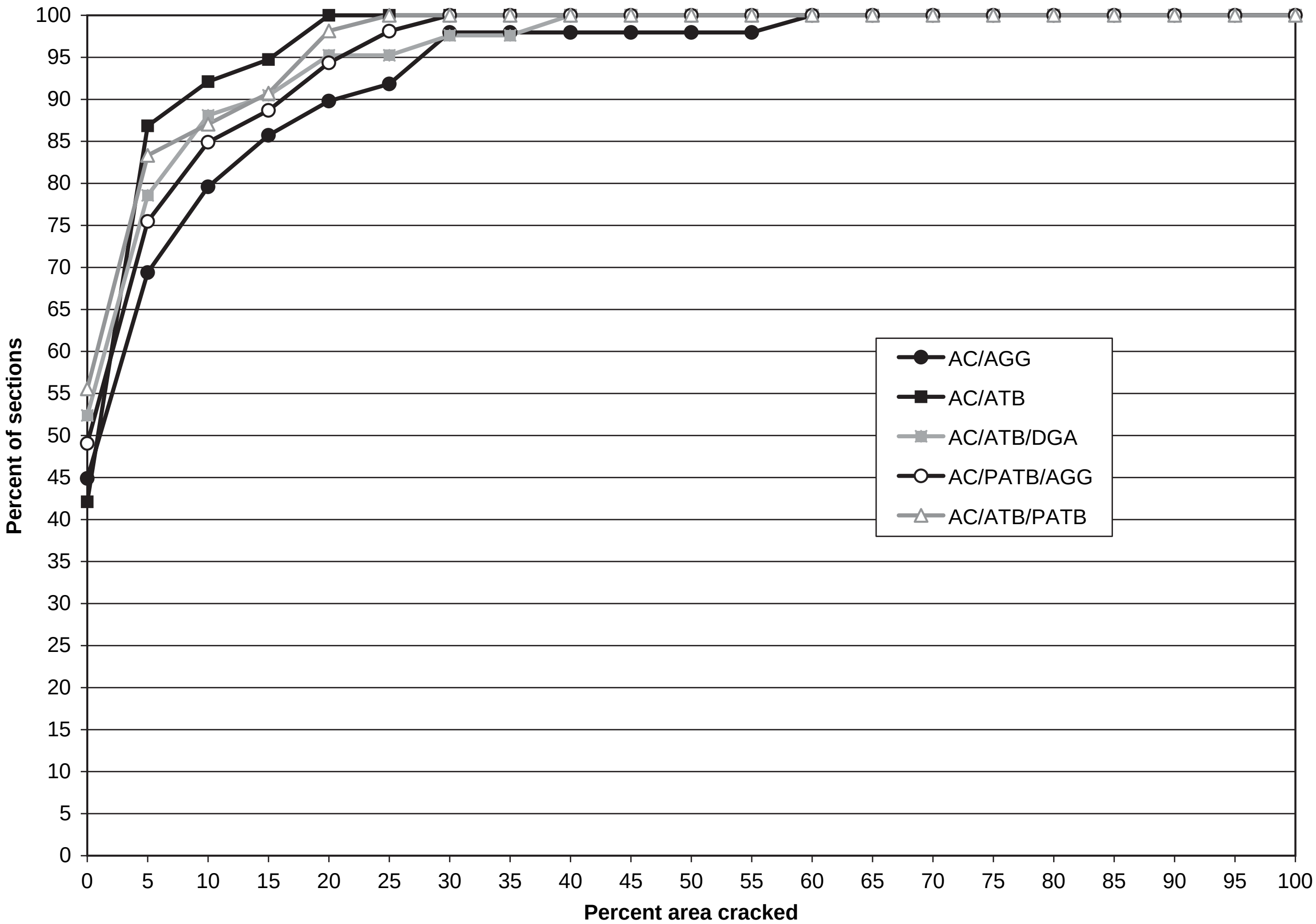

Figure 102. Cumulative frequency distributions of cracking for SPS-1 pavement sections.

Table 29. Significance of SPS-2 regression variables to IRI.

Independent Variable	Combined r^2 with this variable added
FIRST_IRI	0.11
TIME_LAST__IRI	0.20
FIRST_K	0.25
B2	0.28
CESAL_LAST__IRI	0.30
TMP	0.32
TMI	0.35
BAR	0.37
B3	0.38
B1	0.40
B5	0.41
WIDE	0.41
AC	0.42
Hpcc	0.43
HIGH	0.43
FIRST_HEQ	0.43
PRECIP	0.44
B4	0.44

undrained aggregate base, but not better than pavements with undrained asphalt-treated base, it is reasonable to conclude that the differences in performance are attributable primarily to the stiffness of the base, and not to the presence or absence of subdrainage.

In the case of rigid pavements, however, the base stiffness that optimizes performance by achieving the best balance between load-related stresses and curling-related stresses is one that is neither too weak nor too stiff. Thus, it is not surprising that pavements with asphalt-treated base would perform better than pavements with either untreated dense-graded aggregate base or lean concrete base, all other things being equal. The difficulty arises in assessing whether the drainability of the permeable asphalt-treated base influenced performance beyond the influence attributable to the stiffness of the base. This is an assessment that needs to be made for each of the performance aspects considered.

At least with respect to the analysis of latest available IRI data, one indication that drainage was not significant to the differences observed is that Thornthwaite moisture index and

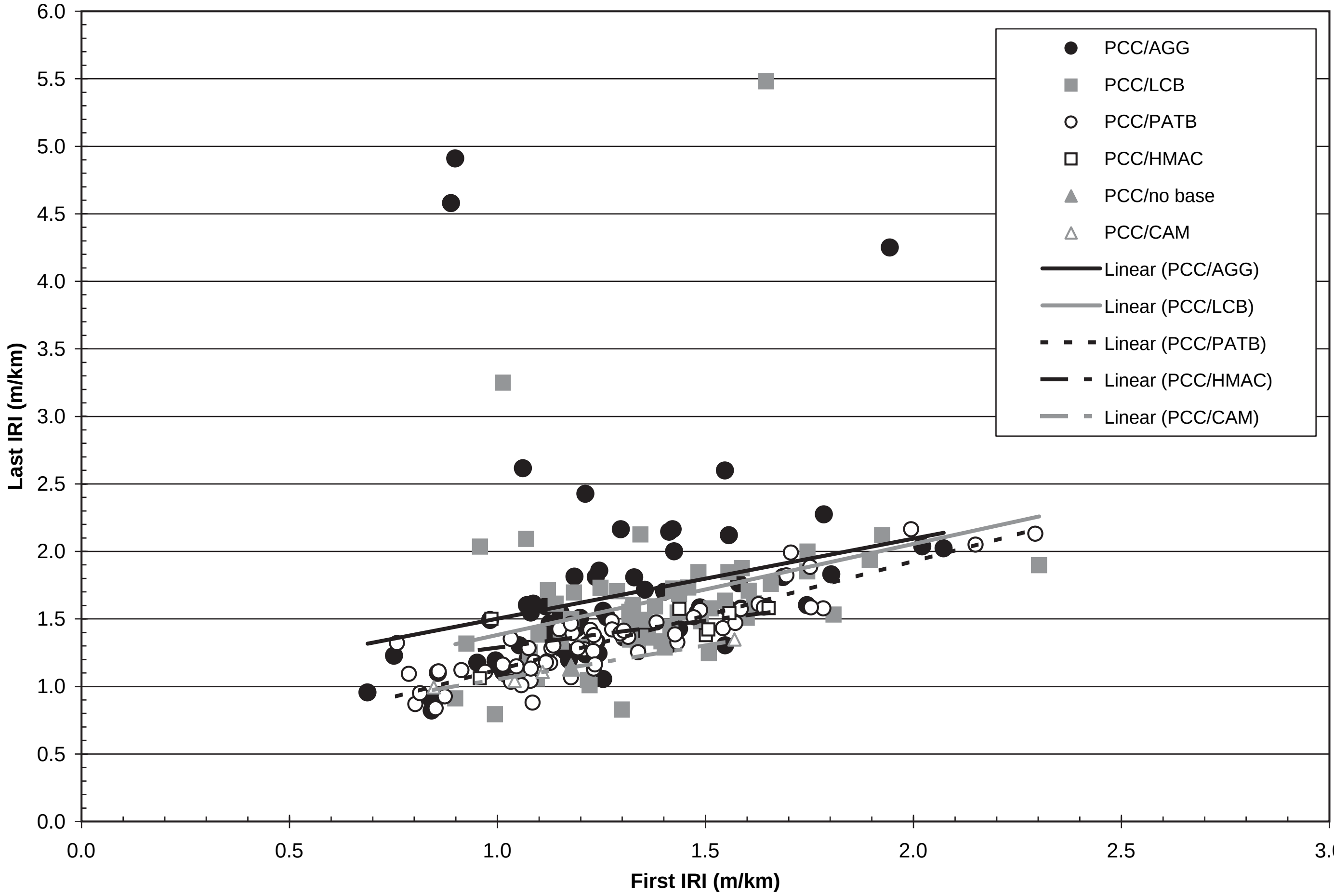

Figure 103. Linear correlations of latest IRI to initial IRI for SPS-2 pavement sections.

average annual precipitation made very slight contributions (3% and 1%, respectively) to the regression. Another indication is that the pavement sections with one of the undrained base types (CAM) exhibited even lower IRI values than the pavement sections with PATB. Again, there are fairly few HMAC and CAM base sections in the experiment. It does make sense, though, that the influence of these base types on concrete slab performance might be comparable to that of PATB since, like PATB, both of them are more rigid than untreated dense-graded aggregate and less rigid than lean concrete.

The relative contributions of the SPS-2 factors to the r^2 of the regression model for change in IRI are shown in Table 30. The most influential variables were age, backcalculated *k* value, the B2 (PATB) base type/drainage variable, accumulated ESALs, average annual temperature, Thornthwaite moisture index, and dowel bar presence. As was the case in the regression for latest IRI, Thornthwaite moisture index and precipitation contribute little to the regression.

The variables that were most influential in the regression for change in IRI are the same, but in a slightly different order, as those that were most influential in the regression for last IRI, except that initial IRI was not influential in the regression for change in IRI. In fact, initial IRI was not even selected by the regression algorithm for inclusion in the model, and thus does not appear in Table 30. Change in IRI is plotted against initial IRI for the SPS-2 sections in Figure 105. There is a slightly negative slope to the overall trend line, but the lack of significance of this slope is indicated by the very low r^2 associated with the trend line. Similar results were obtained for change in IRI versus initial IRI for the SPS-1 pavements (see Figure 95).

The cumulative frequency distributions of change in IRI for the different base type/drainage combinations in the SPS-2 experiment are shown in Figure 106. As was the case for latest IRI, the largest changes in IRI occurred in the undrained PCC/AGG sections, followed by the undrained PCC/LCB sections and then the drained PATB sections. Though they are few in number, the undrained PCC/HMAC and PCC/CAM sections exhibited even smaller changes in IRI than the PATB sections.

The cumulative frequency distributions of initial IRI were examined to assess how much of the differences in latest IRI should be attributed to changes in IRI over time in service. These distributions are plotted in Figure 107. The disparity

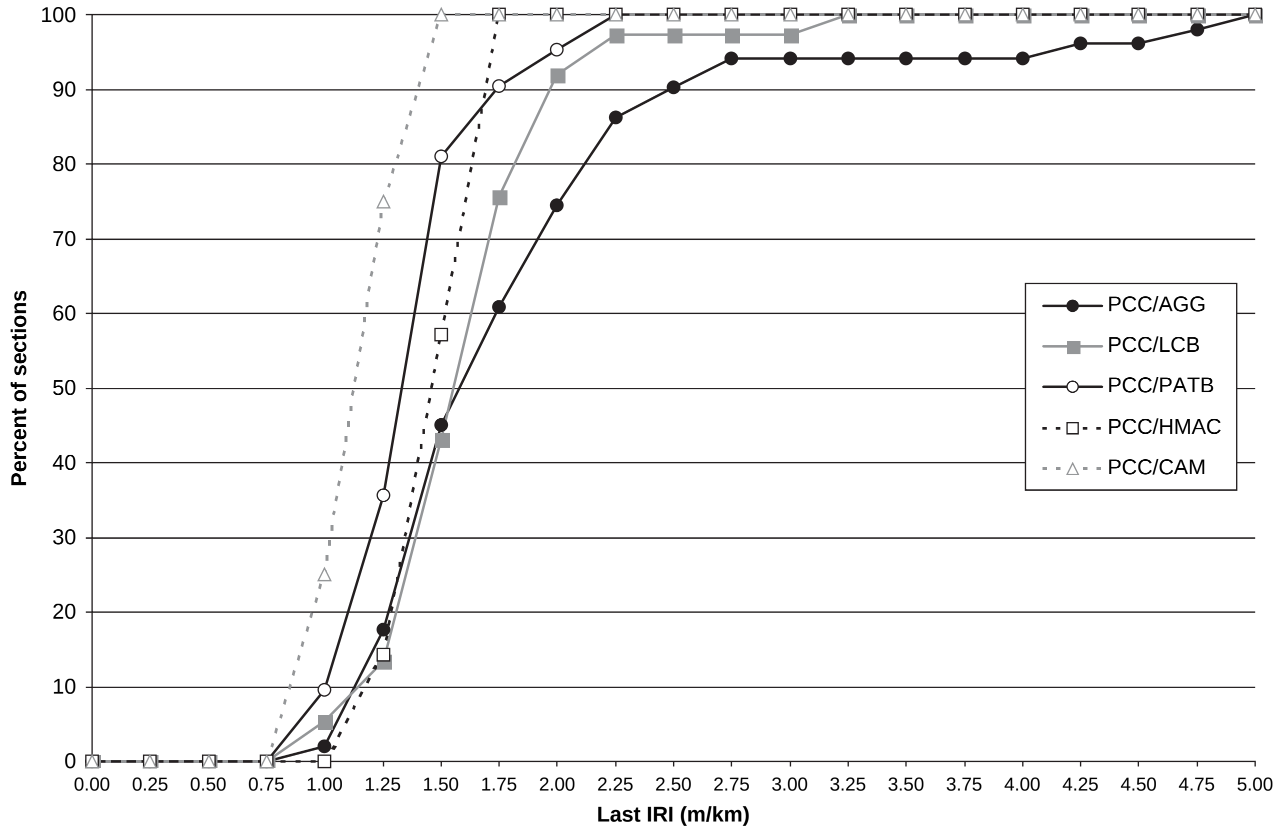

Figure 104. Cumulative frequency distributions of last IRI for SPS-2 pavement sections.

among the initial IRI distributions for the different types of SPS-2 pavements is even greater than for the different types of SPS-1 pavements (see Figure 97). This is especially true in the broad middles of the distributions, in the vicinity of the median values. The SPS-2 sections with the highest median initial IRI values were the supplemental sections built on HMAC base. The next highest were the core experiment sections built on LCB, followed by those built on AGG base, followed by those built on PATB. The supplemental sections built on CAM base had the lowest median initial IRI.

Figure 107 shows that sections built on PATB tended to be smoother initially than sections built on LCB or AGG, which explains some of the differences in latest IRI values among these base types. Figure 107 also shows that sections built on AGG tended to be smoother initially than sections built on LCB. This seems to have been countered by larger changes in IRI in the AGG sections than in the LCB sections (see Figure 106), resulting in fairly similar median values of latest observed IRI for AGG sections and LCB sections (see Figure 104). At the upper end of these cumulative frequency distributions, the pavement sections that exhibited the largest changes in IRI were mostly AGG sections, with some LCB sections (see Figures 103 and 105).

From these findings it is reasonable to conclude that whatever effect the base type/drainage factor has had on the SPS-2 pavement sections' latest observed IRI values and rates of change in IRI over time has been predominantly due to differences in base stiffness. The potential effect of drainage is not necessarily ruled out, but no particular evidence was detected for the role of drainage, independent of the role of base stiffness, in the development of roughness in the SPS-2

Table 30. Significance of SPS-2 regression variables to change in IRI.

Independent Variable	Combined r^2 with this Variable Added
TIME_DELTA_IRI_	0.14
FIRST_K	0.20
B2	0.22
CESAL_DELTA_IRI	0.24
TMP	0.26
TMI	0.29
BAR	0.31
B3	0.32
B1	0.34
B5	0.35
WIDE	0.36
Hpcc	0.36
AC	0.38
HIGH	0.38
FIRST_HEQ	0.38
B4	0.38
PRECIP	0.38
FIRST_IRI	0.38

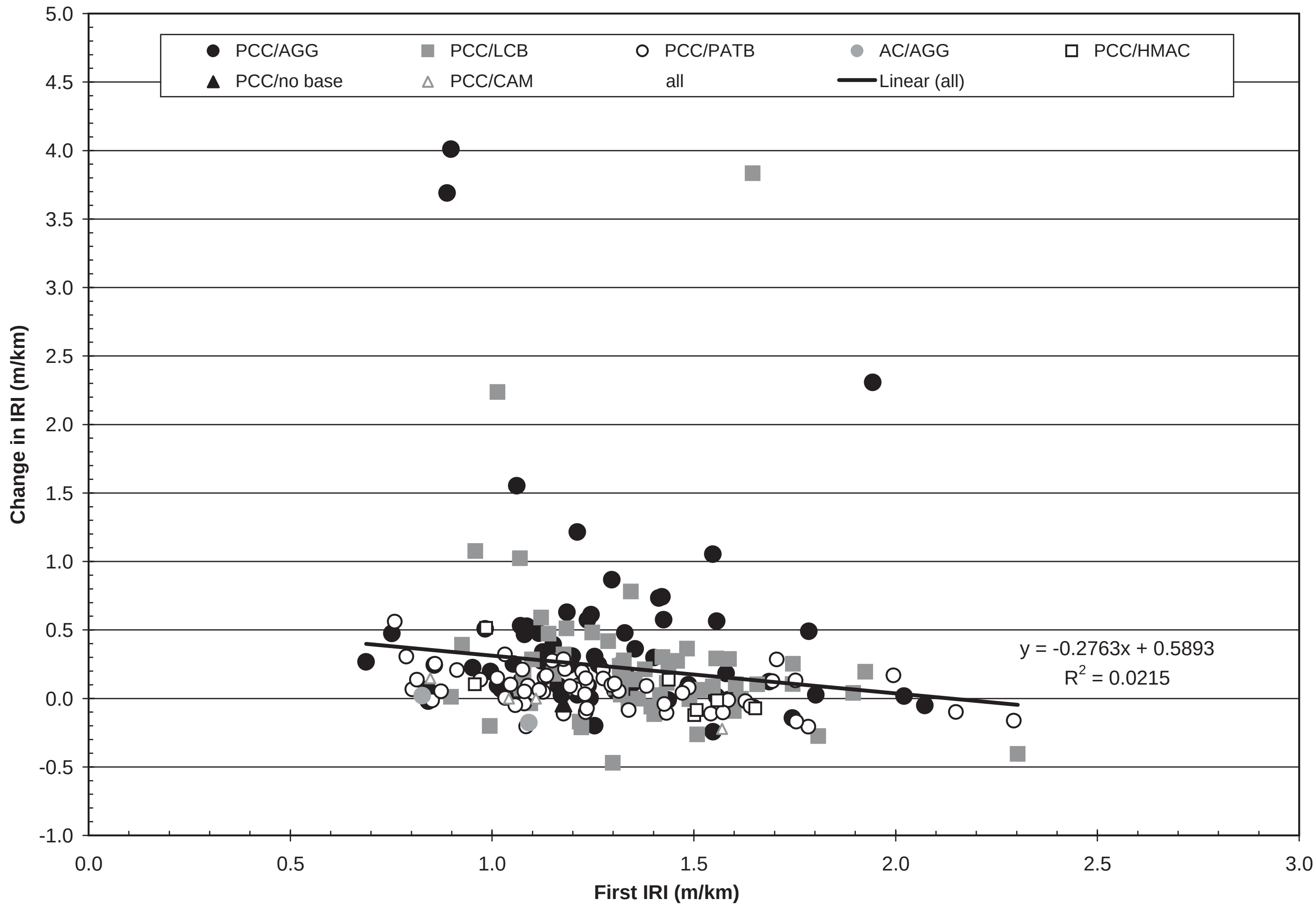

Figure 105. Linear correlation of change in IRI to initial IRI for SPS-2 pavement sections.

pavements. Furthermore, the differences in IRI by base type are not entirely attributable to different rates of change in IRI over the time that the SPS-2 pavements have been in service, because there is evidence of some significant differences in initial IRI values by base type. Of the three main base types in the SPS-2 experiment, the lean concrete base was associated with the highest initial IRI values, while the dense aggregate base was associated with the highest long-term IRI values.

Selection of Faulting Data for Analysis

In the LTPP studies, as in other pavement performance studies that include PCC pavements, it has been common practice to measure transverse joint faulting at about 1 ft and 2.5 ft from the outer lane edge. The *Distress Identification Manual for the Long-Term Pavement Performance Program* indicates that faulting at joints in LTPP sections should be measured "0.3 m and 0.75 m from the outside slab edge (approximately the outer wheel path)" (*33*). The LTPP database contains edge and wheelpath faulting measurements for joints and cracks in all of the jointed concrete test sections (for both SPS and general pavement studies sites). It is not obvious why field technicians should spend time measuring and recording faulting at two locations at each joint and crack or why time should be spent entering the measurements at both locations in the wheelpath. A rationale sometimes offered is that measurement at both locations offers compatibility with data from other studies in which faulting might have been measured at only one of the two locations. In fact, it does not appear that this has ever really been an issue in analysis of faulting data, since faulting has been measured at both the edge and wheelpath in most if not all of the major PCC pavement performance studies conducted in the United States over the past 30 years.

The fact that pavement researchers attach importance to measuring faulting at both edge and wheelpath locations suggests that some significant difference is believed to exist between the two. Yet when faulting data are used to develop faulting prediction models, it is common practice not to mention which set of faulting measurements was used in the model development and thus which location's faulting the model is presumed to predict (*11, 34-36*). A review of the literature has found only one comparison of edge and

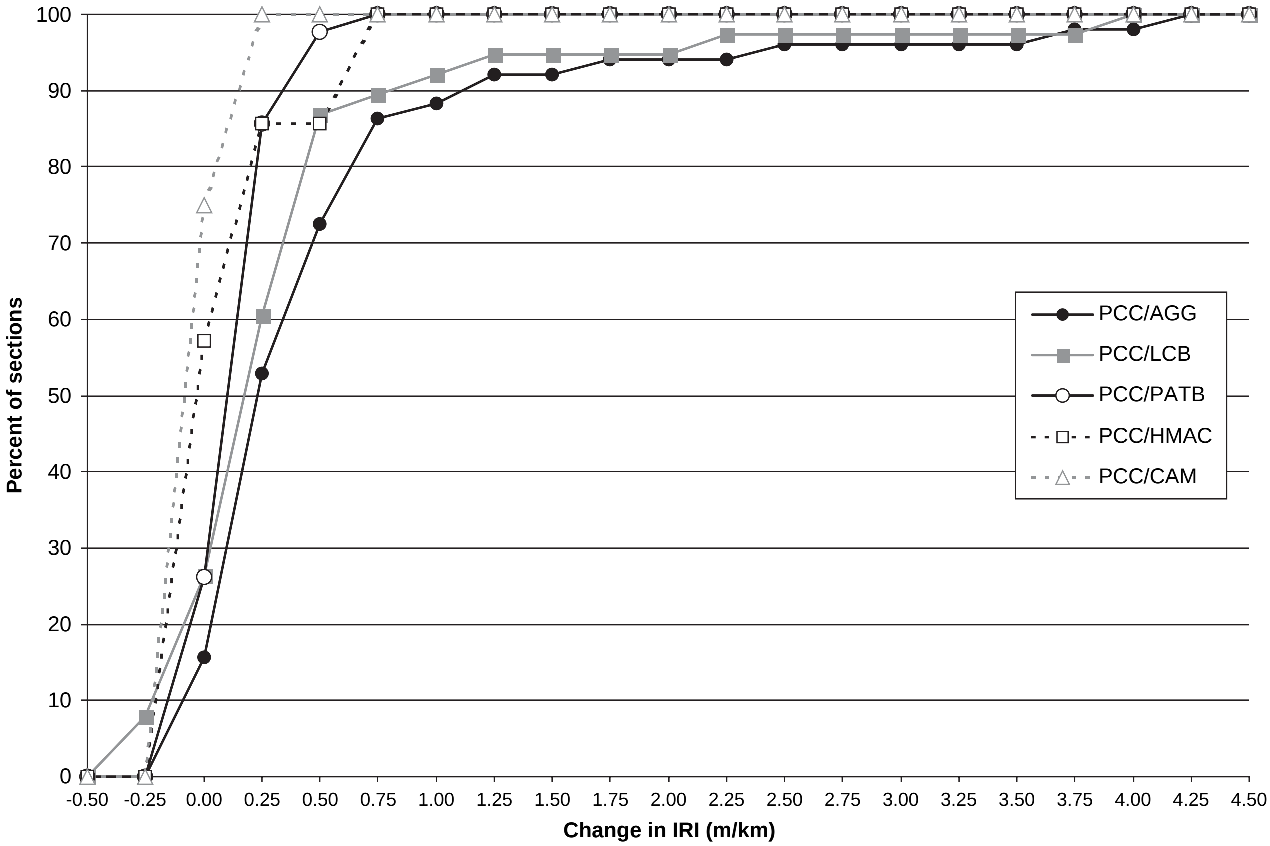

Figure 106. Cumulative frequency distributions of change in IRI for SPS-2 pavement sections.

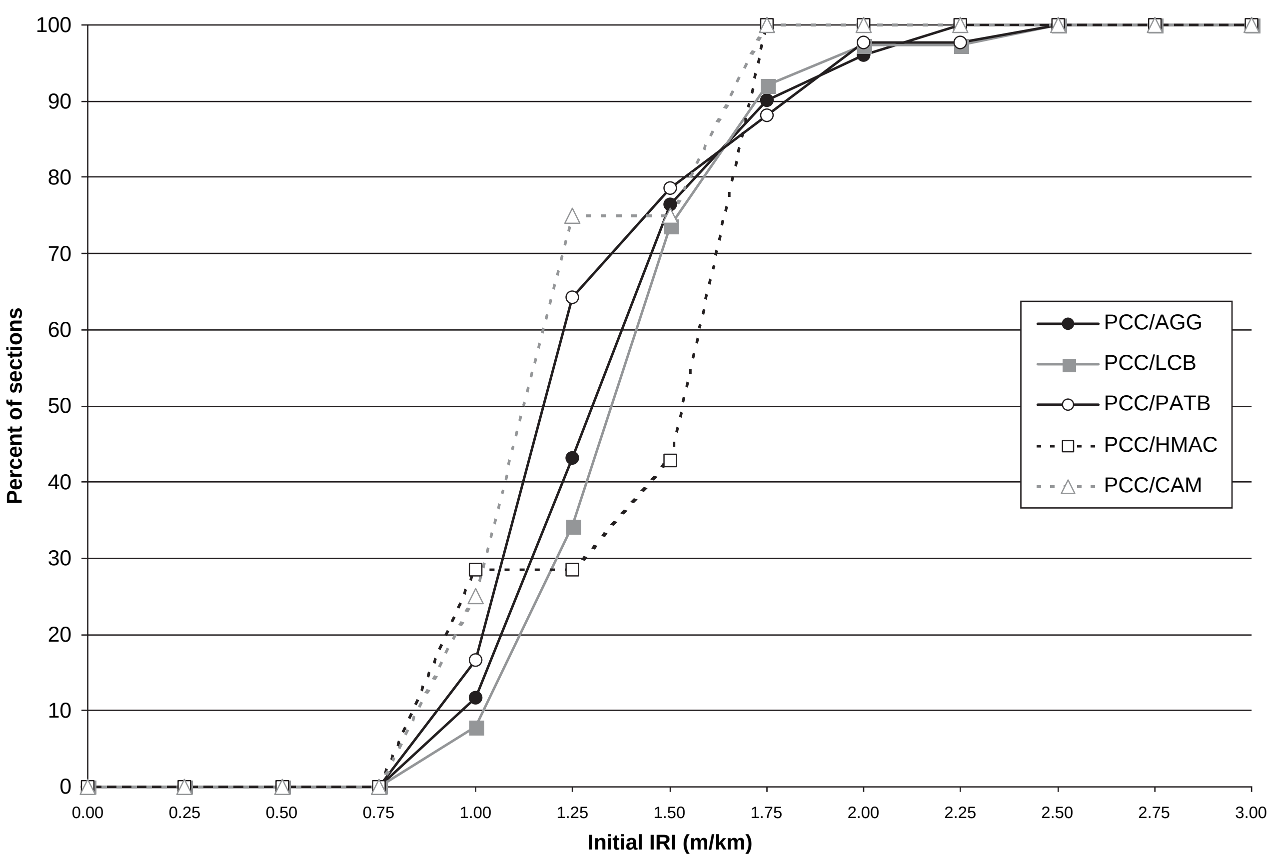

Figure 107. Cumulative frequency distributions of initial IRI for SPS-2 pavement sections.

wheelpath faulting: in a 2000 evaluation of LTPP faulting data, in more than 90% of the pairs of edge and wheelpath faulting measurements examined, the difference between the two measurements was found to be between −1 mm and 1 mm (*37*). Since this range is the same as the precision of the faultmeter used in monitoring LTPP test sections, the researchers conducting that evaluation judged the difference between edge and wheelpath faulting to be insignificant.

In this study, all of the edge and wheelpath faulting measurements for the SPS-2 rigid pavement test sections—more than 40,000 edge and wheelpath measurement pairs in total—were retrieved from the LTPP database and subjected to a paired difference *t*-test. As the results in Table 31 show, wheelpath faulting exceeded edge faulting by a slight 0.006 mm on average, and this mean difference was not found to be statistically different from zero at the 95% confidence level. This finding reinforces the earlier study's conclusion that edge and wheelpath faulting are not significantly different, at least in the LTPP database (*37*). The wheelpath faulting data set was selected for use in the analysis for this study.

Regression Analysis of Factors Affecting Faulting in SPS-2 Rigid Pavements

The relative contributions of the SPS-2 factors to the r^2 of the regression model for faulting are summarized in Table 32. Not surprisingly, the most influential factor in the regression was the BAR variable indicating the presence or absence of dowels, which contributed 13% to the total possible r^2 of 31%. The next most influential factors were the accumulated ESALs, the B2, B1, and B3 base type/drainage variables (indicating the presence of PATB, LCB, and AGG, respectively), and age. Variables related to the slab thickness, slab width, concrete strength, and backcalculated pavement stiffness or subgrade *k* value did not contribute much to the regression, nor did any of the three climatic variables that were considered.

The cumulative frequency distributions of faulting for the different base type/drainage combinations in the SPS-2

Table 31. Significance of difference in wheelpath versus edge faulting in SPS-2 data.

	Wheelpath Minus Edge Faulting (mm)
Mean difference	0.006
Number of pairs, n	41,168
S_D	0.692
t calc	1.75
Test at 95% confidence level:	
α	0.05
$t_{\alpha/2,\ n-1}$	1.96
Lower limit of confidence interval	-0.0007
Upper limit of confidence interval	0.0126
Reject null hypothesis?	no

Table 32. Significance of SPS-2 regression variables to faulting.

Independent Variable	Combined r^2 with this Variable Added
BAR	0.13
CESAL_LAST_FAULT	0.18
B2	0.20
B1	0.23
B3	0.25
TIME_LAST_FAULT	0.26
FIRST_HEQ	0.27
WIDE	0.28
B5	0.28
HIGH	0.29
TMI	0.29
PRECIP	0.30
TMP	0.30
FIRST_K	0.31
B4	0.31
Hpcc	0.31

experiment are shown in Figure 108. The distributions for undrained LCB and drained PATB are very similar, while the rightward displacement of the distribution for undrained AGG base indicates that pavements with this base type developed more faulting than pavements with either of the other two base types. Plotting the distributions without including the undowelled sections does not change this disparity. Note that two of the undowelled sections had AGG base, four had PATB, one had LCB, and one had HMAC base. Among these eight undowelled sections, the two with the highest faulting levels, 2.9 and 3.0 mm, were the two undowelled sections with aggregate base at the Arizona SPS-2 site. Faulting in the remaining six undowelled sections (at the Arizona, North Dakota, and Washington sites) ranged from 0 to 1.3 mm.

These findings, particularly the similarity of results for undrained LCB and drained PATB, suggest that whatever effect the base type/drainage factor has had on the development of faulting in pavements in the SPS-2 experiment has been due to the stiffness of these bases, compared with the lesser stiffness of the undrained dense-graded aggregate base. This conclusion is reinforced by the observation that the undowelled pavements with aggregate base developed more than twice as much faulting as undowelled pavements with drained or undrained stabilized bases, even those at the same sites.

Regression Analysis of Factors Affecting Cracking in SPS-2 Rigid Pavements

The relative contributions of the SPS-2 factors to the r^2 of the regression model for cracking are summarized in Table 33. Age and Thornthwaite moisture index were the most influential variables, with each contributing 13% to the total

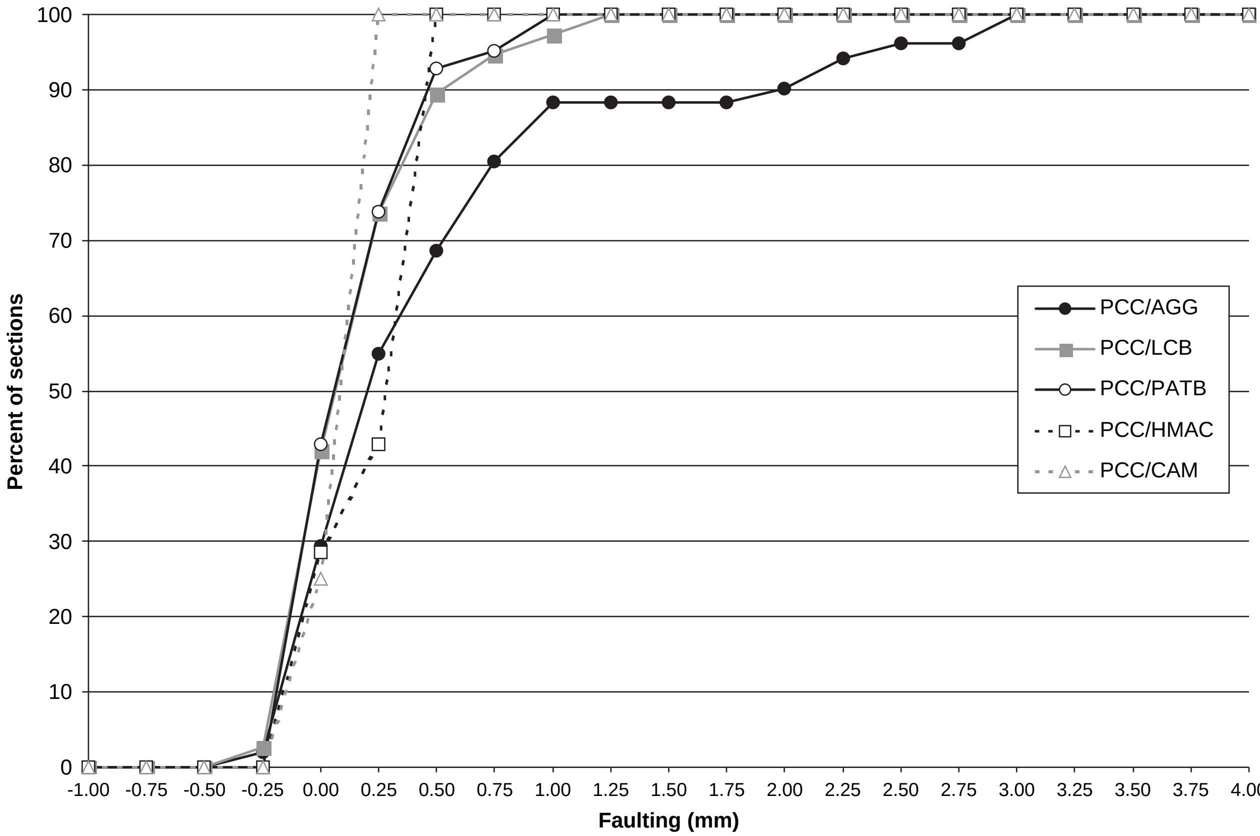

Figure 108. Cumulative frequency distributions of faulting for SPS-2 pavement sections.

possible r^2 of 42%. Accumulated ESALs, average annual temperature, and average annual precipitation were the next most influential variables. These were followed by the B1 base type variable (indicating the presence of lean concrete base), the backcalculated effective *k* value, and the B2 and B3 variables (PATB and AGG base, respectively), although the contributions of the last three variables, and all of the remaining variables considered, were very slight.

Table 33. Significance of SPS-2 regression variables to cracking.

Independent Variable	Combined r^2 with this Variable Added
TIME_LAST_CRACK	0.13
TMI	0.26
CESAL_LAST_CRACK	0.29
TMP	0.33
PRECIP	0.37
B1	0.38
FIRST_K	0.40
B2	0.41
B3	0.41
BAR	0.41
Hpcc	0.41
B5	0.42
FIRST_HEQ	0.42
WIDE	0.42
HIGH	0.42
B4	0.42

The cumulative frequency distributions of cracking for the three different base type/drainage combinations in the main SPS-2 experiment are shown in Figure 109. This plot shows that the LCB sections were much more likely to develop cracking than the AGG and PATB sections. More than 60% of the LCB sections had some cracking, while only about 30% of the AGG sections and the PATB sections had some cracking. Of those two, more cracking occurred in the AGG sections than in the PATB sections. Distributions are not shown for the undrained PCC/HMAC and undrained PCC/CAM sections because none of these sections had any cracking.

The largest amounts of cracking were observed in the LCB sections at the Nevada SPS-2 site, which, construction records indicate, had problems with excessive concrete shrinkage and slab cracking during the construction of some sections. The disparity between the cumulative frequency distribution curves for cracking in LCB sections and cracking on AGG and PATB sections is not, however, a distortion caused by the rather anomalous performance of the pavements at the Nevada site. The LCB sections developed more cracking than did comparable sections with AGG or PATB base at several SPS-2 sites, including Arkansas, Michigan, North Dakota,

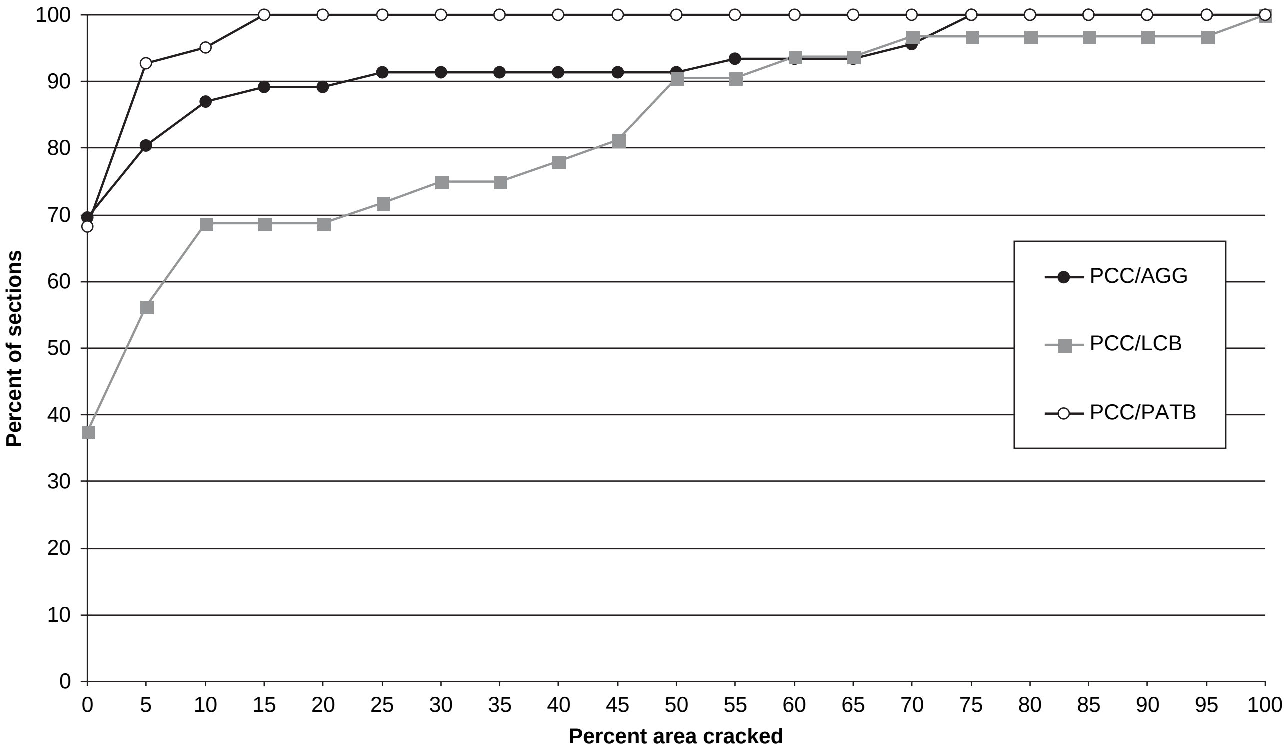

Figure 109. Cumulative frequency distributions of cracking in SPS-2 pavement sections.

Ohio, and Washington. The sections that exhibited the most cracking were the sections with lean concrete base and thin (8-in.) concrete slabs (test section designs 0205, 0206, 0217, and 0218; see Table 6).

The stiffest base type in the experiment, lean concrete base, may have been good for performance in terms of roughness and faulting, but it had a pronounced detrimental effect on cracking performance, particularly in the thinner concrete slabs in the experiment. Sections with undrained AGG, the weakest base type, also had more cracking than sections with drained PATB. Sections with undrained HMAC and CAM bases had even less cracking than sections with drained PATB. As with the other SPS-2 performance measures discussed previously, while the design of the experiment makes it difficult to rule out a potential effect of drainage on cracking development, the above findings suggest that the differences in cracking observed to date are due not to drainage differences but to differences in base stiffness.

CHAPTER 6

Conclusions and Recommendations

Design of the SPS-1 and SPS-2 Experiments

The LTPP Program's SPS-1 and SPS-2 experiments were designed to assess the effects of several factors on the performance of flexible and rigid pavements. These factors include layer thickness, base type, subdrainage, climate, subgrade, and truck traffic level. The SPS-2 experimental factors also include lane width and concrete flexural strength. There is a great deal that can be learned from the SPS-1 and SPS-2 experiments about the factors that influence AC and PCC pavement performance.

Drainage is the experimental factor for which it is most difficult to draw conclusions from the SPS-1 and SPS-2 experiments. This is because two experimental factors, base type and subdrainage, are confounded in both of the experiments. Some base types have drains and other base types do not; the experimental design does not include bases of the same type but with and without drains. This makes it difficult to discern how much any differences in performance between drained and undrained test sections are due to the presence or absence of a functioning drainage system, versus how much any such differences are due to variations in base stiffness.

It is somewhat easier to draw inferences about the role of drainage versus the role of base stiffness for the SPS-1 experiment than for the SPS-2 experiment, given the greater number of base type/drainage combinations in the SPS-1 experiment and the expectation that increased base stiffness in a flexible pavement will yield improved pavement performance. If SPS-1 sections with less stiff bases perform worse and sections with stiffer bases perform better than pavement sections with drained permeable asphalt-treated base layers, then it is reasonable to infer that base stiffness is the more important component of the base type/drainage experimental design factor. If, on the other hand, sections with permeable asphalt-treated layers perform better than both sections with less stiff bases and sections with stiffer bases, then it is reasonable to infer that drainage is the more important component.

For rigid pavements, however, performance is optimized with a base that is neither too weak nor too stiff, the former being associated with high load-related stresses and the latter being associated with high curling stresses. Of the three base types in the SPS-2 experiment, the base of middle stiffness is also the one drained base type—permeable asphalt-treated aggregate—while the less stiff base (untreated aggregate) and the most stiff base (lean concrete) are both undrained. This makes it more difficult to draw inferences about whether base type or drainage is the more important component of the base type/drainage factor in the SPS-2 experiment. Supplemental sections at some SPS-2 sites provide additional insight, as do the results of regression analysis indicating the relative significance of these as well as other experimental factors.

Characteristics of the Sites

Climate

The SPS-1 and SPS-2 sites are comparable in terms of geographic distribution throughout the United States and with respect to rainfall and temperature. Climatic data from the SPS-1 and SPS-2 sites were used to show that design storm parameters typically used to design subsurface drainage systems can be estimated from correlations with more readily known average annual precipitation data.

The Thornthwaite moisture index, which describes a location's climate in a way that reflects the monthly variations in both precipitation and temperature, was suggested as a better climatic parameter for use in analysis of pavement performance than average annual precipitation or average annual temperature. In the regressions for roughness and distress in the SPS-1 and SPS-2 pavement sections, the Thornthwaite moisture index was almost always more significant than average precipitation or average annual temperature.

Soils

The natural drainage characteristics of the soils at the SPS-1 and SPS-2 sites were examined by studying county soil reports and the taxonomic classifications of the predominant soil series at the sites. The soils of the SPS-1 and SPS-2 sites range from very well drained (or, in natural drainage class terminology, "somewhat excessively drained" for agricultural purposes) to very poorly drained. Clearly some of the SPS-1 and SPS-2 sites have subgrade soils with such good natural drainage characteristics that any water that entered the pavement structure would be able to flow downward quickly into the subgrade without accumulating in the vicinity of the constructed base. Some other SPS-1 and SPS-2 sites have subgrade soils with such poor natural drainage characteristics that water that entered the pavement structure would probably flow downward very slowly, if at all, and could accumulate in and around the base unless drained laterally. Whether such accumulation occurs to a degree sufficient to detrimentally affect pavement performance is a separate question.

Speaking very generally, the types of soils in the continental United States that appear most likely to be classified as somewhat poorly to very poorly drained are the aquic (wet) suborders of the alfisol, ultisol, mollisol, and histosol soil orders. Alfisols are fertile but poorly draining soils that are commonly found in a broad swath from the Great Lakes region down through the lower Mississippi Valley. Ultisols are low-nutrient clays found throughout much of the southeastern United States. Mollisols are the soft, dark, grassland soils that cover much of the Midwest and Great Plains; the wet suborder of mollisols are found in parts of the Great Lakes region and northeastern Great Plains, as well as in some parts of Florida. Histosols are organic soils found in wetlands such as those along the Gulf of Mexico, the Atlantic coast, and the upper Midwest. Each of these soil orders has dry suborders as well, describing soils with much better drainage characteristics than those in the wet suborders. Thus, it is best not to assume too much about the drainage characteristics of a soil based on its general geographic location. Rather, the county soil report and taxonomic classification should be studied to determine the natural drainage class and other drainage-related properties of the soil at the specific place where a pavement is located or is to be located.

Age and Traffic

The SPS-1 sites ranged in age from 9 to 12 years at the time of this analysis. The SPS-1 sites for which traffic data were available had accumulated flexible pavement ESALs that ranged from less than 1 million to slightly more than 7 million. All but one of the sites, though, had less than 5 million accumulated flexible pavement ESALs.

The SPS-2 sites ranged in age from 9 to 13 years. Of the SPS-2 sites for which traffic data were available, one had less than 1 million accumulated rigid pavement ESALs, and the rest had between 4 million and 24 million accumulated rigid pavement ESALs. (Traffic data are not available for six of the 18 SPS-1 sites or for three of the 14 SPS-2 sites.) An unfortunate consequence of so many of the SPS-1 sites having been located on lower volume roads is that the findings related to the performance of the SPS-1 flexible pavements are less reliably applicable to high traffic volume conditions than are findings related to the performance of the SPS-2 rigid pavements.

Permeable Base Drainage System Flow Testing

A procedure for field testing the rate of flow of water through a permeable base with edgedrains and outlets was developed for this study and used to test the flow times of the permeable base sections at all of the SPS-1 and SPS-2 sites. At many of the sites, the outlet headwalls were unmarked and were obscured by tall vegetation. At some sites, the outlet headwalls were also completely covered by dirt, gravel, and other vegetation that had to be dug out with hand tools. Even outlets that were fairly easy to locate usually had to be cleared out with hand tools before the drainage flow time testing could be conducted. It should be noted that, for the purposes of the flow testing, the in situ conditions were modified by the clearing of the outlets at many of the test sections. The degree to which the drainage outlets at the various SPS-1 and SPS-2 sites are or are not maintained is presumed to be typical of the level of maintenance conducted for drainage outlets on other, nonexperimental pavements.

For drained test sections with measurable outflow, the calculated drainage system permeabilities ranged from 6,000 to more than 32,000 ft/day. It should be remembered, however, that (*a*) this reflects not only the permeability of the permeable asphalt-treated base layer, but also the movement of water through the edgedrain and outlets, and (*b*) the actual magnitude of the drainage system permeability calculated is a function of an assumed width of the flow plume away from the core hole. The calculated drainage system permeabilities are perhaps better considered as indicators of the relative functioning of the drainage systems at the different sites. Furthermore, for the purpose of evaluating the permeability of the permeable asphalt-treated base material, independent of the flow rate through the edgedrain and outlet, the better measure obtained from the field testing might be the steady-state infiltration rate in gallons per minute.

At all but two sites, water outflow from the drainage outlets occurred in at least one drained test section, even at some sites with subgrade soils classified as well drained to somewhat excessively drained. This suggests that once a pavement structure is constructed, water in a drainable base layer may find that lateral outflow is less restricted than downward flow even though the natural drainage characteristics of the subgrade soil, if exposed, would be conducive to downward flow. On the other hand, the lack of outflow for some drained test sections, along with observations of the fairly pristine condition of the outlets, suggests that in such test sections, water has never moved laterally from the base into the edgedrains and to the outlets, but rather has flowed downward into the subgrade soil.

Results from Deflection Analysis

All of the deflection data collected on the SPS-1 and SPS-2 test sections, from the time of their construction to the upload of the data in Release 19 of the LTPP database, was retrieved from the LTPP database and analyzed for this study. For the sake of comparisons among the different test sections, the analysis results for the first set of deflection data are presented in this report. The results from the first set of deflection data and the most recent set of deflection data are also compared. While differences between the backcalculation results from the first year of testing and the most recent year of testing were observed, the differences were sufficiently variable that no statistically significant increase or decrease was detectable, for either the drained or the undrained test sections.

For the flexible pavement sections in the SPS-1 experiment, a two-layer analysis procedure was used to determine the in-place elastic modulus of the subgrade and an elastic modulus of the pavement structure (all layers combined) above the subgrade, using deflections measured at load levels closest to 9,000 lb and normalized to 9,000 lb, and also normalized with respect to temperature. For the purpose of comparing the relative structural capacities of the pavement sections at each site, the actual total pavement thickness and backcalculated pavement modulus were used to calculate an equivalent thickness for a fixed asphalt concrete modulus of 500,000 psi.

Similarly, for the rigid pavement sections in the SPS-2 experiment, a two-layer analysis procedure was used to determine the in-place dynamic *k* value of the subgrade and an elastic modulus of the pavement structure, above the subgrade, using deflections measured at load levels closest to 9,000 lb and normalized to 9,000 lb. As part of this deflection analysis, slab size corrections were applied to the radius of relative stiffness and the deflection under the load plate. Data on the temperature gradient through the concrete slab at the time of deflection testing was used to identify and correct for possible loss of contact between the concrete slab and underlying base. For the purpose of comparing the relative structural capacities of the pavement sections at each site, the actual total pavement thickness and backcalculated pavement modulus were used to calculate an equivalent thickness for a fixed concrete modulus of 5,000,000 psi.

The weakest pavement sections in the SPS-1 experiment were found to be those with undrained, untreated aggregate bases, and the strongest pavements were found to be those with undrained, dense-graded asphalt-treated bases. The undrained sections with asphalt-treated base over aggregate and the drained sections with permeable asphalt-treated base over aggregate or asphalt-treated base over permeable asphalt-treated base fell between those two in terms of pavement strength (as indicated by backcalculated effective pavement thickness).

The pavement sections in the SPS-2 experiment that were expected to be the weakest—those with untreated dense aggregate base—did not, in fact, have backcalculated effective pavement thicknesses much different than the pavement sections with permeable asphalt-treated base. This may be because the concrete slab modulus is so much greater than the modulus of either of these two base types that it dominates the calculation of the effective pavement thickness. On the other hand, the effective thickness of the pavement sections with lean concrete base was, in most cases, notably greater than the effective thickness of otherwise comparable pavement sections with the other two types of base. In short, the drained sections with permeable asphalt-treated base were not much more rigid than the sections with undrained aggregate base, but the undrained sections with lean concrete base were notably more rigid than the drained sections with permeable asphalt-treated base.

SPS-2 deflection data were also analyzed to assess joint load transfer measurements from deflections measured with the load plate on the approach and leave sides of the joint. Contrary to the conventional wisdom, but consistent with the finding of another recent analysis of LTPP deflection load transfer data (*31*), leave-side load transfer values were found to be greater than approach-side load transfer values, and the average difference between the two was found to be statistically significant. The difference between approach and leave load transfer was found to be insensitive to slab temperature, which suggests that it is unrelated to the magnitude of joint opening. Leave-side load transfer values were selected for use in this study for comparisons among the three different base types in the SPS-2 experiment.

Cumulative frequency distributions of load transfer values in the first year of deflection testing and in the most recent year of testing showed some decrease in load transfer associated with all three base types. In fact, the greatest increase in the percentage of joints with load transfer at levels below 80% occurred in the sections with drained permeable asphalt-treated base. The percentage of joints with poor load transfer, however, remains low for all three base types, even after 10 or more years of service and more than 15 million accumulated ESALs at some sites. It is not too surprising that only a small percentage of joints associated with any of the treatments are exhibiting poor load transfer, considering that the joints in nearly all of the SPS-2 sections are dowelled. Overall, after some 10 years in service and considerable truck traffic at many of the SPS-2 sites, load transfer values in the pavement sections with undrained aggregate base and undrained lean concrete base are no worse than in the pavement sections with drained permeable asphalt-treated base.

Results from Performance Analysis

Factors Affecting Distress and Roughness in SPS-1 Flexible Pavements

Long-term IRI values for the SPS-1 flexible pavements were found to be more strongly correlated to initial IRI values than to all of the SPS-1 experimental factors combined. The next most influential factors were found to be age, back-calculated equivalent thickness of the pavement structure, Thornthwaite moisture index, and average annual precipitation. The base type/drainage factors showed very little correlation to long-term IRI values.

The cumulative frequency distributions for long-term IRI and change in IRI (latest minus initial) were all fairly similar for the five different base type/drainage combinations in the SPS-1 experiment. The SPS-1 sections without a dense-graded asphalt-treated base layer (undrained aggregate and drained permeable asphalt-treated base over aggregate) were found to have both higher initial IRI values and higher long-term IRI values than the SPS-1 sections with a dense-graded asphalt-treated base layer (undrained asphalt-treated base, undrained asphalt-treated base over aggregate, and undrained asphalt-treated base over permeable asphalt-treated base). The largest changes in IRI tended to occur in the undrained aggregate base sections, followed by the drained permeable asphalt-treated base sections, followed by the three groups of undrained sections with an asphalt-treated base layer.

Whatever fairly minor effect the base type/drainage factor has had on the development of roughness in the SPS-1 pavement sections is concluded to be due to differences in base stiffness and not differences in drainage. Furthermore, the differences observed in IRI by base type are not entirely due to different rates of change in IRI over the time that the pavement sections have been in service, because there is evidence that the pavements with weaker bases, both drained and undrained, tended to be rougher initially than the pavements with stiffer bases.

Although some pavement sections developed unusually high rutting at a young age (less than 6 years), the vast majority of the SPS-1 pavement sections do not appear to have started to develop increased rutting with increasing age and traffic. This is probably related to the low levels of truck traffic at most of the SPS-1 sites. Rutting levels were similar for all of the base type/drainage combinations, except that the undrained aggregate base group had a higher percentage of sections with unusually high rutting at an early age. Base stiffness, rather than drainage, is concluded to be the aspect of the base type/drainage experimental factor that is responsible for whatever role this factor has played in the development of rutting in the SPS-1 test sections.

About half of the SPS-1 test sections in each base type/drainage group have not yet developed any cracking. Among those that have, the weaker pavement sections (undrained aggregate base and drained permeable asphalt-treated base) have more cracking than the stronger pavement sections (undrained asphalt-treated base, undrained asphalt-treated base over aggregate, and drained asphalt-treated base over permeable asphalt-treated base). Whatever minor effect the base type/drainage factor has had on cracking in the SPS-1 pavement sections to date is concluded to be due to differences in base stiffness, rather than differences in drainage.

Factors Affecting Distress and Roughness in SPS-2 Rigid Pavements

Long-term IRI values for the SPS-2 rigid pavements were more strongly correlated to initial IRI values than to any of the other factors considered, although the correlation between long-term IRI and initial IRI was not as strong for the SPS-2 pavements as it was for the SPS-1 pavements. Long-term IRI values for the pavement sections with the two undrained base types in the SPS-2 experiment (dense-graded aggregate and lean concrete) were similar and both higher than the long-term IRI values for the pavement sections with drained permeable asphalt-treated base. Changes in IRI over time were also greatest in the undrained dense-graded aggregate and lean concrete sections, followed by the drained permeable asphalt-treated base group.

The SPS-2 experiment includes a small number of test sections with undrained hot-mix asphalt concrete base and undrained cement-aggregate mixture base. The sections with undrained hot-mix asphalt concrete base had the highest median initial IRI values, but exhibited smaller changes in IRI than sections in the drained permeable asphalt-treated base group, and as a result had long-term IRI values similar to the sections in the drained permeable asphalt-treated base group. The sections with undrained cement-aggregate mixture base had the smallest changes in IRI and the lowest long-term IRI values of any of the base type/drainage combinations in the SPS-2 experiment.

Whatever effect the base type/drainage factor has had on the SPS-2 pavement sections' latest observed IRI values and rates of change in IRI over time is concluded to be due predominantly to differences in base stiffness. The potential effect of drainage is not necessarily ruled out, but no particular evidence was detected for the role of drainage, independent of the role of base stiffness, in the development of roughness in the SPS-2 pavements. Furthermore, the differences in IRI by base type are not entirely attributable to different rates of change in IRI over the time that the SPS-2 pavements have been in service, because there is evidence of some significant differences in initial IRI values by base type. Of the three base types in the main SPS-2 experiment, the lean concrete base was associated with the highest initial IRI values, while the dense aggregate base was associated with the highest long-term IRI values.

The SPS-2 sections with undrained lean concrete base and drained permeable asphalt-treated base have developed very similar levels of joint faulting, while the sections with undrained aggregate base have developed more faulting. This is true whether undowelled SPS-2 sections are included in or excluded from the comparisons.

Of the eight undowelled pavement sections in the SPS-2 experiment, two have an undrained aggregate base, four have a drained permeable asphalt-treated base, one has an undrained lean concrete base, and one has an undrained hot-mix asphalt concrete base. Among these eight sections, the two with the highest faulting levels (2.9 mm and 3.0 mm), were the undowelled sections with aggregate base at the Arizona SPS-2 site (which has a Thornthwaite moisture index of –51 and subgrade soils that are naturally well drained to somewhat excessively drained). Faulting in the remaining six undowelled sections (at the Arizona, North Dakota, and Washington sites) ranged from 0 to 1.3 mm.

These findings, particularly the similarity of results for undrained lean concrete base and drained permeable asphalt-treated base, suggest that whatever effect the base type/drainage factor has had on the development of faulting in pavements in the SPS-2 experiment has been due to the stiffness of these bases compared with the lesser stiffness of the undrained dense-graded aggregate base. This conclusion is reinforced by the observation that the undowelled pavements with aggregate base developed more than twice as much faulting as undowelled pavements with drained or undrained stabilized bases, even those at the same sites.

More than 60% of the SPS-2 sections with undrained lean concrete base have developed some cracking, while only about 30% of both the undrained aggregate base sections and the drained permeable asphalt-treated base sections have developed some cracking. At one of the SPS-2 sites (the Nevada site), excessive drying shrinkage and premature slab cracking during or shortly after construction occurred in many of the test sections, particularly the sections with lean concrete base. However, more cracking occurred in the lean concrete base sections than in the aggregate and permeable asphalt-treated base sections at several other SPS-2 sites and did not appear to be construction related.

The stiffest base type in the SPS-2 experiment, lean concrete base, may have been good for performance in terms of roughness and faulting, but it had a pronounced detrimental effect on cracking performance, particularly in the thinner concrete slabs in the experiment. Sections with the weakest base type, undrained aggregate base, also had more cracking than sections with drained permeable asphalt-treated base. On the other hand, sections with undrained hot-mix asphalt concrete and cement-aggregate mixture bases had even less cracking than sections with drained permeable asphalt-treated base. As with the other SPS-2 performance measures, while the design of the experiment makes it difficult to rule out a potential effect of drainage on the development of cracking in the SPS-2 pavement sections, the above findings suggest that the differences in cracking observed to date are due not to drainage differences but to differences in base stiffness.

Final Comments and Recommendations

This report began with the observation that pavement engineers have for many decades observed that an excess of water in pavement structures can accelerate certain types of distress in both AC and PCC pavements. It is undoubtedly true that poor subsurface drainage was detrimental to the performance of many pavements built in the United States in the decades following World War II, and that many of these pavements would have benefited from subsurface drainage systems.

In many ways, the pavements built in the United States today, particularly those on Interstate highways and U.S. routes, are less vulnerable to the detrimental effects of excessive moisture than pavements built in the past. Flexible pavements are now built with thicker AC surface layers and thicker, usually stabilized, base layers. Rigid pavements are built with thicker PCC slabs, usually with dowelled joints and with stabilized base layers, and with better-quality aggregates. So while subsurface drainage systems may still be needed to achieve good performance in some pavements in some places, it appears to be far less true than it was 20 or more years ago that subsurface drainage systems are needed to achieve good performance in most pavements in most places.

Consider, as an analogy, tire chains, which were routinely used to improve tire traction in snow throughout the northern United States, up through the late 1960s and early 1970s. Tire chains function as well today as they ever did, and they are still used in some locations in heavy snow conditions. But they are no longer needed for most wintertime driving because of improvements in tire tread, vehicle, and winter maintenance technologies. Similarly, it is not that pavement subsurface drainage systems do not work (although sometimes that is the case), but rather that many of the pavements being built today do not need them as much as many of the pavements built decades ago needed them.

The analyses conducted for this study did not identify any aspect of the behavior or performance of the AC and PCC pavement structures in the SPS-1 and SPS-2 experiments that could be shown to have been improved by the presence of subsurface pavement drainage. What does appear to have influenced every aspect of pavement behavior and performance analyzed for these pavements—namely, deflection response, roughness, rutting, faulting, and cracking—is not the drainability of the base layers used but rather their stiffness. Overall, the best-performing pavements in the SPS-1 experiment were those with the stiffest bases (incorporating a dense-graded asphalt-treated base layer), whether drained or undrained. The best-performing pavements in the SPS-2 experiments were those with bases that were neither too weak (untreated aggregate) nor too stiff (lean concrete). These include not only the sections with drained permeable asphalt-treated concrete base, but also the sections with undrained hot-mix asphalt base and cement-aggregate mixture base.

It is still important, however, for pavement engineers to be able to identify situations in which a pavement subsurface drainage system is likely to be necessary and cost-effective. Based on the findings from this study, the following recommendations are made for investigating the need for subsurface drainage.

- The Thornthwaite moisture index and monthly precipitation data are recommended for use in identifying sites with year-round or seasonal excesses of available moisture.
- County soil reports and soil taxonomy information are recommended for use in identifying subgrade soils with poor natural drainage characteristics.
- At sites with wet climates and poorly draining soils, the need for a subsurface drainage system should be considered; this is particularly true for pavement designs likely to be vulnerable to moisture-related distress, including thin asphalt and thin concrete pavements on untreated aggregate base layers, especially when, in the case of jointed concrete pavements, the joints are to be undowelled. Evidence of adverse effects of poor drainage in nearby pavements (for example, pumping, faulting, potholes) should also be considered, as should local experience. Even in such situations, however, it is recommended that the possibility be considered that a stiffer base layer (for PCC pavements, not too stiff a base layer) may be a more cost-effective design improvement than a subsurface drainage system.

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Abbreviations and Acronyms

AASHTO—American Association of State Highway and Transportation Officials

AC—asphalt concrete

AGG—aggregate

AGG1—unbound aggregate layer directly beneath an AC or PCC layer

AGG2—unbound aggregate layer beneath a treated base layer

ATB—asphalt-treated base

ATB/DGG—asphalt-treated base over dense-graded aggregate

ATB/PATB—asphalt-treated base over permeable asphalt-treated base

CAM—cement-aggregate mixture

DGA—dense-graded aggregate

DOT—department of transportation

FHWA—Federal Highway Administration

FWD—falling weight deflectometer

GPS—general pavement studies

HMAC—hot-mix asphalt concrete

HMA—hot-mix asphalt

IRI—international roughness index

JPCP—jointed plain concrete pavement

LCB—lean concrete base

LTPP—long-term pavement performance

MnRoad—Minnesota Road Research Project

NHI—National Highway Institute

NRCS—Natural Resources Conservation Service

PATB—permeable asphalt-treated base

PATB/AGG—permeable asphalt-treated base over aggregate

PCC—portland cement concrete

SHRP—Strategic Highway Research Program

SPS-1—Strategic Study of Structural Factors for Flexible Pavements

SPS-2—Strategic Study of Structural Factors for Rigid Pavements

SPS—specific pavement studies

APPENDIX A

SPS-1 and SPS-2 Test Section Layout Diagrams

SPS-1 Layout Diagrams and Locations of Inspected Outlets

The following codes are used in the LTPP database for pavement materials and soils in SPS-1 and SPS-2 test sections:

1	hot-mixed, hot-laid, dense-graded AC
2	hot-mixed, hot-laid open-graded AC
4	portland cement concrete (JPCP)
20	other
74	woven geotextile
75	nonwoven geotextile
78	dense-graded asphalt concrete interlayer
101	clay
102	lean inorganic clay
103	fat inorganic clay
104	clay with gravel
106	fat clay with gravel
107	clay with sand
108	lean clay with sand
109	fat clay with sand
113	sandy clay
114	sandy lean clay
115	sandy fat clay
131	silty clay
133	silty clay with sand
134	gravelly silty clay
135	sandy silty clay
137	sandy silty clay with gravel
141	silt
143	silt with sand
145	sandy silt
147	sandy silt with gravel
148	clayey silt
201	sand
202	poorly graded sand
204	poorly graded sand with silt
205	poorly graded sand with silt and gravel

209	well-graded sand with gravel
210	well-graded sand with silt
211	well graded sand with silt and gravel
213	well graded sand with clay and gravel
214	silty sand
215	silty sand with gravel
216	clayey sand
217	clayey sand with gravel
251	gravel
252	poorly graded gravel
253	poorly graded gravel with sand
255	poorly graded gravel with silt
261	well-graded gravel with silt and sand
267	clayey gravel with sand
282	rock
303	crushed stone
304	crushed gravel
306	sand
307	soil-aggregate mixture, predominantly fine-grained
308	soil-aggregate mixture, predominantly coarse-grained
309	fine-grained soils
319	HMAC
321	asphalt-treated mixture
325	open-graded, hot-laid central plant mix
331	cement-aggregate mixture
333	cement-treated soil
334	lean concrete
337	limerock, caliche
338	lime-treated soil
340	pozzolan-aggregate mixture
350	other

Note: In SPS-1 layout diagrams, the material type for the surface layer is hot-mixed, hot-laid, dense graded AC (material type code = 1), unless otherwise indicated.

ALABAMA - SPS-1

Station (ft)	Station (m)
0	0
500	152
725	221
1,225	373
1,350	412
1,850	564
2,100	640
2,600	793
3,200	975
3,700	1,128
4,050	1,234
4,550	1,387
4,950	1,509
5,450	1,661
8,600	2,621
9,100	2,774
9,550	2,911
10,050	3,063
10,300	3,139
10,800	3,292
11,000	3,353
11,500	3,505
11,700	3,566
12,200	3,719
12,550	3,825
13,050	3,978
17,975	5,479
18,475	5,631
18,900	5,761
19,400	5,913

Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
010107	Y		AC	PATB	AGG2	4.6	3.6	4.1
010108	Y		AC	PATB	AGG2	7.3	4.2	7.9
010109	Y		AC	PATB	AGG2	7.6	4.2	11.9
010163 Sup			AC	ATB	PATB	4.3	6.1	4.0
010110	Y		AC	ATB	PATB	7.9	4.2	3.5
010111	Y		AC	ATB	PATB	4.0	7.9	3.7
010112	Y		AC	ATB	PATB	3.4	12.4	3.3
010106	N		AC	ATB	AGG2	7.2	8.5	3.8
010104	N		AC	ATB		6.5	11.7	
010162 Sup	N		AC	ATB		4.1	10.0	
010103	N		AC	ATB		4.6	7.4	
010105	N		AC	ATB	AGG2	4.2	3.9	4.0
010101	N		AC	AGG1		7.5	7.9	
010102	N		AC	AGG1		4.2	11.9	
010161 Sup			AC	ATB	AGG2	4.1	6.1	6.0

ARIZONA - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0 – 500	0 – 152	040160 Sup			PCC	AGG1		11.2	4.0	
850 – 1,350	259 – 412	040115	N		AC	ATB		6.6	8.5	
1,650 – 2,150	503 – 655	040117	N		AC	ATB	AGG2	7.4	4	4.2
2,600 – 3,100	793 – 945	040124	Y		AC	ATB	PATB	6.7	11.7	4.1
3,700 – 4,200	1,128 – 1,280	040123	Y		AC	ATB	PATB	6.8	7.9	3.8
5,050 – 5,550	1,539 – 1,692	040119	Y		AC	PATB	AGG2	6.3	4.5	4.2
6,250 – 6,750	1,905 – 2,057	040114	N		AC	AGG1		7.3	12.0	
7,100 – 7,600	2,164 – 2,317	040116	N		AC	ATB		4.5	12.1	
7,950 – 8,450	2,423 – 2,576	040118	N		AC	ATB	AGG2	4.4	7.7	4.1
8,700 – 9,200	2,652 – 2,804	040122	Y		AC	ATB	PATB	4.7	4.0	4.6
9,450 – 9,950	2,880 – 3,033	040121	Y		AC	PATB	AGG2	4.6	4.2	11.8
10,600 – 11,100	3,231 – 3,383	040120	Y		AC	PATB	AGG2	4.5	4.3	7.6
11,500 – 12,000	3,505 – 3,658	040113	N		AC	AGG1		4.9	7.5	
12,300 – 12,800	3,749 – 3,901	040161 Sup			AC	AGG1		6.2	3.8	
13,200 – 13,700	4,023 – 4,176	040162 Sup			AC			9.0		
14,050 – 14,550	4,282 – 4,435	040163 Sup			AC	PCC		1	15.0	

ARKANSAS - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0	0	050119	Y		AC	PATB	AGG2	7.0	3.2	4.2
500	152									
1,000	305	050120	Y		AC	PATB	AGG2	4.5	3.1	8.1
1,500	457									
1,800	549	050121	Y		AC	PATB	AGG2	4.5	2.9	12.3
2,300	701									
2,850	869	050122	Y		AC	ATB	PATB	4.4	4.2	3.3
3,350	1,021									
4,000	1,219	050123	Y		AC	ATB	PATB	7.2	8.3	3.5
4,500	1,372									
4,700	1,433	050124	Y		AC	ATB	PATB	6.9	11.1	3.7
5,200	1,585									
5,700	1,737	050118	N		AC	ATB	AGG2	4.1	7.9	3.5
6,200	1,890									
6,650	2,027	050116	N		AC	ATB		4.1	12.0	
7,150	2,179									
7,650	2,332	050115	N		AC	ATB		6.9	7.4	
8,150	2,484									
8,350	2,545	050117	N		AC	ATB	AGG2	7.0	4.0	4.1
8,850	2,698									
9,250	2,819	050114	N		AC	AGG1		7.0	11.3	
9,750	2,972									
10,250	3,124	050113	N		AC	AGG1		4.0	8.2	
10,750	3,277									

DELAWARE - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers	Layer Thicknesses (inches)
0 – 500	0 – 152	100160 Sup			AC / ATB / AGG2	8.2 / 5.6 / 5.6
700 – 1,200	213 – 366	100107	Y		AC / PATB / AGG2	5.8 / 3.8 / 3.9
1,400 – 1,900	427 – 579	100105	N		AC / ATB / AGG2	5.4 / 4.4 / 3.4
2,100 – 2,600	640 – 793	100102	N		AC / AGG1	5.1 / 11.8
2,800 – 3,300	853 – 1,006	100101	N		AC / AGG1	8.1 / 8.1
3,800 – 4,300	1,158 – 1,311	100103	N		AC / ATB	5.8 / 8
4,500 – 5,000	1,372 – 1,524	100111	Y		AC / ATB / PATB	4.7 / 8.7 / 3.9
5,200 – 5,700	1,585 – 1,737	100112	Y		AC / ATB / PATB	5.5 / 12.3 / 3.4
5,900 – 6,400	1,798 – 1,951	100110	Y		AC / ATB / PATB	8.2 / 4.1 / 3.6
6,600 – 7,100	2,012 – 2,164	100108	Y		AC / PATB / AGG2	8.0 / 3.7 / 7.3
7,300 – 7,800	2,225 – 2,377	100109	Y		AC / PATB / AGG2	8.3 / 4.2 / 12.1
8,000 – 8,500	2,438 – 2,591	100159 Sup			AC / ATB / AGG2	6.7 / 6.6 / 7.6
8,700 – 9,200	2,652 – 2,804	100106	N		AC / ATB / AGG2	7.7 / 8.5 / 3.9
9,325 – 9,825	2,842 – 2,995	100104	N		AC / ATB	7.7 / 12.0

FLORIDA - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0 – 500	0 – 152	120161 Sup			AC	AGG1		4.0	10.2	
2,600 – 3,100	793 – 945	120102	N		AC	AGG1		3.8	12.1	
3,950 – 4,450	1,204 – 1,356	120101	N		AC	AGG1		6.8	8.1	
4,950 – 5,450	1,509 – 1,661	120105	N		AC	ATB	AGG2	3.9	4.0	4.0
5,950 – 6,450	1,814 – 1,966	120103	N		AC	ATB		4.1	8.0	
7,100 – 7,600	2,164 – 2,317	120104	N		AC	ATB		6.8	12.1	
8,800 – 9,300	2,682 – 2,835	120109	Y		AC	PATB	AGG2	7.3	4.1	11.9
10,250 – 10,750	3,124 – 3,277	120112	Y		AC	ATB	PATB	4.0	12.4	3.9
11,900 – 12,400	3,627 – 3,780	120111	Y		AC	ATB	PATB	3.9	8.2	4.0
13,400 – 13,900	4,084 – 4,237	120110	Y		AC	ATB	PATB	7.3	4.1	4.1
16,100 – 16,600	4,907 – 5,060	120106	N		AC	ATB	AGG2	7.1	8.4	4.0
17,200 – 17,700	5,243 – 5,395	120108	Y		AC	PATB	AGG2	6.4	4.0	7.9
19,200 – 19,700	5,852 – 6,005	120107	Y		AC	PATB	CS	3.8	4.1	4.1

IOWA - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0 500	0 152	190159 Sup			AC	ATB	AGG2	4.0	9.0	10.0
4,100 4,600	1,250 1,402	190108	Y	▬	AC	PATB	AGG2	5.9	4.6	8.0
5,400 5,900	1,646 1,798	190104	N	▬	AC	ATB		7.0	12.4	
6,100 6,600	1,859 2,012	190106	N	▬	AC	ATB	AGG2	6.8	9.0	4.0
6,800 7,300	2,073 2,225	190109	Y	▬	AC	PATB	AGG2	7.5	4.9	12.0
7,800 8,300	2,377 2,530	190110	Y		AC	ATB	PATB	7.9	3.2	4.4
8,900 9,400	2,713 2,865	190111	Y		AC	ATB	PATB	4.4	7.5	4.3
10,600 11,100	3,231 3,383	190112	Y	▬	AC	ATB	PATB	4.6	12.5	4.1
11,500 12,000	3,505 3,658	190101	N		AC	AGG1		8.0	8.0	
12,600 13,100	3,841 3,993	190102	N	▬	AC	AGG1		5.1	12.0	
13,600 14,100	4,145 4,298	190105	N	▬	AC	ATB	AGG2	3.5	4.7	4.0
14,300 14,800	4,359 4,511	190103	N	▬	AC	ATB		3.8	8.4	
15,550 16,050	4,740 4,892	190107	Y		AC	PATB	AGG2	6.4	4.2	4.0

KANSAS - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers	Layer Thicknesses (inches)
0 – 500	0 – 152	200162 Sup			AC	11.4
5,800 – 6,300	1,768 – 1,920	200163 Sup			AC / ATB / AGG2	1.5 / 2.5 / 8.0
6,900 – 7,400	2,103 – 2,256	200164 Sup			AC / ATB	1.5 / 10.5
27,000 – 27,500	8,230 – 8,382	200159 Sup			AC	10.8
27,650 – 28,150	8,428 – 8,580	200101	N		AC / AGG1	7.6 / 8.5
29,250 – 29,750	8,915 – 9,068	200102	N		AC / AGG1	4.0 / 12.3
29,900 – 30,400	9,114 – 9,266	200106	N		AC / ATB / AGG2	7.3 / 7.3 / 4.0
31,500 – 32,000	9,601 – 9,754	200107	Y		AC / PATB / AGG2	4.1 / 4.1 / 3.7
32,150 – 32,650	9,799 – 9,952	200108	Y		AC / PATB / AGG2	7.6 / 3.6 / 7.9
33,050 – 33,550	10,074 – 10,226	200109	Y		AC / PATB / AGG2	7.0 / 3.6 / 11.9
33,700 – 34,200	10,272 – 10,424	200110	Y		AC / ATB / PATB	7.0 / 3.8 / 3.9
34,350 – 34,850	10,470 – 10,622	200112	Y		AC / ATB / PATB	5.0 / 12.0 / 3.6
35,000 – 35,500	10,668 – 10,820	200111	Y		AC / ATB / PATB	4.0 / 8.5 / 3.6
37,250 – 37,750	11,354 – 11,506	200105	N		AC / ATB / AGG2	3.9 / 3.8 / 4.1
38,300 – 38,800	11,674 – 11,826	200103	N		AC / ATB	3.6 / 7.7
38,950 – 39,450	11,872 – 12,024	200104	N		AC / ATB	6.8 / 12.1
49,600 – 50,100	15,118 – 15,271	200160 Sup			AC / AGG1	5.5 / 7.0
54,800 – 55,300	16,703 – 16,855	200161 Sup			AC / AGG1	5.5 / 11.0

LOUISIANA - SPS-1

Station (ft)	Station (m)
0	0
500	152
700	213
1,200	366
1,675	511
2,175	663
2,650	808
3,150	960
3,425	1,044
3,925	1,196
4,875	1,486
5,375	1,638
5,975	1,821
6,475	1,974
7,075	2,157
7,575	2,309
7,775	2,370
8,275	2,522
8,475	2,583
8,975	2,736
9,400	2,865
9,900	3,018
10,100	3,079
10,600	3,231

Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
220119	Y		AC	PATB	AGG2	7.1	3.7	4.4
220120	Y		AC	PATB	AGG2	3.9	3.9	8.1
220121	Y		AC	PATB	AGG2	4.3	3.9	13.2
220122	Y		AC	ATB	PATB	4.6	3.4	3.7
220123	Y		AC	ATB	PATB	6.8	7.3	4.2
220124	Y		AC	ATB	PATB	7.2	10.6	3.6
220118	N		AC	ATB	AGG2	4.4	7.0	4.1
220116	N		AC	ATB		4.7	11.3	
220115	N		AC	ATB		7.0	9.0	
220117	N		AC	ATB	AGG2	7.0	3.9	5.3
220114	N		AC	AGG1		9.5	11.4	
220113	N		AC	AGG1		4.9	8.1	

MICHIGAN - SPS-1

Station (ft)	Station (m)
0	0
500	152
600	183
1,100	335
1,875	572
2,375	724
2,475	754
2,975	907
3,050	930
3,550	1,082
4,050	1,234
4,550	1,387
8,750	2,667
9,250	2,819
9,350	2,850
9,850	3,002
9,950	3,033
10,450	3,185
10,550	3,216
11,050	3,368
11,850	3,612
12,350	3,764
12,450	3,795
12,950	3,947
13,050	3,978
13,550	4,130

Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
260121	Y		AC	PATB	AGG2	3.9	4.0	12.0
260120	Y		AC	PATB	AGG2	3.6	4.0	8.0
260118	N		AC	ATB	AGG2	3.5	8.3	4.0
260116	N		AC	ATB		3.9	12.0	
260124	Y		AC	ATB	PATB	6.3	12.2	4.0
260123	Y		AC	ATB	PATB	6.2	8.0	4.0
260122	Y		AC	ATB	PATB	3.7	4.3	4.0
260113	N		AC	AGG1		4.4	8.0	
260114	N		AC	AGG1		6.6	12.0	
260119	Y		AC	PATB	AGG2	6.5	4.0	4.0
260117	N		AC	ATB	AGG2	6.4	5.2	4.0
260115	N		AC	ATB		5.9	9.6	
260159 Sup			AC	PATB	AGG2	5.9	4.0	4.0

MONTANA - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
	0 – 152	300113	N		AC			5		
	213 – 366	300118	N		AC	ATB	AGG2	4.6	8.5	4.2
	427 – 579	300116	N		AC	ATB		4.7	12.6	
	640 – 793	300115	N		AC	ATB		7.5	9.1	
	853 – 1,006	300117	N		AC	ATB	AGG2	7.2	4.6	4.7
	1,067 – 1,219	300114	N		AC			7.2		
	1,280 – 1,433	300124	Y		AC	ATB	PATB	7.1	13.7	4.2
	1,494 – 1,646	300123	Y		AC	ATB	PATB	7.5	8.4	4.5
	1,707 – 1,859	300119	Y		AC	PATB	AGG2	7.6	4.7	4.3
	1,920 – 2,073	300120	Y		AC	PATB	AGG2	4.2	4.6	8.1
	2,134 – 2,286	300122	Y		AC	ATB	PATB	4.6	4.1	4.3
	2,347 – 2,499	300121	Y		AC	PATB	AGG2	4.4	4.3	12.5

NEBRASKA - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0 – 500	0 – 152	310124	Y		AC	ATB	PATB	7.4	10.5	3.4
850 – 1,350	259 – 412	310123	Y		AC	ATB	PATB	7.0	8.0	4.0
1,450 – 1,950	442 – 594	310114	N		AC	AGG1		6.7	12.0	
2,050 – 2,550	625 – 777	310119	Y		AC	PATB	AGG2	7.2	4.0	4.0
2,650 – 3,150	808 – 960	310117	N		AC	ATB	AGG2	6.9	3.9	4.0
3,400 – 3,900	1,036 – 1,189	310115	N		AC	ATB		6.5	8.6	
4,000 – 4,500	1,219 – 1,372	310121	Y		AC	PATB	AGG2	4.3	4.0	12.0
4,600 – 5,100	1,402 – 1,555	310120	Y		AC	PATB	AGG2	4.2	4.0	8.0
5,450 – 5,950	1,661 – 1,814	310118	N		AC	ATB	AGG2	3.9	8.1	4.0
6,400 – 6,900	1,951 – 2,103	310116	N		AC	ATB		4.1	12.2	
7,050 – 7,550	2,149 – 2,301	310122	Y		AC	ATB	PATB	3.8	4.2	4.0
7,750 – 8,250	2,362 – 2,515	310113	N		AC	AGG1		4.4	8.0	

NEVADA - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers	Layer Thicknesses (inches)
0 – 500	0 – 152	320101	N		AC, AGG1	7.2, 8.5
970 – 1,470	296 – 448	320104	N		AC, ATB	7.3, 12.4
1,770 – 2,270	540 – 692	320106	N		AC, ATB, AGG2	7.2, 8.8, 3.7
2,670 – 3,170	814 – 966	320110	Y		AC, ATB, PATB	6.6, 4.2, 4.4
3,520 – 4,020	1,073 – 1,225	320109	Y		AC, PATB, AGG2	7.0, 4.0, 12.1
4,220 – 4,720	1,286 – 1,439	320108	Y		AC, PATB, AGG2	7.0, 4.5, 7.7
4,920 – 5,420	1,500 – 1,652	320107	Y		AC, PATB, AGG2	4.4, 4.1, 3.8
5,670 – 6,170	1,728 – 1,881	320112	Y		AC, ATB, PATB	4.5, 12.4, 4.2
6,570 – 7,070	2,003 – 2,155	320111	Y		AC, ATB, PATB	4.1, 8.4, 4.4
7,390 – 7,890	2,253 – 2,405	320103	N		AC, ATB	4.1, 8.8
8,070 – 8,570	2,460 – 2,612	320105	N		AC, ATB, AGG2	4.2, 4.8, 3.6
8,770 – 9,270	2,673 – 2,826	320102	N		AC, AGG1	4.3, 11.7

NEW MEXICO - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0 – 500	0 – 152	350101	N		AC	AGG1		7.2	7.9	
750 – 1,250	229 – 381	350102	N		AC	AGG1		4.8	12.2	
1,700 – 2,200	518 – 671	350103	N		AC	ATB		5.3	7.2	
2,350 – 2,850	716 – 869	350104	N		AC	ATB		8.1	11.1	
3,000 – 3,500	914 – 1,067	350105	N		AC	ATB	AGG2	5.9	4.0	3.7
3,650 – 4,150	1,113 – 1,265	350106	N		AC	ATB	AGG2	7.6	8.0	2.9
4,300 – 4,800	1,311 – 1,463	350107	Y		AC	PATB	AGG2	5.9	3.7	4.0
4,900 – 5,400	1,494 – 1,646	350108	Y		AC	PATB	AGG2	7.8	4.2	8.0
5,550 – 6,050	1,692 – 1,844	350109	Y		AC	PATB	AGG2	8.0	4.5	11.9
7,150 – 7,650	2,179 – 2,332	350110	Y		AC	ATB	PATB	7.9	4.6	3.7
7,800 – 8,300	2,377 – 2,530	350111	Y		AC	ATB	PATB	4.9	7.6	3.7
8,900 – 9,400	2,713 – 2,865	350112	Y		AC	ATB	PATB	5.0	11.7	3.1

OHIO - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0	0	390112	Y		AC	ATB	PATB	4.0	11.8	4.0
500	152									
800	244	390111	Y		AC	ATB	PATB	4.0	7.8	4.3
1,300	396									
1,600	488	390104	N		AC	ATB		7.2	11.8	
2,100	640									
2,300	701	390106	N		AC	ATB	AGG2	6.8	7.9	3.9
2,800	853									
3,000	914	390101	N		AC	AGG1		6.9	8.0	
3,500	1,067									
3,800	1,158	390107	Y		AC	PATB	AGG2	3.8	3.9	4.1
4,300	1,311									
5,000	1,524	390102	N		AC	AGG1		3.9	11.8	
5,500	1,676									
	1,737	390160 Sup			AC	ATB	AGG2	4.1	10.9	4.0
	1,889									
6,750	2,057	390105	N		AC	ATB	AGG2	3.7	3.7	4.0
7,250	2,210									
7,475	2,278	390108	Y		AC	PATB	AGG2	6.6	4.0	8.0
7,975	2,431									
8,150	2,484	390109	Y		AC	PATB	AGG2	7.0	3.9	12.0
8,650	2,637									
8,850	2,698	390110	Y		AC	ATB	PATB	7.3	3.7	3.9
9,350	2,850									
9,575	2,919	390103	N		AC	ATB		4.1	8.0	
10,075	3,071									
10,800	3,292	390159 Sup			AC	AGG1		4.1	4.0	
11,300	3,444									

OKLAHOMA - SPS-1

Station Start (ft)	Station Start (m)	Station End (ft)	Station End (m)	Section	Design with Drains	Layers			Layer Thicknesses (inches)		
0	0	500	152	400160 Sup		?	?	?	No layer material types or thicknesses in database for this section.		
1,100	335	1,600	488	400114	N	AC	AGG1		8.1	11.3	
3,800	1,158	4,300	1,311	400118	N	AC	ATB	AGG2	4.6	8.3	3.6
4,600	1,402	5,100	1,555	400116	N	AC	ATB		4.2	11.7	
5,400	1,646	5,900	1,798	400115	N	AC	ATB		7.5	9.0	
6,300	1,920	6,800	2,073	400117	N	AC	ATB	AGG2	7.8	4.0	4.0
7,400	2,256	7,900	2,408	400113	N	AC	AGG1		4.5	7.9	
8,200	2,499	8,700	2,652	400122	Y	AC	ATB	PATB	4.3	3.9	4.8
10,400	3,170	10,900	3,322	400119	Y	AC	PATB	AGG2	7.5	4.0	4.3
11,500	3,505	12,000	3,658	400120	Y	AC	PATB	AGG2	4.8	5.0	7.7
12,800	3,901	13,300	4,054	400121	Y	AC	PATB	AGG2	4.2	4.9	11.1
13,800	4,206	14,300	4,359	400123	Y	AC	ATB	PATB	7.3	8.7	4.4
14,700	4,481	15,200	4,633	400124	Y	AC	ATB	PATB	7.4	10.9	4.3

TEXAS - SPS-1

Station (ft) start	Station (ft) end	Station (m) start	Station (m) end	Section	Design with Drains	Video Inspection	Layer 1	Layer 2	Layer 3	Thickness 1 (in.)	Thickness 2 (in.)	Thickness 3 (in.)
0	500	0	152	480115	N		AC	ATB		7.4	7.6	
800	1,300	244	396	480116	N		AC	ATB		5.8	10.9	
1,600	2,100	488	640	480124	Y		AC	ATB	PATB	6.2	10.8	4.2
2,400	2,900	732	884	480123	Y		AC	ATB	PATB	5.3	7.8	4.4
3,700	4,200	1,128	1,280	480122	Y		AC	ATB	PATB	4.6	4.0	4.8
4,500	5,000	1,372	1,524	480117	N		AC	ATB	AGG2	7.4	4.0	3.3
5,300	5,800	1,615	1,768	480118	N		AC	ATB	AGG2	4.8	8.6	1.7
6,100	6,600	1,859	2,012	480113	N		AC	AGG1		5.2	7.8	
6,900	7,400	2,103	2,256	480165 Sup			AC	AGG1		4.6	7.3	
7,700	8,200	2,347	2,499	480164 Sup			AC	AGG1		4.3	9.4	
8,900	9,400	2,713	2,865	480167 Sup			AC	AGG1		4.9	13.0	
9,700	10,200	2,957	3,109	480114	N		AC	AGG1		6.9	12.2	
10,500	11,000	3,200	3,353	480121	Y		AC	PATB	AGG2	4.5	3.7	11.8
11,300	11,800	3,444	3,597	480120	Y		AC	PATB	AGG2	4.7	4.0	7.4
12,100	12,600	3,688	3,841	480119	Y		AC	PATB	AGG2	7.4	3.5	4.0
12,900	13,400	3,932	4,084	480163 Sup			AC	AGG1		4.8	10.2	
13,700	14,200	4,176	4,328	480162 Sup			AC	AGG1		5.0	8.0	
15,100	15,600	4,603	4,755	480161 Sup			AC	AGG1		4.8	8.3	
15,900	16,400	4,846	4,999	480160 Sup			AC	AGG1		5.5	10.6	
16,700	17,200	5,090	5,243	480166 Sup			AC	AGG1		5.3	13.5	

VIRGINIA - SPS-1

Station (ft)		Station (m)		Section	Design with Drains	Layers			Layer Thicknesses (inches)		
0	500	0	152	510114	N	AC	AGG1		7.2	11.9	
2,800	3,300	853	1,006	510121	Y	AC	PATB	AGG2	3.7	4.3	12.5
3,600	4,100	1,097	1,250	510120	Y	AC	PATB	AGG2	4.1	4.3	7.8
4,350	4,850	1,326	1,478	510159 Sup		AC	ATB	PATB	3.4	5.5	4.0
5,050	5,550	1,539	1,692	510119	Y	AC	PATB	AGG2	6.4	4.4	3.9
5,850	6,350	1,783	1,936	510122	Y	AC	ATB	PATB	3.9	3.9	3.9
6,750	7,250	2,057	2,210	510123	Y	AC	ATB	PATB	6.5	8.1	4.1
7,550	8,050	2,301	2,454	510124	Y	AC	ATB	PATB	6.3	12.5	3.4
8,600	9,100	2,621	2,774	510116	N	AC	ATB		4.5	12.4	
9,850	10,350	3,002	3,155	510115	N	AC	ATB		6.4	8.6	
10,800	11,300	3,292	3,444	510117	N	AC	ATB	AGG2	6.6	4.0	3.9
11,550	12,050	3,520	3,673	510118	N	AC	ATB	AGG2	4.1	8.0	3.4
13,000	13,500	3,962	4,115	510113	N	AC	AGG1		4.0	7.9	

WISCONSIN - SPS-1

Station (ft)	Station (m)	Section	Design with Drains	Video Inspection	Layers			Layer Thicknesses (inches)		
0	0	550114	N		AC	AGG1		8.1	11.0	
500	152									
650	198	550117	N		AC	ATB	AGG2	6.4	4.6	3.2
1,150	351									
1,450	442	550115	N		AC	ATB		7.3	7.5	
1,950	594									
2,350	716	550123	Y		AC	ATB	PATB	6.8	8.1	4.3
2,850	869									
3,050	930	550124	Y		AC	ATB	PATB	7.1	11.7	3.3
3,550	1,082									
4,050	1,234	550119	Y		AC	PATB	AGG2	6.6	3.4	4.0
4,550	1,387									
4,750	1,448	550121	Y		AC	PATB	AGG2	4.2	4.2	13.3
5,250	1,600									
5,450	1,661	550120	Y		AC	PATB	AGG2	3.9	4.8	8.0
5,950	1,814									
6,750	2,057	550122	Y		AC	ATB	PATB	4.5	4.8	4.9
7,250	2,210									
7,450	2,271	550118	N		AC	ATB	AGG2	4.0	8.9	4.4
7,950	2,423									
8,450	2,576	550116	N		AC	ATB		4.1	12.0	
8,950	2,728									
9,150	2,789	550113	N		AC	AGG1		5.5	8.0	
9,650	2,941									

		AC	PCC	AGG1	ATB	PATB	AGG2	total
10101	A	7.5		7.9				15.4
10102	A	4.2		11.9				16.1
10103	B	4.6			7.4			12
10104	B	6.5			11.7			18.2
10105	C	4.2			3.9		4	12.1
10106	C	7.2			8.5		3.8	19.5
10107	D	4.6				3.6	4.1	12.3
10108	D	7.3				4.2	7.9	19.4
10109	D	7.6				4.2	11.9	23.7
10110	E	7.9			4.2	3.5		15.6
10111	E	4			7.9	3.7		15.6
10112	E	3.4			12.4	3.3		19.1
10161	C	4.1			6.1		6	16.2
10162	B	4.1			10			14.1
10163	E	4.3			6.1	4	6	20.4
40113	A	4.9		7.5				12.4
40114	A	7.3		12				19.3
40115	B	6.6			8.5			15.1
40116	B	4.5			12.1			16.6
40117	C	7.4			4		4.2	15.6
40118	C	4.4			7.7		4.1	16.2
40119	D	6.3				4.5	4.2	15
40120	D	4.5				4.3	7.6	16.4
40121	D	4.6				4.2	11.8	20.6
40122	E	4.7			4	4.6		13.3
40123	E	6.8			7.9	3.8		18.5
40124	E	6.7			11.7	4.1		22.5
40160	F	0	11.2	4				15.2
40161	A	6.2		3.8				10
40162	A	9						9
40163	F	1	15					16
50113	A	4		8.2				12.2
50114	A	7		11.3				18.3
50115	B	6.9			7.4			14.3
50116	B	4.1			12			16.1
50117	C	7			4		4.1	15.1
50118	C	4.1			7.9		3.5	15.5
50119	D	7				3.2	4.2	14.4
50120	D	4.5				3.1	8.1	15.7
50121	D	4.5				2.9	12.3	19.7
50122	E	4.4			4.2	3.3		11.9
50123	E	7.2			8.3	3.5		19
50124	E	6.9			11.1	3.7		21.7
100101	A	8.1		8.1				16.2
100102	A	5.1		11.8				16.9
100103	B	5.8			8			13.8
100104	B	7.7			12			19.7
100105	C	5.4			4.4		3.4	13.2
100106	C	7.7			8.5		3.9	20.1
100107	D	5.8				3.8	3.9	13.5
100108	D	8				3.7	7.3	19
100109	D	8.3				4.2	12.1	24.6
100110	E	8.2			4.1	3.6		15.9
100111	E	4.7			8.7	3.9		17.3
100112	E	5.5			12.3	3.4		21.2
100159	C	6.7			6.6		7.6	20.9
100160	C	8.2			5.6		5.6	19.4
120101	A	6.8		8.1				14.9
120102	A	3.8		12.1				15.9
120103	B	4.1			8			12.1
120104	B	6.8			12.1			18.9
120105	C	3.9			4		4	11.9
120106	C	7.1			8.4		4	19.5

		AC	PCC	AGG1	ATB	PATB	AGG2	total
120107	D	3.8				4.1	4.1	12
120108	D	6.4				4	7.9	18.3
120109	D	7.3				4.1	11.9	23.3
120110	E	7.3			4.1	4.1		15.5
120111	E	3.9			8.2	4		16.1
120112	E	4			12.4	3.9		20.3
120161	A	4		10.2				14.2
190101	A	8		8				16
190102	A	5.1		12				17.1
190103	B	3.8			8.4			12.2
190104	B	7			12.4			19.4
190105	C	3.5			4.7		4	12.2
190106	C	6.8			9		4	19.8
190107	D	6.4				4.2	4	14.6
190108	D	5.9				4.6	8	18.5
190109	D	7.5				4.9	12	24.4
190110	E	7.9			3.2	4.4		15.5
190111	E	4.4			7.5	4.3		16.2
190112	E	4.6			12.5	4.1		21.2
190159	C	4			9		10	23
200101	A	7.6		8.5				16.1
200102	A	4		12.3				16.3
200103	B	3.6			7.7			11.3
200104	B	6.8			12.1			18.9
200105	C	3.9			3.8		4.1	11.8
200106	C	7.3			7.3		4	18.6
200107	D	4.1				4.1	3.7	11.9
200108	D	7.6				3.6	7.9	19.1
200109	D	7				3.6	11.9	22.5
200110	E	7			3.8	3.9		14.7
200111	E	4			8.5	3.6		16.1
200112	E	5			12	3.6		20.6
200159	A	10.8						10.8
200160	A	5.5		7				12.5
200161	A	5.5		11				16.5
200162	A	11.4						11.4
200163	C	1.5			2.5		8	12
200164	B	1.5			10.5			12
220113	A	4.9		8.1				13
220114	A	9.5		11.4				20.9
220115	B	7			9			16
220116	B	4.7			11.3			16
220117	C	7			3.9		5.3	16.2
220118	C	4.4			7		4.1	15.5
220119	D	7.1				3.7	4.4	15.2
220120	D	3.9				3.9	8.1	15.9
220121	D	4.3				3.9	13.2	21.4
220122	E	4.6			3.4	3.7		11.7
220123	E	6.8			7.3	4.2		18.3
220124	E	7.2			10.6	3.6		21.4
260113	A	4.4		8				12.4
260114	A	6.6		12				18.6
260115	B	5.9			9.6			15.5
260116	B	3.9			12			15.9
260117	C	6.4			5.2		4	15.6
260118	C	3.5			8.3		4	15.8
260119	D	6.5				4	4	14.5
260120	D	3.6				4	8	15.6
260121	D	3.9				4	12	19.9
260122	E	3.7			4.3	4		12
260123	E	6.2			8	4		18.2
260124	E	6.3			12.2	4		22.5
260159		5.9				4	4	13.9

		AC	PCC	AGG1	ATB	PATB	AGG2	total
300113	A	5						5
300114	A	7.2						7.2
300115	B	7.5			9.1			16.6
300116	B	4.7			12.6			17.3
300117	C	7.2			4.6		4.7	16.5
300118	C	4.6			8.5		4.2	17.3
300119	D	7.6				4.7	4.3	16.6
300120	D	4.2				4.6	8.1	16.9
300121	D	4.4				4.3	12.5	21.2
300122	E	4.6			4.1	4.3		13
300123	E	7.5			8.4	4.5		20.4
300124	E	7.1			13.7	4.2		25
310113	A	4.4		8				12.4
310114	A	6.7		12				18.7
310115	B	6.5			8.6			15.1
310116	B	4.1			12.2			16.3
310117	C	6.9			3.9		4	14.8
310118	C	3.9			8.1		4	16
310119	D	7.2				4	4	15.2
310120	D	4.2				4	8	16.2
310121	D	4.3				4	12	20.3
310122		3.8			4.2	4		12
310123	E	7			8	4		19
310124	E	7.4			10.5	3.4		21.3
320101	A	7.2		8.5				15.7
320102	A	4.3		11.7				16
320103	B	4.1			8.8			12.9
320104	B	7.3			12.4			19.7
320105	C	4.2			4.8		3.6	12.6
320106	C	7.2			8.8		3.7	19.7
320107	D	4.4				4.1	3.8	12.3
320108	D	7				4.5	7.7	19.2
320109	D	7				4	12.1	23.1
320110	E	6.6			4.2	4.4		15.2
320111	E	4.1			8.4	4.4		16.9
320112	E	4.5			12.4	4.2		21.1
350101	A	7.2		7.9				15.1
350102	A	4.8		12.2				17
350103	B	5.3			7.2			12.5
350104	B	8.1			11.1			19.2
350105	C	5.9			4		3.7	13.6
350106	C	7.6			8		2.9	18.5
350107	D	5.9				3.7	4	13.6
350108	D	7.8				4.2	8	20
350109	D	8				4.5	11.9	24.4
350110	E	7.9			4.6	3.7		16.2
350111	E	4.9			7.6	3.7		16.2
350112	E	5			11.7	3.1		19.8
390101	A	6.9		8				14.9
390102	A	3.9		11.8				15.7
390103	B	4.1			8			12.1
390104	B	7.2			11.8			19
390105	C	3.7			3.7		4	11.4
390106	C	6.8			7.9		3.9	18.6
390107	D	3.8				3.9	4.1	11.8
390108	D	6.6				4	8	18.6
390109	D	7				3.9	12	22.9
390110	E	7.3			3.7	3.9		14.9
390111	E	4			7.8	4.3		16.1
390112	E	4			11.8	4		19.8
390159	A	4.1		4				8.1
390160	C	4.1			10.9		4	19
400113	A	4.5		7.9				12.4
400114	A	8.1		11.3				19.4

		AC	PCC	AGG1	ATB	PATB	AGG2	total
400115	B	7.5			9			16.5
400116	B	4.2			11.7			15.9
400117	C	7.8			4		4	15.8
400118	C	4.6			8.3		3.6	16.5
400119	D	7.5				4	4.3	15.8
400120	D	4.8				5	7.7	17.5
400121	D	4.2				4.9	11.1	20.2
400122	E	4.3			3.9	4.8		13
400123	E	7.3			8.7	4.4		20.4
400124	E	7.4			10.9	4.3		22.6
400160		0						0
400160		0						0
480113	A	5.2		7.8				13
480114	A	6.9		12.2				19.1
480115	B	7.4			7.6			15
480116	B	5.8			10.9			16.7
480117	C	7.4			4		3.3	14.7
480118	C	4.8			8.6		1.7	15.1
480119	D	7.4				3.5	4	14.9
480120	D	4.7				4	7.4	16.1
480121	D	4.5				3.7	11.8	20
480122	E	4.6			4	4.8		13.4
480123	E	5.3			7.8	4.4		17.5
480124	E	6.4			10.8	4.2		21.4
480160	A	5.5		10.6				16.1
480161		4.8		8.3				13.1
480162	A	5		8				13
480163	A	4.8		10.2				15
480164	A	4.3		9.4				13.7
480165	A	4.6		7.3				11.9
480166	A	5.3		13.5				18.8
480167	A	4.9		13				17.9
510113	A	4		7.9				11.9
510114	A	7.2		11.9				19.1
510115	B	6.4			8.6			15
510116	B	4.5			12.4			16.9
510117	C	6.6			4		3.9	14.5
510118	C	4.1			8		3.4	15.5
510119	D	6.4				4.4	3.9	14.7
510120	D	4.1				4.3	7.8	16.2
510121	D	3.7				4.3	12.5	20.5
510122	E	3.9			3.9	3.9		11.7
510123	E	6.5			8.1	4.1		18.7
510124	E	6.3			12.5	3.4		22.2
510159	E	3.4			5.5	4	7.4	20.3
550113	A	5.5		8				13.5
550114	A	8.1		11				19.1
550115	B	7.3			7.5			14.8
550116	B	4.1			12			16.1
550117	C	6.4			4.6		3.2	14.2
550118	C	4			8.9		4.4	17.3
550119	D	6.6				3.4	4	14
550120	D	3.9				4.8	8	16.7
550121	D	4.2				4.2	13.3	21.7
550122	E	4.5			4.8	4.9		14.2
550123	E	6.8			8.1	4.3		19.2
550124	E	7.1			11.7	3.3		22.1

SPS-2 Layout Diagrams and Locations of Inspected Outlets

The following codes are used in the LTPP database for pavement materials and soils in SPS-1 and SPS-2 test sections:

1	hot-mixed, hot-laid, dense-graded AC	209	well-graded sand with gravel
2	hot-mixed, hot-laid open-graded AC	210	well-graded sand with silt
4	portland cement concrete (JPCP)	211	well graded sand with silt and gravel
20	other	213	well graded sand with clay and gravel
74	woven geotextile	214	silty sand
75	nonwoven geotextile	215	silty sand with gravel
78	dense-graded asphalt concrete interlayer	216	clayey sand
101	clay	217	clayey sand with gravel
102	lean inorganic clay	251	gravel
103	fat inorganic clay	252	poorly graded gravel
104	clay with gravel	253	poorly graded gravel with sand
106	fat clay with gravel	255	poorly graded gravel with silt
107	clay with sand	261	well-graded gravel with silt and sand
108	lean clay with sand	267	clayey gravel with sand
109	fat clay with sand	282	rock
113	sandy clay	303	crushed stone
114	sandy lean clay	304	crushed gravel
115	sandy fat clay	306	sand
131	silty clay	307	soil-aggregate mixture, predominantly fine-grained
133	silty clay with sand	308	soil-aggregate mixture, predominantly coarse-grained
134	gravelly silty clay	309	fine-grained soils
135	sandy silty clay	319	HMAC
137	sandy silty clay with gravel	321	asphalt-treated mixture
141	silt	325	open-graded, hot-laid central plant mix
143	silt with sand	331	cement-aggregate mixture
145	sandy silt	333	cement-treated soil
147	sandy silt with gravel	334	lean concrete
148	clayey silt	337	limerock, caliche
201	sand	338	lime-treated soil
202	poorly graded sand	340	pozzolan-aggregate mixture
204	poorly graded sand with silt	350	other
205	poorly graded sand with silt and gravel		

ARIZONA - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers		Layer Thicknesses (inches)	
0	0	040261 Sup					AC	AGG1	8.9	4.0
500	152									
705	215	040214	N		12	900	PCC	AGG1	8.3	6.1
1,205	367									
1,410	430	040222	Y		12	900	PCC	PATB	8.6	3.9
1,910	582									
2,160	658	040218	N		12	900	PCC	LCB	8.3	6.2
2,660	811									
3,210	978	040220	N		14	900	PCC	LCB	11.2	6.2
3,710	1,131									
3,930	1,198	040224	Y		14	900	PCC	PATB	10.6	4.4
4,430	1,350									
4,650	1,417	040216	N		14	900	PCC	AGG1	11.2	6.3
5,150	1,570									
5,625	1,715	040215	N		12	550	PCC	AGG1	11.0	6.3
6,125	1,867									
6,330	1,929	040223	Y		12	550	PCC	PATB	11.1	4.1
6,830	2,082									
7,095	2,163	040219	N		12	550	PCC	LCB	10.8	6.2
7,595	2,315									
7,890	2,405	040217	N		14	550	PCC	LCB	8.1	6.1
8,390	2,557									
8,640	2,634	040221	Y		14	550	PCC	PATB	8.1	4.2
9,140	2,786									
9,375	2,858	040213	N		14	550	PCC	AGG1	7.9	5.8
9,875	3,010									
10,080	3,072	040262 Sup					PCC	AGG1	8.1	6.1
10,580	3,225									
11,080	3,377	040263 Sup					PCC	PATB	8.2	4.4
11,580	3,530									
11,829	3,606	040264 Sup					PCC	PATB	11.5	3.8
12,329	3,758									
12,480	3,804	040265 Sup					PCC	AGG1	10.8	6.8
12,980	3,956									
13,180	4,017	040266 Sup					PCC	HMAC	12.3	3.9
13,680	4,170									
13,880	4,231	040267 Sup					PCC	HMAC	11.3	3.9
14,380	4,383									
14,580	4,444	040268 Sup					PCC	HMAC	8.5	3.8
15,080	4,596									
15,316	4,668	040260 Sup					AC	AGG1	9.4	4.0
15,780	4,821									

ARKANSAS - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 500	0 152	050215	N		12	550	PCC	AGG1		11.5	10.1
800 1,300	244 396	050223	Y		12	550	PCC	PATB		10.9	3.9
2,550 3,050	777 930	050214	N		12	900	PCC	AGG1		8.4	10.1
3,550 4,050	1,082 1,234	050222	N		12	900	PCC	PATB		8.3	2.4
4,900 5,400	1,494 1,646	050219	N		12	550	PCC	LCB		11.1	6.1
5,800 6,300	1,768 1,920	050218	N		12	900	PCC	LCB		8.2	6.4
7,300 7,800	2,225 2,377	050217	N		14	550	PCC	LCB		8.3	6.3
8,100 8,600	2,469 2,621	050220	N		14	900	PCC	LCB		10.7	7.0
8,900 9,400	2,713 2,865	050224	Y		14	900	PCC	PATB		10.9	3.2
9,700 10,200	2,957 3,109	050216	N		14	900	PCC	AGG1		11.0	10.1
10,700 11,200	3,261 3,414	050213	N		14	550	PCC	AGG1		7.4	10.1
12,850 13,350	3,917 4,069	050221	Y		14	550	PCC	PATB		8.3	4.3

CALIFORNIA - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
	0 152	060203	N		14	550	PCC	AGG1		11.4	5.8
	181 334	060211	Y		14	550	PCC	PATB		12.1	3.4
	370 522	060207	N		14	550	PCC	LCB		11.0	6.2
	558 711	060206	N		14	900	PCC	LCB		8.0	5.9
	747 899	060210	Y		14	900	PCC	PATB		8.6	3.8
	936 1,088	060202	N		14	900	PCC	AGG1		8.0	6.0
	1,150 1,303	060204	N		12	900	PCC	AGG1		11.1	6.3
	1,339 1,491	060212	Y		12	900	PCC	PATB		11.1	3.7
	1,528 1,680	060208	N		12	900	PCC	LCB		10.7	6.6
	1,711 1,863	060205	N		12	550	PCC	LCB		8.2	6.0
	1,899 2,052	060209	Y		12	550	PCC	PATB		8.4	3.6
	2,088 2,240	060201	N		12	550	PCC	AGG1		8.3	6.0

COLORADO - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Video Inspection	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 – 500	0 – 152	080216	N		14	900	PCC	AGG1		11.9	5.9
675 – 1,175	206 – 358	080213	N		14	550	PCC	AGG1		8.6	5.9
1,330 – 1,830	405 – 558	080214	N		12	900	PCC	AGG1		8.4	5.9
2,075 – 2,575	633 – 785	080215	N		12	550	PCC	AGG1		11.4	6.0
3,950 – 4,450	1,204 – 1,356	080218	N		12	900	PCC	LCB		8.6	6.7
4,805 – 5,305	1,465 – 1,617	080219	N		12	550	PCC	LCB		9.9	6.1
5,465 – 5,965	1,666 – 1,818	080217	N		14	550	PCC	LCB		8.6	6.7
6,140 – 6,640	1,872 – 2,024	080220	N		14	900	PCC	LCB		11.2	6.2
6,800 – 7,300	2,073 – 2,225	080224	Y		14	900	PCC	PATB		11.6	4.6
8,405 – 8,905	2,562 – 2,714	080221	Y		14	550	PCC	PATB		8.3	3.8
9,095 – 9,595	2,772 – 2,925	080222	Y		12	900	PCC	PATB		8.5	4.5
9,800 – 10,300	2,987 – 3,139	080223	Y		12	550	PCC	PATB		11.7	4.2
12,010 – 12,510	3,661 – 3,813	080259 Sup					PCC			11.9	

DELAWARE - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0	0	100259 Sup					PCC	AGG1		10.2	7.9
500	152										
700	213	100204	Y		12	900	PCC	AGG1		11.0	6.3
1,200	366										
1,350	412	100208	N		12	900	PCC	LCB		12.1	6.0
1,850	564										
2,050	625	100212	Y		12	900	PCC	PATB		12.4	3.7
2,550	777										
3,400	1,036	100210	Y		14	900	PCC	PATB		8.3	3.8
3,900	1,189										
4,250	1,295	100202	N		14	900	PCC	AGG1		8.8	6.2
4,750	1,448										
4,975	1,516	100206	N		14	900	PCC	LCB		8.9	6.1
5,475	1,669										
5,650	1,722	100207	N		14	550	PCC	LCB		11.3	6.9
6,150	1,875										
6,350	1,936	100203	N		14	550	PCC	AGG1		11.7	6.1
6,850	2,088										
7,150	2,179	100211	Y		14	550	PCC	PATB		11.8	3.7
7,650	2,332										
7,850	2,393	100209	Y		12	550	PCC	PATB		8.2	4.7
8,350	2,545										
8,550	2,606	100201	N		12	550	PCC	AGG1		8.3	6.2
9,050	2,758										
9,550	2,911	100205	N		12	550	PCC	LCB		9.2	5.5
10,050	3,063										
10,130	3,088	100260 Sup					PCC	AGG1		10.2	7.8
10,630	3,240										

IOWA - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 – 500	0 – 152	190217	N		14	550	PCC	LCB		8.1	6.5
800 – 1,300	244 – 396	190218	N		12	900	PCC	LCB		8.2	6.4
1,400 – 1,900	427 – 579	190219	N		12	550	PCC	LCB		11.2	6.8
2,400 – 2,900	732 – 884	190220	N		14	900	PCC	LCB		11.4	6.9
3,895 – 4,395	1,187 – 1,340	190215	N		12	550	PCC	AGG1		11.8	5.8
4,705 – 5,205	1,434 – 1,587	190216	N		14	900	PCC	AGG1		11.6	5.9
5,997 – 6,497	1,828 – 1,980	190213	N		14	550	PCC	AGG1		8.5	6.1
7,030 – 7,530	2,143 – 2,295	190214	N		12	900	PCC	AGG1		8.4	6.3
8,094 – 8,594	2,467 – 2,620	190259					PCC	AGG1		8.4	6.3
8,898 – 9,398	2,712 – 2,865	190221	Y		14	550	PCC	PATB		9.4	3.9
9,691 – 10,191	2,954 – 3,106	190222	Y		12	900	PCC	PATB		8.3	3.4
10,691 – 11,191	3,259 – 3,411	190223	Y		12	550	PCC	PATB		11.7	3.5
11,496 – 11,996	3,504 – 3,656	190224	Y		14	900	PCC	PATB		11.6	4.9

KANSAS - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0	0	200203	N		14	550	PCC	AGG1		11.1	5.7
500	152										
645	197	200204	N		12	900	PCC	AGG1		11.3	5.5
1,145	349										
3,165	965	200201	N		12	550	PCC	AGG1		7.7	6.1
3,665	1,117										
3,810	1,161	200202	N		14	900	PCC	AGG1		7.4	5.9
4,310	1,314										
4,455	1,358	200206	N		14	900	PCC	LCB		7.9	6.0
4,955	1,510										
5,100	1,555	200205	N		12	550	PCC	LCB		7.8	6.0
5,600	1,707										
5,745	1,751	200207	N		14	550	PCC	LCB		11.3	5.9
6,245	1,904										
6,390	1,948	200208	N		12	900	PCC	LCB		11.0	6.0
6,890	2,100										
7,020	2,140	200212	Y		12	900	PCC	PATB		10.9	4.4
7,520	2,292										
9,705	2,958	200211	Y		14	550	PCC	PATB		11.1	4.2
10,205	3,111										
12,240	3,731	200210	Y		14	900	PCC	PATB		8.3	3.7
12,740	3,883										
12,885	3,927	200209	Y		12	550	PCC	PATB		8.5	3.9
13,385	4,080										
13,535	4,126	200259 Sup					PCC	CAM		12.2	6.0
14,035	4,278										

MICHIGAN - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 500	0 152	260219	N		12	550	PCC	LCB		10.9	6.3
675 1,175	206 358	260218	N		12	900	PCC	LCB		7.1	6.9
1,275 1,775	389 541	260214	N		12	900	PCC	AGG1		8.9	5.8
2,112 2,612	644 796	260259					PCC	PATB		11.2	4.0
2,975 3,475	907 1,059	260222	Y		12	900	PCC	PATB		8.4	4.2
3,645 4,145	1,111 1,263	260223	Y		12	550	PCC	PATB		11.0	4.1
4,515 5,015	1,376 1,529	260215	N		12	550	PCC	AGG1		11.2	6.2
9,050 9,550	2,758 2,911	260220	N		14	900	PCC	LCB		11.1	5.8
9,680 10,180	2,951 3,103	260216	N		14	900	PCC	AGG1		11.4	5.9
10,310 10,810	3,143 3,295	260224	Y		14	900	PCC	PATB		11.2	4.3
10,985 11,485	3,348 3,501	260221	Y		14	550	PCC	PATB		8.2	4.2
11,600 12,100	3,536 3,688	260213	N		14	550	PCC	AGG1		8.6	6.1
12,375 12,875	3,772 3,924	260217	N		14	550	PCC	LCB		8.5	6.2

NEVADA - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 – 500	0 – 152	320259					PCC	HMAC		10.8	9.5
2,337 – 2,837	712 – 865	320205	N		12	550	PCC	LCB		8.5	6.8
3,058 – 3,558	932 – 1,085	320201	N		12	550	PCC	AGG1		9.2	5.9
3,703 – 4,203	1,129 – 1,281	320209	Y		12	550	PCC	PATB		8.9	4.0
4,409 – 4,909	1,344 – 1,496	320211	Y		14	550	PCC	PATB		11.3	4.1
5,196 – 5,696	1,584 – 1,736	320203	N		14	550	PCC	AGG1		11.9	5.7
6,163 – 6,663	1,879 – 2,031	320207	N		14	550	PCC	LCB		10.9	6.8
7,065 – 7,565	2,153 – 2,306	320208	N		12	900	PCC	LCB		11.0	7.5
8,086 – 8,586	2,465 – 2,617	320204	N		12	900	PCC	AGG1		11.8	6.2
8,777 – 9,277		320212	Y		12	900	PCC	PATB			
10,134 – 10,634	3,089 – 3,241	320210	Y		14	900	PCC	PATB		10.1	3.7
10,840 – 11,340	3,304 – 3,456	320202	N		14	900	PCC	AGG1		8.2	5.8
13,649 – 14,149	4,160 – 4,313	320206	N		14	900	PCC	LCB		7.8	6.6

NORTH CAROLINA - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0–500	0–152	370259					PCC	HMAC		10.2	5.6
2,200–2,700	671–823	370205	N		12	550	PCC	LCB		8.0	6.5
2,900–3,400	884–1,036	370201	N		12	550	PCC	AGG1		9.0	9.3
3,600–4,100	1,097–1,250	370209	Y		12	550	PCC	PATB		8.6	5.6
4,300–4,800	1,311–1,463	370210	Y		14	900	PCC	PATB		9.1	5.3
5,000–5,500	1,524–1,676	370202	N		14	900	PCC	AGG1		8.9	9.0
5,700–6,200	1,737–1,890	370206	N		14	900	PCC	LCB		8.4	6.7
7,200–7,700	2,195–2,347	370203	N		14	550	PCC	AGG1		11.2	5.6
7,900–8,400	2,408–2,560	370207	N		14	550	PCC	LCB		11.6	5.6
8,600–9,100	2,621–2,774	370260					PCC	HMAC		11.5	6.8
9,685–10,185	2,952–3,104	370211	Y		14	550	PCC	PATB		11.4	3.6
10,600–11,100	3,231–3,383	370212	Y		12	900	PCC	PATB		10.9	4.3
11,300–11,800	3,444–3,597	370208	N		12	900	PCC	LCB		11.2	5.9
19,100–19,600	5,822–5,974	370204	N		12	900	PCC	AGG1		11.2	5.4

NORTH DAKOTA - SPS-2

Station (feet)	Station (m)	Section with Drains	Design w/Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 – 500	0 – 152	380260 Sup					PCC	AGG1		11.0	5.8
798 – 1,298	243 – 396	380261 Sup					PCC	AGG1		11.0	6.1
1,689 – 2,189	515 – 667	380215	N		12	550	PCC	AGG1		11.0	6.4
2,536 – 3,036	773 – 925	380216	N		14	900	PCC	AGG1		11.2	6.1
3,538 – 4,038	1,078 – 1,231	380214	N		12	900	PCC	AGG1		7.9	6.2
4,168 – 4,668	1,270 – 1,423	380213	N		14	550	PCC	AGG1		8.2	5.7
4,784 – 5,284	1,458 – 1,611	380217	N		14	550	PCC	LCB		7.9	6.5
5,416 – 5,916	1,651 – 1,803	380218	N		12	900	PCC	LCB		7.9	6.6
6,354 – 6,854	1,937 – 2,089	380220	N		14	900	PCC	LCB		10.9	6.7
7,144 – 7,644	2,178 – 2,330	380262 Sup					PCC	LCB		11.1	6.6
7,890 – 8,390	2,405 – 2,557	380219	N		12	550	PCC	LCB		10.9	6.5
8,752 – 9,252	2,668 – 2,820	380223	Y		12	550	PCC	PATB		11.1	4.1
13,244 – 13,744	4,037 – 4,189	380263 Sup					PCC	PATB		10.8	3.8
14,124 – 14,624	4,305 – 4,457	380264 Sup					PCC	PATB		11.0	3.9
14,945 – 15,445	4,555 – 4,708	380224	Y		14	900	PCC	PATB		10.8	4.0
15,874 – 16,374	4,838 – 4,991	380221	Y		14	550	PCC	PATB		8.1	4.4
16,561 – 17,061	5,048 – 5,200	380222	Y		12	900	PCC	PATB		8.2	3.8
17,608 – 18,108	5,367 – 5,519	380259 Sup					PCC	PATB		9.5	3.9

OHIO - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0	0										
		390264					PCC	AGG1		11.6	4.0
500	152										
800	244										
		390263					PCC	AGG1		11.0	6.2
1,300	396										
1,725	526										
		390262					PCC	CAM		11.1	4.0
2,225	678										
2,475	754										
		390208	N		12	900	PCC	LCB		11.0	6.5
2,975	907										
3,125	953										
		390207	N		14	550	PCC	LCB		11.1	6.1
3,625	1,105										
3,850	1,174										
		390203	N		14	550	PCC	AGG1		10.9	6.2
4,350	1,326										
4,640	1,414										
		390265					PCC	PATB		11.3	3.8
5,140	1,567										
5,350	1,631										
		390211	Y		14	550	PCC	PATB		11.4	3.9
5,850	1,783										
6,475	1,974										
		390261					PCC	CAM		11.1	4.2
6,975	2,126										
7,225	2,202										
		390209	Y		12	550	PCC	PATB		8.1	4.0
7,725	2,355										
7,950	2,423										
		390201	N		12	550	PCC	AGG1		7.9	6.1
8,450	2,576										
8,675	2,644										
		390205	N		12	550	PCC	LCB		8.0	6.1
9,175	2,797										
9,500	2,896										
		390206	N		14	900	PCC	LCB		7.9	6.2
10,000	3,048										
10,350	3,155										
		390202	N		14	900	PCC	AGG1		8.3	5.8
10,850	3,307										
11,100	3,383										
		390260					PCC	PATB		11.4	3.9
11,600	3,536										
11,900	3,627										
		390210	Y		14	900	PCC	PATB		8.0	4.1
12,400	3,780										
12,850	3,917										
		390212	Y		12	900	PCC	PATB		10.6	4.4
13,350	4,069										
14,700	4,481										
		390204	N		12	900	PCC	AGG1		11.1	5.8
15,200	4,633										
15,700	4,785										
		390259					PCC	AGG1		11.0	6.3
16,200	4,938										

WASHINGTON - SPS-2

Station (feet)	Station (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
0 – 500	0 – 152	530259 Sup					PCC	HMAC		10.3	2.8
705 – 1,205	215 – 367	530203	N		14	550	PCC	AGG1		11.1	6.9
1,515 – 2,015	462 – 614	530202	N		14	900	PCC	AGG1		8.3	6.5
2,295 – 2,795	700 – 852	530210	Y		14	900	PCC	PATB		8.3	3.8
3,000 – 3,500	914 – 1,067	530211	Y		14	550	PCC	PATB		11.8	3.9
3,690 – 4,190	1,125 – 1,277	530209	Y		12	550	PCC	PATB		9.0	3.9
4,380 – 4,880	1,335 – 1,487	530212	Y		12	900	PCC	PATB		11.3	3.5
5,070 – 5,570	1,545 – 1,698	530204	N		12	900	PCC	AGG1		11.2	5.9
5,730 – 6,230	1,747 – 1,899	530201	N		12	550	PCC	AGG1		8.7	5.8
6,435 – 6,935	1,961 – 2,114	530205	N		12	550	PCC	LCB		8.5	6.1
7,410 – 7,910	2,259 – 2,411	530208	N		12	900	PCC	LCB		11.2	6.5
8,205 – 8,705	2,501 – 2,653	530206	N		14	900	PCC	LCB		8.6	6.2
8,985 – 9,485	2,739 – 2,891	530207	N		14	550	PCC	LCB		11.1	6.1

WISCONSIN - SPS-2

Station Start (feet)	Station Start (m)	Station End (feet)	Station End (m)	Section	Design with Drains	Drain Inspected	Lane Width (feet)	Strength (psi)	Layers			Layer Thicknesses (inches)	
	-1,765		-1,612	550266					PCC	AGG1		11.0	6.0
	-372		-220	550264					PCC	AGG1		11.0	4.9
	-152		0	550265					PCC	AGG1		11.3	6.0
0	0	500	152	550260					PCC	AGG1		11.4	6.0
720	220	1,220	372	550259					PCC	AGG1		11.3	6.0
1,410	430	1,910	582	550263					PCC	AGG1		10.1	6.0
2,790	850	3,290	1,003	550221	Y		14	550	PCC	PATB		8.3	3.7
3,540	1,079	4,040	1,231	550224	Y		14	900	PCC	PATB		11.4	3.1
4,260	1,298	4,760	1,451	550216	N		14	900	PCC	AGG1		11.1	7.0
4,980	1,518	5,480	1,670	550220	N		14	900	PCC	LCB		11.2	6.2
5,700	1,737	6,200	1,890	550217	N		14	550	PCC	LCB		8.2	6.0
7,920	2,414	8,420	2,566	550213	N		14	550	PCC	AGG1		8.5	8.1
9,000	2,743	9,500	2,896	550261					PCC	CAM		8.9	7.0
9,690	2,954	10,190	3,106	550223	Y		12	550	PCC	PATB		11.3	4.2
10,380	3,164	10,880	3,316	550222	Y		12	900	PCC	PATB		8.5	3.9
11,070	3,374	11,570	3,527	550214	N		12	900	PCC	AGG1		8.4	6.0
12,150	3,703	12,650	3,856	550262					PCC	AGG1		8.4	6.0
13,050	3,978	13,550	4,130	550218	N		12	900	PCC	LCB		8.4	5.9
13,770	4,197	14,270	4,350	550219	N		12	550	PCC	LCB		11.3	5.9
14,680	4,475	15,180	4,627	550215	N		12	550	PCC	AGG1		11.3	6.0

APPENDIX B

Permeability Calculations from Field Measurements

Table B.1. Permeability Calculations, Alabama SPS-1.

Date:	**08/18/03**	**08/18/03**	**08/18/03**	**08/18/03**	**08/18/03**	**08/18/03**	**08/18/03**
SHRP Site ID:	**010107**	**010108**	**010109**	**10163**	**010110**	**010111**	**010112**
Core Hole Test Station	**0 - 68**	**0 - 102**	**5 + 23**	**5 + 63**	**0 - 38**	**0 - 163**	**5 + 06**
GPS Coordinates:	**N 32o 36.344'**	**N 32o 36.425'**	**N 32o 36.556'**	**N 32o 36.634'**	**N 32o 36.687'**	**N 32o 36.776'**	**N 32o 36.924'**
	W 85o 15.027'	**W 85o 15.136'**	**W 85o 15.325'**	**W 85o 15.439'**	**W 85o 15.522'**	**W 85o 15.627'**	**W 85o 15.861'**
Cross Slope, %:	**1.2**	**1.6**	**2.3**	**1.6**	**1.8**	**2.9**	**2.7**
Long. Grade, %:	**0.8**	**1.1**	**1.0**	**1.3**	**1.1**	**1.0**	**1.2**
Distance Measures, ft							
Core to Edge:	**5.7**	**5.7**	**6.0**	**6.0**	**7.0**	**5.8**	**6.0**
Core to Outlet:	**80.0**	**20.0**	**25.0**	**16.0**	**15.0**	**17.0**	**204.0**
Edge to Outlet:	**21.0**	**27.0**	**21.0**	**29.0**	**28.0**	**29.0**	**31.0**
Elevation Readings, ft							
Top of Pavt at Core:	**1.58**	**1.79**	**2.75**	**2.71**	**1.88**	**1.79**	**1.98**
Top of PATB after Coring:	**1.96**	**2.42**	**3.10**	**3.65**	**2.81**	**2.67**	**3.42**
Edge of Pavt:	**1.67**	**1.88**	**2.90**	**2.81**	**1.96**	**1.88**	**2.04**
Edge at Outlet:	**2.50**	**2.10**	**3.13**	**3.00**	**2.15**	**2.04**	**4.56**
Outlet:	**5.92**	**5.81**	**7.02**	**7.44**	**5.42**	**5.77**	**9.46**
Infiltration Measures							
Steady State Infiltration Rate (gal/min	**6**	**8**	**8**	**8**	**8**	**8**	**8**
Time to First Outflow (min:sec)	**13:58**	**8:25**	**8:12**	**8:51**	**5:46**	**6:39**	**13:52**
Cumulative. Inflow to Tracer Input (gal)	**15 @ 2:33**	**20 @ 2:13**	**15 @ 1:48**	**20 @ 2:17**	**20 @ 2:18**	**20 @ 2:10**	**25 @ 2:55**
Time to Tracer Outflow (min:sec)	**13:58**	**8:25**	**8:12**	**8:51**	**7:00**	**6:39**	**13:52**
Maximum Inflow Rate (gal/min)	**6**	**12.3**	**9.1**	**11.8**	**12**	**13.5**	**11**
Water Inflow Stopped:	**Stop @ 83 gal**	**Stop @ 72 gal**	**Stop @ 68 gal**	**Stop @ 75 gal**	**Stop @ 60 gal**	**Stop @ 60 gal**	**Stop @ 121**
Cross Slope, % (elevation measures)	1.5%	1.5%	2.4%	1.7%	1.2%	1.4%	1.0%
Long. Grade, % (elevation measures)	1.0%	1.1%	0.9%	1.2%	1.3%	1.0%	1.2%
Thickness of pavement above PATB (elevation measures) ft	0.38	0.63	0.35	0.94	0.94	0.88	1.44
Thickness of pavement above PATB (elevation measures) in	4.5	7.5	4.3	11.3	11.3	10.5	17.3
Thickness of pavement above PATB (LTPP database) ft	0.38	0.61	0.63	0.87	1.01	0.99	1.32
Thickness of pavement above PATB (LTPP database) in	**4.6**	**7.3**	**7.6**	**10.4**	**12.1**	**11.9**	**15.8**
Thickness of PATB (LTPP database) ft	0.30	0.35	0.35	0.33	0.29	0.31	0.28
Thickness of PATB (LTPP database) in	**3.6**	**4.2**	**4.2**	**4.0**	**3.5**	**3.7**	**3.3**
Hpavt, ft	0.38	0.63	0.35	0.94	0.94	0.88	1.44
Hpatb, ft	0.30	0.35	0.35	0.33	0.29	0.31	0.28
Q, ft^3/day	1,154	2,366	1,750	2,270	2,308	2,597	2,116
dh, ft	0.76	1.06	0.85	1.38	1.31	1.27	1.78
L, ft	5.7	5.7	6.0	6.0	7.0	5.8	6.0
I, ft/ft	0.13	0.19	0.14	0.23	0.19	0.22	0.30
Assumed width of flow plume, ft	3	3	3	3	3	3	3
A, ft^2	0.9	1.05	1.05	1	0.875	0.925	0.825
k, fpd	**9,583**	**12,065**	**11,768**	**9,905**	**14,069**	**12,744**	**8,670**

Table B.2. Permeability Calculations, Arizona SPS-1.

Date:	04/16/03	04/16/03	04/16/03	04/16/03	04/16/03	04/16/03
SHRP Site ID:	040119	040120	040121	040122	040123	040124
Core Hole Test Station	5 + 05	- 0 + 09	- 0 + 06	5 + 29	5 + 38	- 0 + 05
GPS Coordinates:	N 35^o 24.721'	N 35^o 25.432'	N 35^o 25.273'	N 35^o 25.252'	N 35^o 24.540'	N 35^o 24.310'
	W 114o 16.202'	W 114o 16.719'	W 114o 16.603'	W 114o 16.579'	W 114o 16.065'	W 114o 15.906'
Cross Slope, %:	4.0	3.6	2.3	2.5	2.6	1.1
Long. Grade, %:	0.5	1.8	1.4	1.2	0.4	0.2
Distance Measures, ft						
Core to Edge:	7.0	7.0	6.3	6.3	5.6	6.8
Core to Outlet:	55.0	209.0	56.0	22.0	11.0	5.0
Edge to Outlet:	20.0	19.0	18.6	21.0	23.5	25.0
Elevation Readings, ft						
Top of Pavt at Core:	1.54	0.17	0.06	0.23	0.27	0.33
Top of PATB after Coring:	2.25	0.63	0.50	0.97	1.65	1.94
Edge of Pavt:	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Edge at Outlet:	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Outlet:	4.96	7.46	3.08	3.60	3.38	4.00
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	10	9.68	10	10	10	7
Time to First Outflow (min:sec)	n.a.	20:23	12:00	11:15	11:30	n.a.
Cumulative. Inflow to Tracer Input (gal)	n.a.	199	117	124	120	n.a.
Time to Tracer Outflow (min:sec)	7:23 @ 10 gal/min	n.a.	7:00	5:17	3:39 @ 7.68 gal/m	n.a.
Maximum Inflow Rate (gal/min)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Water Inflow Stopped:						
Cross Slope, % (elevation measures)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Long. Grade, % (elevation measures)	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Thickness of pavement above PATB (elevation measures) ft	0.71	0.46	0.44	0.74	1.38	1.61
Thickness of pavement above PATB (elevation measures) in	8.5	5.5	5.3	8.9	16.5	19.3
Thickness of pavement above PATB (LTPP database) ft	0.90	0.58	0.58	0.37	1.41	1.04
Thickness of pavement above PATB (LTPP database) in	**10.8**	**7.0**	**7.0**	**4.4**	**16.9**	**12.5**
Thickness of PATB (LTPP database) ft	0.37	0.33	0.38	0.34	0.35	0.37
Thickness of PATB (LTPP database) in	**4.4**	**4.0**	**4.5**	**4.1**	**4.2**	**4.4**
Hpavt, ft	0.71	0.46	0.44	0.74	1.38	1.61
Hpatb, ft	0.37	0.33	0.38	0.34	0.35	0.37
Q, ft^3/day	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
dh, ft	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
L, ft	7.0	7.0	6.3	6.3	5.6	6.8
I, ft/ft	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.1	1	1.125	1.025	1.05	1.1
k, fpd	**#VALUE!**	**#VALUE!**	**#VALUE!**	**#VALUE!**	**#VALUE!**	**#VALUE!**

Table B.3. Permeability Calculations, Arkansas SPS-1.
(Note: data are in different format because pilot testing was conducted at this site.).

Date:	12/17/02	12/17/02	12/17/02	12/17/02	12/17/02	12/17/02	12/17/02
SHRP Site ID:	050119	050120	050120	050121	050122	050123	050124
Core Hole Test Station	0 - 35.3	0 - 24.9	5 + 57	5 + 97	5 + 55	0 - 03	0 - 52.6
GPS Coordinates:	N 35o 42.999'	N 35o 43.151'	N 35o 43.251'	n.a.	n.a.	n.a.	n.a.
	W 90o 34.745'	W 90o 34.786'	W 90o 34.789'	0	0	0	0
Cross Slope, %:	6.9	7.2	3.0	2.9	3.3	2.9	2.4
Long. Grade, %:	0.2	0.1	0.0	0.2	0.0	0.0	0.3
Distance Measures, ft							
Core to Edge:	6.7	6.0	5.9	6.0	6.4	7.0	6.2
Core to Outlet:	11.7	11.5	10.8	9.3	0.0	6.0	5.7
Edge to Outlet:	32.5	30.9	31.6	34.0	31.2	31.0	31.0
Elevation Readings, ft							
Top of Pavt at Core:	2.92	2.58	3.32	2.27	2.98	2.65	2.27
Top of PATB after Coring:	2.72	3.18	3.76	2.66	3.81	3.98	3.79
Edge of Pavt:	2.80	3.00	3.44	2.41	3.13	2.82	2.41
Edge at Outlet:	2.80	3.01	3.44	2.40	3.13	2.82	2.42
Outlet:	8.26	7.78	8.79	7.67	7.71	7.74	7.82
Draindown Times, sec							
30 - 25 gal:	40.9	12.3	15.4	15.5	14.4	12.4	15
- 20 gal:	75.6	30	31.6	36	28.2	28.5	35.1
- 15 gal:	94.3	47.3	47.6	54.2	41.5	42.8	53
- 10 gal:	118.7	67.9	69.6	77.3	58.6	59.9	73.2
- 5 gal:	138.4	87.8	88.6	97.8	72.4	72.9	92.6
Outlet response Times, mm:ss							
Time to start outflow:	6:13	no flow	no flow	4:00 est	10:47	11:40	7:43

Table B.4. Permeability Calculations, Delaware SPS-1.

Date:	08/13/03	08/13/03	08/13/03	08/13/03	08/13/03	08/13/03
SHRP Site ID:	100107	100111	100112	100110	100108	100109
Core Hole Test Station	0 - 05	0 - 68	0 - 05	5 + 49	5 + 70	0 - 52
GPS Coordinates:	N 38° 50.744'	N 38° 46.729'	N 38° 46.602'	N 38° 46.396'	N 38° 46.277'	N 38° 46.265'
	W 75° 26.357'	W 75° 26.323'	W 75° 26.320'	W 75° 26.317'	W 75° 26.316'	W 75° 26.316'
Cross Slope, %:	2.1	1.8	2.1	2.3	1.7	2.2
Long. Grade, %:	0.3	0.1	0.1	0.2	0.1	0.0
Distance Measures, ft						
Core to Edge:	5.8	5.7	5.5	6.0	5.5	5.5
Core to Outlet:	115.0	8.0	352.0	96.0	10.0	7.5
Edge to Outlet:	18.0	25.0	27.0	26.0	25.0	27.0
Elevation Readings, ft						
Top of Pavt at Core:	1.92	1.79	1.96	1.81	1.79	1.79
Top of PATB after Coring:	2.50	3.04	3.44	2.88	2.46	2.54
Edge of Pavt:	2.06	1.92	2.10	1.94	1.92	1.92
Edge at Outlet:	2.17	1.94	2.25	2.23	1.92	1.92
Outlet:	4.58	5.17	5.50	4.60	5.25	5.58
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	11	11.4	11.6	11.6	10.8	11.6
Time to First Outflow (min:sec)	n.a.	6:00	1:00	23:07	6:14	6:15
Cumulative. Inflow to Tracer Input (gal)	20 @ 2:00	15 @ 1:20	20 @ 1:45	20 @ 1:42	15 @ 1:22	15 @ 1:20
Time to Tracer Outflow (min:sec)	n.a.	6:00	n.a.	25:00	7:01	7:45
Maximum Inflow Rate (gal/min)	16	12.5	12.6	12.5	12.7	12.7
Water Inflow Stopped:	Stop @ 124 gal	Stop @ 75 gal	Stop @ 152 gal	Stop @ 147 gal	Stop @ 81 gal	Stop @ 93 gal
Cross Slope, % (elevation measures)	2.5%	2.2%	2.7%	2.1%	2.3%2	2.3%
Long. Grade, % (elevation measures)	0.1%	0.3%	0.0%	0.3%	0.0%0	0.0%
Thickness of pavement above PATB (elevation measures) ft	0.58	1.25	1.48	1.06	0.67	0.75
Thickness of pavement above PATB (elevation measures) in	7.0	15.0	17.8	12.8	8.0	9.0
Thickness of pavement above PATB (LTPP database) ft	0.48	1.12	1.48	1.03	0.67	0.69
Thickness of pavement above PATB (LTPP database) in	**5.8**	**13.4**	**17.8**	**12.3**	**8.0**	**8.3**
Thickness of PATB (LTPP database) ft	0.32	0.33	0.33	0.30	0.31	0.35
Thickness of PATB (LTPP database) in	**3.8**	**3.9**	**3.9**	**3.6**	**3.7**	**4.2**
Hpavt, ft	0.58	1.25	1.48	1.06	0.67	0.75
Hpatb, ft	0.32	0.33	0.33	0.30	0.31	0.35
Q, ft^3/day	3,078	2,404	2,424	2,404	2,443	2,443
dh, ft	1.05	1.70	1.95	1.49	1.10	1.23
L, ft	5.8	5.7	5.5	6.0	5.5	5.5
I, ft/ft	0.18	0.30	0.35	0.25	0.20	0.22
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	0.95	0.975	0.975	0.9	0.925	1.05
k, fpd	**17,812**	**8,220**	**7,011**	**10,776**	**13,205**	**10,446**

Table B.5. Permeability Calculations, Florida SPS-1.

Date:	05/21/03	05/21/03	05/21/03	05/21/03	05/21/03	05/21/03
SHRP Site ID:	120107	120108	120109	120110	120111	120112
Core Hole Test Station	- 0 + 03.5	5 + 87 and (6 +	- 0 + 04	5 + 03	n.a.	- 0 + 04.4
GPS Coordinates:	N 26o 28' 44.4"	N 26o 28' 57.0"	N 26o 30' 10.0"	N 26o 29' 29.1"	n.a.	N 26o 29' 58.3"
	W 80o 38' 59.1"	W 80o 39' 08.4"	W 80o 40' 05.0"	W 80o 39' 32.1"	n.a.	W 80o 39' 56.1"
Cross Slope, %:	1.0	1.3	1.5	1.6	n.a.	1.7
Long. Grade, %:	0.0	0.1	0.0	0.0	n.a.	0.0
Distance Measures, ft						
Core to Edge:	3.5	4.5	5.0	4.0	n.a.	5.0
Core to Outlet:	154.0	14.0 and (18.0)	152.0	152.0	n.a.	203.0
Edge to Outlet:	22.0	32.0	27.5	33.0	n.a.	33.0
Elevation Readings, ft						
Top of Pavt at Core:	2.02	2.00	1.98	1.98	n.a.	1.96
Top of PATB after Coring:	2.42	2.67	2.65	3.00	n.a.	3.31
Edge of Pavt:	2.08	2.08	2.08	2.08	n.a.	2.06
Edge at Outlet:	2.13	2.08	2.08	2.08	n.a.	2.08
Outlet:	5.63	5.60	6.33	6.00	n.a.	6.54
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	8	8	8	n.a.	8
Time to First Outflow (min:sec)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Cumulative Inflow to Tracer Input (gal)	20	20	40	20	n.a.	20
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Maximum Inflow Rate (gal/min)	13.83	14.4	14.5	14.7	n.a.	13.83
Water Inflow Stopped:	150 gal@18:35	100 gal @ 12:00	200 gal	160 gal @ 19:30	no outlet found	209 gal
Cross Slope, % (elevation measures)	1.8%	1.9%	2.1%	2.6%	#VALUE!	2.1%
Long. Grade, % (elevation measures)	0.0%	#VALUE!	0.0%	0.0%	#VALUE!	0.0%
Thickness of pavement above PATB (elevation measures) ft	0.40	0.67	0.67	1.02	#VALUE!	1.35
Thickness of pavement above PATB (elevation measures) in	4.8	8.0	8.0	12.3	#VALUE!	16.2
Thickness of pavement above PATB (LTPP database) ft	0.32	0.53	0.61	0.95	1.01	1.37
Thickness of pavement above PATB (LTPP database) in	**3.8**	**6.4**	**7.3**	**11.4**	**12.1**	**16.4**
Thickness of PATB (LTPP database) ft	0.34	0.33	0.34	0.34	0.33	0.33
Thickness of PATB (LTPP database) in	**4.1**	**4.0**	**4.1**	**4.1**	**4.0**	**3.9**
Hpavt, ft	0.40	0.67	0.67	1.02	#VALUE!	1.35
Hpatb, ft	0.34	0.33	0.34	0.34	0.33	0.33
Q, ft^3/day	2,660	2,770	2,789	2,828	#VALUE!	2,660
dh, ft	0.80	1.08	1.11	1.47	#VALUE!	1.78
L, ft	3.5	4.5	5.0	4.0	n.a.	5.0
I, ft/ft	0.23	0.24	0.22	0.37	#VALUE!	0.36
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.025	1	1.025	1.025	1	0.975
k, fpd	**11,355**	**11,506**	**12,230**	**7,524**	**#VALUE!**	**7,668**

Table B.6. Permeability Calculations, Iowa SPS-1.

Date:	07/01/03	07/01/03	07/01/03	07/01/03	07/01/03	07/01/03
SHRP Site ID:	190108	190109	190110	190111	190112	190107
Core Hole Test Station	0 - 81	0 - 47	0 - 86	5 + 83	- 1 - 39	6 + 02
GPS Coordinates:	N 40.68600o	N 40.67942o	N 40.67763o	N 40.67451o	N 40.67284o	N 40.65919o
	W 91.25070o	W 91.25445o	W 91.25717o	W 91.26208o	W 91.26474o	W 91.27336o
Cross Slope, %:	2.4	1.3	0.9	2.4	1.5	2.3
Long. Grade, %:	0.4	0.2	0.2	0.1	1.0	0.8
Distance Measures, ft						
Core to Edge:	5.5	5.1	5.2	4.9	5.3	5.0
Core to Outlet:	15.8	51.2	1.0	10.7	7.4	6.0
Edge to Outlet:	37.0	36.3	34.5	32.5	39.5	35.0
Elevation Readings, ft						
Top of Pavt at Core:	1.85	1.83	1.90	1.83	1.79	1.79
Top of PATB after Coring:	2.33	2.50	2.85	2.85	3.19	2.35
Edge of Pavt:	1.98	1.96	2.00	1.92	1.96	1.88
Edge at Outlet:	2.10	2.17	2.02	1.96	1.96	1.94
Outlet:	7.31	6.48	5.88	5.27	6.46	5.52
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	8	8	8	8	8
Time to First Outflow (min:sec)	17:35	20:30	14:30	14:40	12:35	15:30
Cumulative Inflow to Tracer Input (gal)	15 @ 1:40	20 @ 1:58	15 @ 1:39	20 @ 1:55	20 @ 1:54	20 @ 2:06
Time to Tracer Outflow (min:sec)	17:35	n.a.	14:30	14:40	12:35	15:30
Maximum Inflow Rate (gal/min)	15	14	12	16	15	15
Water Inflow Stopped:	Stop @ 120 gal	Stop @ 120 gal	Stop @ 120 gal	Stop @ 120 gal	Stop @ 107 gal	Stop @ 125 gal
Cross Slope, % (elevation measures)	2.3%	2.5%	2.0%	1.7%	3.1%	1.7%
Long. Grade, % (elevation measures)	0.8%	0.4%	2.1%	0.4%	0.0%	1.0%
Thickness of pavement above PATB (elevation measures) ft	0.48	0.67	0.96	1.02	1.40	0.56
Thickness of pavement above PATB (elevation measures) in	5.8	8.0	11.5	12.3	16.8	6.8
Thickness of pavement above PATB (LTPP database) ft	0.49	0.63	0.93	0.99	1.41	0.53
Thickness of pavement above PATB (LTPP database) in	**5.9**	**7.5**	**11.1**	**11.9**	**16.9**	**6.4**
Thickness of PATB (LTPP database) ft	0.38	0.41	0.37	0.37	0.34	0.35
Thickness of PATB (LTPP database) in	**4.6**	**4.9**	**4.4**	**4.4**	**4.1**	**4.2**
Hpavt, ft	0.48	0.67	0.96	1.02	1.40	0.56
Hpatb, ft	0.38	0.41	0.37	0.37	0.34	0.35
Q, ft^3/day	2,885	2,616	2,212	3,039	2,885	2,808
dh, ft	0.99	1.20	1.43	1.47	1.90	1.00
L, ft	5.5	5.1	5.2	4.9	5.3	5.0
I, ft/ft	0.18	0.24	0.28	0.30	0.36	0.20
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.15	1.225	1.1	1.1	1.025	1.05
k, fpd	**13,974**	**9,046**	**7,270**	**9,236**	**7,884**	**13,429**

Table B.7. Permeability Calculations, Kansas SPS-1.

Date:	06/25/03	06/25/03	06/25/03	06/25/03	06/25/03	06/25/03
SHRP Site ID:	200108a	200108b	200109	200110	200112	200111
Core Hole Test Station	- 2 + 00	5 + 08	0 - 08	0 - 08	0 - 08	0 - 08
GPS Coordinates:	N 37.60619°	N 37.61223°	N 37.61227°	N 37.61241°	N 37.61256°	N 37.61274°
	W 99.14832°	W 99.14152°	W 99.14024°	W 99.13795°	W 99.13575°	W 99.13343°
Cross Slope, %:	2.1	1.8	1.6	1.8	2	1.9
Long. Grade, %:	1.2	0.8	0.2	0.1	0.3	0
Distance Measures, ft						
Core to Edge:	5.6	5.8	6.0	6.0	5.5	5.5
Core to Outlet:	24.8	307.0	306.0	307.0	307.0	257.0
Edge to Outlet:	19.7	20.0	27.5	30.0	31.5	30.0
Elevation Readings, ft						
Top of Pavt at Core:	1.67	1.90	2.00	2.00	1.98	2.00
Top of PATB after Coring:	2.38	2.63	2.75	3.06	3.42	3.02
Edge of Pavt:	1.77	2.00	2.10	2.10	2.08	2.08
Edge at Outlet:	2.04	5.17	2.58	2.58	2.33	2.13
Outlet:	4.83	7.60	6.58	6.92	6.75	5.92
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	1.8	3.9	8	8	8
Time to First Outflow (min:sec)	n.a.	n.a.	n.a.	n.a.	n.a.	23:23
Cumulative. Inflow to Tracer Input (gal)	15 @ 2:00	10 @ 7:30	10 @ 2:27	15 @ 1:55	20 @ 2:30	20 @ 2:31
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	n.a.	n.a.	1:10
Maximum Inflow Rate (gal/min)	8.8	1.8	3.9	8.3	8.2	8
Water Inflow Stopped:	Stop @ 125 gal	Stop @ 88 gal	Stop @ 52 gal	Stop @ 150 gal	Stop @ 126 gal	Stop @ 125 gal
Cross Slope, % (elevation measures)	1.9%	1.8%	1.7%	1.7%	1.9%	1.5%
Long. Grade, % (elevation measures)	1.1%	1.0%	0.2%	0.2%	0.1%	0.0%
Thickness of pavement above PATB (elevation measures) ft	0.71	0.73	0.75	1.06	1.44	1.02
Thickness of pavement above PATB (elevation measures) in	8.5	8.8	9.0	12.8	17.3	12.3
Thickness of pavement above PATB (LTPP database) ft	0.63	0.63	0.58	0.90	1.42	1.04
Thickness of pavement above PATB (LTPP database) in	**7.6**	**7.6**	**7.0**	**10.8**	**17.0**	**12.5**
Thickness of PATB (LTPP database) ft	0.30	0.30	0.30	0.33	0.30	0.30
Thickness of PATB (LTPP database) in	**3.6**	**3.6**	**3.6**	**3.9**	**3.6**	**3.6**
Hpavt, ft	0.71	0.73	0.75	1.06	1.44	1.02
Hpatb, ft	0.30	0.30	0.30	0.33	0.30	0.30
Q, ft^3/day	1,693	346	750	1,597	1,577	1,539
dh, ft	1.11	1.13	1.15	1.49	1.84	1.40
L, ft	5.6	5.8	6.0	6.0	5.5	5.5
I, ft/ft	0.20	0.19	0.19	0.25	0.33	0.26
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	0.9	0.9	0.9	0.975	0.9	0.9
k, fpd	**9,439**	**1,980**	**4,333**	**6,587**	**5,234**	**6,697**

Table B.8. Permeability Calculations, Louisiana SPS-1.

Date:	05/28/03	05/28/03	05/28/03	05/28/03	05/28/03	05/28/03
SHRP Site ID:	220119	220120	220121	220122	220123	220124
Core Hole Test Station	n.a.	5 + 44	- 0 + 33.5	n.a.	5 + 71	5 + 26
GPS Coordinates:	N 30o 20.346'	N 30o 20.548'	N 30o 20.613'	N 30o 20.779'	N 30o 21.001'	N 30o 21.230'
	W 93o 12.003'	W 93o 12.006'	W 93o 12.006'	W 93o 12.007'	W 93o 12.007'	W 93o 12.007'
Cross Slope, %:	n.a.	2.1	1.5	n.a.	1.7	1.7
Long. Grade, %:	n.a.	0.0	0.0	n.a.	0.0	0.2
Distance Measures, ft						
Core to Edge:	n.a.	6.0	5.7	n.a.	5.8	4.6
Core to Outlet:	n.a.	7.3	10.0	n.a.	3.0	6.7
Edge to Outlet:	n.a.	24.0	27.0	n.a.	20.5	22.5
Elevation Readings, ft						
Top of Pavt at Core:	n.a.	1.83	1.83	n.a.	1.85	1.88
Top of PATB after Coring:	n.a.	2.19	2.19	n.a.	3.17	3.36
Edge of Pavt:	n.a.	2.01	1.98	n.a.	2.02	1.98
Edge at Outlet:	n.a.	2.02	2.00	n.a.	2.02	1.98
Outlet:	n.a.	4.88	5.27	n.a.	4.54	4.52
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	n.a.	6.8	8	n.a.	8	8
Time to First Outflow (min:sec)	n.a.	12:14	18:00	n.a.	n.a.	10:45
Cumulative Inflow to Tracer Input (gal)	n.a.	15 @ 2:15	15 @ 1:45	n.a.	15 @ 1:45	15 @ 1:35
Time to Tracer Outflow (min:sec)	n.a.	12:46	No sign after	n.a.	n.a.	Pink trace @
Maximum Inflow Rate (gal/min)	n.a.	6.8	10.85	n.a.	8.44	12.18
Water Inflow Stopped:	n.a.	86.3 gal	150 gal@18:37	n.a.	n.a.	20 gal@2:10
Cross Slope, % (elevation measures)	#VALUE!	3.0%	2.6%	#VALUE!	2.9%	2.3%
Long. Grade, % (elevation measures)	#VALUE!	0.1%	0.2%	#VALUE!	0.0%	0.0%
Thickness of pavement above PATB (elevation measures) ft	#VALUE!	0.35	0.35	#VALUE!	1.31	1.48
Thickness of pavement above PATB (elevation measures) in	#VALUE!	4.3	4.3	#VALUE!	15.8	17.8
Thickness of pavement above PATB (LTPP database) ft	0.59	0.33	0.36	0.67	1.18	1.48
Thickness of pavement above PATB (LTPP database) in	**7.1**	**3.9**	**4.3**	**8.0**	**14.1**	**17.8**
Thickness of PATB (LTPP database) ft	0.31	0.33	0.33	0.31	0.35	0.30
Thickness of PATB (LTPP database) in	**3.7**	**3.9**	**3.9**	**3.7**	**4.2**	**3.6**
Hpavt, ft	#VALUE!	0.35	0.35	#VALUE!	1.31	1.48
Hpatb, ft	0.31	0.33	0.33	0.31	0.35	0.30
Q, ft^3/day	#VALUE!	1,308	2,087	#VALUE!	1,623	2,343
dh, ft	#VALUE!	0.86	0.83	#VALUE!	1.83	1.89
L, ft	n.a.	6.0	5.7	n.a.	5.8	4.6
I, ft/ft	#VALUE!	0.14	0.15	#VALUE!	0.31	0.41
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	0.925	0.975	0.975	0.925	1.05	0.9
k, fpd	**#VALUE!**	**9,401**	**14,712**	**#VALUE!**	**4,931**	**6,321**

Table B.9. Permeability Calculations, Michigan SPS-1.

Date:	10/22/03	10/22/03	10/22/03
SHRP Site ID:	260121	260123	260123
Core Hole Test Station	1 + 18	0 - 130	5 + 60
GPS Coordinates:	N 42° 59.538'	N 42° 58.817'	N 42° 58.686'
	W 84° 31.152'	W 84° 31.146'	W 84° 31.142'
Cross Slope, %:	2.8	1.3	2.2
Long. Grade, %:	0.3	0.9	0.4
Distance Measures, ft			
Core to Edge:	6.5	6.5	6.7
Core to Outlet:	16.0	26.0	25.0
Edge to Outlet:	29.0	29.0	30.0
Elevation Readings, ft			
Top of Pavt at Core:	1.94	1.83	2.00
Top of PATB after Coring:	2.38	2.46	2.85
Edge of Pavt:	2.04	1.92	2.08
Edge at Outlet:	2.10	2.17	2.21
Outlet:	6.92	6.69	6.42
Infiltration Measures			
Steady State Infiltration Rate (gal/min)	5.3	8	2
Time to First Outflow (min:sec)	24:30	19:30	n.a.
Cumulative. Inflow to Tracer Input (gal)	15 @ 3:05	20 @ 2:20	15 @ 4:40
Time to Tracer Outflow (min:sec)	30:00	n.a.	n.a.
Maximum Inflow Rate (gal/min)	5.3	12.4	3.1
Water Inflow Stopped:	Stop @ 93 gal	Stop @ 125 gal	Stop @ 50 gal
Cross Slope, % (elevation measures)	1.6%	1.3%	1.3%
Long. Grade, % (elevation measures)	0.4%	1.0%	0.5%
Thickness of pavement above PATB (elevation measures) ft	0.44	0.63	0.85
Thickness of pavement above PATB (elevation measures) in	5.3	7.5	10.3
Thickness of pavement above PATB (LTPP database) ft	0.33	1.18	1.18
Thickness of pavement above PATB (LTPP database) in	3.9	14.2	14.2
Thickness of PATB (LTPP database) ft	0.33	0.33	0.33
Thickness of PATB (LTPP database) in	4.0	4.0	4.0
Hpavt, ft	0.44	0.63	0.85
Hpatb, ft	0.33	0.33	0.33
Q, ft^3/day	1,019	2,385	596
dh, ft	0.88	1.04	1.27
L, ft	6.5	6.5	6.7
I, ft/ft	0.13	0.16	0.19
Assumed width of flow plume, ft	3	3	3
A, ft^2	1	1	1
k, fpd	7,573	14,884	3,128

Table B.10. Permeability Calculations, Montana SPS-1.

Date:	07/09/03	07/09/03	07/09/03	07/09/03	07/09/03	07/09/03
SHRP Site ID:	300124	300123	300119	300120	300122	300121
Core Hole Test Station	5 + 03	5 + 65	n.a.	0 - 70	0 - 97	5 + 42
GPS Coordinates:	N 47.40056°	N 47.40205°	n.a.	N 47.40370°	N 47.40514°	N 47.40788°
	W 111.54976°	W 111.54806°	n.a.	W 111.54602°	W 111.54426°	W 111.54086°
Cross Slope, %:	2.4	2.4	n.a.	2.8	3.1	3.5
Long. Grade, %:	0.1	0.0	n.a.	0.0	0.2	0.2
Distance Measures, ft						
Core to Edge:	7.0	6.5	n.a.	7.0	6.5	7.0
Core to Outlet:	15.0	0.0	n.a.	0.0	3.0	8.0
Edge to Outlet:	28.0	27.0	n.a.	26.0	26.0	27.0
Elevation Readings, ft						
Top of Pavt at Core:	1.88	1.92	n.a.	1.90	1.94	1.96
Top of PATB after Coring:	3.50	3.08	n.a.	2.33	2.38	2.21
Edge of Pavt:	2.02	2.04	n.a.	2.02	2.04	2.06
Edge at Outlet:	2.08	2.04	n.a.	2.02	2.04	2.08
Outlet:	6.06	6.02	n.a.	5.31	5.50	6.04
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	8	n.a.	8	8	8
Time to First Outflow (min:sec)	12:35	9:04	n.a.	23:00	15:30	n.a.
Cumulative. Inflow to Tracer Input (gal)	15 @ 1:31	24 @ 2:15	n.a.	15 @ 1:50	15 @ 1:50	15 @ 2:17
Time to Tracer Outflow (min:sec)	12:35	9:04	n.a.	n.a.	n.a.	n.a.
Maximum Inflow Rate (gal/min)	12.8	16.7	n.a.	9.5	11.7	6.5
Water Inflow Stopped:	Stop @ 106 gal	Stop @ 79 gal	n.a.	Stop @ 125 gal	Stop @ 132 gal	Stop @ 120 gal
Cross Slope, % (elevation measures)	2.1%	1.9%		1.8%	1.6%	1.5%
Long. Grade, % (elevation measures)	0.4%	#DIV/0!		#DIV/0!	0.0%	0.3%
Thickness of pavement above PATB (elevation measures) ft	1.63	1.17		0.44	0.44	0.25
Thickness of pavement above PATB (elevation measures) in	19.5	14.0		5.3	5.3	3.0
Thickness of pavement above PATB (LTPP database) ft	1.73	1.33		0.35	0.73	0.37
Thickness of pavement above PATB (LTPP database) in	**20.8**	**15.9**	**7.6**	**4.2**	**8.7**	**4.4**
Thickness of PATB (LTPP database) ft	0.35	0.38		0.38	0.36	0.36
Thickness of PATB (LTPP database) in	**4.2**	**4.5**	**4.7**	**4.6**	**4.3**	**4.3**
Hpavt, ft	1.63	1.17		0.44	0.44	0.25
Hpatb, ft	0.35	0.38		0.38	0.36	0.36
Q, ft^3/day	2,462	3,212		1,827	2,251	1,250
dh, ft	2.12	1.67		0.95	0.90	0.71
L, ft	7.0	6.5		7.0	6.5	7.0
I, ft/ft	0.30	0.26		0.14	0.14	0.10
Assumed width of flow plume, ft	3	3		3	3	3
A, ft^2	1.05	1.125		1.15	1.075	1.075
k, fpd	**7,740**	**11,136**		**11,760**	**15,120**	**11,427**

Table B.11. Permeability Calculations, Nevada SPS-1.

Date:	10/29/03	10/29/03	10/29/03	10/29/03	10/29/03	10/29/03
SHRP Site ID:	320110	320109	320108	320107	320112	320111
Core Hole Test Station	0 - 13	0 - 38	0 - 38	5 + 52	0 - 9	0 - 9
GPS Coordinates:	N 40° 41.244'	N 40° 41.144'	N 40° 41.061'	N 40° 40.910'	N 40° 40.891'	N 40° 40.786'
	W 116° 59.739'	W 116° 59.617'	W 116° 59.508'	W 116° 59.316'	W 116° 59.295'	W 116° 59.152'
Cross Slope, %:	1.2	1.4	1.3	1.8	2.1	1.8
Long. Grade, %:	0.1	0.1	0.1	0.6	0.1	0.3
Distance Measures, ft						
Core to Edge:	6.0	5.6	5.7	5.5	6.4	5.0
Core to Outlet:	88.0	8.0	6.0	17.0	65.0	19.0
Edge to Outlet:	22.0	22.0	22.0	31.0	32.0	36.0
Elevation Readings, ft						
Top of Pavt at Core:	2.00	2.00	2.00	1.96	1.96	1.98
Top of PATB after Coring:	2.88	2.60	2.58	2.38	2.71	2.73
Edge of Pavt:	2.08	2.08	2.08	2.06	2.08	2.06
Edge at Outlet:	2.17	2.08	2.08	2.13	2.13	1.10
Outlet:	4.67	4.00	4.00	5.50	5.54	6.04
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	6.8	8	4.8	1	8
Time to First Outflow (min:sec)	n.a.	n.a.	n.a.	n.a.	n.a.	22:20
Cumulative. Inflow to Tracer Input (gal)	15 @ 1:45	15 @ 2:15	15 @ 1:58	20 @ 4:20	7.7 @ 13:13	20 @ 2:30
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Maximum Inflow Rate (gal/min)	9.8	6.8	8	4.8	1	10
Water Inflow Stopped:	Stop @ 110 gal	Stop @ 100 gal	Stop @ 100 gal	Stop @ 100 gal	Stop @ 8 gal	Stop @ 125 gal
Cross Slope, % (elevation measures)	1.4%	1.5%	1.5%	1.9%	1.9%	1.7%
Long. Grade, % (elevation measures)	0.1%	0.0%	0.0%	0.4%	0.1%	-5.0%
Thickness of pavement above PATB (elevation measures) ft	0.88	0.60	0.58	0.42	0.75	0.75
Thickness of pavement above PATB (elevation measures) in	10.5	7.3	7.0	5.0	9.0	9.0
Thickness of pavement above PATB (LTPP database) ft	0.90	0.58	0.58	0.37	1.41	1.04
Thickness of pavement above PATB (LTPP database) in	**10.8**	**7.0**	**7.0**	**4.4**	**16.9**	**12.5**
Thickness of PATB (LTPP database) ft	0.37	0.33	0.38	0.34	0.35	0.37
Thickness of PATB (LTPP database) in	**4.4**	**4.0**	**4.5**	**4.1**	**4.2**	**4.4**
Hpavt, ft	0.88	0.60	0.58	0.42	0.75	0.75
Hpatb, ft	0.37	0.33	0.38	0.34	0.35	0.37
Q, ft^3/day	1,885	1,308	1,539	923	192	1,924
dh, ft	1.33	1.02	1.04	0.86	1.23	1.20
L, ft	6.0	5.6	5.7	5.5	6.4	5.0
I, ft/ft	0.22	0.18	0.18	0.16	0.19	0.24
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.1	1	1.125	1.025	1.05	1.1
k, fpd	**7,760**	**7,154**	**7,441**	**5,744**	**960**	**7,286**

Table B.12. Permeability Calculations, New Mexico SPS-1.

Date:	07/24/03	07/24/03	07/24/03	07/24/03	07/24/03	07/24/03
SHRP Site ID:	350107	350108	350109	350110	350111	350112
Core Hole Test Station	0 - 06	0 - 08	n.a.	5 + 45	5 + 13	0 - 36
GPS Coordinates:	N 32.67646°	N 32.67690°	N 32.67683°	N 32.67636°	N 32.67625°	N 32.67617°
	W 107.07915°	W 107.08668°	W 107.0806°	W 107.09505°	W 107.09705°	W 107.09885°
Cross Slope, %:	2.1	0.8	1.6	0.8	1.7	2.3
Long. Grade, %:	0.8	0.5	0.3	0.2	1.5	1.1
Distance Measures, ft						
Core to Edge:	6.0	7.0	n.a.	6.5	6.0	6.5
Core to Outlet:	208.0	181.0	n.a.	7.0	15.0	12.0
Edge to Outlet:	17.0	20.0	n.a.	21.0	21.0	20.0
Elevation Readings, ft						
Top of Pavt at Core:	1.81	2.02	n.a.	1.98	1.69	1.50
Top of PATB after Coring:	2.33	2.58	n.a.	2.77	2.50	2.71
Edge of Pavt:	1.90	2.08	n.a.	2.06	1.77	1.63
Edge at Outlet:	2.92	2.50	n.a.	2.08	1.98	1.85
Outlet:	5.19	5.00	n.a.	4.40	4.60	4.46
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	8	n.a.	8	8	8
Time to First Outflow (min:sec)	n.a.	n.a.	n.a.	10:50	n.a.	15:10
Cumulative. Inflow to Tracer Input (gal)	25 @ 2:20	20 @ 1:59	n.a.	15 @ 1:35	20 @ 2:06	15 @ 1:31
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	10:50	n.a.	15:10
Maximum Inflow Rate (gal/min)	16.9	14.3	n.a.	12.4	14.3	16.6
Water Inflow Stopped:	Stop @ 150 gal	Stop @ 150 gal	n.a.	Stop @ 91 gal	Stop @ 153 gal	Stop @ 130 gal
Cross Slope, % (elevation measures)	1.4%	0.9%	#VALUE!	1.3%	1.4%	1.9%
Long. Grade, % (elevation measures)	0.5%	0.2%	#VALUE!	0.3%	1.4%	1.9%
Thickness of pavement above PATB (elevation measures) ft	0.52	0.56	#VALUE!	0.79	0.81	1.21
Thickness of pavement above PATB (elevation measures) in	6.3	6.8	#VALUE!	9.5	9.8	14.5
Thickness of pavement above PATB (LTPP database) ft	0.49	0.65	0.67	1.04	1.04	1.39
Thickness of pavement above PATB (LTPP database) in	**5.9**	**7.8**	**8.0**	**12.5**	**12.5**	**16.7**
Thickness of PATB (LTPP database) ft	0.31	0.35	0.38	0.31	0.31	0.26
Thickness of PATB (LTPP database) in	**3.7**	**4.2**	**4.5**	**3.7**	**3.7**	**3.1**
Hpavt, ft	0.52	0.56	#VALUE!	0.79	0.81	1.21
Hpatb, ft	0.31	0.35	0.38	0.31	0.31	0.26
Q, ft^3/day	3,251	2,751	#VALUE!	2,385	2,751	3,193
dh, ft	0.91	0.98	#VALUE!	1.18	1.20	1.59
L, ft	6.0	7.0	n.a.	6.5	6.0	6.5
I, ft/ft	0.15	0.14	#VALUE!	0.18	0.20	0.24
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	0.925	1.05	1.125	0.925	0.925	0.775
k, fpd	**23,108**	**18,808**		**14,164**	**14,817**	**16,826**

Table B.13. Permeability Calculations, Ohio SPS-1.

Date:	06/05/03	06/05/03	06/05/03	06/05/03	06/05/03	06/05/03
SHRP Site ID:	390159	390110	390109	390108	390111	390112
Core Hole Test Station	Unknown	2 + 01	1 + 00	0 + 00	- 0 + 02	5 + 13.7
GPS Coordinates:	n.a.	N 40° 25.318'	N 40° 25.217'	N 40° 25.123'	N 40° 24.013'	N 40° 23.808'
	n.a.	W 83° 04.473'	W 83° 04.471'	W 83° 04.469'	W 83° 04.456'	W 83° 04.453'
Cross Slope, %:	1.0	1.4	3.0	2.5	1.2	1.4
Long. Grade, %:	0.0	0.7	0.1	0.2	0.2	0.0
Distance Measures, ft						
Core to Edge:	7.2	2.3	2.5	2.6	5.4	7.8
Core to Outlet:	0.0	2.3	20.5	9.8	53.0	5.0
Edge to Outlet:	29.0	20.0	20.0	20.0	21.0	22.0
Elevation Readings, ft						
Top of Pavt at Core:	1.94	1.94	2.06	2.10	1.94	1.94
Top of PATB after Coring:	3.50	2.83	2.83	2.81	2.96	3.33
Edge of Pavt:	2.08	1.96	2.08	2.06	2.00	2.04
Edge at Outlet:	2.08	1.96	2.08	2.06	2.19	2.06
Outlet:	6.23	6.00	7.88	6.27	6.88	6.92
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	6	4.09	8	8	8	8
Time to First Outflow (min:sec)	n.a.	4:30	n.a.	n.a.	8:49	20:50
Cumulative. Inflow to Tracer Input (gal)	15 @ 2:00	15 @ 3:30	15 @ 2:00	20 @ 2:30	20 @ 2:05	20 @ 2:08
Time to Tracer Outflow (min:sec)	n.a.	8:00	n.a.	n.a.	11:00	29:00
Maximum Inflow Rate (gal/min)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Water Inflow Stopped:	Stop @ 150 gal		Stop @ 100 gal	Stop @ 150 gal		Stop @ 157 gal
Cross Slope, % (elevation measures)	2.0%	0.9%	0.8%	-1.6%	1.2%	1.3%
Long. Grade, % (elevation measures)	#DIV/0!	0.0%	0.0%	0.0%	0.4%	0.4%
Thickness of pavement above PATB (elevation measures) ft	1.56	0.90	0.77	0.71	1.02	1.40
Thickness of pavement above PATB (elevation measures) in	18.8	10.8	9.3	8.5	12.3	16.8
Thickness of pavement above PATB (LTPP database) ft	0.34	0.92	0.58	0.55	0.98	1.32
Thickness of pavement above PATB (LTPP database) in	**4.1**	**11.0**	**7.0**	**6.6**	**11.8**	**15.8**
Thickness of PATB (LTPP database) ft	0.33	0.33	0.33	0.33	0.36	0.33
Thickness of PATB (LTPP database) in	**4.0**	**3.9**	**3.9**	**4.0**	**4.3**	**4.0**
Hpavt, ft	1.56	0.90	0.77	0.71	1.02	1.40
Hpatb, ft	0.33	0.33	0.33	0.33	0.36	0.33
Q, ft^3/day	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!	#VALUE!
dh, ft	2.04	1.24	1.12	1.00	1.44	1.83
L, ft	7.2	2.3	2.5	2.6	5.4	7.8
I, ft/ft	0.28	0.55	0.45	0.39	0.27	0.24
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1	0.975	0.975	1	1.075	1
k, fpd	**#VALUE!**	**#VALUE!**	**#VALUE!**	**#VALUE!**	**#VALUE!**	**#VALUE!**

Table B.14. Permeability Calculations, Oklahoma SPS-1.

Date:	06/23/03	06/23/03	06/23/03	06/23/03	06/23/03	06/23/03
SHRP Site ID:	400122	400119	400120	400121	400123	400124
Core Hole Test Station	0 - 04	0 - 60	5 + 42	0 - 14	0 - 11	5 + 62
GPS Coordinates:	N 34.634750	N 34.635550	N 34.636210	N 34.636480	N 34.636860	N 34.637410
	W 98.682430	W 98.675370	W 98.669750	W 98.667320	W 98.664000	W 98.659120
Cross Slope, %:	2.3	2.8	2.4	2.8	1.7	2.2
Long. Grade, %:	0.6	1.2	0.7	0.7	1.2	0.1
Distance Measures, ft						
Core to Edge:	4.0	4.7	4.4	5.8	5.2	5.2
Core to Outlet:	2.0	7.6	8.2	13.0	11.6	0.0
Edge to Outlet:	28.5	27.7	27.8	27.0	26.3	26.8
Elevation Readings, ft						
Top of Pavt at Core:	1.88	1.81	1.79	1.77	1.90	1.79
Top of PATB after Coring:	2.56	2.42	2.15	2.15	3.13	2.83
Edge of Pavt:	1.98	1.96	1.90	1.92	2.02	1.98
Edge at Outlet:	1.98	2.04	1.96	2.02	2.17	1.98
Outlet:	4.77	4.67	4.58	4.52	4.58	5.40
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	8	8	8	8	8
Time to First Outflow (min:sec)	6:13	6:15	6:00	7:15	12:20	6:15
Cumulative Inflow to Tracer Input (gal)	15 @ 1:38	15 @ 1:37	15 @ 1:45	15 @ 1:42	15 @ 1:38	15 @ 1:47
Time to Tracer Outflow (min:sec)	7:08	6:15	6:25	7:15	14:20	6:52
Maximum Inflow Rate (gal/min)	13.2	14.6	11.5	13.7	14.1	10.9
Water Inflow Stopped:	Stop @ 58 gal	Stop @ 53 gal	Stop @ 53 gal	Stop @ 61 gal	Stop @ 105 gal	Stop @ 48 gal
Cross Slope, % (elevation measures)	2.6%	3.1%	2.4%	2.5%	2.4%	3.6%
Long. Grade, % (elevation measures)	0.0%	1.1%	0.8%	0.8%	1.3%	#DIV/0!
Thickness of pavement above PATB (elevation measures) ft	0.69	0.60	0.35	0.38	1.23	1.04
Thickness of pavement above PATB (elevation measures) in	8.3	7.3	4.3	4.5	14.8	12.5
Thickness of pavement above PATB (LTPP database) ft	0.68	0.63	0.40	0.35	1.33	1.53
Thickness of pavement above PATB (LTPP database) in	**8.2**	**7.5**	**4.8**	**4.2**	**16.0**	**18.3**
Thickness of PATB (LTPP database) ft	0.40	0.33	0.42	0.41	0.37	0.36
Thickness of PATB (LTPP database) in	**4.8**	**4.0**	**5.0**	**4.9**	**4.4**	**4.3**
Hpavt, ft	0.69	0.60	0.35	0.38	1.23	1.04
Hpatb, ft	0.40	0.33	0.42	0.41	0.37	0.36
Q, ft^3/day	2,539	2,808	2,212	2,635	2,712	2,097
dh, ft	1.19	1.08	0.88	0.93	1.72	1.59
L, ft	4.0	4.7	4.4	5.8	5.2	5.2
I, ft/ft	0.30	0.23	0.20	0.16	0.33	0.31
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.2	1	1.25	1.225	1.1	1.075
k, fpd	**7,102**	**12,098**	**8,933**	**13,313**	**7,403**	**6,348**

Table B.15. Permeability Calculations, Texas SPS-1.

Date:	11/12/03	11/12/03	11/12/03	11/12/03	11/12/03	11/12/03
SHRP Site ID:	480124	480123	480122	480121	480120	480119
Core Hole Test Station	0 - 92	5 + 89	1 + 95	0 - 95	5 + 15	5 + 13
GPS Coordinates:	N 26o 43.984'	N 26o 43.739'	N 26o 43.597'	N 26o 42.531'	N 26o 42.304'	N 26o 42.172'
	W 98o 06.353'	W 98o 06.396'	W 98o 06.423'	W 98o 06.618'	W 98o 06.663'	W 98o 06.681'
Cross Slope, %:	3.8	2.3	2.5	2.6	2.6	2.6
Long. Grade, %:	0.2	0.3	0.1	0.1	0.2	0.2
Distance Measures, ft						
Core to Edge:	5.0	5.0	3.0	6.0	5.6	5.3
Core to Outlet:	10.5	10.0	2.5	7.5	15.0	313.0
Edge to Outlet:	25.0	31.0	31.0	32.0	32.0	32.0
Elevation Readings, ft						
Top of Pavt at Core:	1.83	1.92	2.00	1.88	1.94	1.96
Top of PATB after Coring:	2.73	2.88	2.67	2.29	2.38	2.63
Edge of Pavt:	2.04	2.04	2.06	2.06	2.08	2.10
Edge at Outlet:	2.08	2.06	2.06	2.08	2.08	2.33
Outlet:	6.75	7.88	6.69	6.40	6.50	6.83
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	7	8	4.5	5.7	8
Time to First Outflow (min:sec)	n.a.	n.a.	12:40	25:36	17:12	n.a.
Cumulative Inflow to Tracer Input (gal)	20 @ 2:25	20 @ 3:00	20 @ 2:35	25 @ 6:05	25 @ 4:40	40 @ 5:00
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	26:36	17:12	n.a.
Maximum Inflow Rate (gal/min)	10	7	11.5	4.5	5.7	8.7
Water Inflow Stopped:	Stop @ 126 gal	Stop @ 125 gal	Stop @ 96 gal	Stop @ 99 gal	Stop @ 97 gal	Stop @ 200 gal
Cross Slope, % (elevation measures)	4.2%	2.5%	2.1%	3.1%	2.6%	2.8%
Long. Grade, % (elevation measures)	0.4%	0.2%	0.0%	0.3%	0.0%	0.1%
Thickness of pavement above PATB (elevation measures) ft	0.90	0.96	0.67	0.42	0.44	0.67
Thickness of pavement above PATB (elevation measures) in	10.8	11.5	8.0	5.0	5.3	8.0
Thickness of pavement above PATB (LTPP database) ft	1.42	1.09	0.72	0.38	0.39	0.62
Thickness of pavement above PATB (LTPP database) in	**17.0**	**13.1**	**8.6**	**4.5**	**4.7**	**7.4**
Thickness of PATB (LTPP database) ft	0.35	0.37	0.40	0.31	0.33	0.29
Thickness of PATB (LTPP database) in	**4.2**	**4.4**	**4.8**	**3.7**	**4.0**	**3.5**
Hpavt, ft	0.90	0.96	0.67	0.42	0.44	0.67
Hpatb, ft	0.35	0.37	0.40	0.31	0.33	0.29
Q, ft^3/day	1,924	1,346	2,212	866	1,096	1,673
dh, ft	1.45	1.45	1.13	0.91	0.92	1.10
L, ft	5.0	5.0	3.0	6.0	5.6	5.3
I, ft/ft	0.29	0.29	0.38	0.15	0.16	0.21
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.05	1.1	1.2	0.925	1	0.875
k, fpd	**6,299**	**4,221**	**4,898**	**6,153**	**6,678**	**9,094**

Table B.16. Permeability Calculations, Virginia SPS-1.

Date:	09/18/04	09/18/04	09/18/04	09/18/04	09/18/04	09/18/04	09/18/04
SHRP Site ID:	510121	510120	510159	510119	510123	510124	510122
Core Hole Test Station	0 - 75	0 - 218	0 - 12	0 - 13	0 - 96	500 + 39	500 + 07
GPS Coordinates:	N 36o 39.083'	N 36o 38.947'	N 36o 38.817'	N 36o 38.699'	N 36o 38.438'	N 36o 38.200'	N 36o 38.498'
	W 79o 21.883'	W 79o 21.881'	W 79o 21.879'	W 79o 21.885'	W 79o 21.887'	W 79o 21.884'	W 79o 21.887'

Cross Slope, %:	3.5	1.3	2.5	1.8	1.5	1.8	1.6
Long. Grade, %:	1.2	2.0	4.1	1.2	1.2	1.8	1.8

Distance Measures, ft							
Core to Edge:	4.0	4.3	4.3	6.0	5.3	4.7	5.0
Core to Outlet:	10.0	14.0	244.0	142.0	19.0	26.0	460.0
Edge to Outlet:	17.0	17.0	20.0	24.0	32.0	19.0	21.0

Elevation Readings, ft							
Top of Pavt at Core:	1.83	1.85	1.63	3.85	1.54	1.50	0.90
Top of PATB after Coring:	2.15	2.33	2.38	4.48	2.58	2.29	1.60
Edge of Pavt:	1.96	1.90	1.69	3.94	1.58	1.63	1.00
Edge at Outlet:	2.04	2.21	11.89	4.94	1.96	2.31	18.71
Outlet:	4.54	4.77	15.27	8.83	6.69	5.60	22.19

Infiltration Measures							
Steady State Infiltration Rate (gal/min)	6.4	8	8	8	8	3.1	7.2
Time to First Outflow (min:sec)	n.a.	11:54	n.a.	n.a.	6:56	7:51	n.a.
Cumulative Inflow to Tracer Input (gal)	n.a.	104 @ 12:37	75 @ 8:53	100 @ 12:16	69 @ 7:30	26.5 @ 8:15	55 @ 7:45
Time to Tracer Outflow (min:sec)	n.a.	16:00	n.a.	n.a.	11:00	12:44	n.a.
Maximum Inflow Rate (gal/min)	6.4	13.5	12.8	9	16.4	3.1	7.2
Water Inflow Stopped:	Stop @ 150 gal	Stop @ 135 gal	Stop @ 205 gal	Stop @ 200 gal	Stop @ 100 gal	Stop @ 40 gal	Stop @ 200 gal

Cross Slope, % (elevation measures)	3.1%	1.1%	1.4%	1.4%	0.8%	2.7%2	2.1%
Long. Grade, % (elevation measures)	0.8%	2.2%	4.2%	0.7%	2.0%	2.6%3	3.9%
Thickness of pavement above PATB (elevation measures) ft	0.31	0.48	0.75	0.63	1.04	0.79	0.71
Thickness of pavement above PATB (elevation measures) in	3.8	5.8	9.0	7.5	12.5	9.58	8.5
Thickness of pavement above PATB (LTPP database) ft	0.31	0.34	0.74	0.53	1.22	1.57	0.65
Thickness of pavement above PATB (LTPP database) in	**3.7**	**4.1**	**8.9**	**6.4**	**14.6**	**18.8**	**7.8**
Thickness of PATB (LTPP database) ft	0.36	0.36	0.33	0.37	0.34	0.28	0.33
Thickness of PATB (LTPP database) in	**4.3**	**4.3**	**4.0**	**4.4**	**4.1**	**3.4**	**3.9**
Hpavt, ft	0.31	0.48	0.75	0.63	1.04	0.79	0.71
Hpatb, ft	0.36	0.36	0.33	0.37	0.34	0.28	0.33
Q, ft^3/day	1,231	2,597	2,462	1,731	3,155	596	1,385
dh, ft	0.80	0.89	1.15	1.08	1.43	1.20	1.14
L, ft	4.0	4.3	4.3	6.0	5.3	4.7	5.0
I, ft/ft	0.20	0.21	0.26	0.18	0.27	0.26	0.23
Assumed width of flow plume, ft	3	3	3	3	3	3	3
A, ft^2	1.075	1.075	1	1.1	1.025	0.85	0.975
k, fpd	**5,756**	**11,568**	**9,311**	**8,784**	**11,519**	**2,728**	**6,244**

Table B.17. Permeability Calculations, Wisconsin SPS-1.

Date:	06/09/03	06/09/03	06/09/03	06/09/03	06/09/03	06/09/03
SHRP Site ID:	550123	550124	550119	550121	550120	550122
Core Hole Test Station	5 + 09	- 0 + 25	- 0 + 46	- 0 + 2.5	5 + 03	5 + 36
GPS Coordinates:	N 40.87082o	N 40.87108o	N 40.87308o	N 40.87458o	N 40.87691o	N 40.87908o
	W 89.29446o	W 89.29486o	W 89.29747o	W 89.29952o	W 89.30287o	W 89.30700o
Cross Slope, %:	1.0	2.0	1.7	1.6	3.1	4.2
Long. Grade, %:	0.6	0.9	1.1	1.0	0.3	0.4
Distance Measures, ft						
Core to Edge:	4.5	5.0	5.5	5.5	17.5	17.8
Core to Outlet:	54.5	7.0	10.5	4.0	206.0	17.7
Edge to Outlet:	22.0	22.0	21.0	22.0	22.0	20.0
Elevation Readings, ft						
Top of Pavt at Core:	1.75	1.75	1.79	1.81	2.08	2.38
Top of PATB after Coring:	3.04	3.33	2.42	2.19	2.48	3.17
Edge of Pavt:	1.85	2.85	1.90	1.94	2.63	2.96
Edge at Outlet:	2.17	2.92	2.02	1.98	3.54	3.04
Outlet:	5.67	5.50	4.77	4.77	6.54	6.04
Infiltration Measures						
Steady State Infiltration Rate (gal/min)	8	8	3.5	8	10	8
Time to First Outflow (min:sec)	n.a.	10:56	n.a.	4:41	22:30	12:55
Cumulative Inflow to Tracer Input (gal)	20 @ 2:07	15 @ 1:31	10 2 2:53	15 @ 1:45	20 @ 1:55	15 @ 1:40
Time to Tracer Outflow (min:sec)	n.a.	11:25	n.a.	5:06	25:00	12:55
Maximum Inflow Rate (gal/min)	15.3	14.8	3.5	12	12.8	13.7
Water Inflow Stopped:	Stop @ 130 gal	Stop @ 94 gal	Stop @ 100 gal	Stop @ 43 gal	Stop @ 225 gal	Stop @ 107 gal
Cross Slope, % (elevation measures)	2.3%	22.1%	1.9%	2.3%	3.1%	3.3%
Long. Grade, % (elevation measures)	0.6%	0.9%	1.2%	1.0%	0.4%	0.5%
Thickness of pavement above PATB (elevation measures) ft	1.29	1.58	0.63	0.38	0.40	0.79
Thickness of pavement above PATB (elevation measures) in	15.5	19.0	7.5	4.5	4.8	9.5
Thickness of pavement above PATB (LTPP database) ft	1.24	1.57	0.55	0.35	0.33	0.78
Thickness of pavement above PATB (LTPP database) in	**14.9**	**18.8**	**6.6**	**4.2**	**3.9**	**9.3**
Thickness of PATB (LTPP database) ft	0.36	0.28	0.28	0.35	0.40	0.41
Thickness of PATB (LTPP database) in	**4.3**	**3.3**	**3.4**	**4.2**	**4.8**	**4.9**
Hpavt, ft	1.29	1.58	0.63	0.38	0.40	0.79
Hpatb, ft	0.36	0.28	0.28	0.35	0.40	0.41
Q, ft^3/day	2,943	2,847	673	2,308	2,462	2,635
dh, ft	1.75	2.96	1.01	0.85	1.34	1.78
L, ft	4.5	5.0	5.5	5.5	17.5	17.8
I, ft/ft	0.39	0.59	0.18	0.15	0.08	0.10
Assumed width of flow plume, ft	3	3	3	3	3	3
A, ft^2	1.075	0.825	0.85	1.05	1.2	1.225
k, fpd	**7,023**	**5,824**	**4,302**	**14,225**	**26,846**	**21,512**

Table B.18. Permeability Calculations, Arizona SPS-2.

Date:	04/18/03	04/18/03	04/18/03	04/18/03
SHRP Site ID:	040221	040222	040223	040224
Core Hole Test Station	5 + 03	-0 + 04	- 0 + 03	- 0 + 03.5
GPS Coordinates:	N 33o 26.802'	N 33o 27.122'	N 33o 26.909'	N 33o 27.001'
	W 112o 42.644'	W 112o 44.115'	W 112o 43.174'	W 112o 43.623'
Cross Slope, %:	2.1	2.1	1.9	2.0
Long. Grade, %:	0.2	0.5	0.4	0.1
Distance Measures, ft				
Core to Edge:	7.5	6.0	5.6	8.0
Core to Outlet:	180.0	157.0	76.0	93.5
Edge to Outlet:	26.0	28.0	29.0	25.0
Elevation Readings, ft				
Top of Pavt at Core:	0.02	0.04	0.21	0.02
Top of PATB after Coring:	0.75	0.79	1.15	0.96
Edge of Pavt:				
Edge at Outlet:				
Outlet:	3.25	3.35	3.33	3.23
Infiltration Measures				
Steady State Infiltration Rate (gal/min)	10	8.19	10	10
Time to First Outflow (min:sec)	n.a.	n.a.	n.a.	38:00
Cumulative Inflow to Tracer Input (gal)	100	410	100	170
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	45:00
Maximum Inflow Rate (gal/min)	13	14.64	14.74	14.49
Water Inflow Stopped:				
Cross Slope, % (elevation measures)	-0.3%	-0.7%	-3.7%	-0.3%
Long. Grade, % (elevation measures)	0.0%	0.0%	0.0%	0.0%
Thickness of pavement above PATB (elevation measures) ft	0.73	0.75	0.94	0.94
Thickness of pavement above PATB (elevation measures) in	8.8	9.0	11.3	11.3
Thickness of pavement above PATB (LTPP database) ft	0.68	0.72	0.93	0.88
Thickness of pavement above PATB (LTPP database) in	**8.1**	**8.6**	**11.1**	**10.6**
Thickness of PATB (LTPP database) ft	0.35	0.33	0.34	0.37
Thickness of PATB (LTPP database) in	**4.2**	**3.9**	**4.1**	**4.4**
Hpavt, ft	0.73	0.75	0.94	0.94
Hpatb, ft	0.35	0.33	0.34	0.37
Q, ft^3/day	2,501	2,816	2,835	2,787
dh, ft	1.06	1.03	1.07	1.28
L, ft	7.5	6.0	5.6	8.0
I, ft/ft	0.14	0.17	0.19	0.16
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	1.05	0.975	1.025	1.1
k, fpd	**16,877**	**16,771**	**14,423**	**15,795**

Table B.19. Permeability Calculations, Arkansas SPS-2.
(Note: data are in different format because pilot testing was conducted at this site.).

Date:	12/18/02	12/18/02	12/18/02	12/18/02	12/18/02
SHRP Site ID:	050224	050223	050222	050222	050221
Core Hole Test Station	0 - 15	0 - 11	5 + 13.7	5 + 47.5	5 + 08
GPS Coordinates:	N 34o 30.560'	n.a.	N 34o 31.170'	n.a.	N 34o 29.963'
	W 92o 41.861'	n.a.	W 92o 41.256'	n.a.	W 92o 42.300'
Cross Slope, %:	1.8	1.2	1.3	1.5	1.4
Long. Grade, %:	1.6	1.5	3.0	2.9	0.6
Distance Measures, ft					
Core to Edge:	7.7	6.4	6.4	5.9	4.0
Core to Outlet:	27.8	287.0	158.0	16.2	14.0
Edge to Outlet:	29.0	33.0	20.8	21.6	23.0
Elevation Readings, ft					
Top of Pavt at Core:	2.34	0.94	0.32	1.80	3.03
Top of PATB after Coring:	3.30	1.86	1.08	2.56	3.73
Edge of Pavt:	2.46	0.98	0.38	1.86	3.08
Edge at Outlet:	2.86	5.35	4.22	2.28	3.13
Outlet:	7.53	10.68	7.14	6.13	6.74
Draindown Times, sec					
30 - 25 gal	12.4	9.9	10.8	14	9.9
- 20 gal:	26.4	19.5	22.2	28.3	22.6
- 15 gal:	37.8	29.1	32	40.4	35.3
- 10 gal:	52.2	42.1	44.6	56.1	49.8
- 5 gal:	63.6	52.7	56.3	70.8	62
Outlet response Times, mm:ss					
Time to start outflow:	7:06	17:00	23:58	no flow	2:34

Table B.20. Permeability Calculations, California SPS-2.

Date:	07/15/03	07/15/03	07/15/03	07/15/03	07/15/03
SHRP Site ID:	060211	060210a	060210b	060212	060209
Core Hole Test Station	5 + 48	5 + 05	0 - 10	5 + 07	0 - 39
GPS Coordinates:	N 37.41725o	N 37.42094o	N 37.41979o	N 37.42441o	N 37.42699o
	W 120.75968o	W 120.76396o	W 120.76257o	W 120.76921o	W 120.77211o
Cross Slope, %:	1.6	1.0	1.2	1.7	1.9
Long. Grade, %:	0.2	0.5	0.3	0.4	0.3
Distance Measures, ft					
Core to Edge:	5.2	4.8	4.2	4.5	4.0
Core to Outlet:	8.0	18.7	102.0	5.0	4.0
Edge to Outlet:	36.0	39.0	39.0	29.0	42.0
Elevation Readings, ft					
Top of Pavt at Core:	1.85	2.13	2.06	1.79	1.77
Top of PATB after Coring:	2.85	2.92	2.79	2.81	2.44
Edge of Pavt:	1.96	2.08	2.08	2.85	1.85
Edge at Outlet:	1.98	2.17	2.42	2.90	1.90
Outlet:	8.54	7.79	8.00	7.92	10.04
Infiltration Measures					
Steady State Infiltration Rate (gal/min)	8	8	8	8	3
Time to First Outflow (min:sec)	4:16	n.a.	n.a.	n.a.	28:00
Cumulative Inflow to Tracer Input (gal)	25 @ 2:12	15 @ 1:38	20 @ 2:10	15 @ 1:32	10 @ 3:10
Time to Tracer Outflow (min:sec)	5:29	n.a.	n.a.	n.a.	n.a.
Maximum Inflow Rate (gal/min)	15	11	15.7	16.2	3.1
Water Inflow Stopped:	Stop @ 54 gal	Stop @ 106 gal	Stop @ 108 gal	Stop @ 100 gal	Stop @ 55 gal
Cross Slope, % (elevation measures)	2.0%	-0.9%	0.5%	23.6%	2.1%
Long. Grade, % (elevation measures)	0.3%	0.4%	0.3%	0.8%	1.0%
Thickness of pavement above PATB (elevation measures) ft	1.00	0.79	0.73	1.02	0.67
Thickness of pavement above PATB (elevation measures) in	12.0	9.5	8.8	12.3	8.0
Thickness of pavement above PATB (LTPP database) ft	1.01	0.72	0.72	0.93	0.70
Thickness of pavement above PATB (LTPP database) in	**12.1**	**8.6**	**8.6**	**11.1**	**8.4**
Thickness of PATB (LTPP database) ft	0.28	0.32	0.32	0.31	0.30
Thickness of PATB (LTPP database) in	**3.4**	**3.8**	**3.8**	**3.7**	**3.6**
Hpavt, ft	1.00	0.79	0.73	1.02	0.67
Hpatb, ft	0.28	0.32	0.32	0.31	0.30
Q, ft^3/day	2,885	2,116	3,020	3,116	596
dh, ft	1.39	1.07	1.07	2.39	1.05
L, ft	5.2	4.8	4.2	4.5	4.0
I, ft/ft	0.27	0.22	0.26	0.53	0.26
Assumed width of flow plume, ft	3	3	3	3	3
A, ft^2	0.85	0.95	0.95	0.925	0.9
k, fpd	**12,640**	**10,092**	**12,418**	**6,339**	**2,524**

Table B.21. Permeability Calculations, Colorado SPS-2.

Date:	07/22/03	07/22/03	07/22/03	07/22/03	07/22/03
SHRP Site ID:	080224	080221a	080221b	080222	080223
Core Hole Test Station	5 + 59	0 - 46	5 + 54	5 + 17	0 - 46
GPS Coordinates:	N 39.96853o	N 39.94721o	N 39.94854o	N 39.94989o	N 39.95019o
	W 104.76253o	W 104.78096o	W 104.77964o	W 104.77815o	W 104.77784o
Cross Slope, %:	4.2	2.4	1.3	1.7	2.4
Long. Grade, %:	0.3	0.3	0.1	0.5	0.7
Distance Measures, ft					
Core to Edge:	8.8	6.5	6.0	7.0	6.0
Core to Outlet:	9.0	22.0	20.0	105.0	21.0
Edge to Outlet:	29.0	31.0	28.0	25.0	28.0
Elevation Readings, ft					
Top of Pavt at Core:	1.67	1.98	2.00	1.79	1.88
Top of PATB after Coring:	2.67	2.54	2.69	2.65	2.85
Edge of Pavt:	1.94	2.04	2.06	1.92	2.04
Edge at Outlet:	1.96	2.13	2.08	2.23	2.13
Outlet:	5.54	5.44	6.17	4.98	4.85
Infiltration Measures					
Steady State Infiltration Rate (gal/min)	8	8	8	8	8
Time to First Outflow (min:sec)	27:30	22:17	16:16	n.a.	24:30
Cumulative Inflow to Tracer Input (gal)	25 @ 2:25	20 @ 2:17	20 @ 2:16	20 @ 1:55	20 @ 1:52
Time to Tracer Outflow (min:sec)	n.a.	22:17	20:00	n.a.	24:30
Maximum Inflow Rate (gal/min)	17.3	11.5	11.4	16.4	16.8
Water Inflow Stopped:	Stop @ 128 gal	Stop @ 146 gal	Stop @ 167 gal	Stop @ 250 gal	Stop @ 150 gal
Cross Slope, % (elevation measures)	3.1%	1.0%	1.0%	1.8%	2.8%
Long. Grade, % (elevation measures)	0.2%	0.4%	0.1%	0.3%	0.4%
Thickness of pavement above PATB (elevation measures) ft	1.00	0.56	0.69	0.85	0.98
Thickness of pavement above PATB (elevation measures) in	12.0	6.8	8.3	10.3	11.8
Thickness of pavement above PATB (LTPP database) ft	0.97	0.69	0.69	0.71	0.98
Thickness of pavement above PATB (LTPP database) in	**11.6**	**8.3**	**8.3**	**8.5**	**11.7**
Thickness of PATB (LTPP database) ft	0.38	0.32	0.32	0.38	0.35
Thickness of PATB (LTPP database) in	**4.6**	**3.8**	**3.8**	**4.5**	**4.2**
Hpavt, ft	1.00	0.56	0.69	0.85	0.98
Hpatb, ft	0.38	0.32	0.32	0.38	0.35
Q, ft^3/day	3,328	2,212	2,193	3,155	3,232
dh, ft	1.65	0.94	1.07	1.35	1.50
L, ft	8.8	6.5	6.0	7.0	6.0
I, ft/ft	0.19	0.14	0.18	0.19	0.25
Assumed width of flow plume, ft	3	3	3	3	3
A, ft^2	1.15	0.95	0.95	1.125	1.05
k, fpd	**15,452**	**16,073**	**12,984**	**14,495**	**12,345**

Table B.22. Permeability Calculations, Delaware SPS-2.

Date:	08/13/03	08/13/03	08/13/03	08/13/03
SHRP Site ID:	100212	100210	100211	100209
Core Hole Test Station	0 - 13	0 - 12	n.a.	0 - 61
GPS Coordinates:	N 38° 51.705'	N 38° 51.482'	n.a.	N 38° 51.754'
	W 75° 26.367'	W 75° 26.364'	n.a.	W 75° 26.357'
Cross Slope, %:	1.9	1.1	n.a.	1.7
Long. Grade, %:	1.0	0.0	n.a.	0.3
Distance Measures, ft				
Core to Edge:	4.0	7.0	n.a.	5.8
Core to Outlet:	210.0	66.0	n.a.	14.5
Edge to Outlet:	27.0	20.0	n.a.	26.0
Elevation Readings, ft				
Top of Pavt at Core:	1.83	2.02	n.a.	1.79
Top of PATB after Coring:	2.88	2.75	n.a.	2.54
Edge of Pavt:	1.92	2.10	n.a.	2.88
Edge at Outlet:	3.43	2.04	n.a.	2.88
Outlet:	7.78	4.75	n.a.	4.75
Infiltration Measures				
Steady State Infiltration Rate (gal/min)	10	10.8	n.a.	12.2
Time to First Outflow (min:sec)	n.a.	n.a.	n.a.	7:18
Cumulative. Inflow to Tracer Input (gal)	20 @ 2:05	35 @ 3:10	n.a.	20 @ 1:40
Time to Tracer Outflow (min:sec)	n.a.	n.a.	n.a.	7:25
Maximum Inflow Rate (gal/min)	14	13	n.a.	13
Water Inflow Stopped:	Stop @ 132 gal	Stop @ 133 gal	n.a.	Stop @ 92 gal
Cross Slope, % (elevation measures)	2.1%	1.2%	#VALUE!	18.8%
Long. Grade, % (elevation measures)	0.7%	-0.1%	#VALUE!	0.0%
Thickness of pavement above PATB (elevation measures) ft	1.04	0.73	#VALUE!	0.75
Thickness of pavement above PATB (elevation measures) in	12.5	8.8	#VALUE!	9.0
Thickness of pavement above PATB (LTPP database) ft	1.03	0.69	0.98	0.68
Thickness of pavement above PATB (LTPP database) in	**12.4**	**8.3**	**11.8**	**8.2**
Thickness of PATB (LTPP database) ft	0.31	0.32	3.70	0.39
Thickness of PATB (LTPP database) in	**3.7**	**3.8**	**3.9**	**4.7**
Hpavt, ft	1.04	0.73	#VALUE!	0.75
Hpatb, ft	0.31	0.32	3.70	0.39
Q, ft^3/day	2,693	2,501	#VALUE!	2,501
dh, ft	1.43	1.13	#VALUE!	2.23
L, ft	4.0	7.0	n.a.	5.8
I, ft/ft	0.36	0.16	#VALUE!	0.39
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	0.925	0.95	11.1	1.175
k, fpd	**8,125**	**16,318**		**5,500**

Table B.23. Permeability Calculations, Iowa SPS-2.

Date:	06/30/03	06/30/03	06/30/03	06/30/03
SHRP Site ID:	190221	190222	190223	190224
Core Hole Test Station	- 1 - 02	0 - 24	0 - 99	5 + 11
GPS Coordinates:	N 41.63077o	N 41.632650	N 41.63518o	N 41.63906o
	W 93.50128o	W 93.50261o	W 93.50426o	W 93.50672o
Cross Slope, %:	3.2	2.5	2.8	2.2
Long. Grade, %:	0.7	0.5	0.7	2.4
Distance Measures, ft				
Core to Edge:	4.3	4.6	4.8	5.3
Core to Outlet:	39.0	16.8	34.6	511.0
Edge to Outlet:	29.6	27.0	28.5	35.0
Elevation Readings, ft				
Top of Pavt at Core:	1.58	1.67	1.52	1.77
Top of PATB after Coring:	2.21	2.35	2.52	2.71
Edge of Pavt:	1.69	1.77	1.67	1.92
Edge at Outlet:	1.96	1.85	1.96	8.44
Outlet:	5.48	4.60	5.33	11.86
Infiltration Measures				
Steady State Infiltration Rate (gal/min)	8	8	8	8
Time to First Outflow (min:sec)	5:14	5:00	3:00	40:00
Cumulative Inflow to Tracer Input (gal)	15 @ 1:32	15 @ 1:42	20 @ 2:00	20 @ 2:15
Time to Tracer Outflow (min:sec)	6:40	8:50	6:30	n.a.
Maximum Inflow Rate (gal/min)	13	12	16	11
Water Inflow Stopped:	Stop @ 58 gal	Stop @ 73 gal	Stop @ 57 gal	Stop @ 250 gal
Cross Slope, % (elevation measures)	2.5%	2.3%	3.0%	2.8%
Long. Grade, % (elevation measures)	0.7%	0.5%	0.8%	1.3%
Thickness of pavement above PATB (elevation measures) ft	0.63	0.69	1.00	0.94
Thickness of pavement above PATB (elevation measures) in	7.5	8.3	12.0	11.3
Thickness of pavement above PATB (LTPP database) ft	0.79	0.69	0.98	0.97
Thickness of pavement above PATB (LTPP database) in	**9.5**	**8.3**	**11.7**	**11.6**
Thickness of PATB (LTPP database) ft	0.33	0.28	0.29	0.41
Thickness of PATB (LTPP database) in	**3.9**	**3.4**	**3.5**	**4.9**
Hpavt, ft	0.63	0.69	1.00	0.94
Hpatb, ft	0.33	0.28	0.29	0.41
Q, ft^3/day	2,424	2,251	3,039	2,174
dh, ft	1.05	1.08	1.44	1.49
L, ft	4.3	4.6	4.8	5.3
I, ft/ft	0.25	0.23	0.30	0.28
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	0.975	0.85	0.875	1.225
k, fpd	**10,022**	**11,289**	**11,679**	**6,245**

Table B.24. Permeability Calculations, Kansas SPS-2.

Date:	06/26/03	06/26/03	06/26/03	06/26/03
SHRP Site ID:	200212	200211	200210	200209
Core Hole Test Station	5 + 63	5 + 18	5 + 09	5 + 15
GPS Coordinates:	N 38.99038°	N 38.99018°	N 38.98999°	N 38.98998°
	W 96.99412°	W 97.00347°	W 97.01234°	W 97.01445°

Cross Slope, %:	1.3	1.3	1.4	1.6
Long. Grade, %:	0.1	0.6	1.8	0.3

Distance Measures, ft

Core to Edge:	4.8	5.5	5.3	6.1
Core to Outlet:	22.7	66.5	63.0	9.9
Edge to Outlet:	24.7	35.0	33.2	30.0

Elevation Readings, ft

Top of Pavt at Core:	1.88	1.60	1.17	1.90
Top of PATB after Coring:	2.69	2.54	1.92	2.69
Edge of Pavt:	1.98	1.71	1.23	2.00
Edge at Outlet:	1.98	1.90	2.52	2.00
Outlet:	4.79	6.40	6.92	6.15

Infiltration Measures

Steady State Infiltration Rate (gal/min)	8	8	8	8
Time to First Outflow (min:sec)	10:30	1:47	8:22	7:30
Cumulative. Inflow to Tracer Input (gal)	15 @ 1:45	15 @ 1:33	15 @ 1:21	15 @ 1:33
Time to Tracer Outflow (min:sec)	14:30	n.a.	8:22	9:30
Maximum Inflow Rate (gal/min)	11.5	15.8	15.5	15.3
Water Inflow Stopped:	Stop @ 109 gal	Stop @ 130 gal	Stop @ 73 gal	Stop @ 79 gal

Cross Slope, % (elevation measures)	2.2%	1.9%	1.2%	1.7%
Long. Grade, % (elevation measures)	0.0%	0.3%	2.1%	0.0%
Thickness of pavement above PATB (elevation measures) ft	0.81	0.94	0.75	0.79
Thickness of pavement above PATB (elevation measures) in	9.8	11.3	9.0	9.5
Thickness of pavement above PATB (LTPP database) ft	0.91	0.93	0.69	0.71
Thickness of pavement above PATB (LTPP database) in	10.9	11.1	8.3	8.5
Thickness of PATB (LTPP database) ft	0.37	0.35	0.31	0.33
Thickness of PATB (LTPP database) in	4.4	4.2	3.7	3.9
Hpavt, ft	0.81	0.94	0.75	0.79
Hpatb, ft	0.37	0.35	0.31	0.33
Q, ft^3/day	2,212	3,039	2,982	2,943
dh, ft	1.28	1.39	1.12	1.22
L, ft	4.8	5.5	5.3	6.1
I, ft/ft	0.27	0.25	0.21	0.20
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	1.1	1.05	0.925	0.975
k, fpd	7,443	11,439	15,098	15,041

Table B.25. Permeability Calculations, Michigan SPS-2.

Date:	10/21/03	10/21/03	10/21/03	10/21/03
SHRP Site ID:	260221	260224	260223	260259
Core Hole Test Station	0 - 13	0 - 43	5 + 60	5 + 20
GPS Coordinates:	N 41° 45.418'	N 41° 45.521'	N 41° 46.716'	N 41° 46.961'
	W 83° 41.665'	W 83° 41.669'	W 83° 41.722'	W 83° 41.737'

Cross Slope, %:	1.7	1.7	1.9	2.5
Long. Grade, %:	0.6	0.1	0.1	0.4

Distance Measures, ft

Core to Edge:	6.0	6.0	5.7	4.0
Core to Outlet:	232.0	94.0	8.3	180.0
Edge to Outlet:	34.0	39.0	30.0	22.0

Elevation Readings, ft

Top of Pavt at Core:	2.00	2.00	2.00	2.00
Top of PATB after Coring:	2.73	2.92	2.92	2.94
Edge of Pavt:	2.13	2.10	2.10	2.06
Edge at Outlet:	2.17	2.13	2.10	3.06
Outlet:	8.69	10.33	6.65	6.56

Infiltration Measures

Steady State Infiltration Rate (gal/min)	8	8	8	8
Time to First Outflow (min:sec)	27:00	14:00	2:15	11:43
Cumulative. Inflow to Tracer Input (gal)	20 @ 2:15	20 @ 2:15	20 @ 2:15	20 @ 2:10
Time to Tracer Outflow (min:sec)	n.a.	15:40	3:30	13:10
Maximum Inflow Rate (gal/min)	12.2	14.5	14.7	14.6
Water Inflow Stopped:	Stop @ 120 gal	Stop @ 120 gal	Stop @ 32 gal	Stop @ 117 gal

Cross Slope, % (elevation measures)	2.1%	1.7%	1.8%	1.6%
Long. Grade, % (elevation measures)	0.0%	0.0%	0.0%	0.6%
Thickness of pavement above PATB (elevation measures) ft	0.73	0.92	0.92	0.94
Thickness of pavement above PATB (elevation measures) in	8.8	11.0	11.0	11.3
Thickness of pavement above PATB (LTPP database) ft	0.68	0.93	0.92	0.93
Thickness of pavement above PATB (LTPP database) in	**8.2**	**11.2**	**11.0**	**11.2**
Thickness of PATB (LTPP database) ft	0.35	0.36	0.34	0.33
Thickness of PATB (LTPP database) in	**4.2**	**4.3**	**4.1**	**4.0**
Hpavt, ft	0.73	0.92	0.92	0.94
Hpatb, ft	0.35	0.36	0.34	0.33
Q, ft^3/day	2,347	2,789	2,828	2,808
dh, ft	1.20	1.38	1.36	1.33
L, ft	6.0	6.0	5.7	4.0
I, ft/ft	0.20	0.23	0.24	0.33
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	1.05	1.075	1.025	1
k, fpd	**11,136**	**11,288**	**11,473**	**8,425**

Table B.26. Permeability Calculations, Nevada SPS-2.

Date:	10/28/03	10/28/03	10/29/03
SHRP Site ID:	320209	320211	320210
Core Hole Test Station	0 - 14	0 - 31	0 - 14
GPS Coordinates:	N 40° 43.135'	N 40° 42.727'	N 40° 42.049'
	W 117° 01.733'	W 117° 01.637'	W 117° 00.772'
Cross Slope, %:	1.6	1.4	1.8
Long. Grade, %:	0.2	0.1	0.2
Distance Measures, ft			
Core to Edge:	6.3	7.3	7.3
Core to Outlet:	204.0	26.0	75.0
Edge to Outlet:	22.0	19.0	19.0
Elevation Readings, ft			
Top of Pavt at Core:	2.00	1.98	1.96
Top of PATB after Coring:	2.73	2.85	2.69
Edge of Pavt:	2.08	2.08	2.08
Edge at Outlet:	2.54	2.13	2.13
Outlet:	4.71	4.60	4.67
Infiltration Measures			
Steady State Infiltration Rate (gal/min)	7.8	8	7.2
Time to First Outflow (min:sec)	n.a.	16:30	n.a.
Cumulative. Inflow to Tracer Input (gal)	15 @ 1:55	15 @ 1:56	20 @ 2:35
Time to Tracer Outflow (min:sec)	n.a.	16:30	n.a.
Maximum Inflow Rate (gal/min)	7.8	9.8	7.2
Water Inflow Stopped:	Stop @ 161 gal	Stop @ 125 gal	Stop @ 110 gal
Cross Slope, % (elevation measures)	1.3%	1.4%	1.7%
Long. Grade, % (elevation measures)	0.2%	0.2%	0.1%
Thickness of pavement above PATB (elevation measures) ft	0.73	0.88	0.73
Thickness of pavement above PATB (elevation measures) in	8.8	10.5	8.8
Thickness of pavement above PATB (LTPP database) ft	0.74	0.94	0.84
Thickness of pavement above PATB (LTPP database) in	**8.9**	**11.3**	**10.1**
Thickness of PATB (LTPP database) ft	0.33	0.34	0.31
Thickness of PATB (LTPP database) in	**4.0**	**4.1**	**3.7**
Hpavt, ft	0.73	0.88	0.73
Hpatb, ft	0.33	0.34	0.31
Q, ft^3/day	1,500	1,885	1,385
dh, ft	1.15	1.32	1.16
L, ft	6.3	7.3	7.3
I, ft/ft	0.18	0.18	0.16
Assumed width of flow plume, ft	3	3	3
A, ft^2	1	1.025	0.925
k, fpd	**8,289**	**10,095**	**9,441**

Table B.27. Permeability Calculations, North Carolina SPS-2.

Date:	11/05/03	11/05/03	11/05/03	11/05/03
SHRP Site ID:	370209	370210	370211	370212
Core Hole Test Station	3 + 32	0 + 94	0 - 232	0 - 168
GPS Coordinates:	N 35° 51.590'	N 35° 51.574'	N 35° 50.901'	N 35° 50.765'
	W 80° 16.136'	W 80° 16.288'	W 80° 16.710'	W 80° 16.826'
Cross Slope, %:	1.1	1.1	1.2	6.6
Long. Grade, %:	0.6	0.5	0.7	0.2
Distance Measures, ft				
Core to Edge:	5.5	5.3	6.6	20.0
Core to Outlet:	16.0	8.5	17.0	37.0
Edge to Outlet:	25.0	23.0	26.0	31.0
Elevation Readings, ft				
Top of Pavt at Core:	2.83	2.85	3.00	3.38
Top of PATB after Coring:	3.60	3.75	3.96	4.42
Edge of Pavt:	2.92	2.94	3.13	4.58
Edge at Outlet:	2.96	3.00	3.21	4.79
Outlet:	7.67	8.17	8.33	8.67
Infiltration Measures				
Steady State Infiltration Rate (gal/min)	8	8	8	8
Time to First Outflow (min:sec)	7:46	n.a.	9:25	12:40
Cumulative. Inflow to Tracer Input (gal)	20 @ 1:55	20 @ 1:55	20 @ 2:10	25 @ 2:22
Time to Tracer Outflow (min:sec)	9:45	n.a.	10:45	12:50
Maximum Inflow Rate (gal/min)	17.6	17.5	17.4	17.5
Water Inflow Stopped:	Stop @ 74 gal	Stop @ 128 gal	Stop @ 90 gal	Stop @ 114 gal
Cross Slope, % (elevation measures)	1.5%	1.6%	1.9%	6.0%
Long. Grade, % (elevation measures)	0.3%	0.7%	0.5%	0.6%
Thickness of pavement above PATB (elevation measures) ft	0.77	0.90	0.96	1.04
Thickness of pavement above PATB (elevation measures) in	9.3	10.8	11.5	12.5
Thickness of pavement above PATB (LTPP database) ft	0.72	0.76	0.95	0.91
Thickness of pavement above PATB (LTPP database) in	**8.6**	**9.10**	**11.40**	**10.9**
Thickness of PATB (LTPP database) ft	0.47	0.44	0.30	0.36
Thickness of PATB (LTPP database) in	**5.6**	**5.3**	**3.6**	**4.3**
Hpavt, ft	0.77	0.90	0.96	1.04
Hpatb, ft	0.47	0.44	0.30	0.36
Q, ft^3/day	3,385	3,366	3,347	3,366
dh, ft	1.32	1.42	1.38	2.61
L, ft	5.5	5.3	6.6	20.0
I, ft/ft	0.24	0.27	0.21	0.13
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	1.4	1.325	0.9	1.075
k, fpd	**10,069**	**9,387**	**17,698**	**24,010**

Table B.28. Permeability Calculations, North Dakota SPS-2.

Date:	06/18/03	06/18/03	06/18/03	06/18/03	06/18/03	06/18/03	06/18/03
SHRP Site ID:	380223	380263	380264	380224	380221	380222	380259
Core Hole Test Station	6 + 19	- 1 + 13	- 0 + 6	6 + 80	5 + 03	- 0 + 04	- 0 + 03
GPS Coordinates:	N 46.87649°	N 46.87648°	N 46.87651°	N 46.87647°	N 46.87646°	N 46.87652°	N 46.87649°
	W 97.16384°	W 97.14888°	W 97.14502°	W 97.13886°	W 97.13584°	W 97.13525°	W 97.13107°
Cross Slope, %:	1.8	1.7	1.4	1.8	1.5	1.7	2.5
Long. Grade, %:	0.4	0.3	0.0	0.0	0.1	0.1	0.1
Distance Measures, ft							
Core to Edge:	6.1	5.9	6.5	5.5	6.8	5.3	6.4
Core to Outlet:	7.4	5.5	7.3	3.0	233.0	69.0	216.0
Edge to Outlet:	28.0	29.3	32.5	34.0	35.0	29.0	30.0
Elevation Readings, ft							
Top of Pavt at Core:	1.90	1.79	1.92	1.79	2.04	1.88	1.96
Top of PATB after Coring:	2.81	2.71	2.77	2.60	2.71	2.56	2.79
Edge of Pavt:	1.96	1.88	2.00	1.88	2.13	1.96	2.10
Edge at Outlet:	2.00	1.88	2.00	1.88	2.17	2.00	2.17
Outlet:	4.92	5.00	5.38	5.23	5.85	5.38	4.92
Infiltration Measures							
Steady State Infiltration Rate (gal/min)	8	8	8	8	3	8	8
Time to First Outflow (min:sec)	6:10	3:30	11:00	7:08	n.a.	6:30	n.a.
Cumulative. Inflow to Tracer Input (gal)	15 @ 1:39	15 @ 1:44	15 @ 1:30	15 @ 1:45	15 @ 4:44	15 @ 1:38	15 @ 1:45
Time to Tracer Outflow (min:sec)	6:52	5:20	14:00	14:00	n.a.	9:20	n.a.
Maximum Inflow Rate (gal/min)	11.1	10.2	14.9	11.9	3.4	11.6	12.2
Water Inflow Stopped:	Stop @ 59 gal	Stop @ 46 gal	Stop @ 125 gal	Stop @ 114 gal	Stop @ 61 gal	Stop @ 80 gal	Stop @ 125 gal
Cross Slope, % (elevation measures)	1.0%	1.4%	1.3%	1.5%	1.2%	1.6%	2.3%
Long. Grade, % (elevation measures)	0.6%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%
Thickness of pavement above PATB (elevation measures) ft	0.92	0.92	0.85	0.81	0.67	0.69	0.83
Thickness of pavement above PATB (elevation measures) in	11.0	11.0	10.3	9.8	8.0	8.3	10.0
Thickness of pavement above PATB (LTPP database) ft	0.93	0.90	0.92	0.90	0.68	0.68	0.79
Thickness of pavement above PATB (LTPP database) in	**11.1**	**10.8**	**11.0**	**10.8**	**8.1**	**8.2**	**9.5**
Thickness of PATB (LTPP database) ft	0.34	0.32	0.33	0.33	0.37	0.32	0.33
Thickness of PATB (LTPP database) in	**4.1**	**3.8**	**3.9**	**4.0**	**4.4**	**3.8**	**3.9**
Hpavt, ft	0.92	0.92	0.85	0.81	0.67	0.69	0.83
Hpatb, ft	0.34	0.32	0.33	0.33	0.37	0.32	0.33
Q, ft^3/day	2,135	1,962	2,866	2,289	654	2,231	2,347
dh, ft	1.32	1.32	1.26	1.23	1.12	1.09	1.30
L, ft	6.1	5.9	6.5	5.5	6.8	5.3	6.4
I, ft/ft	0.22	0.22	0.19	0.22	0.17	0.20	0.20
Assumed width of flow plume, ft	3	3	3	3	3	3	3
A, ft^2	1.025	0.95	0.975	1	1.1	0.95	0.975
k, fpd	**9,594**	**9,281**	**15,134**	**10,242**	**3,594**	**11,519**	**11,842**

Table B.29. Permeability Calculations, Ohio SPS-2.

Date:	06/06/03	06/06/03	06/06/03	06/06/03	06/06/03	06/06/03	06/06/03
SHRP Site ID:	390212	390210a	390210b	390260	390209	390261	390265
Core Hole Test Station	6 + 00	3.8	5 + 44	- 0 + 59	5 + 66	6 + 18	5 + 94
GPS Coordinates:	N 40° 23.487'	N 40° 25.539'	N 40° 23.635'	N 40° 23.662'	N 40° 24.409'	N 40° 24.535'	N 40° 24.839'
	W 83° 04.425'	W 83° 04.428'	W 83° 04.433'	W 83° 04.429'	W 83° 04.443'	W 83° 04.441'	W 83° 04.445'
Cross Slope, %:	1.7	1.5	1.6	2.1	1.5	1.2	2.0
Long. Grade, %:	0.2	0.5	0.3	0.7	0.1	0.1	0.4
Distance Measures, ft							
Core to Edge:	4.9	3.8	5.5	4.3	3.2	4.5	3.8
Core to Outlet:	0.0	6.8	6.3	10.5	5.8	7.3	9.0
Edge to Outlet:	24.0	25.0	21.3	21.0	23.2	24.0	24.6
Elevation Readings, ft							
Top of Pavt at Core:	1.79	1.94	2.02	1.83	2.04	1.98	2.00
Top of PATB after Coring:	2.71	2.65	2.75	2.85	2.77	2.94	2.96
Edge of Pavt:	1.85	1.98	2.08	1.94	2.08	2.02	2.06
Edge at Outlet:	1.85	2.00	2.10	2.00	2.08	2.04	2.08
Outlet:	6.17	5.83	6.29	6.21	6.46	5.33	6.42
Infiltration Measures							
Steady State Infiltration Rate (gal/min)	8	8	8	8	8	8	8
Time to First Outflow (min:sec)	8:50	n.a.	16:00	12:00	20:00	n.a.	n.a.
Cumulative. Inflow to Tracer Input (gal)	15 @ 1:35	15 @ 1:33	15 @ 1:28	15 @ 1:37	15 @ 1:37	25 @ 2:54	15 @ 1:40
Time to Tracer Outflow (min:sec)	8:50	n.a.	16:00	12:00	n.a.	n.a.	n.a.
Maximum Inflow Rate (gal/min)	16.4	16.2	15.9	15.8	15.9	11	15.5
Water Inflow Stopped:	Stop @ 75 gal	Stop @ 150 gal			Stop @ 125 gal	Stop @ 98 gal	Stop @ 150 gal
Cross Slope, % (elevation measures)	1.3%	1.1%	1.1%	2.5%	1.3%	0.9%	1.6%
Long. Grade, % (elevation measures)	#DIV/0!	0.3%	0.3%	0.6%	0.0%	0.3%	0.2%
Thickness of pavement above PATB (elevation measures) ft	0.92	0.71	0.73	1.02	0.73	0.96	0.96
Thickness of pavement above PATB (elevation measures) in	11.0	8.5	8.8	12.3	8.8	11.5	11.5
Thickness of pavement above PATB (LTPP database) ft	0.88	0.67	0.67	0.95	0.68	0.93	0.94
Thickness of pavement above PATB (LTPP database) in	**10.6**	**8.0**	**8.0**	**11.4**	**8.1**	**11.1**	**11.3**
Thickness of PATB (LTPP database) ft	0.37	0.34	0.34	0.33	0.33	0.35	0.32
Thickness of PATB (LTPP database) in	**4.4**	**4.1**	**4.1**	**3.9**	**4.0**	**4.2**	**3.8**
Hpavt, ft	0.92	0.71	0.73	1.02	0.73	0.96	0.96
Hpatb, ft	0.37	0.34	0.34	0.33	0.33	0.35	0.32
Q, ft^3/day	3,155	3,116	3,058	3,039	3,058	2,116	2,982
dh, ft	1.35	1.09	1.13	1.45	1.10	1.35	1.34
L, ft	4.9	3.8	5.5	4.3	3.2	4.5	3.8
I, ft/ft	0.27	0.29	0.21	0.34	0.35	0.30	0.35
Assumed width of flow plume, ft	3	3	3	3	3	3	4
A, ft^2	1.1	1.025	1.025	0.975	1	1.05	1.267
k, fpd	**10,477**	**10,443**	**14,480**	**9,136**	**8,771**	**6,717**	**6,746**

Table B.30. Permeability Calculations, Washington SPS-2.

Date:	07/10/03	07/10/03	07/10/03	07/10/03
SHRP Site ID:	530210	530211	530209	530212
Core Hole Test Station	0 - 12	0 - 56	0 - 12	5 + 12
GPS Coordinates:	N 47.06129o	N 47.06295o	N 47.06497o	N 47.06826o
	W 118.41225o	W 118.41120o	W 118.41036o	W 118.40956o
Cross Slope, %:	3.3	2.9	2.9	3.3
Long. Grade, %:	0.3	0.3	0.8	0.3
Distance Measures, ft				
Core to Edge:	19.5	17.0	18.0	16.5
Core to Outlet:	86.5	21.5	89.0	126.0
Edge to Outlet:	32.5	33.0	37.0	39.5
Elevation Readings, ft				
Top of Pavt at Core:	2.06	2.25	2.06	2.08
Top of PATB after Coring:	2.83	3.29	2.94	3.08
Edge of Pavt:	2.67	2.77	2.65	2.58
Edge at Outlet:	2.92	2.85	2.92	2.88
Outlet:	6.79	7.83	6.83	6.75
Infiltration Measures				
Steady State Infiltration Rate (gal/min)	8	8	8	8
Time to First Outflow (min:sec)	n.a.	18:50	21:25	n.a.
Cumulative Inflow to Tracer Input (gal)	15 @ 1:30	20 @ 1:58	20 @ 1:55	20 @ 2:06
Time to Tracer Outflow (min:sec)	n.a.	18:50	21:25	n.a.
Maximum Inflow Rate (gal/min)	16.4	17.2	17.2	13.6
Water Inflow Stopped:	Stop @ 152 gal	Stop @ 143 gal	Stop @ 185 gal	Stop @ 165 gal
Cross Slope, % (elevation measures)	3.1%	3.1%	3.2%	3.0%
Long. Grade, % (elevation measures)	0.3%	0.4%	0.3%	0.2%
Thickness of pavement above PATB (elevation measures) ft	0.77	1.04	0.88	1.00
Thickness of pavement above PATB (elevation measures) in	9.3	12.5	10.5	12.0
Thickness of pavement above PATB (LTPP database) ft	0.69	0.98	0.75	0.94
Thickness of pavement above PATB (LTPP database) in	**8.3**	**11.8**	**9.0**	**11.3**
Thickness of PATB (LTPP database) ft	0.32	0.33	0.33	0.29
Thickness of PATB (LTPP database) in	**3.8**	**3.9**	**3.9**	**3.5**
Hpavt, ft	0.77	1.04	0.88	1.00
Hpatb, ft	0.32	0.33	0.33	0.29
Q, ft^3/day	3,155	3,309	3,309	2,616
dh, ft	1.69	1.89	1.78	1.79
L, ft	19.5	17.0	18.0	16.5
I, ft/ft	0.09	0.11	0.10	0.11
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	0.95	0.975	0.975	0.875
k, fpd	**38,278**	**30,563**	**34,251**	**27,534**

Table B.31. Permeability Calculations, Wisconsin SPS-2.

Date:	06/09/03	06/09/03	06/09/03	06/09/03
SHRP Site ID:	550221	550224	550223	550222
Core Hole Test Station	- 0 + 97	- 0 + 72	5 + 11	5 + 41
GPS Coordinates:	N 44.828090	N 44.829250	N 44.845170	N 44.846990
	W 89.245410	W 89.247780	W 89.259790	W 89.261650
Cross Slope, %:	5.3	5.2	1.7	2.8
Long. Grade, %:	0.5	0.5	0.8	0.5
Distance Measures, ft				
Core to Edge:	4.8	4.8	18.5	18.7
Core to Outlet:	12.5	8.5	18.0	21.0
Edge to Outlet:	30.0	27.0	19.0	22.0
Elevation Readings, ft				
Top of Pavt at Core:	1.63	1.63	2.42	2.42
Top of PATB after Coring:	2.40	2.63	3.44	3.21
Edge of Pavt:	1.88	1.85	2.94	2.92
Edge at Outlet:	1.94	1.90	3.00	2.96
Outlet:	6.73	6.75	5.85	5.79
Infiltration Measures				
Steady State Infiltration Rate (gal/min)	8	8	8	8
Time to First Outflow (min:sec)	3:49	3:30	13:12	14:50
Cumulative Inflow to Tracer Input (gal)	20 @ 2:20	20 @ 2:08	15 @ 1:42	20 @ 2:10
Time to Tracer Outflow (min:sec)	4:55	4:45	13:28	14:50
Maximum Inflow Rate (gal/min)	11.5	12.2	11.4	10.6
Water Inflow Stopped:	Stop @ 42 gal	Stop @ 45 gal	Stop @ 112 gal	Stop @ 125 gal
Cross Slope, % (elevation measures)	5.3%	4.8%	2.8%	2.7%
Long. Grade, % (elevation measures)	0.5%	0.5%	0.3%	0.2%
Thickness of pavement above PATB (elevation measures) ft	0.77	1.00	1.02	0.79
Thickness of pavement above PATB (elevation measures) in	9.3	12.0	12.3	9.5
Thickness of pavement above PATB (LTPP database) ft	0.69	0.95	0.94	0.71
Thickness of pavement above PATB (LTPP database) in	**8.3**	**11.4**	**11.3**	**8.5**
Thickness of PATB (LTPP database) ft	0.31	0.26	0.35	0.33
Thickness of PATB (LTPP database) in	**3.7**	**3.1**	**4.2**	**3.9**
Hpavt, ft	0.77	1.00	1.02	0.79
Hpatb, ft	0.31	0.26	0.35	0.33
Q, ft^3/day	2,212	2,347	2,193	2,039
dh, ft	1.33	1.49	1.89	1.62
L, ft	4.8	4.8	18.5	18.7
I, ft/ft	0.28	0.31	0.10	0.09
Assumed width of flow plume, ft	3	3	3	3
A, ft^2	0.925	0.775	1.05	0.975
k, fpd	**8,546**	**9,669**	**20,424**	**24,146**

Table B.32. Permeability Calculations, MnRoad.

Date:	06/17/03	06/17/03	06/17/03	06/17/03	06/17/03
SHRP Site ID:	MnRoad10	MnRoad9	MnRoad8	MnRoad7	MnRoad12
Core Hole Test Station	4 + 90	5 + 06	5 + 05	5 + 05	n.a.
GPS Coordinates:	N 45.26502o	N 45.26837o	N 45.269926o	N 45.27013o	n.a.
	W 93.71578o	W 93.72188o	W 93.72354o	W 93.72514o	n.a.
Cross Slope, %:	1.2	1.3	2.1	1.6	n.a.
Long. Grade, %:	0.1	0.2	0.3	0.6	n.a.
Distance Measures, ft					
Core to Edge:	5.4	3.7	6.0	4.3	n.a.
Core to Outlet:	12.0	8.3	18.0	13.0	n.a.
Edge to Outlet:	21.5	21.0	21.7	20.0	n.a.
Elevation Readings, ft					
Top of Pavt at Core:	1.79	1.88	1.88	1.81	n.a.
Top of PATB after Coring:	1.65	2.54	2.58	2.46	n.a.
Edge of Pavt:	1.85	1.98	2.00	1.88	n.a.
Edge at Outlet:	1.90	1.98	2.02	1.96	n.a.
Outlet:	4.60	4.17	4.21	4.10	n.a.
Infiltration Measures					
Steady State Infiltration Rate (gal/min)	8	8	8	8	n.a.
Time to First Outflow (min:sec)	3:23	5:25	5:19	6:33	n.a.
Cumulative Inflow to Tracer Input (gal)	15 @ 1:47	15 @ 1:47	15 @ 1:29	15 @ 1:38	n.a.
Time to Tracer Outflow (min:sec)	6:50	8:40	8:20	9:00	n.a.
Maximum Inflow Rate (gal/min)	12.5	13	14.4	12	n.a.
Water Inflow Stopped:	Stop @ 41 gal	Stop @ 56 gal	Stop @ 72 gal	Stop @ 72 gal	n.a.
					n.a.
Cross Slope, % (elevation measures)	1.2%	2.8%	2.1%	1.4%	#VALUE!
Long. Grade, % (elevation measures)	0.3%	0.0%	0.1%	0.6%	#VALUE!
Thickness of pavement above PATB (elevation measures) ft	-0.15	0.67	0.71	0.65	#VALUE!
Thickness of pavement above PATB (elevation measures) in	-1.8	8.0	8.5	7.8	#VALUE!
Thickness of pavement above PATB (LTPP database) ft					0.00
Thickness of pavement above PATB (LTPP database) in					
Thickness of PATB (LTPP database) ft					0.00
Thickness of PATB (LTPP database) in					
Hpavt, ft	0.67	0.67	0.71	0.65	#VALUE!
Hpatb, ft	0.33	0.33	0.33	0.33	0.00
Q, ft^3/day	2,404	2,501	2,770	2,308	#VALUE!
dh, ft	1.06	1.10	1.16	1.04	#VALUE!
L, ft	5.4	3.7	6.0	4.3	n.a.
I, ft/ft	0.20	0.30	0.19	0.24	#VALUE!
Assumed width of flow plume, ft	3	3	3	3	3
A, ft^2	0.99	0.99	0.99	0.99	0
k, fpd	**12,382**	**8,413**	**14,430**	**9,731**	**#VALUE!**

APPENDIX C

Data Used in Regression Analyses

Table C.1. SPS-1 Test Section Identification Numbers and Design, Climate, and Backcalculation Data Used in Regression Analyses.

ID	HAC	HB	B1	B2	B3	B4	DRN	TMP	PRECIP	TMI	E SUB REG	H EQUIV
10101	7.5	7.9	0	0	0	0	0	63.2	51.5	51	28.3	9.1
10102	4.2	11.9	0	0	0	0	0	63.2	51.5	51	35.9	6.9
10103	4.6	7.4	1	0	0	0	0	63.2	51.5	51	36.0	10.6
10104	6.5	11.7	1	0	0	0	0	63.2	51.5	51	31.3	20.8
10105	4.2	7.9	0	1	0	0	0	63.2	51.5	51	34.9	8.0
10106	7.2	12.3	0	1	0	0	0	63.2	51.5	51	30.6	20.8
10107	4.6	7.7	0	0	1	0	1	63.2	51.5	51	21.5	7.2
10108	7.3	12.1	0	0	1	0	1	63.2	51.5	51	31.7	12.0
10109	7.6	16.1	0	0	1	0	1	63.2	51.5	51	38.6	15.2
10110	7.9	7.7	0	0	0	1	1	63.2	51.5	51	18.0	11.8
10111	4	11.6	0	0	0	1	1	63.2	51.5	51	26.2	12.5
10112	3.4	15.7	0	0	0	1	1	63.2	51.5	51	30.4	17.5
10161	4.1	12.1	0	1	0	0	0	63.2	51.5	51	22.1	14.2
10162	4.1	10.0	1	0	0	0	0	63.2	51.5	51	33.3	14.4
10163	4.3	16.1	0	0	0	1	1	63.2	51.5	51	34.7	14.3
40113	4.9	7.5	0	0	0	0	0	66.5	8.1	-48	60.5	7.2
40114	7.3	12.0	0	0	0	0	0	66.5	8.1	-48	108.7	12.1
40115	6.6	8.5	1	0	0	0	0	66.5	8.1	-48	48.2	19.0
40116	4.5	12.1	1	0	0	0	0	66.5	8.1	-48	87.7	19.5
40117	7.4	8.2	0	1	0	0	0	66.5	8.1	-48	52.1	16.0
40118	4.4	11.8	0	1	0	0	0	66.5	8.1	-48	72.5	15.7
40119	6.3	8.7	0	0	1	0	1	66.5	8.1	-48	50.4	12.3
40120	4.5	11.9	0	0	1	0	1	66.5	8.1	-48	80.0	10.8
40121	4.6	16.0	0	0	1	0	1	66.5	8.1	-48	72.3	13.4
40122	4.7	8.6	0	0	0	1	1	66.5	8.1	-48	89.6	12.5
40123	6.8	11.7	0	0	0	1	1	66.5	8.1	-48	51.6	20.4
40124	6.7	15.8	0	0	0	1	1	66.5	8.1	-48	72.4	26.9
40160	0	4.0	0	0	0	0	0	66.5	8.1	-48		
40161	6.2	3.8	0	0	0	0	0	66.5	8.1	-48	44.4	6.0
40162	9	0.0	0	0	0	0	0	66.5	8.1	-48	66.6	6.0
40163	1	0.0	0	0	0	0	0	66.5	8.1	-48	52.1	15.0
50113	4	8.2	0	0	0	0	0	60.1	48.1	56	23.3	6.9
50114	7	11.3	0	0	0	0	0	60.1	48.1	56	26.8	10.7
50115	6.9	7.4	1	0	0	0	0	60.1	48.1	56	30.5	16.7
50116	4.1	12.0	1	0	0	0	0	60.1	48.1	56	31.9	19.2
50117	7	8.1	0	1	0	0	0	60.1	48.1	56	27.8	12.1
50118	4.1	11.4	0	1	0	0	0	60.1	48.1	56	30.7	15.3
50119	7	7.4	0	0	1	0	1	60.1	48.1	56	24.4	12.1
50120	4.5	11.2	0	0	1	0	1	60.1	48.1	56	27.8	10.1
50121	4.5	15.2	0	0	1	0	1	60.1	48.1	56	26.3	11.5
50122	4.4	7.5	0	0	0	1	1	60.1	48.1	56	27.3	10.9
50123	7.2	11.8	0	0	0	1	1	60.1	48.1	56	33.1	17.7
50124	6.9	14.8	0	0	0	1	1	60.1	48.1	56	34.9	20.3
100101	8.1	8.1	0	0	0	0	0	55.6	45.3	79	24.5	9.1
100102	5.1	11.8	0	0	0	0	0	55.6	45.3	79	24.6	9.0
100103	5.8	8.0	1	0	0	0	0	55.6	45.3	79	23.1	14.6
100104	7.7	12.0	1	0	0	0	0	55.6	45.3	79	23.9	22.7
100105	5.4	7.8	0	1	0	0	0	55.6	45.3	79	18.6	10.1
100106	7.7	12.4	0	1	0	0	0	55.6	45.3	79	25.0	20.9
100107	5.8	7.7	0	0	1	0	1	55.6	45.3	79	25.1	8.1
100108	8	11.0	0	0	1	0	1	55.6	45.3	79	22.9	14.1
100109	8.3	16.3	0	0	1	0	1	55.6	45.3	79	21.4	18.3
100110	8.2	7.7	0	0	0	1	1	55.6	45.3	79	27.6	16.5
100111	4.7	12.6	0	0	0	1	1	55.6	45.3	79	27.8	18.9
100112	5.5	15.7	0	0	0	1	1	55.6	45.3	79	31.0	24.4
100159	6.7	14.2	0	1	0	0	0	55.6	45.3	79	20.6	17.2
100160	8.2	11.2	0	1	0	0	0	55.6	45.3	79	22.8	20.5
120101	6.8	8.1	0	0	0	0	0	73.5	52.5	3	242.1	11.2
120102	3.8	12.1	0	0	0	0	0	73.5	52.5	3	212.4	10.7
120103	4.1	8.0	1	0	0	0	0	73.5	52.5	3	155.7	13.4
120104	6.8	12.1	1	0	0	0	0	73.5	52.5	3	181.4	21.7
120105	3.9	8.0	0	1	0	0	0	73.5	52.5	3	201.0	9.4
120106	7.1	12.4	0	1	0	0	0	73.5	52.5	3	216.7	18.8
120107	3.8	8.2	0	0	1	0	1	73.5	52.5	3	205.2	8.2
120108	6.4	11.9	0	0	1	0	1	73.5	52.5	3	262.2	15.2
120109	7.3	16.0	0	0	1	0	1	73.5	52.5	3	200.6	21.5

Table C.1. (Continued).

120110	7.3	8.2	0	0	0	1	1	73.5	52.5	3	134.9	13.5
120111	3.9	12.2	0	0	0	1	1	73.5	52.5	3	136.5	14.6
120112	4	16.3	0	0	0	1	1	73.5	52.5	3	148.4	22.5
120161	4	10.2	0	0	0	0	0	73.5	52.5	3	180.4	9.0
190101	8	8.0	0	0	0	0	0	52.0	39.2	64	20.1	8.9
190102	5.1	12.0	0	0	0	0	0	52.0	39.2	64	20.7	7.4
190103	3.8	8.4	1	0	0	0	0	52.0	39.2	64	27.9	9.3
190104	7	12.4	1	0	0	0	0	52.0	39.2	64	25.1	24.8
190105	3.5	8.7	0	1	0	0	0	52.0	39.2	64	19.2	6.6
190106	6.8	13.0	0	1	0	0	0	52.0	39.2	64	21.6	21.7
190107	6.4	8.2	0	0	1	0	1	52.0	39.2	64	11.4	5.3
190108	5.9	12.6	0	0	1	0	1	52.0	39.2	64	18.3	11.0
190109	7.5	16.9	0	0	1	0	1	52.0	39.2	64	21.6	12.2
190110	7.9	7.6	0	0	0	1	1	52.0	39.2	64	16.3	9.0
190111	4.4	11.8	0	0	0	1	1	52.0	39.2	64	18.2	9.4
190112	4.6	16.6	0	0	0	1	1	52.0	39.2	64	23.7	20.7
190159	4	19.0	0	1	0	0	0	52.0	39.2	64	28.5	16.6
200101	7.6	8.5	0	0	0	0	0	55.1	25.0	3	26.3	12.5
200102	4	12.3	0	0	0	0	0	55.1	25.0	3	32.6	10.1
200103	3.6	7.7	1	0	0	0	0	55.1	25.0	3	33.7	10.0
200104	6.8	12.1	1	0	0	0	0	55.1	25.0	3	29.1	18.0
200105	3.9	7.9	0	1	0	0	0	55.1	25.0	3	33.0	7.8
200106	7.3	11.3	0	1	0	0	0	55.1	25.0	3	32.8	16.9
200107	4.1	7.8	0	0	1	0	1	55.1	25.0	3	33.5	6.8
200108	7.6	11.5	0	0	1	0	1	55.1	25.0	3	34.4	13.0
200109	7	15.5	0	0	1	0	1	55.1	25.0	3	32.0	14.6
200110	7	7.7	0	0	0	1	1	55.1	25.0	3	29.0	13.2
200111	4	12.1	0	0	0	1	1	55.1	25.0	3	30.6	16.6
200112	5	15.6	0	0	0	1	1	55.1	25.0	3	34.7	22.0
200159	10.8	0.0	0	0	0	0	0	55.1	25.0	3	34.5	13.5
200160	5.5	7.0	0	0	0	0	0	55.1	25.0	3	32.6	5.8
200161	5.5	11.0	0	0	0	0	0	55.1	25.0	3	30.8	9.6
200162	11.4	0.0	0	0	0	0	0	55.1	25.0	3	28.5	12.6
200163	1.5	10.5	0	1	0	0	0	55.1	25.0	3	25.9	5.8
200164	1.5	10.5	1	0	0	0	0	55.1	25.0	3	35.2	11.6
220113	4.9	8.1	0	0	0	0	0	68.0	59.8	38	20.7	8.6
220114	9.5	11.4	0	0	0	0	0	68.0	59.8	38	22.8	14.0
220115	7	9.0	1	0	0	0	0	68.0	59.8	38	29.3	16.5
220116	4.7	11.3	1	0	0	0	0	68.0	59.8	38	30.0	18.0
220117	7	9.2	0	1	0	0	0	68.0	59.8	38	23.5	13.5
220118	4.4	11.1	0	1	0	0	0	68.0	59.8	38	21.8	12.3
220119	7.1	8.1	0	0	1	0	1	68.0	59.8	38	23.6	14.9
220120	3.9	12.0	0	0	1	0	1	68.0	59.8	38	21.4	12.2
220121	4.3	17.1	0	0	1	0	1	68.0	59.8	38	21.6	14.3
220122	4.6	7.1	0	0	0	1	1	68.0	59.8	38	23.4	11.1
220123	6.8	11.5	0	0	0	1	1	68.0	59.8	38	28.2	16.4
220124	7.2	14.2	0	0	0	1	1	68.0	59.8	38	36.6	21.2
260113	4.4	8.0	0	0	0	0	0	47.8	31.7	73		
260114	6.6	12.0	0	0	0	0	0	47.8	31.7	73		
260115	5.9	9.6	1	0	0	0	0	47.8	31.7	73	42.1	19.2
260116	3.9	12.0	1	0	0	0	0	47.8	31.7	73	42.8	18.0
260117	6.4	9.2	0	1	0	0	0	47.8	31.7	73	41.0	13.4
260118	3.5	12.3	0	1	0	0	0	47.8	31.7	73	40.4	14.2
260119	6.5	8.0	0	0	1	0	1	47.8	31.7	73		
260120	3.6	12.0	0	0	1	0	1	47.8	31.7	73	39.7	8.4
260121	3.9	16.0	0	0	1	0	1	47.8	31.7	73	41.0	10.7
260122	3.7	8.3	0	0	0	1	1	47.8	31.7	73		
260123	6.2	12.0	0	0	0	1	1	47.8	31.7	73	44.6	22.6
260124	6.3	16.2	0	0	0	1	1	47.8	31.7	73	48.4	28.3
260159	5.9	8.0	0	0	0	0	0	47.8	31.7	73	34.7	12.2
300113	5	0.0	0	0	0	0	0	44.8	14.2	13	27.8	4.8
300114	7.2	0.0	0	0	0	0	0	44.8	14.2	13	25.8	9.0
300115	7.5	9.1	1	0	0	0	0	44.8	14.2	13	31.5	23.3
300116	4.7	12.6	1	0	0	0	0	44.8	14.2	13	35.5	25.8
300117	7.2	9.3	0	1	0	0	0	44.8	14.2	13	25.8	18.2
300118	4.6	12.7	0	1	0	0	0	44.8	14.2	13	30.4	20.9
300119	7.6	9.0	0	0	1	0	1	44.8	14.2	13	26.6	16.0

Table C.1. (Continued).

300120	4.2	12.7	0	0	1	0	1	44.8	14.2	13	22.1	11.6
300121	4.4	16.8	0	0	1	0	1	44.8	14.2	13	26.3	13.7
300122	4.6	8.4	0	0	0	1	1	44.8	14.2	13	21.7	14.6
300123	7.5	12.9	0	0	0	1	1	44.8	14.2	13	33.6	25.9
300124	7.1	17.9	0	0	0	1	1	44.8	14.2	13	40.7	33.0
310113	4.4	8.0	0	0	0	0	0	52.5	29.5	23	16.4	5.0
310114	6.7	12.0	0	0	0	0	0	52.5	29.5	23	17.1	6.5
310115	6.5	8.6	1	0	0	0	0	52.5	29.5	23	20.5	9.1
310116	4.1	12.2	1	0	0	0	0	52.5	29.5	23	19.5	12.2
310117	6.9	7.9	0	1	0	0	0	52.5	29.5	23	15.6	8.3
310118	3.9	12.1	0	1	0	0	0	52.5	29.5	23	23.1	10.9
310119	7.2	8.0	0	0	1	0	1	52.5	29.5	23	22.2	8.1
310120	4.2	12.0	0	0	1	0	1	52.5	29.5	23	17.4	8.2
310121	4.3	16.0	0	0	1	0	1	52.5	29.5	23	18.5	9.4
310122	3.8	8.2	0	0	0	0	0	52.5	29.5	23	24.6	7.8
310123	7	12.0	0	0	0	1	1	52.5	29.5	23	23.0	13.4
310124	7.4	13.9	0	0	0	1	1	52.5	29.5	23	25.4	15.9
320101	7.2	8.5	0	0	0	0	0	49.7	9.0	-23	39.1	10.2
320102	4.3	11.7	0	0	0	0	0	49.7	9.0	-23	35.3	7.5
320103	4.1	8.8	1	0	0	0	0	49.7	9.0	-23	40.1	7.5
320104	7.3	12.4	1	0	0	0	0	49.7	9.0	-23	44.5	17.4
320105	4.2	8.4	0	1	0	0	0	49.7	9.0	-23	35.4	6.7
320106	7.2	12.5	0	1	0	0	0	49.7	9.0	-23	39.6	16.1
320107	4.4	7.9	0	0	1	0	1	49.7	9.0	-23	35.4	7.0
320108	7	12.2	0	0	1	0	1	49.7	9.0	-23	38.1	12.0
320109	7	16.1	0	0	1	0	1	49.7	9.0	-23	41.1	14.4
320110	6.6	8.6	0	0	0	1	1	49.7	9.0	-23	35.5	11.5
320111	4.1	12.8	0	0	0	1	1	49.7	9.0	-23	43.2	24.1
320112	4.5	16.6	0	0	0	1	1	49.7	9.0	-23	36.2	14.3
350101	7.2	7.9	0	0	0	0	0	60.4	10.6	-39	35.1	8.5
350102	4.8	12.2	0	0	0	0	0	60.4	10.6	-39	45.9	8.3
350103	5.3	7.2	1	0	0	0	0	60.4	10.6	-39	24.9	8.0
350104	8.1	11.1	1	0	0	0	0	60.4	10.6	-39	58.6	11.6
350105	5.9	7.7	0	1	0	0	0	60.4	10.6	-39	94.2	6.1
350106	7.6	10.9	0	1	0	0	0	60.4	10.6	-39	37.2	9.6
350107	5.9	7.7	0	0	1	0	1	60.4	10.6	-39	27.8	7.9
350108	7.8	12.2	0	0	1	0	1	60.4	10.6	-39	25.2	11.6
350109	8	16.4	0	0	1	0	1	60.4	10.6	-39	27.2	12.8
350110	7.9	8.3	0	0	0	1	1	60.4	10.6	-39	49.0	8.1
350111	4.9	11.3	0	0	0	1	1	60.4	10.6	-39	53.6	8.1
350112	5	14.8	0	0	0	1	1	60.4	10.6	-39	70.3	10.1
390101	6.9	8.0	0	0	0	0	0	50.2	38.3	87	28.5	7.7
390102	3.9	11.8	0	0	0	0	0	50.2	38.3	87	22.9	5.9
390103	4.1	8.0	1	0	0	0	0	50.2	38.3	87	23.2	7.8
390104	7.2	11.8	1	0	0	0	0	50.2	38.3	87	31.5	18.3
390105	3.7	7.7	0	1	0	0	0	50.2	38.3	87	26.6	6.7
390106	6.8	11.8	0	1	0	0	0	50.2	38.3	87	27.8	16.1
390107	3.8	8.0	0	0	1	0	1	50.2	38.3	87	27.0	5.7
390108	6.6	12.0	0	0	1	0	1	50.2	38.3	87	26.2	12.2
390109	7	15.9	0	0	1	0	1	50.2	38.3	87	29.4	13.8
390110	7.3	7.6	0	0	0	1	1	50.2	38.3	87	28.1	9.8
390111	4	12.1	0	0	0	1	1	50.2	38.3	87	28.7	13.0
390112	4	15.8	0	0	0	1	1	50.2	38.3	87	28.8	17.6
390159	4.1	4.0	0	0	0	0	0	50.2	38.3	87	48.4	24.5
390160	4.1	14.9	0	1	0	0	0	50.2	38.3	87	32.0	17.4
400113	4.5	7.9	0	0	0	0	0	61.7	30.7	-2	26.8	7.1
400114	8.1	11.3	0	0	0	0	0	61.7	30.7	-2	123.7	14.3
400115	7.5	9.0	1	0	0	0	0	61.7	30.7	-2	49.1	24.7
400116	4.2	11.7	1	0	0	0	0	61.7	30.7	-2	196.1	21.9
400117	7.8	8.0	0	1	0	0	0	61.7	30.7	-2	62.8	16.8
400118	4.6	11.9	0	1	0	0	0	61.7	30.7	-2	143.4	17.3
400119	7.5	8.3	0	0	1	0	1	61.7	30.7	-2	59.2	16.1
400120	4.8	12.7	0	0	1	0	1	61.7	30.7	-2	31.1	13.1
400121	4.2	16.0	0	0	1	0	1	61.7	30.7	-2	79.7	13.1
400122	4.3	8.7	0	0	0	1	1	61.7	30.7	-2	33.5	17.3
400123	7.3	13.1	0	0	0	1	1	61.7	30.7	-2	59.7	25.7
400124	7.4	15.2	0	0	0	1	1	61.7	30.7	-2	46.7	31.0

Table C.1. (Continued).

400160	0	0.0	0	0	0	0	0	61.7	30.7	-2	38.8	0.0
480113	5.2	7.8	0	0	0	0	0	54.9	22.1	4	40.2	9.8
480114	6.9	12.2	0	0	0	0	0	54.9	22.1	4	52.5	15.9
480115	7.4	7.6	1	0	0	0	0	54.9	22.1	4	44.1	19.2
480116	5.8	10.9	1	0	0	0	0	54.9	22.1	4	44.2	19.6
480117	7.4	7.3	0	1	0	0	0	54.9	22.1	4	44.9	13.4
480118	4.8	10.3	0	1	0	0	0	54.9	22.1	4	46.8	16.6
480119	7.4	7.5	0	0	1	0	1	54.9	22.1	4	47.3	15.4
480120	4.7	11.4	0	0	1	0	1	54.9	22.1	4	51.5	14.8
480121	4.5	15.5	0	0	1	0	1	54.9	22.1	4	58.0	15.9
480122	4.6	8.8	0	0	0	1	1	54.9	22.1	4	38.1	13.1
480123	5.3	12.2	0	0	0	1	1	54.9	22.1	4	57.7	20.6
480124	6.4	15.0	0	0	0	1	1	54.9	22.1	4	77.7	27.0
480160	5.5	10.6	0	0	0	0	0	54.9	22.1	4	50.7	15.7
480161	4.8	8.3	0	0	0	0	0	54.9	22.1	4	52.6	14.1
480162	5	8.0	0	0	0	0	0	54.9	22.1	4	45.1	10.3
480163	4.8	10.2	0	0	0	0	0	54.9	22.1	4	41.8	10.8
480164	4.3	9.4	0	0	0	0	0	54.9	22.1	4	40.5	9.8
480165	4.6	7.3	0	0	0	0	0	54.9	22.1	4	38.8	10.3
480166	5.3	13.5	0	0	0	0	0	54.9	22.1	4	48.6	12.4
480167	4.9	13.0	0	0	0	0	0	54.9	22.1	4	48.5	12.1
510113	4	7.9	0	0	0	0	0	57.5	44.2	106	24.3	5.3
510114	7.2	11.9	0	0	0	0	0	57.5	44.2	106	21.9	9.5
510115	6.4	8.6	1	0	0	0	0	57.5	44.2	106	30.5	21.7
510116	4.5	12.4	1	0	0	0	0	57.5	44.2	106	34.3	24.2
510117	6.6	7.9	0	1	0	0	0	57.5	44.2	106	15.7	14.5
510118	4.1	11.4	0	1	0	0	0	57.5	44.2	106	23.7	16.2
510119	6.4	8.3	0	0	1	0	1	57.5	44.2	106	18.9	14.5
510120	4.1	12.1	0	0	1	0	1	57.5	44.2	106	22.6	10.8
510121	3.7	16.8	0	0	1	0	1	57.5	44.2	106	33.5	12.3
510122	3.9	7.8	0	0	0	1	1	57.5	44.2	106	18.3	14.9
510123	6.5	12.2	0	0	0	1	1	57.5	44.2	106	26.7	22.9
510124	6.3	15.9	0	0	0	1	1	57.5	44.2	106	40.4	27.7
510159	3.4	16.9	0	0	0	1	1	57.5	44.2	106	13.5	17.6
550113	5.5	8.0	0	0	0	0	0	42.6	32.1	106	34.5	7.7
550114	8.1	11.0	0	0	0	0	0	42.6	32.1	106	30.1	9.8
550115	7.3	7.5	1	0	0	0	0	42.6	32.1	106	34.2	14.0
550116	4.1	12.0	1	0	0	0	0	42.6	32.1	106	46.8	10.9
550117	6.4	7.8	0	1	0	0	0	42.6	32.1	106	33.9	12.0
550118	4	13.3	0	1	0	0	0	42.6	32.1	106	46.5	11.4
550119	6.6	7.4	0	0	1	0	1	42.6	32.1	106	24.9	9.1
550120	3.9	12.8	0	0	1	0	1	42.6	32.1	106	43.3	8.4
550121	4.2	17.5	0	0	1	0	1	42.6	32.1	106	26.2	11.7
550122	4.5	9.7	0	0	0	1	1	42.6	32.1	106	42.4	8.7
550123	6.8	12.4	0	0	0	1	1	42.6	32.1	106	31.1	17.3
550124	7.1	15.0	0	0	0	1	1	42.6	32.1	106	38.3	20.1

Table C.2. SPS-1 Test Section Identification Numbers and Performance Data Used in Regression Analyses.

ID	LAST IRI	DELTA IRI	LAST RUT	DELTA RUT	LAST CRACK	DELTA CRACK	FIRST IRI	FIRST RUT	FIRST CRACK
10101	0.804	0.147	6	2	12.2	12.2	0.657	4	0.0
10102	3.296	2.329	12	7	26.1	26.1	0.967	5	0.0
10103	0.773	-0.006	7	4	7.2	7.2	0.778	3	0.0
10104	0.601	0.051	7	3	1.8	1.8	0.550	4	0.0
10105	0.633	0.062	9	4	19.0	19.0	0.572	5	0.0
10106	0.692	-0.249	9	4	4.9	4.9	0.940	5	0.0
10107	0.954	-0.003	9	2	3.3	3.3	0.957	7	0.0
10108	0.713	-0.312	7	2	16.7	16.7	1.025	5	0.0
10109	0.701	0.007	7	2	20.7	20.7	0.694	5	0.0
10110	0.639	-0.010	7	-1	14.0	14.0	0.649	8	0.0
10111	0.592	0.065	8	3	15.6	15.6	0.527	5	0.0
10112	0.705	-0.293	9	4	3.0	3.0	0.998	5	0.0
10161	0.774	0.124	8	3	16.0	16.0	0.650	5	0.0
10162	0.845	-0.286	8	3	3.3	3.3	1.131	5	0.0
10163	0.856	-0.041	8	2	10.7	10.7	0.897	6	0.0
40113	1.334	0.180	5	1	1.2	1.2	1.154	4	0.0
40114	0.844	0.107	5	-3	0.0	0.0	0.737	8	0.0
40115	1.285	0.576	3	0	0.9	0.9	0.709	3	0.0
40116	0.919	0.109	4	-2	1.0	1.0	0.810	6	0.0
40117	0.814	0.075	5	-1	0.7	0.7	0.739	6	0.0
40118	1.165	0.099	5	-2	0.0	0.0	1.066	7	0.0
40119	1.223	0.068	10	-1	3.7	3.7	1.154	11	0.0
40120	1.025	0.010	5	-1	0.0	0.0	1.015	6	0.0
40121	1.043	0.119	5	-1	0.0	0.0	0.924	6	0.0
40122	1.221	-0.007	5	-1	0.0	0.0	1.228	6	0.0
40123	1.471	0.637	5	-1	0.3	0.3	0.834	6	0.0
40124	1.475	0.882	4	-2	3.2	3.2	0.593	6	0.0
40160	1.691	0.163				0.0	1.528	4	
40161	1.204	0.033	4	-2	0.0	0.0	1.171	6	0.0
40162	1.260	-0.080	3	-3	0.0	0.0	1.340	6	0.0
40163	1.683	0.663	4	0	0.0	0.0	1.020	4	0.0
50113	1.280	0.414	4	-2	6.9	6.8	0.866	6	0.1
50114	0.968	0.176	7	2	10.6	10.6	0.792	5	0.0
50115	0.957	0.105	7	3	4.0	4.0	0.852	4	0.0
50116	0.981	-0.073	9	3	2.8	2.8	1.054	6	0.0
50117	0.951	0.096	6	2	4.5	4.5	0.856	4	0.0
50118	0.866	0.109	7	2	5.1	5.1	0.757	5	0.0
50119	1.549	0.795	7	1	28.7	28.7	0.754	6	0.0
50120	1.823	0.894	6	0	11.9	11.9	0.929	6	0.0
50121	1.289	0.490	7	1	18.1	18.1	0.799	6	0.0
50122	0.845	0.157	7	1	3.6	3.6	0.687	6	0.0
50123	0.912	0.107	7	2	1.8	1.8	0.805	5	0.0
50124	0.944	0.095	7	0	3.1	3.1	0.849	7	0.0
100101	0.957	0.096	6	5	16.3	16.3	0.861	1	0.0
100102	0.961	-0.046	7	3	20.4	18.6	1.007	4	1.8
100103	0.741	0.005	4	3	0.1	0.1	0.736	1	0.0
100104	0.806	-0.058	4	3	8.3	8.3	0.864	1	0.0
100105	0.936	0.200	6	4	5.3	5.3	0.736	2	0.0
100106	0.661	-0.015	3	2	5.6	5.6	0.676	1	0.0
100107	0.974	0.346	4	3	12.8	12.8	0.628	1	0.0
100108	0.739	0.014	4	3	0.7	0.7	0.725	1	0.0
100109	0.721	-0.018	3	1	2.2	2.2	0.739	2	0.0
100110	0.652	-0.026	4	3	0.0	0.0	0.678	1	0.0
100111	0.647	-0.029	3	2	8.2	8.2	0.677	1	0.0
100112	0.569	-0.034	3	2	0.0	0.0	0.603	1	0.0
100159	0.645	-0.026	3	2	6.8	6.8	0.671	1	0.0
100160	0.705	-0.186	3	2	0.0	0.0	0.891	1	0.0
120101	0.980	0.007	5	1	0.0	0.0	0.973	4	0.0
120102	0.976	0.108	3	1	0.0	0.0	0.868	2	0.0
120103	0.975	0.106	6	0	0.1	0.1	0.869	6	0.0
120104	0.836	0.056	5	1	0.0	0.0	0.780	4	0.0
120105	0.944	0.212	5	0	0.2	0.2	0.732	5	0.0
120106	0.729	0.088	5	0	0.0	0.0	0.642	5	0.0
120107	0.971	0.080	6	2	0.3	0.3	0.891	4	0.0
120108	1.009	-0.091	4	0	0.1	0.1	1.100	4	0.0

Table C.2. (Continued).

120109	0.785	0.011	3	-1	0.0	0.0	0.774	4	0.0
120110	1.042	0.032	5	1	0.0	0.0	1.010	4	0.0
120111	0.899	0.066	6	2	0.0	0.0	0.833	4	0.0
120112	0.791	0.005	4	1	0.0	0.0	0.786	3	0.0
120161	1.342	0.005	3	-1	0.0	0.0	1.336	4	0.0
190101	1.905	0.568	4	1	0.0	0.0	1.337	3	0.0
190102	2.609	1.722	4	2	0.0	0.0	0.887	2	0.0
190103	1.335	0.615	2	0	0.2	0.2	0.720	2	0.0
190104	1.227	0.462	3	2	0.0	0.0	0.765	1	0.0
190105	1.423	0.368	3	0	0.0	0.0	1.054	3	0.0
190106	1.276	0.395	4	2	0.2	0.2	0.881	2	0.0
190107	1.158	0.182	6	-1	0.0	0.0	0.976	7	0.0
190108	1.939	1.104	7	1	0.0	0.0	0.834	6	0.0
190109	1.001	0.286	5	1	0.0	0.0	0.715	4	0.0
190110	1.545	0.646	3	1	0.0	0.0	0.899	2	0.0
190111	1.238	0.491	3	1	0.0	0.0	0.747	2	0.0
190112	1.013	0.322	3	-1	0.0	0.0	0.691	4	0.0
190159	0.883	0.244	3	1	1.6	1.6	0.639	2	0.0
200101	1.491	0.560	17	16	3.5	3.5	0.931	1	0.0
200102	1.344	0.213	29	28	5.7	5.7	1.130	1	0.0
200103	1.011	0.155	3	2	0.0	0.0	0.856	1	0.0
200104	1.052	0.245	2	1	0.0	0.0	0.807	1	0.0
200105	1.049	0.065	4	3	0.0	0.0	0.985	1	0.0
200106	0.564	-0.243	2	1	0.0	0.0	0.807	1	0.0
200107	1.142	0.445	19	18	7.9	7.9	0.697	1	0.0
200108	0.590	-0.206	2	1	0.0	0.0	0.796	1	0.0
200109	0.480	-0.235	1	0	0.0	0.0	0.715	1	0.0
200110	0.563	-0.152	1	0	0.0	0.0	0.715	1	0.0
200111	0.524	-0.280	1	0	0.0	0.0	0.804	1	0.0
200112	0.510	-0.477	1	0	0.0	0.0	0.987	1	0.0
200159	0.783	-0.262	2	0	0.0	0.0	1.044	2	0.0
200160		-2.548	19	18	26.5	26.5	2.548	1	0.0
200161	0.919	0.089	6	5	2.0	2.0	0.830	1	0.0
200162	0.757	-0.157	2	1	0.0	0.0	0.914	1	0.0
200163		0.000	5	4	0.0	0.0		1	0.0
200164	0.677	-0.381	9	8	0.0	0.0	1.057	1	0.0
220113		0.000	4	2	0.0	0.0		2	0.0
220114		0.000	4	2	0.0	0.0		2	0.0
220115		0.000	5	3	0.0	0.0		2	0.0
220116		0.000	5	3	0.0	0.0		2	0.0
220117		0.000	6	3	0.0	0.0		3	0.0
220118		0.000	4	1	0.0	0.0		3	0.0
220119		0.000	3	1	0.0	0.0		2	0.0
220120		0.000	4	2	0.0	0.0		2	0.0
220121		0.000	4	3	0.0	0.0		1	0.0
220122		0.000	2	0	0.0	0.0		2	0.0
220123		0.000	3	1	0.0	0.0		2	0.0
220124		-0.677	4	2	0.0	0.0	0.677	2	0.0
260113		0.000		0		0.0			
260114		0.000		0		0.0			
260115	0.768	0.056	2	1	0.0	0.0	0.712	1	0.0
260116	0.589	0.063	2	-1	0.0	0.0	0.525	3	0.0
260117	0.753	0.039	4	0	0.0	0.0	0.715	4	0.0
260118	1.273	0.397	5	4	0.0	0.0	0.877	1	0.0
260119		0.000		0		0.0			
260120	0.914	0.084	6	5	0.0	0.0	0.830	1	0.0
260121	1.022	-0.071	5	4	0.0	0.0	1.093	1	0.0
260122		0.000		0		0.0			
260123	0.651	0.187	2	1	0.0	0.0	0.464	1	0.0
260124	0.769	0.084	3	2	0.0	0.0	0.685	1	0.0
260159	0.898	0.011	3	-1	0.0	0.0	0.887	4	0.0
300113	1.191	0.506	6	5	8.0	8.0	0.685	1	0.0
300114	0.987	0.265	4	3	8.4	8.4	0.722	1	0.0
300115	0.861	0.127	3	2	11.6	11.6	0.734	1	0.0
300116	0.784	0.078	4	3	1.5	1.5	0.706	1	0.0
300117	1.022	0.362	3	1	12.1	12.1	0.661	2	0.0
300118	0.663	0.133	3	1	1.0	1.0	0.531	2	0.0

Table C.2. (Continued).

300119	1.350	0.297	4	2	8.6	8.6	1.053	2	0.0
300120	1.659	0.461	7	5	21.9	21.9	1.198	2	0.0
300121	1.720	0.588	8	7	19.4	19.4	1.131	1	0.0
300122	1.148	0.439	5	4	21.2	21.2	0.709	1	0.0
300123	1.030	0.249	4	2	4.1	4.1	0.781	2	0.0
300124	0.949	0.180	3	2	2.7	2.7	0.769	1	0.0
310113	1.978	0.489	29	28	0.0	0.0	1.489	1	0.0
310114	1.036	-0.061	14	13	0.0	0.0	1.097	1	0.0
310115	1.018	-0.074	14	13	0.0	0.0	1.092	1	0.0
310116	0.918	-0.125	6	5	0.0	0.0	1.043	1	0.0
310117	0.855	-0.216	7	6	0.0	0.0	1.071	1	0.0
310118	0.859	-0.307	11	10	0.0	0.0	1.166	1	0.0
310119	1.067	-0.138	5	4	0.0	0.0	1.205	1	0.0
310120	1.185	-0.142	7	6	0.0	0.0	1.327	1	0.0
310121	1.294	0.052	5	4	0.0	0.0	1.242	1	0.0
310122	1.075	-0.085	5	4	0.0	0.0	1.160	1	0.0
310123	0.735	-0.147	14	13	0.0	0.0	0.882	1	0.0
310124	1.009	0.054	14	13	0.0	0.0	0.955	1	0.0
320101	0.897	-0.011	2	1	0.2	0.2	0.908	1	0.0
320102	3.070	2.317	5	3	11.9	11.9	0.753	2	0.0
320103	0.723	-0.046	4	2	0.3	0.3	0.769	2	0.0
320104	0.737	-0.008	2	0	0.0	0.0	0.745	2	0.0
320105	0.783	-0.037	5	3	0.3	0.3	0.820	2	0.0
320106	0.711	-0.007	3	2	0.0	0.0	0.718	1	0.0
320107	1.019	0.120	3	1	0.3	0.3	0.899	2	0.0
320108	0.768	0.005	3	2	0.0	0.0	0.763	1	0.0
320109	0.672	-0.029	3	0	0.2	0.2	0.701	3	0.0
320110	0.750	0.020	3	1	0.2	0.2	0.730	2	0.0
320111	0.757	-0.015	4	3	0.0	0.0	0.771	1	0.0
320112	0.869	0.001	5	3	0.0	0.0	0.868	2	0.0
350101	1.002	0.383	6	1	0.2	0.2	0.619	5	0.0
350102	1.236	0.467	7	2	0.9	0.9	0.769	5	0.0
350103	1.437	0.763	6	1	0.0	0.0	0.675	5	0.0
350104	0.912	0.288	7	1	0.1	0.1	0.625	6	0.0
350105	0.875	0.287	7	1	0.0	0.0	0.588	6	0.0
350106	0.941	0.298	7	3	0.0	0.0	0.643	4	0.0
350107	1.255	0.536	7	2	0.2	0.2	0.719	5	0.0
350108	1.030	0.152	7	2	0.0	0.0	0.878	5	0.0
350109	0.903	0.311	7	1	0.1	0.1	0.592	6	0.0
350110	0.754	0.099	8	3	0.0	0.0	0.655	5	0.0
350111	0.651	0.183	7	2	0.0	0.0	0.468	5	0.0
350112	1.403	0.651	6	1	0.0	0.0	0.752	5	0.0
390101	4.584	3.232	13	6	0.0	0.0	1.352	7	0.0
390102	3.548	2.187	20	18	0.0	0.0	1.360	2	0.0
390103	3.294	1.647	11	9	0.5	0.5	1.647	2	0.0
390104	1.470	0.743	3	-1	0.2	0.2	0.727	4	0.0
390105	1.983	0.871	7	3	0.0	0.0	1.112	4	0.0
390106	1.992	0.866	3	0	0.0	0.0	1.126	3	0.0
390107	1.769	0.469	8	6	0.0	0.0	1.301	2	0.0
390108	2.012	1.054	11	7	0.0	0.0	0.958	4	0.0
390109	1.834	1.091	9	6	0.0	0.0	0.744	3	0.0
390110	1.672	0.376	3	0	0.0	0.0	1.296	3	0.0
390111	1.575	0.782	3	0	0.3	0.3	0.793	3	0.0
390112	1.597	0.688	4	0	0.0	0.0	0.909	4	0.0
390159	1.253	0.268	3	-1	19.8	19.8	0.985	4	0.0
390160	2.377	1.101	3	1	0.3	0.3	1.276	2	0.0
400113	1.216	0.207	11	9	0.5	0.5	1.009	2	0.0
400114	1.004	0.091	4	3	2.3	2.3	0.913	1	0.0
400115	1.184	0.059	7	4	0.0	0.0	1.124	3	0.0
400116	0.890	-0.006	5	2	0.9	0.9	0.896	3	0.0
400117	1.063	0.116	8	3	0.0	0.0	0.946	5	0.0
400118	0.905	0.123	4	2	0.3	0.3	0.782	2	0.0
400119	0.769	-0.022	5	2	0.5	0.5	0.791	3	0.0
400120	0.709	0.033	6	3	1.9	1.9	0.676	3	0.0
400121	0.817	0.007	5	2	3.1	3.1	0.810	3	0.0
400122	0.928	0.050	8	6	1.5	1.5	0.878	2	0.0
400123	0.703	0.061	5	2	1.4	1.4	0.642	3	0.0

Table C.2. (Continued).

400124	0.878	0.119	4	2	0.2	0.2	0.759	2	0.0
400160	1.294	-0.004	6	4	0.0	0.0	1.298	2	0.0
480113	0.951	-0.111	2	-3	0.0	0.0	1.062	5	0.0
480114	0.973	0.255	2	-5	0.0	0.0	0.718	7	0.0
480115	1.155	0.419	6	-7	0.0	0.0	0.736	13	0.0
480116	0.951	0.012	2	-12	0.0	0.0	0.939	14	0.0
480117	1.110	0.424	2	-2	0.0	0.0	0.686	4	0.0
480118	1.193	0.236	3	-4	0.0	0.0	0.957	7	0.0
480119	1.084	0.307	2	-7	0.0	0.0	0.777	9	0.0
480120	1.149	0.432	2	-4	0.0	0.0	0.716	6	0.0
480121	1.077	0.376	2	-4	0.0	0.0	0.701	6	0.0
480122	1.064	0.274	2	-4	0.0	0.0	0.790	6	0.0
480123	1.040	0.371	2	-7	0.0	0.0	0.669	9	0.0
480124	0.831	-0.053	2	-9	0.0	0.0	0.884	11	0.0
480160	1.186	0.384	3	-3	0.0	0.0	0.802	6	0.0
480161	1.305	0.280	5	0	0.0	0.0	1.025	5	0.0
480162	1.111	0.372	2	-5	0.0	0.0	0.739	7	0.0
480163	1.139	0.256	2	-5	0.0	0.0	0.883	7	0.0
480164	0.945	0.111	3	-3	0.0	0.0	0.834	6	0.0
480165	1.125	0.331	2	-4	0.0	0.0	0.794	6	0.0
480166	0.837	-0.013	6	3	0.0	0.0	0.849	3	0.0
480167	1.085	0.225	3	-3	0.8	0.8	0.860	6	0.0
510113	1.763	0.772	19	18	55.6	55.6	0.991	1	0.0
510114	1.007	0.054	5	4	29.0	29.0	0.953	1	0.0
510115	0.980	0.044	4	3	15.8	15.8	0.936	1	0.0
510116	0.888	-0.020	4	3	15.1	15.1	0.908	1	0.0
510117	0.942	0.025	5	4	27.3	27.3	0.916	1	0.0
510118	1.053	0.063	5	4	35.4	35.4	0.989	1	0.0
510119	1.099	0.174	4	3	9.8	9.8	0.925	1	0.0
510120	1.260	0.195	4	3	5.2	5.2	1.065	1	0.0
510121	1.033	0.037	3	2	8.4	8.4	0.996	1	0.0
510122	0.937	-0.002	3	2	17.3	17.3	0.939	1	0.0
510123	0.893	0.040	3	2	16.5	16.5	0.853	1	0.0
510124	0.901	0.133	4	3	15.5	15.5	0.768	1	0.0
510159	1.016	0.049	3	1	8.4	8.4	0.966	2	0.0
550113	0.940	0.064	6	4	0.5	0.5	0.876	2	0.0
550114	0.982	0.148	6	5	5.8	5.8	0.834	1	0.0
550115	1.255	0.349	8	7	0.0	0.0	0.907	1	0.0
550116	1.174	0.399	10	8	2.8	2.8	0.775	2	0.0
550117	1.151	0.387	8	7	0.0	0.0	0.764	1	0.0
550118	1.025	0.332	9	8	0.0	0.0	0.693	1	0.0
550119	0.956	0.150	7	2	0.0	0.0	0.806	5	0.0
550120	0.752	0.046	5	4	0.0	0.0	0.706	1	0.0
550121	0.775	-0.053	6	5	0.0	0.0	0.828	1	0.0
550122	0.913	0.247	7	4	0.0	0.0	0.667	3	0.0
550123	1.122	0.359	7	6	0.0	0.0	0.763	1	0.0
550124	1.144	0.340	8	7	0.0	0.0	0.804	1	0.0

Table C.3. SPS-1 Test Section Identification Numbers and ESAL and Age Data Used in Regression Analyses.

ID	CESAL LAST IRI	CESAL DELTA IRI	TIME LAST IRI	TIME DELTA IRI	CESAL LAST RUT	CESAL DELTA RUT	TIME LAST RUT	TIME DELTA RUT	CESAL LAST CRACK	CESAL DELTA CRACK	TIME LAST CRACK	TIME DELTA CRACK
10101			11.16	8.49		0	10.98	9.88		0.00	10.98	9.88
10102			11.16	9.67		0	10.98	9.88		0.00	10.98	9.88
10103			11.16	8.30		0	10.98	9.88		0.00	10.98	9.88
10104			11.16	8.30		0	10.97	9.87		0.00	10.97	9.87
10105			11.16	8.30		0	10.98	9.88		0.00	10.98	9.88
10106			11.16	9.67		0	10.97	9.87		0.00	10.97	9.87
10107			8.04	6.55		0	8.02	6.92		0.00	8.02	6.92
10108			11.16	9.68		0	10.97	9.87		0.00	10.97	9.87
10109			11.16	8.30		0	10.97	9.87		0.00	10.97	9.87
10110			11.16	8.30		0	10.97	9.87		0.00	10.97	9.87
10111			9.02	6.16		0	10.97	9.87		0.00	10.97	9.87
10112			11.16	9.67		0	10.97	9.87		0.00	10.97	9.87
10161			11.16	8.30		0	10.98	9.88		0.00	10.98	9.88
10162			11.16	9.67		0	10.97	9.87		0.00	10.97	9.87
10163			11.16	10.71		0	10.97	9.87		0.00	10.97	9.87
40113	2.96	2.86	11.10	10.61	2.84	2.49	10.72	9.06	2.66	2.33	10.62	9.06
40114	2.96	2.86	11.10	10.61	2.84	2.49	10.72	9.06	2.66	2.34	10.60	9.06
40115	2.8	2.7	10.61	10.12	2.83	2.51	10.72	9.17	2.51	2.19	10.71	9.17
40116	2.8	2.7	10.61	10.12	2.84	2.49	10.72	9.06	2.51	2.18	10.61	9.06
40117	2.8	2.7	10.61	10.12	2.83	2.48	10.72	9.06	2.51	2.19	10.60	9.06
40118	2.8	2.7	10.61	10.12	2.84	2.49	10.72	9.06	2.51	2.18	10.61	9.06
40119	2.8	2.7	10.61	10.12	2.84	2.52	10.72	9.17	2.51	2.19	10.72	9.17
40120	2.8	2.7	10.61	10.12	2.84	2.49	10.72	9.06	2.51	2.18	10.62	9.06
40121	2.8	2.7	10.61	10.12	2.94	2.59	11.03	9.37	2.51	2.18	10.93	9.37
40122	2.8	2.7	10.61	10.12	2.84	2.49	10.72	9.06	2.51	2.18	10.61	9.06
40123	2.8	2.7	10.61	10.12	2.84	2.49	10.72	9.06	2.51	2.19	10.60	9.06
40124	2.8	2.7	10.61	10.12	2.83	2.48	10.72	9.06	2.51	2.19	10.60	9.06
40160	2.8	2.7	10.61	10.12						0.00		
40161	2.8	2.7	10.61	10.12	2.69	2.34	10.26	8.60	2.36	2.03	10.16	8.60
40162	2.8	2.7	10.61	10.12	2.69	2.34	10.26	8.60	2.36	2.03	10.16	8.60
40163	2.8	2.7	10.61	10.12	2.69	2.34	10.26	8.60	2.36	2.03	10.16	8.60
50113	5.26	5.1	9.55	8.70	5.24	4.98	9.53	8.27	5.24	4.98	9.53	8.27
50114	5.26	5.1	9.55	8.70	5.24	4.98	9.53	8.27	5.24	4.98	9.53	8.27
50115	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50116	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50117	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50118	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50119	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50120	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50121	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50122	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50123	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
50124	5.26	5.1	9.55	8.70	5.22	4.96	9.51	8.25	5.22	4.96	9.51	8.25
100101	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100102	3.41	3.48	7.30	7.49	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100103	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100104	3.41	2.97	7.30	6.20	3.38	3.3	7.27	7.06	3.39	3.31	7.27	7.06
100105	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100106	3.41	2.97	7.30	6.20	3.38	3.3	7.27	7.06	3.39	3.31	7.27	7.06
100107	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100108	3.41	2.97	7.30	6.20	3.39	3.31	7.27	7.06	3.39	3.31	7.26	7.06
100109	3.41	2.97	7.30	6.20	3.39	3.31	7.27	7.06	3.39	3.31	7.27	7.06
100110	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100111	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100112	3.41	2.97	7.30	6.20	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
100159	3.41	2.97	7.30	6.20	3.58	3.5	7.62	7.41	3.39	3.31	7.62	7.41
100160	3.41	3.17	7.30	6.71	3.38	3.3	7.26	7.06	3.38	3.30	7.26	7.06
120101	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.19	3.27	2.73	5.33	4.19
120102	3.78	3.19	8.43	7.19	3.79	1.82	8.47	4.21	3.27	2.73	5.34	4.21

Table C.3. (Continued).

120103	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.19	3.27	2.73	5.33	4.19
120104	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.20	3.27	2.73	5.33	4.20
120105	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.19	3.27	2.73	5.33	4.19
120106	3.78	3.19	8.43	7.19	3.8	1.82	8.47	4.20	3.27	2.73	5.33	4.20
120107	3.78	3.19	8.43	7.19	3.8	1.82	8.47	4.20	3.27	2.73	5.33	4.20
120108	3.78	3.19	8.43	7.19	3.8	1.82	8.47	4.20	3.27	2.73	5.33	4.20
120109	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.20	3.27	2.73	5.33	4.20
120110	3.78	3.19	8.43	7.19	3.8	1.82	8.47	4.20	3.27	2.73	5.33	4.20
120111	3.78	3.19	8.43	7.19	3.89	1.91	8.70	4.43	3.27	2.73	5.56	4.43
120112	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.20	3.27	2.73	5.33	4.20
120161	3.78	3.19	8.43	7.19	3.79	1.81	8.47	4.19	3.27	2.73	5.33	4.19
190101	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190102	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190103	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190104	1.66	1.64	9.48	9.10	1.63	1.65	9.38	9.91	1.63	1.61	10.21	9.91
190105	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190106	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190107	1.66	1.64	9.48	7.77	1.44	1.42	8.69	8.39	1.63	1.61	8.69	8.39
190108	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190109	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190110	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190111	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190112	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.08	1.63	1.61	9.38	9.08
190159	1.66	1.64	9.48	9.10	1.63	1.61	9.38	9.07	1.63	1.61	9.38	9.07
200101	0.4	0.33	2.48	1.95	0.4	0.4	2.48	2.49	0.4	0.40	2.48	2.49
200102	0.4	0.33	2.48	1.95	0.4	0.4	2.48	2.49	0.4	0.40	2.48	2.49
200103	3.07	3	10.37	9.84	3.12	3.12	10.48	10.49	2.44	2.44	10.48	10.49
200104	3.07	3	10.37	9.84	3.12	3.12	10.47	10.48	2.44	2.44	10.47	10.48
200105	3.07	3	10.37	9.84	3.12	3.12	10.48	10.49	2.44	2.44	10.48	10.49
200106	3.07	3	10.37	9.84	3.11	3.11	10.47	10.48	2.44	2.44	10.47	10.48
200107	0.4	0.33	2.48	1.95	0.4	0.4	2.48	2.49	0.4	0.40	2.48	2.49
200108	3.07	3	10.37	9.84	3.11	3.11	10.47	10.48	2.44	2.44	10.47	10.48
200109	3.07	3	10.37	9.84	3.11	3.11	10.47	10.50	2.44	2.44	10.49	10.50
200110	3.07	3	10.37	9.84	3.11	3.11	10.47	10.48	2.44	2.44	10.47	10.48
200111	3.07	3	10.37	9.84	3.11	3.11	10.47	10.48	2.44	2.44	10.47	10.48
200112	3.07	3	10.37	9.84	3.11	3.11	10.47	10.48	2.44	2.44	10.47	10.48
200159	3.07	2.67	10.37	7.89	3.11	3.11	10.47	10.48	2.44	2.44	10.47	10.48
200160		-0.58			0.61	0.61	3.40	3.41	0.61	0.61	3.40	3.41
200161	0.58	0.39	3.29	1.98	0.61	0.61	3.40	3.41	0.61	0.61	3.40	3.41
200162	0.4	0.21	2.48	1.17	0.4	0.4	2.48	2.49	0.4	0.40	2.48	2.49
200163		0				0	0.00	0.00	0.4	0.40		
200164	0.77	0.58	4.04	2.74	0.4	0.4	2.48	2.49	0.4	0.40	2.48	2.49
220113		0				0	0.00	0.00		0.00		
220114		0				0	0.00	0.00		0.00		
220115		0				0	0.00	0.00		0.00		
220116		0				0	0.00	0.00		0.00		
220117		0				0	0.00	0.00		0.00		
220118		0				0	0.00	0.00		0.00		
220119		0				0	0.00	0.00		0.00		
220120		0				0	0.00	0.00		0.00		
220121		0				0	0.00	0.00		0.00		
220122		0				0	0.00	0.00		0.00		
220123		0				0	0.00	0.00		0.00		
220124		0				0	5.62	4.77		0.00	5.62	4.77
260113		0				0	0.00	0.00		0.00		
260114		0				0	0.00	0.00		0.00		
260115	0.72	0.69	7.44	6.28		0	7.69	7.69		0.00	7.69	7.69
260116	0.72	0.69	7.44	6.28		-0.02	7.69	7.01		0.00	7.02	7.01
260117	0.72	0.69	7.44	6.28		-0.02	7.69	7.01		0.00	7.02	7.01
260118	0.58	0.55	6.57	5.41		0	5.86	5.85		0.00	5.86	5.85
260119		0				0	0.00	0.00		0.00		
260120	0.29	0.26	4.47	3.30		0	5.86	5.85		0.00	5.86	5.85
260121	0.29	0.28	4.47	4.06		0	5.86	5.85		0.00	5.86	5.85
260122		0				0	0.00	0.00		0.00		
260123		0	7.44	6.28		0	7.69	7.68		0.00	7.69	7.68
260124	0.72	0.69	7.44	6.28		0	7.69	7.68		0.00	7.69	7.68

Table C.3. (Continued).

260159	0.72	0.69	7.44	7.03		-0.02	7.69	7.01		0.00	7.02	7.01
300113		0	5.88	5.74	0.96	0.81	5.78	5.67		0.00	5.78	5.67
300114		0	5.88	5.74	1	0.85	5.98	5.86		0.00	5.98	5.86
300115		0	5.88	5.74	0.96	0.81	5.78	5.67		0.00	5.78	5.67
300116		0	5.88	5.74	0.96	0.81	5.78	5.67		0.00	5.78	5.67
300117		0	5.88	5.74	0.96	0.81	5.78	5.67		0.00	5.78	5.67
300118		0	5.88	5.74	0.96	0.81	5.78	5.67		0.00	5.78	5.67
300119		0	5.88	5.74	0.96	0.81	5.79	5.67		0.00	5.79	5.67
300120		0	5.88	5.74	0.96	0.81	5.79	5.67		0.00	5.79	5.67
300121		0	5.88	5.74	0.96	0.81	5.79	5.67		0.00	5.79	5.67
300122		0	5.88	5.74	0.96	0.81	5.79	5.67		0.00	5.79	5.67
300123		0	5.88	5.74	0.96	0.81	5.79	5.67		0.00	5.79	5.67
300124		0	5.88	5.74	0.96	0.81	5.79	5.67		0.00	5.79	5.67
310113	0.47	0.44	4.64	4.38	0.49	0.49	4.94	4.94	0.03	0.03	4.94	4.94
310114	0.6	0.57	6.80	6.55	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
310115	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
310116	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.93	0.6	0.60	6.94	6.93
310117	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
310118	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.93	0.6	0.60	6.94	6.93
310119	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
310120	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.93	0.6	0.60	6.94	6.93
310121	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
310122	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.93	0.6	0.60	6.94	6.93
310123	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
310124	0.59	0.56	6.73	6.48	0.6	0.6	6.94	6.94	0.6	0.60	6.94	6.94
320101	5.14	4.53	8.93	7.67	4.9	4.62	8.57	7.99	4.9	4.62	8.58	7.99
320102	4.93	4.13	8.62	6.98	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320103	4.93	4.13	8.62	6.98	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320104	5.14	4.34	8.93	7.29	4.9	4.62	8.57	7.99	4.9	4.62	8.58	7.99
320105	4.93	4.13	8.62	6.98	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320106	5.14	4.34	8.93	7.29	4.9	4.62	8.57	7.99	4.9	4.62	8.58	7.99
320107	5.14	4.34	8.93	7.29	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320108	5.14	4.34	8.93	7.29	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320109	5.14	4.34	8.93	7.29	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320110	5.14	4.34	8.93	7.29	4.9	4.62	8.57	7.99	4.9	4.62	8.57	7.99
320111	5.14	4.34	8.93	7.29	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
320112	5.14	4.34	8.93	7.29	4.9	4.62	8.58	7.99	4.9	4.62	8.58	7.99
350101	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350102	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350103	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350104	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350105	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350106	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350107	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350108	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350109	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350110	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350111	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
350112	1.12	0.92	7.19	5.83	1.32	1.1	8.38	6.88	1.32	1.10	8.38	6.88
390101	0.07	0.02	1.16	0.37	0.06	0.01	1.01	0.21	0.06	0.01	1.01	0.21
390102	0.05	0	0.83	0.04	0.05	0	0.83	0.04	0.05	0.00	0.83	0.04
390103	0.44	0.37	6.01	4.85	0.42	0.36	5.86	4.85	0.42	0.36	5.86	4.85
390104	0.63	0.58	8.26	7.47	0.58	0.53	7.69	6.88	0.58	0.53	7.69	6.88
390105	0.14	0.09	2.10	1.32	0.18	0.13	2.63	1.82	0.18	0.13	2.63	1.82
390106	0.63	0.58	8.26	7.47	0.58	0.53	7.69	6.88	0.58	0.53	7.69	6.88
390107	0.05	0	0.83	0.04	0.05	0	0.83	0.04	0.05	0.00	0.83	0.04
390108	0.44	0.39	6.01	5.22	0.42	0.37	5.86	5.05	0.42	0.37	5.86	5.05
390109	0.44	0.39	6.01	5.22	0.42	0.37	5.86	5.05	0.42	0.37	5.86	5.05
390110	0.44	0.39	6.01	5.22	0.42	0.37	5.86	5.05	0.42	0.37	5.86	5.05
390111	0.63	0.58	8.26	7.47	0.58	0.53	7.69	6.88	0.58	0.53	7.69	6.88
390112	0.63	0.58	8.26	7.47	0.58	0.53	7.69	6.88	0.58	0.53	7.69	6.88
390159	0.63	0.43	8.26	5.23	0.58	0.25	7.69	2.95	0.58	0.32	6.70	2.95
390160	0.63	0.56	8.26	7.10	0.58	0.52	7.69	6.67	0.58	0.53	7.48	6.67
400113		0	6.39	6.00		0	7.15	7.09		0.00	7.15	7.09
400114		0	6.39	6.00		0	7.15	7.08		0.00	7.15	7.08
400115		0	6.39	6.00		0	7.15	6.72		0.00	6.79	6.72

Table C.3. (Continued).

400116		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400117		0	6.39	6.00		0	7.15	6.72		0.00	6.79	6.72
400118		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400119		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400120		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400121		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400122		0	6.39	6.00		0	7.15	7.09		0.00	7.15	7.09
400123		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400124		0	6.39	6.00		0	7.15	6.73		0.00	6.79	6.73
400160		0	6.39	6.00		0	7.15	7.08		0.00	7.15	7.08
480113		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480114		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480115		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480116		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480117		0	5.89	5.70		0	6.98	6.82		0.00	6.98	6.82
480118		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480119		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480120		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480121		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480122		0	5.89	5.70		0	6.98	6.82		0.00	6.98	6.82
480123		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480124		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480160		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480161		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480162		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480163		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480164		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480165		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480166		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
480167		0	5.89	5.70		0	6.98	6.83		0.00	6.98	6.83
510113	1.62	1.71	5.03	5.22	1.61	1.9	4.95	5.54	1.61	1.90	4.96	5.54
510114	1.86	1.95	7.35	7.54	1.86	2.15	7.45	8.04	1.86	2.15	7.45	8.04
510115	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.47	7.05
510116	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.46	7.05
510117	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.47	7.05
510118	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.47	7.05
510119	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.46	7.05
510120	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.04	1.8	2.09	6.46	7.04
510121	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.04	1.8	2.09	6.46	7.04
510122	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.46	7.05
510123	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.46	7.05
510124	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.46	7.05
510159	1.85	1.94	7.15	7.33	1.8	2.09	6.46	7.05	1.8	2.09	6.46	7.05
550113		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550114		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550115		0	5.45	5.37		0	6.72	6.24		0.00	6.72	6.24
550116		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550117		0	5.45	5.37		0	6.72	6.24		0.00	6.72	6.24
550118		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550119		0	5.45	5.37		0	6.72	4.11		0.00	4.58	4.11
550120		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550121		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550122		0	5.45	5.37		0	6.72	6.25		0.00	6.72	6.25
550123		0	5.45	5.37		0	6.72	6.24		0.00	6.72	6.24
550124		0	5.45	5.37		0	6.72	6.24		0.00	6.72	6.24

Table C.4. SPS-2 Test Section Identification Numbers and Design, Climate, and Backcalculation Data Used in Regression Analyses.

ID	GROUP	HPCC	AC	BAR	HIGH	WIDE	B1	B2	B3	B4	B5	DRN	TMP	PRECIP	TMI	K	HEQUIV
40213	A	7.9	0	1	0	1	0	0	0	0	0	0	71.4	7.6	-51	337	14.9
40214	A	8.3	0	1	1	0	0	0	0	0	0	0	71.4	7.6	-51	262	16.7
40215	A	11.0	0	1	0	0	0	0	0	0	0	0	71.4	7.6	-51	344	16.9
40216	A	11.2	0	1	1	1	0	0	0	0	0	0	71.4	7.6	-51	305	18.0
40217	B	8.1	0	1	0	1	1	0	0	0	0	0	71.4	7.6	-51	369	20.5
40218	B	8.3	0	1	1	0	1	0	0	0	0	0	71.4	7.6	-51	244	20.8
40219	B	10.8	0	1	0	0	1	0	0	0	0	0	71.4	7.6	-51	424	16.7
40220	B	11.2	0	1	1	1	1	0	0	0	0	0	71.4	7.6	-51	477	17.8
40221	C	8.1	0	1	0	1	0	1	0	0	0	1	71.4	7.6	-51	316	14.6
40222	C	8.6	0	1	1	0	0	1	0	0	0	1	71.4	7.6	-51	352	13.6
40223	C	11.1	0	1	0	0	0	1	0	0	0	1	71.4	7.6	-51	421	15.6
40224	C	10.6	0	1	1	1	0	1	0	0	0	1	71.4	7.6	-51	343	17.0
40260	D	0.0	1	1	0	0	0	0	0	0	0		71.4	7.6	-51		
40261	D	0.0	1	1	0	0	0	0	0	0	0		71.4	7.6	-51		
40262	A	8.1	0	0	0	0	0	0	0	0	0		71.4	7.6	-51	375	15.1
40263	C	8.2	0	0	0	0	0	1	0	0	0		71.4	7.6	-51	288	14.5
40264	C	11.5	0	0	0	0	0	1	0	0	0		71.4	7.6	-51	364	15.3
40265	A	10.8	0	0	0	0	0	0	0	0	0		71.4	7.6	-51	268	18.3
40266	E	12.3	0	1	0	0	0	0	1	0	0		71.4	7.6	-51	469	17.2
40267	E	11.3	0	1	0	0	0	0	1	0	0		71.4	7.6	-51	446	15.9
40268	E	8.5	0	1	0	0	0	0	1	0	0		71.4	7.6	-51	498	14.4
50213	A	7.4	0	1	0	1	0	0	0	0	0	0	61.7	53	61	220	22.4
50214	A	8.4	0	1	1	0	0	0	0	0	0	0	61.7	53	61	190	20.1
50215	A	11.5	0	1	0	0	0	0	0	0	0	0	61.7	53	61	232	20.8
50216	A	11.0	0	1	1	1	0	0	0	0	0	0	61.7	53	61	173	22.0
50217	B	8.3	0	1	0	1	1	0	0	0	0	0	61.7	53	61	314	22.0
50218	B	8.2	0	1	1	0	1	0	0	0	0	0	61.7	53	61	342	22.2
50219	B	11.1	0	1	0	0	1	0	0	0	0	0	61.7	53	61	255	22.0
50220	B	10.7	0	1	1	1	1	0	0	0	0	0	61.7	53	61	220	23.4
50221	C	8.3	0	1	0	1	0	1	0	0	0	1	61.7	53	61	249	15.2
50222	C	8.3	0	1	1	0	0	1	0	0	0	1	61.7	53	61	185	14.2
50223	C	10.9	0	1	0	0	0	1	0	0	0	1	61.7	53	61	421	15.3
50224	C	10.9	0	1	1	1	0	1	0	0	0	1	61.7	53	61	268	17.7
60201	A	8.3	0	1	0	0	0	0	0	0	0	0	61.8	11.9	-32	220	15.2
60202	A	8.0	0	1	1	1	0	0	0	0	0	0	61.8	11.9	-32	302	16.2
60203	A	11.4	0	1	0	1	0	0	0	0	0	0	61.8	11.9	-32	465	17.0
60204	A	11.1	0	1	1	0	0	0	0	0	0	0	61.8	11.9	-32	475	38.1
60205	B	8.2	0	1	0	0	1	0	0	0	0	0	61.8	11.9	-32	236	20.7
60206	B	8.0	0	1	1	1	1	0	0	0	0	0	61.8	11.9	-32	344	15.2
60207	B	11.0	0	1	0	1	1	0	0	0	0	0	61.8	11.9	-32	369	19.6
60208	B	10.7	0	1	1	0	1	0	0	0	0	0	61.8	11.9	-32	218	23.1
60209	C	8.4	0	1	0	0	0	1	0	0	0	1	61.8	11.9	-32	207	13.2
60210	C	8.6	0	1	1	1	0	1	0	0	0	1	61.8	11.9	-32	298	13.9
60211	C	12.1	0	1	0	1	0	1	0	0	0	1	61.8	11.9	-32	415	13.6
60212	C	11.1	0	1	1	0	0	1	0	0	0	1	61.8	11.9	-32	234	15.2
80213	A	8.6	0	1	0	1	0	0	0	0	0	0	49.7	14.7	-5	112	13.7
80214	A	8.4	0	1	1	0	0	0	0	0	0	0	49.7	14.7	-5	145	13.4
80215	A	11.5	0	1	0	0	0	0	0	0	0	0	49.7	14.7	-5	317	16.4
80216	A	11.9	0	1	1	1	0	0	0	0	0	0	49.7	14.7	-5	192	18.5
80217	B	8.6	0	1	0	1	1	0	0	0	0	0	49.7	14.7	-5	164	16.4
80218	B	7.6	0	1	1	0	1	0	0	0	0	0	49.7	14.7	-5	171	15.1
80219	B	9.9	0	1	0	0	1	0	0	0	0	0	49.7	14.7	-5	233	19.9
80220	B	11.2	0	1	1	1	1	0	0	0	0	0	49.7	14.7	-5	271	16.6
80221	C	8.3	0	1	0	1	0	1	0	0	0	1	49.7	14.7	-5	171	12.1
80222	C	8.5	0	1	1	0	0	1	0	0	0	1	49.7	14.7	-5	155	14.4
80223	C	11.7	0	1	0	0	0	1	0	0	0	1	49.7	14.7	-5	220	14.7
80224	C	11.6	0	1	1	1	0	1	0	0	0	1	49.7	14.7	-5	180	15.1
80259	F	11.9	0	1	0	0	0	0	0	1	0		49.7	14.7	-5	202	10.3
100201	A	8.3	0	1	0	0	0	0	0	0	0	0	55.7	45.4	78	206	16.1
100202	A	8.8	0	1	1	1	0	0	0	0	0	0	55.7	45.4	78	212	17.1
100203	A	11.7	0	1	0	1	0	0	0	0	0	0	55.7	45.4	78	278	18.4
100204	A	11.0	0	1	1	0	0	0	0	0	0	0	55.7	45.4	78	193	18.1

Table C.4. (Continued).

100205	B	9.2	0	1	0	0	1	0	0	0	0	0	55.7	45.4	78	290	19.1
100206	B	8.9	0	1	1	1	1	0	0	0	0	0	55.7	45.4	78	198	24.4
100207	B	11.3	0	1	0	1	1	0	0	0	0	0	55.7	45.4	78	309	23.0
100208	B	12.1	0	1	1	0	1	0	0	0	0	0	55.7	45.4	78	227	21.7
100209	C	8.2	0	1	0	0	0	1	0	0	0	1	55.7	45.4	78	238	15.3
100210	C	8.3	0	1	1	1	0	1	0	0	0	1	55.7	45.4	78	208	14.9
100211	C	11.8	0	1	0	1	0	1	0	0	0	1	55.7	45.4	78	313	16.9
100212	C	12.4	0	1	1	0	0	1	0	0	0	1	55.7	45.4	78	264	16.7
100259	A	10.2	0	1	0	0	0	0	0	0	0		55.7	45.4	78	257	20.1
100260	A	10.2	0	1	0	0	0	0	0	0	0		55.7	45.4	78	281	20.7
190213	A	8.5	0	1	0	1	0	0	0	0	0	0	48.9	33.1	53	143	15.9
190214	A	8.4	0	1	1	0	0	0	0	0	0	0	48.9	33.1	53	180	14.9
190215	A	11.8	0	1	0	0	0	0	0	0	0	0	48.9	33.1	53	119	17.3
190216	A	11.6	0	1	1	1	0	0	0	0	0	0	48.9	33.1	53	127	18.0
190217	B	8.1	0	1	0	1	1	0	0	0	0	0	48.9	33.1	53	191	21.4
190218	B	8.2	0	1	1	0	1	0	0	0	0	0	48.9	33.1	53	337	18.7
190219	B	11.2	0	1	0	0	1	0	0	0	0	0	48.9	33.1	53	291	20.4
190220	B	11.4	0	1	1	1	1	0	0	0	0	0	48.9	33.1	53	369	21.1
190221	C	9.4	0	1	0	1	0	1	0	0	0	1	48.9	33.1	53	243	12.1
190222	C	8.3	0	1	1	0	0	1	0	0	0	1	48.9	33.1	53	163	24.3
190223	C	11.7	0	1	0	0	0	1	0	0	0	1	48.9	33.1	53	198	15.1
190224	C	11.6	0	1	1	1	0	1	0	0	0	1	48.9	33.1	53	255	16.8
190259	A	8.4	0	1	0	0	0	0	0	0	0		48.9	33.1	53	207	17.3
200201	A	7.7	0	1	0	0	0	0	0	0	0	0	54.9	31.9	21	129	15.0
200202	A	7.4	0	1	1	1	0	0	0	0	0	0	54.9	31.9	21	103	15.9
200203	A	11.1	0	1	0	1	0	0	0	0	0	0	54.9	31.9	21	203	17.7
200204	A	11.3	0	1	1	0	0	0	0	0	0	0	54.9	31.9	21	150	18.5
200205	B	7.8	0	1	0	0	1	0	0	0	0	0	54.9	31.9	21	111	27.4
200206	B	7.9	0	1	1	1	1	0	0	0	0	0	54.9	31.9	21	159	21.5
200207	B	11.3	0	1	0	1	1	0	0	0	0	0	54.9	31.9	21	135	28.5
200208	B	11.0	0	1	1	0	1	0	0	0	0	0	54.9	31.9	21	232	23.9
200209	C	8.5	0	1	0	0	0	1	0	0	0	1	54.9	31.9	21	112	15.5
200210	C	8.3	0	1	1	1	0	1	0	0	0	1	54.9	31.9	21	165	14.8
200211	C	11.1	0	1	0	1	0	1	0	0	0	1	54.9	31.9	21	130	17.7
200212	C	10.9	0	1	1	0	0	1	0	0	0	1	54.9	31.9	21	168	16.4
200259	G	12.2	0	1	0	0	0	0	0	0	1		54.9	31.9	21	347	17.7
260213	A	8.6	0	1	0	1	0	0	0	0	0	0	49.9	33	61	313	15.0
260214	A	8.9	0	1	1	0	0	0	0	0	0	0	49.9	33	61	416	15.1
260215	A	11.2	0	1	0	0	0	0	0	0	0	0	49.9	33	61	347	17.4
260216	A	11.4	0	1	1	1	0	0	0	0	0	0	49.9	33	61	371	17.4
260217	B	8.5	0	1	0	1	1	0	0	0	0	0	49.9	33	61	474	20.7
260218	B	7.1	0	1	1	0	1	0	0	0	0	0	49.9	33	61	780	17.3
260219	B	10.9	0	1	0	0	1	0	0	0	0	0	49.9	33	61	621	21.1
260220	B	11.1	0	1	1	1	1	0	0	0	0	0	49.9	33	61	598	16.7
260221	C	8.2	0	1	0	1	0	1	0	0	0	1	49.9	33	61	296	14.0
260222	C	8.4	0	1	1	0	0	1	0	0	0	1	49.9	33	61	268	14.3
260223	C	11.0	0	1	0	0	0	1	0	0	0	1	49.9	33	61	356	16.1
260224	C	11.2	0	1	1	1	0	1	0	0	0	1	49.9	33	61	308	15.9
260259	C	11.2	0	1	0	0	0	1	0	0	0		49.9	33	61	370	15.4
320201	A	9.2	0	1	0	0	0	0	0	0	0	0	49.7	8.9	-23	369	13.8
320202	A	8.2	0	1	1	1	0	0	0	0	0	0	49.7	8.9	-23	407	7.6
320203	A	11.9	0	1	0	1	0	0	0	0	0	0	49.7	8.9	-23	262	14.3
320204	A	11.8	0	1	1	0	0	0	0	0	0	0	49.7	8.9	-23	285	16.5
320205	B	8.5	0	1	0	0	1	0	0	0	0	0	49.7	8.9	-23	517	21.7
320206	B	7.8	0	1	1	1	1	0	0	0	0	0	49.7	8.9	-23	237	17.7
320207	B	10.9	0	1	0	1	1	0	0	0	0	0	49.7	8.9	-23	579	21.4
320208	B	11.0	0	1	1	0	1	0	0	0	0	0	49.7	8.9	-23	287	23.3
320209	C	8.9	0	1	0	0	0	1	0	0	0	1	49.7	8.9	-23	379	11.5
320210	C	10.1	0	1	1	1	0	1	0	0	0	1	49.7	8.9	-23	416	11.1
320211	C	11.3	0	1	0	1	0	1	0	0	0	1	49.7	8.9	-23	229	12.7
320259	E	10.8	0	1	0	0	0	0	1	0	0		49.7	8.9	-23	584	23.2
370201	A	9.0	0	1	0	0	0	0	0	0	0	0	58.6	44.2	56	301	19.1
370202	A	8.9	0	1	1	1	0	0	0	0	0	0	58.6	44.2	56	232	18.9
370203	A	11.2	0	1	0	1	0	0	0	0	0	0	58.6	44.2	56	201	17.3
370204	A	11.2	0	1	1	0	0	0	0	0	0	0	58.6	44.2	56	108	19.0
370205	B	8.0	0	1	0	0	1	0	0	0	0	0	58.6	44.2	56	196	23.9

Table C.4. (Continued).

370206	B	8.4	0	1	1	1	1	0	0	0	0	0	58.6	44.2	56	268	21.5
370207	B	11.6	0	1	0	1	1	0	0	0	0	0	58.6	44.2	56	198	23.4
370208	B	11.2	0	1	1	0	1	0	0	0	0	0	58.6	44.2	56	255	22.8
370209	C	8.6	0	1	0	0	0	1	0	0	0	1	58.6	44.2	56	337	15.2
370210	C	9.1	0	1	1	1	0	1	0	0	0	1	58.6	44.2	56	180	15.0
370211	C	11.4	0	1	0	1	0	1	0	0	0	1	58.6	44.2	56	204	15.1
370212	C	10.9	0	1	1	0	0	1	0	0	0	1	58.6	44.2	56	332	16.2
370259	E	10.2	0	1	0	0	0	0	1	0	0		58.6	44.2	56	578	15.9
370260	E	11.5	0	1	0	0	0	0	1	0	0		58.6	44.2	56	259	23.1
380213	A	8.2	0	1	0	1	0	0	0	0	0	0	41.3	22.3	36	128	16.9
380214	A	7.9	0	1	1	0	0	0	0	0	0	0	41.3	22.3	36	114	18.5
380215	A	11.0	0	1	0	0	0	0	0	0	0	0	41.3	22.3	36	147	18.6
380216	A	11.2	0	1	1	1	0	0	0	0	0	0	41.3	22.3	36	144	19.4
380217	B	7.9	0	1	0	1	1	0	0	0	0	0	41.3	22.3	36	121	27.8
380218	B	7.9	0	1	1	0	1	0	0	0	0	0	41.3	22.3	36	126	21.0
380219	B	10.9	0	1	0	0	1	0	0	0	0	0	41.3	22.3	36	167	24.5
380220	B	10.9	0	1	1	1	1	0	0	0	0	0	41.3	22.3	36	181	19.8
380221	C	8.1	0	1	0	1	0	1	0	0	0	1	41.3	22.3	36	179	15.0
380222	C	8.2	0	1	1	0	0	1	0	0	0	1	41.3	22.3	36	192	14.9
380223	C	11.1	0	1	0	0	0	1	0	0	0	1	41.3	22.3	36	175	16.5
380224	C	10.8	0	1	1	1	0	1	0	0	0	1	41.3	22.3	36	198	17.1
380259	C	9.5	0	1	0	0	0	1	0	0	0		41.3	22.3	36	237	16.0
380260	A	11.0	0	1	0	0	0	0	0	0	0		41.3	22.3	36	147	18.6
380261	A	11.0	0	0	0	0	0	0	0	0	0		41.3	22.3	36	145	18.9
380262	B	11.1	0	0	0	0	1	0	0	0	0		41.3	22.3	36	165	26.3
380263	C	10.8	0	0	0	0	0	1	0	0	0		41.3	22.3	36	196	16.1
380264	C	11.0	0	0	0	0	0	1	0	0	0		41.3	22.3	36	196	16.2
390201	A	7.9	0	1	0	0	0	0	0	0	0	0	50.2	38.3	87	238	15.4
390202	A	8.3	0	1	1	1	0	0	0	0	0	0	50.2	38.3	87	169	15.5
390203	A	10.9	0	1	0	1	0	0	0	0	0	0	50.2	38.3	87	275	16.8
390204	A	11.1	0	1	1	0	0	0	0	0	0	0	50.2	38.3	87	442	19.3
390205	B	8.0	0	1	0	0	1	0	0	0	0	0	50.2	38.3	87	362	15.9
390206	B	7.9	0	1	1	1	1	0	0	0	0	0	50.2	38.3	87	258	17.0
390207	B	11.1	0	1	0	1	1	0	0	0	0	0	50.2	38.3	87	376	16.1
390208	B	11.0	0	1	1	0	1	0	0	0	0	0	50.2	38.3	87	305	17.2
390209	C	8.1	0	1	0	0	0	1	0	0	0	1	50.2	38.3	87	293	13.8
390210	C	8.0	0	1	1	1	0	1	0	0	0	1	50.2	38.3	87	334	13.5
390211	C	11.4	0	1	0	1	0	1	0	0	0	1	50.2	38.3	87	302	15.2
390212	C	10.6	0	1	1	0	0	1	0	0	0	1	50.2	38.3	87	333	16.6
390259	A	11.0	0	1	0	0	0	0	0	0	0		50.2	38.3	87	318	16.9
390260	C	11.4	0	1	0	0	0	1	0	0	0		50.2	38.3	87	323	15.5
390261	G	11.1	0	1	0	0	0	0	0	0	1		50.2	38.3	87	314	18.0
390262	G	11.1	0	1	0	0	0	0	0	0	1		50.2	38.3	87	309	17.9
390263	A	11.0	0	1	0	0	0	0	0	0	0		50.2	38.3	87	273	17.7
390264	A	11.6	0	1	0	0	0	0	0	0	0		50.2	38.3	87	491	9.7
390265	C	11.3	0	1	0	0	0	1	0	0	0		50.2	38.3	87	327	15.4
530201	A	8.7	0	1	0	0	0	0	0	0	0	0	49.1	10.8	-10	358	14.4
530202	A	8.3	0	1	1	1	0	0	0	0	0	0	49.1	10.8	-10	438	15.1
530203	A	11.1	0	1	0	1	0	0	0	0	0	0	49.1	10.8	-10	253	16.2
530204	A	11.2	0	1	1	0	0	0	0	0	0	0	49.1	10.8	-10	397	16.5
530205	B	8.5	0	1	0	0	1	0	0	0	0	0	49.1	10.8	-10	633	18.0
530206	B	8.6	0	1	1	1	1	0	0	0	0	0	49.1	10.8	-10	691	16.0
530207	B	11.1	0	1	0	1	1	0	0	0	0	0	49.1	10.8	-10	522	18.6
530208	B	11.2	0	1	1	0	1	0	0	0	0	0	49.1	10.8	-10	925	16.2
530209	C	9.0	0	1	0	0	0	1	0	0	0	1	49.1	10.8	-10	457	12.5
530210	C	8.3	0	1	1	1	0	1	0	0	0	1	49.1	10.8	-10	274	12.9
530211	C	11.8	0	1	0	1	0	1	0	0	0	1	49.1	10.8	-10	426	14.1
530212	C	11.3	0	1	1	0	0	1	0	0	0	1	49.1	10.8	-10	367	14.1
530259	E	10.3	0	0	0	0	0	0	1	0	0		49.1	10.8	-10	296	12.9
550213	A	8.5	0	1	0	1	0	0	0	0	0	0	42.7	32.1	105	171	16.3
550214	A	8.4	0	1	1	0	0	0	0	0	0	0	42.7	32.1	105	346	16.9
550215	A	11.3	0	1	0	0	0	0	0	0	0	0	42.7	32.1	105	269	15.7
550216	A	11.1	0	1	1	1	0	0	0	0	0	0	42.7	32.1	105	326	18.5
550217	B	8.2	0	1	0	1	1	0	0	0	0	0	42.7	32.1	105	348	24.1
550218	B	8.4	0	1	1	0	1	0	0	0	0	0	42.7	32.1	105	428	22.2
550219	B	11.3	0	1	0	0	1	0	0	0	0	0	42.7	32.1	105	324	22.1

Table C.4. (Continued).

550220	B	11.2	0	1	1	1	1	0	0	0	0	0	42.7	32.1	105	262	27.0
550221	C	8.3	0	1	0	1	0	1	0	0	0	1	42.7	32.1	105	244	13.0
550222	C	8.5	0	1	1	0	0	1	0	0	0	1	42.7	32.1	105	394	14.2
550223	C	11.3	0	1	0	0	0	1	0	0	0	1	42.7	32.1	105	266	14.6
550224	C	11.4	0	1	1	1	0	1	0	0	0	1	42.7	32.1	105	419	15.7
550259	A	11.3	0	1	0	0	0	0	0	0	0		42.7	32.1	105	242	18.2
550260	A	11.4	0	1	0	0	0	0	0	0	0		42.7	32.1	105	318	17.7
550261	G	8.9	0	1	0	0	0	0	0	0	1		42.7	32.1	105	250	17.8
550262	A	8.4	0	1	0	0	0	0	0	0	0		42.7	32.1	105	203	14.0
550263	A	10.1	0	1	0	0	0	0	0	0	0		42.7	32.1	105	168	16.9
550264	A	11.0	0	1	0	0	0	0	0	0	0		42.7	32.1	105	441	15.6
550265	A	11.3	0	1	0	0	0	0	0	0	0		42.7	32.1	105	568	16.1
550266	A	11.0	0	1	0	0	0	0	0	0	0		42.7	32.1	105		

Table C.5. SPS-2 Test Section Identification Numbers and Performance Data Used in Regression Analyses.

ID	LAST IRI	DELTA IRI	LAST FAULT	DELTA FAULT	LAST CRACK	DELTA CRACK
40213	1.586	0.099	0.1	-0.4	70.8	70.8
40214	1.330	0.092	0.2	-0.4	0.0	0.0
40215	2.164	0.742	0.9	0.3	0.0	0.0
40216	1.493	0.159	0.2	-0.2	0.0	0.0
40217	1.009	-0.213	0.0	-0.6	104.6	104.6
40218	0.829	-0.470	0.0	-0.5	37.5	37.5
40219	1.492	0.139	-0.1	-0.8	9.0	9.0
40220	1.047	-0.170	0.0	-0.6	1.0	1.0
40221	1.066	-0.111	0.0	-0.7	8.2	8.2
40222	0.880	-0.204	0.0	-0.4	2.5	2.5
40223	1.275	0.065	0.0	-0.6	0.0	0.0
40224	1.051	0.016	0.0	-0.4	1.6	1.6
40260	0.915	-0.177		0.0		0.0
40261	0.847	0.020		0.0		0.0
40262	2.614	1.553	2.9	1.3	0.0	0.0
40263	1.285	0.210	0.0	-0.9	0.6	0.6
40264	1.883	0.131	0.1	-0.5	0.0	0.0
40265	2.146	0.733	3.0	1.6	0.0	0.0
40266	1.574	0.137	0.4	-0.5	0.0	0.0
40267	1.579	-0.073	0.3	-0.3	0.0	0.0
40268	1.379	-0.122	0.5	-0.3	0.0	0.0
50213	2.163	0.867	2.0	2.0	234.4	234.4
50214	2.274	0.489	0.6	0.6	0.0	0.0
50215	2.000	0.575	2.2	2.2	0.0	0.0
50216	1.808	0.478	0.6	0.6	0.0	0.0
50217	2.124	0.780	-0.4	-0.4	198.0	198.0
50218	1.441	0.025	0.1	-0.1	304.3	304.3
50219	1.553	0.236	0.3	0.2	0.0	0.0
50220	1.999	0.253	0.2	0.2	4.0	4.0
50221	1.120	0.207	0.6	0.6	0.0	0.0
50222	1.282	0.088	0.8	0.9	0.0	0.0
50223	1.281	0.152	0.2	0.2	0.0	0.0
50224	1.608	-0.020	0.9	0.9	4.0	4.0
60201	1.545	0.393	0.1	-0.9	71.9	68.3
60202	1.491	0.508	0.9	0.9	66.1	66.1
60203	1.809	0.122	0.0	0.0	4.6	4.6
60204	1.560	0.305	0.0	0.2	0.0	0.0
60205	1.058	-0.037	0.1	0.1	45.7	45.7
60206	1.457	0.139	0.0	0.3	47.6	47.6
60207	1.360	-0.002	0.0	0.0	3.3	3.3
60208	1.568	0.243	0.0	0.1	43.1	43.1
60209	1.394	0.214	0.0	-0.1	0.0	0.0
60210	1.111	0.252	0.0	-0.1	0.0	0.0
60211	1.821	0.126	0.0	0.0	3.0	3.0
60212	1.301	0.167	0.0	-0.3	0.0	0.0
80213	1.257	0.093	0.0	-0.1	1.4	1.4
80214	1.202	0.129	0.0	-0.4	0.0	0.0
80215	1.592	0.475	0.0	-0.2	0.0	0.0
80216	1.192	0.196	0.1	-0.3	159.7	159.7
80217	1.846	0.290	-0.1	0.1	23.9	21.9
80218	1.547	0.114	0.0	0.4	3.7	0.0
80219	1.875	0.288	0.1	0.3	0.0	0.0
80220	1.760	0.103	0.0	0.2	0.0	0.0
80221	1.431	-0.111	0.1	-0.1	0.0	0.0
80222	1.130	-0.102	0.0	-0.1	1.1	1.1
80223	1.577	-0.206	0.3	0.0	0.0	0.0
80224	1.587	-0.062	0.0	-0.5	0.0	0.0
80259	1.140	-0.037	0.1	-0.4	0.0	0.0
100201	1.396	0.273	-0.2	-0.2	0.0	0.0
100202	0.822	-0.020	0.0	0.0	0.0	0.0
100203	1.154	0.073	0.0	-0.1	0.0	0.0
100204	1.463	0.117	0.0	0.0	0.0	0.0
100205	1.291	0.081	1.1	0.4	26.9	26.9
100206	0.793	-0.201	-0.2	-0.2	0.0	0.0
100207	1.382	0.284	0.2	0.2	48.4	22.2

Table C.5. (Continued).

100208	1.733	0.274	0.0	0.0	0.0	0.0
100209	0.869	0.067	0.2	0.3	2.9	2.9
100210	0.950	0.136	0.0	0.0	0.0	0.0
100211	0.837	-0.014	0.0	0.0	0.0	0.0
100212	1.473	0.091	0.0	-0.1	0.0	0.0
100259	1.142	0.056	0.1	0.1	0.0	0.0
100260	1.237	0.026	0.2	0.2	0.0	0.0
190213	1.107	0.093	0.2	0.2	3.1	3.1
190214	1.809	0.572	0.5	0.5	0.0	0.0
190215	2.021	-0.051	0.6	0.6	0.0	0.0
190216	1.700	0.299	0.6	0.6	0.0	0.0
190217	1.729	0.481	0.4	0.4	8.6	4.9
190218	1.696	0.512	0.6	0.6	0.0	0.0
190219	1.482	-0.007	0.2	0.2	0.0	0.0
190220	1.331	0.179	0.2	0.2	0.0	0.0
190221	1.417	0.194	0.4	0.4	0.0	0.0
190222	2.163	0.168	0.2	0.2	0.0	0.0
190223	2.131	-0.162	0.2	0.2	0.0	0.0
190224	1.325	-0.107	0.2	0.2	4.7	4.7
190259	1.304	-0.107	0.0	-0.1	0.0	0.0
200201	1.813	0.628	0.1	0.1	9.8	9.8
200202	1.055	-0.200	0.5	0.3	8.6	8.6
200203	1.450	0.103	0.4	0.1	0.0	0.0
200204	1.310	0.093	0.1	-0.1	4.0	4.0
200205	1.498	0.321	0.2	0.2	8.0	8.0
200206	1.532	-0.276	0.3	0.1	2.1	2.1
200207	1.577	0.063	0.0	-0.2	0.0	0.0
200208	1.935	0.040	0.5	0.4	1.1	1.1
200209	1.142	0.040	0.0	-0.1	0.0	0.0
200210	1.367	0.053	0.4	0.3	0.0	0.0
200211	1.341	0.105	0.2	0.1	0.0	0.0
200212	1.585	-0.169	0.3	0.1	0.0	0.0
200259	1.347	-0.223	0.2	0.1	0.0	0.0
260213	2.426	1.215	0.0	0.0	12.9	12.9
260214	4.250	2.307	0.8	0.8	20.6	16.6
260215	4.909	4.010	2.1	2.1	7.4	7.4
260216	1.571	0.014	0.0	0.0	0.0	0.0
260217	3.249	2.236	0.1	0.1	5.8	5.8
260218	5.479	3.833	0.8	0.8	69.5	69.5
260219	1.604	0.277	0.2	0.2	0.0	0.0
260220	1.684	0.247	0.0	0.0	0.0	0.0
260221	1.161	0.148	0.1	0.1	0.0	0.0
260222	1.482	0.207	0.4	0.4	0.0	0.0
260223	1.424	0.275	0.3	0.3	0.0	0.0
260224	1.186	0.067	0.0	0.0	0.0	0.0
260259	1.174	0.047	0.0	0.0	3.9	3.9
320201	4.579	3.690	0.1	-0.7	52.2	36.0
320202	2.599	1.052	0.1	-1.5	492.8	192.5
320203	1.226	0.475	0.3	-0.3	561.1	387.2
320204	2.120	0.564	0.2	-0.4	152.5	138.4
320205	2.035	1.076	0.4	-0.5	652.7	495.5
320206	1.724	0.302	0.1	0.0	526.4	130.7
320207	1.317	0.391	0.6	-0.3	96.9	96.9
320208	1.708	0.104	0.3	-0.4	171.7	145.5
320209	1.093	0.306	0.2	-0.6	14.6	14.6
320210	1.352	0.320	0.1	-1.1	214.9	192.4
320211	1.320	0.561	0.3	-0.5	13.8	9.7
320259	1.500	0.514	0.3	-0.5	0.0	-0.3
370201	1.425	-0.011	0.5	0.4	1.0	1.0
370202	1.394	0.064	-0.1	-0.3	0.0	0.0
370203	1.762	0.182	0.6	0.3	0.0	0.0
370204	1.465	0.339	0.8	0.7	0.0	-4.0
370205	1.897	-0.405	0.0	0.0	59.8	59.8
370206	1.334	-0.061	0.2	0.0	0.0	0.0
370207	1.850	0.105	0.3	0.4	0.0	0.0
370208	2.119	0.194	0.2	-0.1	0.0	0.0
370209	1.421	0.145	0.3	0.3	0.0	0.0

Table C.5. (Continued).

370210	1.464	0.287	0.2	0.1	4.3	-4.5
370211	1.392	0.097	0.1	0.4	0.0	0.0
370212	1.180	0.092	0.0	-0.3	0.0	-8.0
370259	1.422	-0.086	0.0	0.0	0.0	0.0
370260	1.544	-0.014	0.2	0.2	0.0	0.0
380213	1.303	-0.244	-0.3	-0.3	0.0	0.0
380214	1.322	-0.084	0.4	0.2	0.0	0.0
380215	2.037	0.016	0.7	1.2	0.0	0.0
380216	1.601	-0.144	-0.1	-0.3	0.0	0.0
380217	1.705	0.417	0.6	0.1	96.2	82.6
380218	1.635	0.088	-0.1	-0.4	10.1	10.1
380219	1.614	-0.003	-0.4	-0.6	1.2	1.2
380220	1.508	-0.092	-0.3	-0.4	0.6	0.6
380221	1.385	-0.042	0.2	0.0	0.0	0.0
380222	1.583	-0.058	0.2	0.1	0.0	0.0
380223	1.565	0.077	0.2	0.1	0.0	0.0
380224	2.050	-0.100	-0.1	-0.3	7.9	7.9
380259	1.991	0.285	0.5	-0.1	0.0	0.0
380260	1.829	0.026	0.3	-0.1	0.0	0.0
380261	1.715	0.361	2.4	2.1	0.0	0.0
380262	1.846	0.363	1.3	1.2	0.0	0.0
380263	1.512	0.039	0.4	0.5	0.0	0.0
380264	1.571	-0.014	0.4	-0.2	0.0	0.0
390201	1.508	0.309	0.0	0.0	40.2	40.2
390202	1.613	0.526	0.1	0.1	60.2	60.2
390203	1.090	0.067	0.2	0.2	0.0	0.0
390204	1.100	0.244	0.0	0.0	47.7	47.7
390205	1.592	0.213	0.2	0.2	92.5	92.5
390206	1.613	0.473	0.0	0.0	82.3	82.3
390207	1.299	-0.039	0.3	0.3	0.0	0.0
390208	1.246	-0.262	0.3	0.3	0.0	0.0
390209	1.107	0.136	0.0	0.0	3.6	3.6
390210	1.147	0.101	0.3	0.3	29.8	29.8
390211	1.253	-0.085	-0.1	-0.1	0.0	0.0
390212	1.042	-0.038	-0.5	-0.5	7.2	7.2
390259	0.954	0.267	0.0	0.0	22.6	18.6
390260	1.035	0.002	0.4	0.4	0.0	0.0
390261	1.108	0.000	0.0	0.0	0.0	0.0
390262	1.041	0.000	0.2	0.2	0.0	0.0
390263	1.303	0.250	0.3	0.3	0.0	0.0
390264	1.857	0.612	0.3	0.3	0.0	0.0
390265	1.379	0.147	0.5	0.5	0.0	0.0
530201	1.458	0.132	0.1	-0.6	0.0	0.0
530202	1.089	0.026	0.0	-0.5	0.0	0.0
530203	1.389	0.058	0.1	-0.4	0.0	0.0
530204	1.196	0.024	0.0	-0.4	0.0	0.0
530205	1.347	0.027	0.0	-0.5	3.3	3.3
530206	2.093	1.024	0.0	-0.6	38.1	38.1
530207	1.251	0.173	0.1	-0.3	0.0	0.0
530208	1.713	0.591	0.1	-0.4	0.0	0.0
530209	1.411	0.107	0.1	-0.4	0.0	0.0
530210	0.926	0.052	0.0	-0.3	0.0	0.0
530211	1.262	0.031	0.0	-0.4	0.0	0.0
530212	1.131	0.050	0.0	-0.5	0.0	0.0
530259	1.060	0.102	0.0	-0.6	0.0	0.0
550213	1.176	0.224	0.1	0.1	0.0	0.0
550214	1.361	0.056	0.0	0.0	0.0	0.0
550215	1.546	0.064	0.0	0.0	0.0	0.0
550216	1.576	-0.010	0.1	0.0	0.0	0.0
550217	0.911	0.012	0.1	0.1	0.0	0.0
550218	1.288	-0.115	0.0	0.0	0.0	0.0
550219	1.138	0.072	0.1	0.1	0.0	0.0
550220	1.387	0.080	0.0	0.0	0.0	0.0
550221	1.178	0.061	-0.2	-0.3	0.0	0.0
550222	1.469	-0.103	-0.2	0.0	0.0	0.0
550223	1.162	-0.073	-0.1	-0.1	0.0	0.0
550224	1.008	-0.050	0.0	0.0	0.0	0.0

Table C.5. (Continued).

550259	1.439	0.259	0.0	-0.1	4.3	4.3
550260	1.602	0.531	-0.1	-0.3	0.0	0.0
550261	0.994	0.147	0.1	0.0	0.0	0.0
550262	1.244	0.001	0.0	0.0	0.0	0.0
550263	0.906	0.066	0.0	0.0	0.0	0.0
550264	1.429	0.239	0.0	0.0	0.0	0.0
550265	1.511	0.248	0.3	0.0		
550266	1.547	0.466		0.0		

Table C.6. SPS-2 Test Section Identification Numbers and ESAL and Age Data Used in Regression Analyses.

ID	CESAL LAST IRI	CESAL DELTA IRI	TIME LAST IRI	TIME DELTA IRI	CESAL LAST FLT	CESAL DELTA FLT	TIME LAST FLT	TIME DELTA FLT	CESAL LAST CRACK	CESAL DELTA CRACK	TIME LAST CRACK	TIME DELTA CRACK
40213	13.5	13.17	10.34	10.03	13.29	11.82	10.21	8.82		0.00	10.21	8.82
40214	13.5	13.17	10.34	10.03	13.28	11.79	10.20	8.80		0.00	10.20	8.80
40215	14.46	14.13	10.94	10.62	14.59	13.1	11.02	9.61		0.00	11.02	9.61
40216	13.5	13.17	10.34	10.03	13.28	11.79	10.21	8.80		0.00	10.21	8.80
40217	13.5	13.17	10.34	10.03	13.29	11.8	10.21	8.80		0.00	10.21	8.80
40218	13.5	13.17	10.34	10.03	15.28	13.79	10.20	8.80		0.00	10.20	8.80
40219	13.5	13.17	10.34	10.03	13.29	11.8	10.21	8.80		0.00	10.21	8.80
40220	13.5	13.17	10.34	10.03	13.28	11.79	10.21	8.80		0.00	10.21	8.80
40221	13.5	13.17	10.34	10.03	13.29	11.8	10.21	8.80		0.00	10.21	8.80
40222	13.5	13.17	10.34	10.03	13.28	11.79	10.20	8.80		0.00	10.20	8.80
40223	13.5	13.17	10.34	10.03	13.29	11.8	10.21	8.80		0.00	10.21	8.80
40224	13.5	13.17	10.34	10.03	13.28	11.79	10.21	8.80		0.00	10.21	8.80
40260	13.5	13.17	10.34	10.03								
40261	13.5	13.17	10.34	10.03								
40262	13.5	13.17	10.34	10.03	10.19	8.7	8.18	6.77		0.00	8.18	6.77
40263	13.5	13.17	10.34	10.03	10.19	8.7	8.18	6.77		0.00	8.18	6.84
40264	13.5	13.17	10.34	10.03	10.19	8.7	8.18	6.77		0.00	8.18	6.77
40265	13.5	13.17	10.34	10.03	10.2	8.71	8.19	6.78		0.00	8.19	6.78
40266	13.5	13.17	10.34	10.03	10.2	8.71	8.19	6.78		0.00	8.19	6.78
40267	13.5	13.17	10.34	10.03	10.2	8.71	8.19	6.78		0.00	8.19	6.78
40268	13.5	13.17	10.34	10.03	10.2	8.71	8.19	6.78		0.00	8.19	6.78
50213	19.54	17.05	8.36	7.09	20.98	18.93	8.88	7.82		0.00	8.88	7.82
50214	19.54	17.05	8.36	7.09	20.96	18.97	8.87	7.85		0.00	8.87	7.85
50215	19.54	17.05	8.36	7.09	20.96	18.93	8.87	7.83		0.00	8.87	7.83
50216	19.54	17.05	8.36	7.09	20.98	18.93	8.88	7.82		0.00	8.88	7.82
50217	19.54	17.05	8.36	7.09	20.97	18.95	8.87	7.84		0.00	8.87	7.84
50218	19.54	17.05	8.36	7.09	20.97	18.95	8.87	7.84		0.00	8.87	7.84
50219	19.54	17.05	8.36	7.09	20.96	18.95	8.87	7.84		0.00	8.87	7.84
50220	19.54	17.05	8.36	7.09	18.36	16.33	7.93	6.89		0.00	7.93	6.89
50221	19.54	17.05	8.36	7.09	18.37	16.31	7.94	6.88		0.00	7.94	6.88
50222	19.54	17.05	8.36	7.09	18.35	16.36	7.93	6.91		0.00	7.93	6.91
50223	19.54	17.05	8.36	7.09	18.34	16.36	7.93	6.91		0.00	7.93	6.91
50224	19.54	17.05	8.36	7.09	18.36	16.31	7.93	6.89		0.00	7.93	6.89
60201		0.00	3.37	3.63		0	3.14	3.47		0.00	3.14	3.47
60202		0.00	3.37	3.63		0	3.13	3.47		0.00	3.13	3.47
60203		0.00	3.37	3.26		0	3.13	3.17		0.00	3.13	3.17
60204		0.00	3.37	3.63		0	3.13	3.47		0.00	3.13	3.47
60205		0.00	3.37	3.63		0	3.13	3.47		0.00	3.13	3.47
60206		0.00	3.37	3.26		0	3.13	3.47		0.00	3.13	3.47
60207		0.00	3.37	3.26		0	3.13	3.47		0.00	3.13	3.47
60208		0.00	3.37	3.63		0	3.13	3.47		0.00	3.13	3.47
60209		0.00	3.37	3.63		0	3.14	3.47		0.00	3.14	3.47
60210		0.00	3.37	3.26		0	3.13	3.47		0.00	3.13	3.47
60211		0.00	3.37	3.26		0	3.13	3.17		0.00	3.13	3.17
60212		0.00	3.37	3.63		0	3.13	3.47		0.00	3.13	3.47
80213	2.48	2.29	9.98	9.53	2.51	1.54	10.63	8.15		0.00	10.63	8.15
80214	2.48	2.29	9.98	9.53	2.51	1.54	10.63	8.15		0.00	10.63	8.15
80215	2.48	2.29	9.98	9.53	2.51	1.54	10.64	8.16		0.00	10.64	8.16
80216	2.48	2.29	9.98	9.53	2.51	1.54	10.63	8.15		0.00	10.63	8.15
80217	2.48	2.29	9.98	9.53	2.51	1.54	10.64	8.16		0.00	10.64	8.16
80218	2.48	2.29	9.98	9.53	2.51	1.54	10.64	8.16		0.00	10.64	8.16
80219	2.48	2.29	9.98	9.53	2.51	1.54	10.64	8.16		0.00	10.64	8.16
80220	2.48	2.29	9.98	9.53	2.51	1.54	10.64	8.16		0.00	10.64	8.16
80221	2.48	2.29	9.98	9.53	2.51	1.53	10.66	8.17		0.00	10.66	8.17
80222	2.48	2.29	9.98	9.53	2.51	1.53	10.66	8.17		0.00	10.66	8.17
80223	2.48	2.29	9.98	9.53	2.51	1.53	10.66	8.17		0.00	10.66	8.17
80224	2.48	2.29	9.98	9.53	2.51	1.54	10.66	8.18		0.00	10.66	8.18
80259	2.48	2.29	9.98	9.53	2.51	1.53	10.66	8.16		0.00	10.66	8.16
100201	3.38	3.14	7.31	6.71	3.5	3.49	7.53	7.51		0.00	7.53	7.51
100202	3.38	3.14	7.31	6.71	3.48	3.47	7.50	7.48		0.00	7.50	7.48
100203	3.38	3.14	7.31	6.71	2.94	2.93	6.48	6.46		0.00	6.48	6.46
100204	3.38	3.14	7.31	6.71	3.48	3.47	7.49	7.48		0.00	7.49	7.48
100205	3.38	3.14	7.31	6.71	3.5	3.49	7.53	7.51		0.00	7.53	7.51
100206	3.38	3.14	7.31	6.71	3.48	3.47	7.50	7.48		0.00	7.50	7.48

Table C.6. (Continued).

100207	3.38	3.14	7.31	6.71	3.48	3.47	7.50	7.48		0.00	7.50	7.48
100208	3.38	3.14	7.31	6.71	3.48	3.47	7.49	7.47		0.00	7.49	7.47
100209	3.38	3.14	7.31	6.71	3.5	3.49	7.53	7.51		0.00	7.53	7.51
100210	3.38	3.14	7.31	6.71	3.48	3.47	7.50	7.48		0.00	7.50	7.48
100211	3.38	3.14	7.31	6.71	2.44	2.43	5.50	5.48		0.00	5.50	5.48
100212	3.38	3.14	7.31	6.71	3.48	3.47	7.49	7.47		0.00	7.49	7.47
100259	3.38	3.14	7.31	6.71	3.48	3.47	7.49	7.48		0.00	7.49	7.48
100260	3.38	3.14	7.31	6.71	3.5	3.49	7.53	7.50		0.00	7.53	7.50
190213	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190214	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190215	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190216	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190217	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190218	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190219	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190220	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190221	0.47	0.47	7.98	7.77	0.45	0.26	7.32	4.91		0.00	7.32	7.44
190222	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190223	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190224	0.47	0.47	7.98	7.77	0.45	0.46	7.32	7.44		0.00	7.32	7.44
190259	0.47	0.47	7.98	7.77	0.45	0.13	6.88	2.45		0.00	6.88	7.00
200201	8.96	8.94	11.61	11.01	8.55	3.32	11.16	3.84		0.00	11.16	10.49
200202	8.96	8.94	11.61	11.58	8.55	3.32	11.16	3.84		0.00	11.16	10.48
200203	8.96	8.94	11.61	11.58	8.55	3.32	11.16	3.84		0.00	11.16	10.49
200204	8.96	8.94	11.61	11.58	8.55	3.32	11.16	3.84		0.00	11.16	10.49
200205	8.96	8.94	11.61	11.58	8.55	3.31	11.17	3.84		0.00	11.17	10.48
200206	8.96	8.94	11.61	11.58	8.55	3.31	11.16	3.83		0.00	11.16	10.48
200207	8.96	8.94	11.61	11.58	8.55	3.31	11.17	3.84		0.00	11.17	10.48
200208	8.96	8.94	11.61	11.58	8.55	3.31	11.17	3.84		0.00	11.17	10.48
200209	8.96	8.94	11.61	11.58	8.72	3.47	11.36	4.01		0.00	11.36	10.66
200210	8.96	8.94	11.61	11.58	8.55	3.3	11.17	3.82		0.00	11.17	10.47
200211	8.96	8.94	11.61	11.58	8.55	3.31	11.17	3.83		0.00	11.17	10.47
200212	8.96	8.94	11.61	11.58	8.55	3.31	11.17	3.84		0.00	11.17	10.48
200259	8.96	8.58	11.61	11.01	8.72	3.47	11.36	4.01		0.00	11.36	10.66
260213	9.6	8.26	5.44	4.60	8.74	8.68	5.00	4.96		0.00	5.00	4.96
260214	18.11	16.77	9.43	8.59	19.3	19.22	9.95	9.90		0.00	9.95	9.90
260215	11.65	10.31	6.46	5.61	10.63	10.57	5.96	5.92		0.00	5.96	5.92
260216	21.02	19.68	10.68	9.83	19.34	19.28	9.97	9.93		0.00	9.97	9.93
260217	9.6	8.26	5.44	4.60	6	5.94	3.55	3.51		0.00	3.55	3.51
260218	6.21	4.87	3.66	2.82	2.58	2.5	1.60	1.55		0.00	1.60	1.55
260219	21.02	19.68	10.68	9.83	19.35	19.27	9.97	9.92		0.00	9.97	9.92
260220	21.02	19.68	10.68	9.83	19.34	19.28	9.97	9.93		0.00	9.97	9.93
260221	21.02	19.68	10.68	9.83	19.34	19.28	9.97	9.93		0.00	9.97	9.93
260222	21.02	19.68	10.68	9.83	19.35	19.28	9.97	9.92		0.00	9.97	9.92
260223	21.02	19.68	10.68	9.83	19.35	19.28	9.97	9.92		0.00	9.97	9.92
260224	21.02	19.68	10.68	9.83	19.34	19.28	9.97	9.93		0.00	9.97	9.93
260259	21.02	19.68	10.68	9.83	19.35	19.27	9.97	9.92		0.00	9.97	9.92
320201	7.74	7.29	8.25	7.43	7.61	7.31	8.15	7.59		0.00	8.15	7.59
320202	0.97	0.52	1.64	0.82	1.05	0.74	1.75	1.18		0.00	1.75	1.18
320203	7.74	7.29	8.25	7.43	7.61	7.31	8.16	7.59		0.00	8.16	7.59
320204	7.74	7.29	8.25	7.43	7.61	7.3	8.16	7.59		0.00	8.16	7.59
320205	7.74	7.29	8.25	7.43	7.61	7.31	8.15	7.59		0.00	8.15	7.59
320206	0.97	0.52	1.64	0.82	1.05	0.73	1.75	1.17		0.00	1.75	1.17
320207	7.74	7.29	8.25	7.43	7.61	7.31	8.16	7.59		0.00	8.16	7.59
320208	7.74	7.29	8.25	7.43	7.61	7.3	8.16	7.59		0.00	8.16	7.59
320209	7.74	7.29	8.25	7.43	7.61	7.31	8.15	7.59		0.00	8.15	7.59
320210	7.74	7.29	8.25	7.43	7.61	7.3	8.16	7.59		0.00	8.16	7.59
320211	7.74	7.29	8.25	7.43	7.61	7.31	8.16	7.59		0.00	8.16	7.59
320259	7.74	7.29	8.25	7.43	7.61	7.31	8.15	7.59		0.00	8.15	7.59
370201	13.41	13.57	8.92	9.17	14.68	14.77	9.45	9.59		0.00	9.45	8.04
370202	13.41	13.57	8.92	9.17	14.43	14.52	9.34	9.49		0.00	9.34	6.63
370203	14.45	14.61	9.35	9.61	14.43	14.52	9.34	9.48		0.00	9.34	6.63
370204	14.46	14.62	9.36	9.61	14.49	11.98	9.37	6.65		0.00	9.35	6.63
370205	13.41	13.57	8.92	9.17	14.68	14.78	9.45	9.59		0.00	9.45	6.74
370206	13.41	13.57	8.92	9.17	14.43	14.52	9.34	9.48		0.00	9.34	6.63
370207	14.45	13.22	9.35	9.61	14.44	14.53	9.35	9.48		0.00	9.35	6.66

Table C.6. (Continued).

370208	14.45	14.61	9.35	7.84	14.44	14.53	9.35	6.66		0.00	9.35	6.66
370209	13.41	13.57	8.92	9.17	14.68	14.77	9.45	9.59		0.00	9.45	8.04
370210	13.41	13.57	8.92	9.17	14.43	14.52	9.34	9.48		0.00	9.34	6.63
370211	14.45	14.61	9.35	9.61	14.44	14.53	9.35	9.48		0.00	9.35	6.66
370212	14.45	14.61	9.35	9.61	14.44	14.53	9.35	6.66		0.00	9.35	6.66
370259	14.46	14.62	9.36	9.61	14.49	14.59	9.37	9.51		0.00	9.37	6.66
370260	13.41	13.57	8.92	9.17	14.44	14.53	9.35	9.48		0.00	9.35	6.66
380213		0.00	9.54	5.89			8.89	8.91		0.00	8.89	8.91
380214		0.00	9.54	5.89			8.89	8.91		0.00	8.89	8.91
380215		0.00	9.54	5.89			8.89	8.91		0.00	8.89	8.91
380216		0.00	9.54	5.89			8.89	8.91		0.00	8.89	8.91
380217		0.00	9.54	5.89			8.90	8.91		0.00	8.90	8.91
380218		0.00	9.54	5.89			8.90	8.91		0.00	8.90	8.91
380219		0.00	9.54	5.89			8.90	8.91		0.00	8.90	8.91
380220		0.00	9.54	5.89			8.90	8.91		0.00	8.90	8.91
380221		0.00	9.54	5.89			8.93	8.94		0.00	8.93	8.94
380222		0.00	9.54	5.89			8.93	8.94		0.00	8.93	8.94
380223		0.00	9.54	5.89			8.90	8.91		0.00	8.90	8.91
380224		0.00	9.54	5.89			8.90	8.92		0.00	8.90	8.92
380259		0.00	9.54	5.89			6.75	6.76		0.00	6.75	6.76
380260		0.00	9.54	5.89			6.73	6.74		0.00	6.73	6.74
380261		0.00	9.54	5.89			6.73	6.74		0.00	6.73	6.74
380262		0.00	9.54	5.89			6.74	6.75		0.00	6.74	6.75
380263		0.00	9.54	5.89			6.74	6.75		0.00	6.74	6.75
380264		0.00	9.54	7.04			6.74	6.75		0.00	6.74	6.75
390201	4.94	5.01	7.34	7.47	4.65	5.67	6.54	6.34		0.00	6.54	6.34
390202	4.94	5.01	7.34	7.47	4.65	5.67	6.53	6.33		0.00	6.53	6.33
390203	4.94	5.01	7.34	7.47	4.65	5.67	6.71	6.51		0.00	6.71	6.51
390204	4.94	5.01	7.34	7.47	4.65	5.67	6.52	6.32		0.00	6.52	6.32
390205	4.94	5.01	7.34	7.47	4.65	5.67	6.54	6.33		0.00	6.54	6.33
390206	4.94	5.01	7.34	7.47	4.65	5.67	6.54	6.33		0.00	6.54	6.33
390207	4.94	5.01	7.34	7.47	4.65	5.67	6.71	6.51		0.00	6.71	6.51
390208	4.94	5.01	7.34	7.47	4.65	5.67	6.71	6.51		0.00	6.71	6.51
390209	4.94	5.01	7.34	7.47	4.68	5.7	6.54	6.34		0.00	6.54	6.34
390210	4.94	5.01	7.34	7.47	4.68	5.7	6.52	6.32		0.00	6.52	6.32
390211	4.94	5.01	7.34	7.47	4.65	5.67	6.54	6.34		0.00	6.54	6.34
390212	4.94	5.01	7.34	7.47	4.66	5.68	6.52	6.32		0.00	6.52	6.32
390259	4.94	4.81	7.34	7.10	3.06	4.08	6.52	6.32		0.00	6.52	6.32
390260	4.94	5.01	7.34	7.47	3.05	4.07	6.53	6.33		0.00	6.53	6.33
390261	4.94	5.01	7.34	7.47	3.05	4.07	6.54	6.34		0.00	6.54	6.34
390262	4.94	4.81	7.34	7.10	3.05	4.07	6.71	6.51		0.00	6.71	6.51
390263	4.94	4.81	7.34	7.10	3.05	4.07	6.71	6.51		0.00	6.71	6.51
390264	4.94	4.81	7.34	7.10	3.05	4.07	6.54	6.34		0.00	6.54	6.34
390265	4.94	5.01	7.34	7.47	3.05	4.07	6.71	6.51		0.00	6.71	6.51
530201	4.88	4.87	8.73	8.68	4.99	4.99	8.83	8.85		0.00	8.83	8.85
530202	4.88	4.87	8.73	8.68	4.98	4.98	8.82	8.84		0.00	8.82	8.84
530203	4.88	4.87	8.73	8.68	4.97	4.97	8.81	8.84		0.00	8.81	8.84
530204	4.88	4.87	8.73	8.68	4.98	4.98	8.82	8.84		0.00	8.82	8.84
530205	4.88	4.87	8.73	8.68	4.99	4.99	8.83	8.85		0.00	8.83	8.85
530206	4.88	4.87	8.73	8.68	4.99	4.99	8.83	8.85		0.00	8.83	8.85
530207	4.88	4.87	8.73	8.68	4.99	4.99	8.83	8.85		0.00	8.83	8.85
530208	4.88	4.87	8.73	8.68	4.99	4.99	8.83	8.85		0.00	8.83	8.85
530209	4.88	4.87	8.73	8.68	4.98	4.98	8.82	8.84		0.00	8.82	8.84
530210	4.88	4.87	8.73	8.68	4.98	4.98	8.82	8.84		0.00	8.82	8.84
530211	4.88	4.87	8.73	8.68	4.98	4.98	8.82	8.84		0.00	8.82	8.84
530212	4.88	4.87	8.73	8.68	4.98	4.98	8.82	8.84		0.00	8.82	8.84
530259	4.88	4.87	8.73	8.68	4.97	4.97	8.81	8.84		0.00	8.81	8.84
550213		0.00	5.45	5.37		0	4.46	3.97		0.00	4.46	3.97
550214		0.00	5.45	4.55		0	4.46	3.99		0.00	4.46	3.97
550215		0.00	5.45	5.37		0	4.47	3.98		0.00	4.47	3.98
550216		0.00	5.45	5.37		0	4.45	3.98		0.00	4.45	3.98
550217		0.00	5.45	5.37		0	4.46	3.97		0.00	4.46	3.97
550218		0.00	5.45	5.37		0	4.46	3.97		0.00	4.46	3.97
550219		0.00	5.45	5.37		0	4.46	3.98		0.00	4.46	3.98
550220		0.00	5.45	5.37		0	4.45	3.97		0.00	4.45	3.97
550221		0.00	5.45	5.37		0	4.45	3.98		0.00	4.45	3.98

Table C.6. (Continued).

550222		0.00	5.45	5.37		0	4.45	3.96		0.00	4.45	3.96
550223		0.00	5.45	5.37		0	4.45	3.97		0.00	4.45	3.97
550224		0.00	5.45	5.37		0	4.45	3.98		0.00	4.45	3.98
550259		0.00	5.45	5.37		0	2.60	2.13		0.00	2.60	2.13
550260		0.00	5.45	5.37		0	2.60	2.13		0.00	2.60	2.13
550261		0.00	5.45	5.37		0	2.59	2.11		0.00	2.59	2.11
550262		0.00	5.45	5.37		0	2.59	2.11		0.00	2.59	2.11
550263		0.00	5.45	5.37		0	2.60	2.13		0.00	2.60	2.13
550264		0.00	5.45	5.37		0	0.49	0.00		0.00	0.49	0.00
550265		0.00	5.45	5.37		0	0.49	0.00				
550266		0.00	5.45	5.37		0		0.00				

Abbreviations and acronyms used without definitions in TRB publications:

AAAE	American Association of Airport Executives
AASHO	American Association of State Highway Officials
AASHTO	American Association of State Highway and Transportation Officials
ACI–NA	Airports Council International–North America
ACRP	Airport Cooperative Research Program
ADA	Americans with Disabilities Act
APTA	American Public Transportation Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
ATA	Air Transport Association
ATA	American Trucking Associations
CTAA	Community Transportation Association of America
CTBSSP	Commercial Truck and Bus Safety Synthesis Program
DHS	Department of Homeland Security
DOE	Department of Energy
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
FMCSA	Federal Motor Carrier Safety Administration
FRA	Federal Railroad Administration
FTA	Federal Transit Administration
IEEE	Institute of Electrical and Electronics Engineers
ISTEA	Intermodal Surface Transportation Efficiency Act of 1991
ITE	Institute of Transportation Engineers
NASA	National Aeronautics and Space Administration
NASAO	National Association of State Aviation Officials
NCFRP	National Cooperative Freight Research Program
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
NTSB	National Transportation Safety Board
SAE	Society of Automotive Engineers
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005)
TCRP	Transit Cooperative Research Program
TEA-21	Transportation Equity Act for the 21st Century (1998)
TRB	Transportation Research Board
TSA	Transportation Security Administration
U.S.DOT	United States Department of Transportation