Pavement Treatment Effectiveness, 1995 SPS-3 and SPS-4 Site Evaluations, National Report

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LTPP

FOREWORD

During the conduct of Strategic Highway Research Programs (SHRP) on highway operations, flexible and rigid pavement preventive maintenance treatments were placed on pavements in the United States and Canada. The placement and performance monitoring of these Specific Pavement Studies (SPS-3 and SPS-4) has been conducted under the SHRP and Federal Highway Administration (FHWA) Long-Term Pavement Performance Program (LTPP).

Field performance reviews of the preventive maintenance treatments have also been conducted by Expert Task Groups (ETG) organized by the Pavement Division of the FHWA. The ETG performance surveys conducted after 5 years of service are summarized in this report and are intended to provide early performance information and guidance to public agencies utilizing preventive maintenance techniques.

This report is prepared as part of an FHWA-sponsored study titled Pavement Maintenance Effectiveness on SHRP Experimental Pavement Sections and conducted for the Long-Term Pavement Performance and Pavement Divisions of the FHWA. The final report for the study will be available in early 1997.

Charles J. Nemmers, P.E., Director
Office of Engineering Research
and Development

NOTICE

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16. Abstract

This report presents an evaluation of the performance of SHRP SPS-3 and SPS-4 experiment sites based on field reviews after 5 years of performance. Condition evaluation of the sections and Expert Task Group performance estimates are the basis for treatment assessments.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3

NOTE: Volumes greater than 1000 l shall be shown in m^3.

Symbol	When You Know	Multiply By	To Find	Symbol
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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INTRODUCTION

Pavement maintenance operations can be conveniently grouped into two categories: "corrective" and "preventive." "Corrective" pavement maintenance operations, including patching, are performed to restore distressed areas to an acceptable condition. "Preventive" maintenance operations are applied to pavement surfaces to prevent the development of damage or to reduce the rate of damage developed.[1] Preventive maintenance operations are intended to preserve, rather than improve, the structural capacity of the pavement.[2] Preventive maintenance operations are the subject of this report.

Several preventive maintenance operations are available for treatment of both asphalt and portland cement concrete surfaced pavements. Typical asphalt pavement preventive maintenance treatments include: thin hot-mix overlays, slurry seals, chip seals, fog seals, and crack sealing. Joint sealing, crack sealing, undersealing, and hot-mix overlays are typical preventive maintenance treatments for portland cement concrete pavements. The selection of the appropriate preventive maintenance treatment is generally made based on the experience of the maintenance supervisor or engineer with responsibility for a region of the roadways within a public agency. The decision is often made without documentation that clearly defines what is the appropriate treatment, when the treatment should be applied during the life of the roadway, and what is the life expectancy of the treatment.

Since billions of dollars[3] are expended for pavement reconstruction, rehabilitation, and maintenance, and since the optimization of the selection of the treatment type could result in substantial savings, a portion of the Strategic Highway Research Program (SHRP) was devoted to the study of preventive pavement maintenance activities for both asphalt and portland cement concrete surfaced roadways. This preventive maintenance program was performed as part of the project H-101, "Pavement Maintenance Effectiveness" and the Long-Term Pavement Performance (LTPP) study. These studies were responsible for placing preventive pavement maintenance treatments on pavement sections throughout the United States and Canada beginning in 1990.

The performance of these sections (after 5 years of service) has been recently evaluated by expert task groups assembled by the Federal Highway Administration (FHWA). The results of these surveys are summarized in this report and are intended to provide early performance information and guidance to the public agencies using preventive maintenance techniques.

BACKGROUND

Study Objectives

Preventive pavement maintenance treatments selected for study under SHRP project H-101 were placed under the LTPP program as specific pavement studies (SPS)–SPS-3 for flexible pavements and SPS-4 for portland cement concrete surfaced pavements (PCCP). The purpose of the research experiments were as follows:

- Define the most effective timing for the application of various treatments.
- Evaluate the effectiveness of treatments in prolonging the life of the pavement.
- Share information and experience among highway agencies and industry.[4]

Preventive Pavement Maintenance Treatments

The flexible pavement preventive maintenance treatments studied included:

- Crack sealing.
- Slurry seal.
- Chip seal.
- Thin hot-mix asphalt overlay.

The portland cement concrete surfaced pavement preventive maintenance treatments studied included:

- Joint/crack sealing.
- Undersealing.

These preventive pavement maintenance treatments were selected to represent the most commonly used techniques and the techniques most likely to be cost-effective.

Limitations of the Report

The information presented in this report is based on the collective opinions of four regional Expert Task Groups (ETG) composed of State, industry, and academic representatives. As a result, the findings of this report are subjective in nature and should not be construed as otherwise. In certain areas, it has been necessary for the project study team to supplement these data with engineering judgment.

The number of sites physically reviewed in the field was limited by the logistics of the trip length and travel time required to visit the 57 SPS-3 and 8 SPS-4 sites reviewed. Of the original 81 SPS-3 sites constructed, some 55 test sections at 19 sites now have some or all of the test sections out of service (appendix A).

Initial construction problems, failure/safety-driven rehabilitation activities, and the sections being included within the limits of a larger rehabilitation project are among the reasons identified by the States for removing sections. Section performance evaluated in this report is based entirely on information from the 57 SPS-3 and 8 SPS-4 sites reviewed in the field during the past summer by the ETGs.

As a result, the treatment performance observations for this subset of sites may be skewed when compared to the performance of the total set of sites.

Experiment Design

The field experiment was designed in 1987 by the Texas Transportation Institute[1] to evaluate the effectiveness of the various preventive maintenance treatments. The main variables in the experiment design for asphalt pavements were climate (wet-no freeze, wet-freeze, dry-no freeze, dry-freeze), subgrade type (fine and coarse grained), traffic volume (low and high), pavement condition (good, fair, and poor), structural number (adequate and inadequate), and treatment type (crack seal, slurry seal, chip seal, thin overlay, no treatment). A total of 96 test sites were desired for the asphalt pavement preventive maintenance study.

The main variables in the experimental design for the portland cement concrete pavements were climate (wet-no freeze, wet-freeze, dry-no freeze, dry-freeze), subgrade type (fine and coarse grained), base type (aggregate and stabilized), pavement type (plain and reinforced), and treatment type (joint/crack sealing, undersealing, and no treatment). A total of 24 test sites were desired for the portland cement concrete preventive maintenance study.

A total of 81 SPS-3 sites and 31 SPS-4 sites actually were placed in the United States and Canada in 1990 and 1991 (figures 1 and 2).

Placement of Sections

To reduce construction and material variability on the flexible pavement sections, the same materials placement crews and placement supervision were used throughout each of the four LTPP regions of the United States and Canada for the slurry seals and chip seals. The crack sealing material was the same for all the regions; however, the crack sealing installation procedure differed. Crack seal specifications are provided in appendix B. Four regional crews applied the crack sealant. Since each State provided the thin overlays, a different hot-mix asphalt and placement crew were used for the thin overlay sections on each project. Individual States were responsible for placement of the portland cement concrete pavement preventive maintenance test sections. Most of the test sites were placed from 1990 to 1991. Colorado placed an SPS-4 site in 1995.

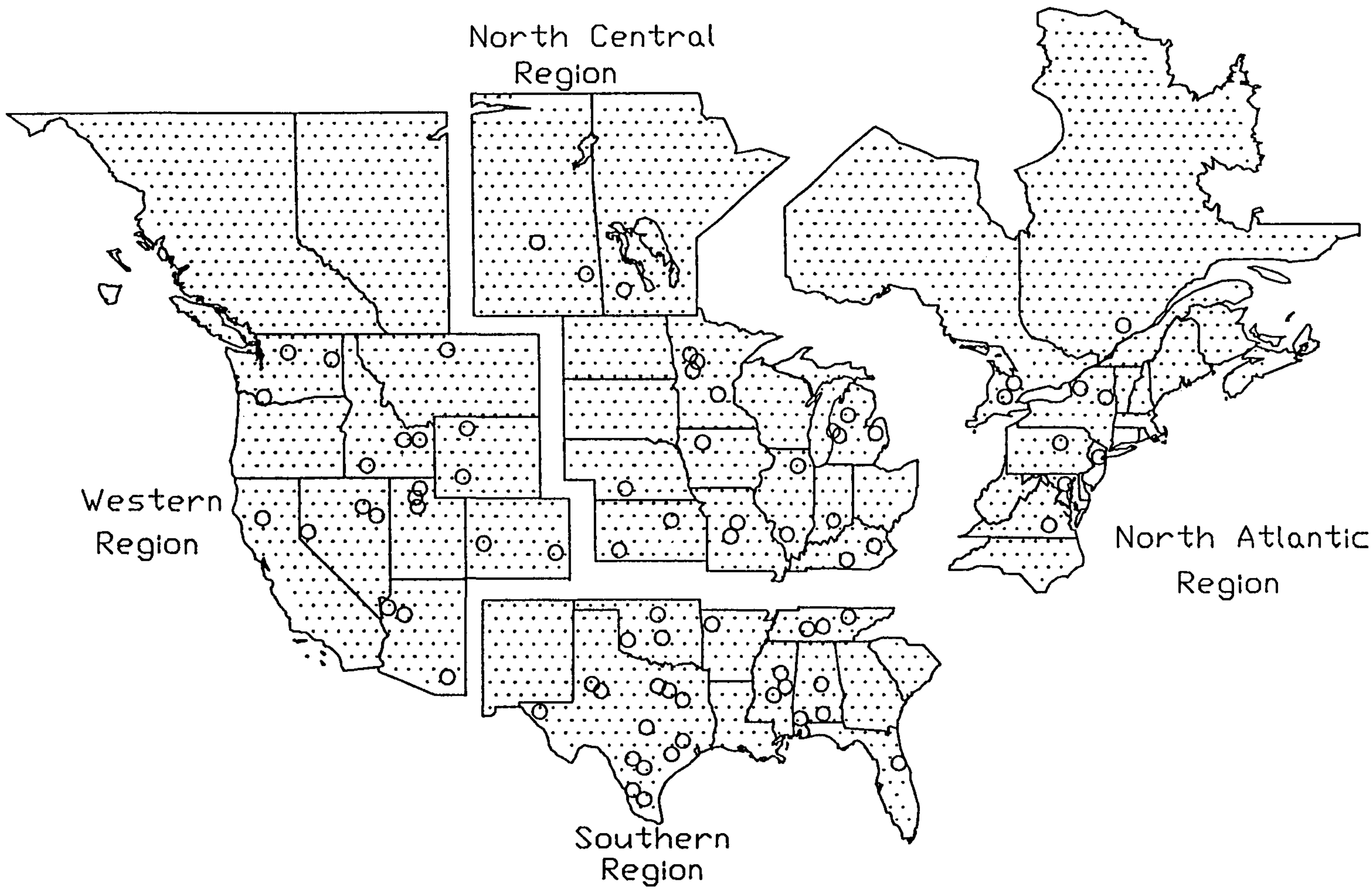

Figure 1. SPS-3 locations.

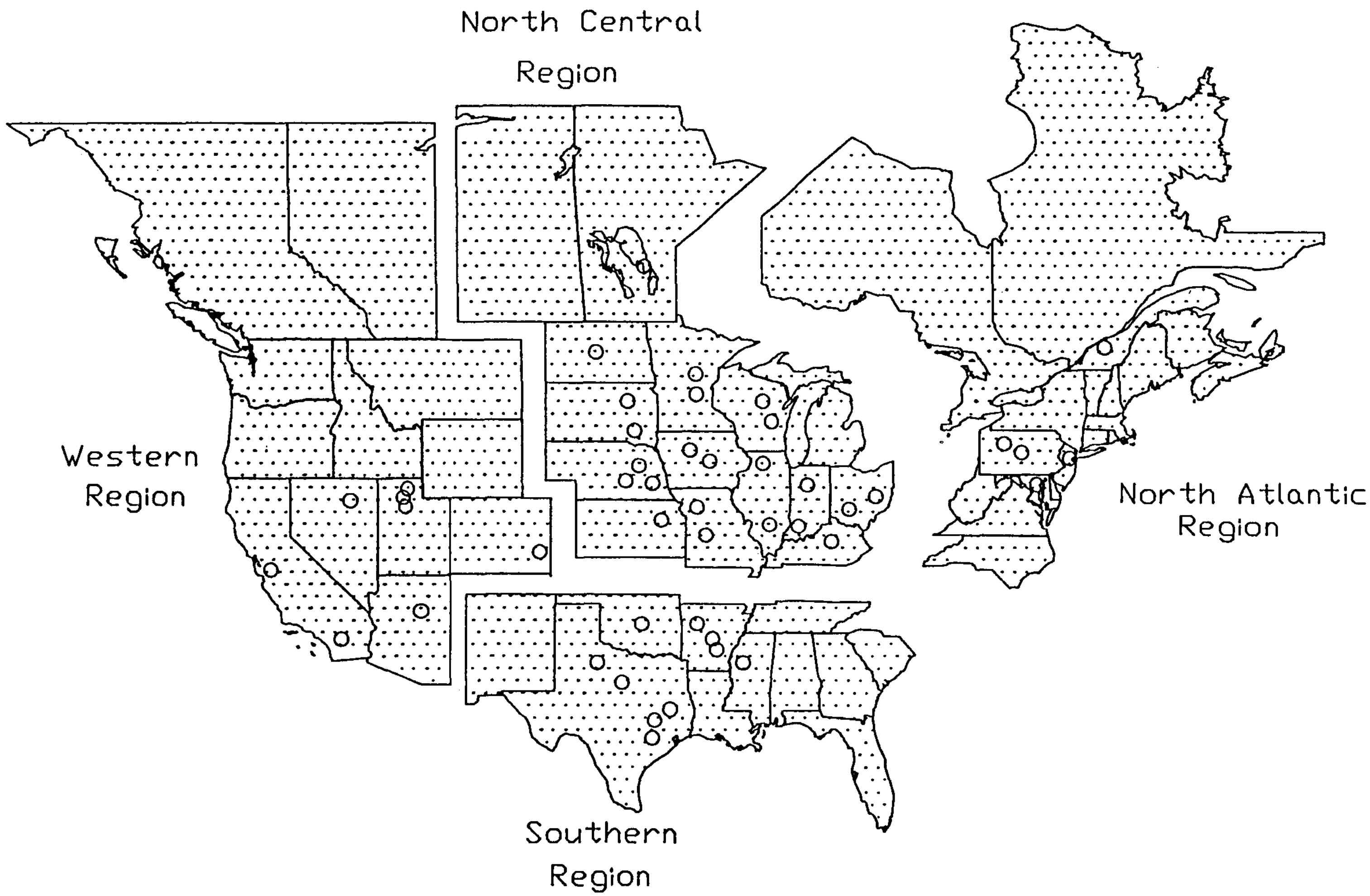

Figure 2. SPS-4 locations.

State Supplemental Studies

Since the experiment did not vary binder type, aggregate type, or design quantities (except by region) and since other types of preventive maintenance treatments were not included, several States placed "supplemental" sections to study some of these variables. State supplemental sections included such treatment variations as rubber-modified chip seals, thin overlays, and alternative joint and crack sealant materials. These special State studies, located adjacent to the standard sites reviewed in the field, are included in the SPS-3 and SPS-4 LTPP evaluation presented in this report.

Performance Evaluation

The performance of each of the SPS-3 and SPS-4 sites is being evaluated under the LTPP program and by an Expert Task Group for each LTPP region. The LTPP program determined the condition of the pavement before the preventive maintenance treatment was applied and at regular intervals after the treatment was applied. The evaluation tools used as part of the LTPP effort include the following:

- Visual condition using the SHRP distress identification manual.
- Photo log using the PASCO, USA device.
- Deflection using the falling-weight deflectometer.
- Ride quality using the K.J. Law-type profilometer.
- Rut depth using the "dip stick" and PASCO data.
- Friction number as collected and submitted to LTPP by individual States.

The frequency of these measurements is on a biannual basis. The information from the LTPP data files is currently being analyzed by a contractor to the Federal Highway Administration. A report will be available in the winter of 1996-1997.

Expert Task Groups are composed of highway agency practitioners, and industry and academia representatives; they are organized on an LTPP regional basis to perform SPS-3 and SPS-4 site evaluations. The western region ETG conducted site reviews in 1991 and 1992. All four LTPP regions conducted evaluations in 1993. A summary report from the 1993 site reviews is available.[5]

The four LTPP regions conducted site reviews in 1995. The results of these reviews, together with an analysis of the data collected during the tours, are presented in this report.

SHRP and LTPP

This report is based on SHRP and LTPP research efforts. Background information on SHRP and LTPP is provided to add context to the study effort contained in this report.

SHRP Program History

The Strategic Highway Research Program (SHRP) was created to support highly focused technical advances in highway research that would improve the way highway systems are operated and maintained. Initiated in 1987, the program provided funding over a 5-year period in four specific areas of research: Long-Term Pavement Performance, Concrete and Structures, Highway Operations, and Asphalt Materials.[5] Each of these program areas pursued technology advancement throughout the 5-year duration of the SHRP program.

LTPP Program History

Unlike the other program areas, the Long-Term Pavement Performance (LTPP) program was originally envisioned as continuing for 20 years, with the objective of collecting a full cycle of pavement performance data. Since the first 5 years of research, which were funded under SHRP, the LTPP program has been under the Federal Highway Administration.

The LTPP program was developed to evaluate the long-term performance of pavements consisting of various material and layer compositions. Originally established as a 20-year project, LTPP has necessarily outlived the SHRP program funded under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA). Under the guidance of FHWA, the primary emphasis to date has been on data collection activities. Data analysis efforts have begun more recently.[6]

The Specific Pavement Studies related to maintenance activities (SPS-3 and SPS-4) and reported upon in this study were developed under the Highway Operations field and continued under the LTPP program. These two experiments were designed to evaluate the effectiveness of standard preventive pavement maintenance activities for asphalt (SPS-3) and portland cement concrete (SPS-4) pavements. A prior field review was conducted in 1993.[7]

STATUS OF TEST SECTIONS

Prior to the start of the regional Expert Task Group SPS-3 and SPS-4 site tours in 1995, an inventory of site status was performed and LTPP data for each site were summarized for the tour participants. The site inventories were prepared by a consulting firm with support from LTPP regional contractors.

Asphalt Pavement Sites (SPS-3)

A number of asphalt pavement SPS-3 sites have "gone out of service" since original construction for a variety of reasons. Problems, including treatment failure during construction, the development of excessive distress, and safety concerns, have resulted in a number of sections no longer being available for the experiment. Section performances evaluated for this report are based entirely on the 57 SPS-3 sites reviewed in the field during the summer and fall of 1995 by the ETG. The site data reflected in this report represent only those sections that are still active and were evaluated in the field.

Portland Cement Concrete Sites (SPS-4)

All 31 SPS-4 test sites remain in service. The majority of these test sites contain only the joint seal treatment and a control section having unsealed joints. Eight sites included both joint seal and undersealing treatment sections. Nine SPS-4 sites were evaluated by the ETG in the summer and fall of 1995. The evaluation information from those nine sites is the basis for the information in this report.

ETG SITE EVALUATIONS

Coordination

The ETG site tours to evaluate the SPS-3 and SPS-4 test sections were coordinated by a consulting firm under contract to the Federal Highway Administration. Each of the four LTPP regional offices arranged and participated in the tours for their region. LTPP regional office personnel were responsible for documenting construction activities, materials sampling, and evaluation of the sections. One individual participated in all four regional tours and was responsible for developing uniformity among the evaluators from the different regions. The regional tours were conducted on the following dates:

North Atlantic	September 17 - 22, 1995
North Central	August 14 - 17 and September 11 - 16, 1995
Southern	September 24 - 29, 1995
Western	October 2 - 8, 1995

Participation

ETG tour participants are given in appendix C. State highway authority, Federal Highway Administration, and industry representatives participated.

Evaluation Forms

Evaluation forms were utilized to collect data from the ETG during the site visits (appendix D). The forms made use of a 0- to 10-point scale (0-2 very poor, 2-4 poor, 4-6 fair, 6-8 good, 8-10 very good) to capture the expert opinions of the ETG members. Specific information obtained from these forms for each section within a site included:

- Overall pavement condition.
- Overall treatment condition.
- Overall treatment effectiveness.
- Future performance life predictions with and without future maintenance treatments.
- Appropriateness of treatment.

- Presence of individual distress types (longitudinal cracking, transverse cracking, fatigue cracking, bleeding, raveling, snowplow damage).
- General comments.

Data recorded for each treatment type for each site were consensus opinions of the ETG members. The project research team developed a standard questionnaire to be completed at each site. Overall, a consensus response was developed for each test section at each site to the items on the questionnaire. Strong minority opinions were accepted as well.

The purpose of the data form was to provide a numerical quantification of relative pavement performance that could be analyzed. In addition, the forms recorded the opinions of the ETG members regarding expected continued performance lives and the suitability of the individual treatments with respect to the original pavement condition.

In addition, each ETG group prepared a regional report expressing the observations and recommendations of the group regarding the treatment sections they observed on the trip. These regional reports are listed as references 8 through 11 of this report. These data have been analyzed and are used in this report to support performance observations as determined by the ETG.

Treatments are purposely not compared with each other in this report. Any comparisons are to control pavement sections.

SPS-3 ETG REVIEW RESULTS

Performance Relationships

The performance evaluations of the SPS-3 sections contained in this report are based on the expert opinions expressed by the tour groups as well as the evaluation forms completed by the tour groups. The data are divided into climatic regions, LTPP regions, condition of the pavement upon which the preventive maintenance treatments were placed, and the type of treatment.

Four climate or environmental zones were used to evaluate some of the data sets. The four environmental zones are shown on figure 3 and are identified as wet-no freeze, wet-freeze, dry-no freeze, and dry-freeze by the SHRP-LTPP study. It should be noted that the four LTPP regional contractors who were responsible for data collection are associated with geographic regions of the United States and Canada and not necessarily with environmental regions. Thus, expert task groups from an LTPP region sometimes evaluated performance in more than one environmental zone. Results of the tour team evaluations are therefore presented both in terms of LTPP regions and environmental regions.

The condition of the pavements upon which the preventive maintenance treatments were placed has been defined as good, fair, and poor. The criteria for good, fair, and poor pavement conditions were originally defined by the SHRP-LTPP contractor and can be found in

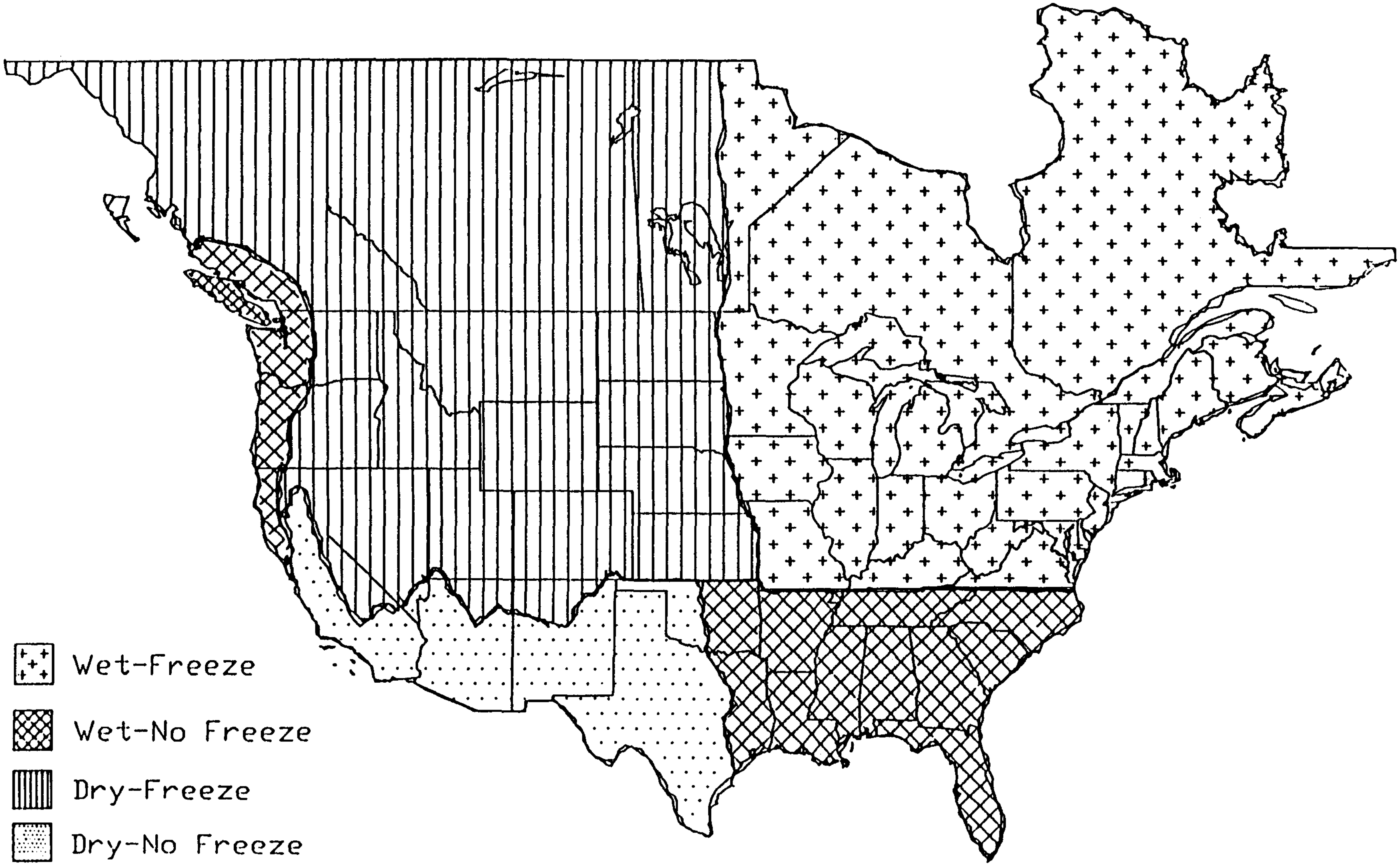

Figure 3. Climatic zone.

reference 1. Performance of the treatment, by treatment type, is included in the report. The order of presentation of the results is crack seal, slurry seal, chip seal, and hot-mix overlay.

Figures 4, 5, 8, 11, and 14 show the average performance after 5 years of each treatment type and the control sections by LTPP region and initial (or pretreatment) condition of the pavement. Figure 4 indicates that the nationwide average for the condition of the control section at each site was nearly the same as the average condition of the control sections within each region when the data are subdivided to consider the initial condition of the pavements. These data (as shown in figure 4) suggest that the condition evaluation of the pavements was reasonably uniform from LTPP region to LTPP region. Grouping of data by environmental regions, which cross LTPP regional boundaries, is therefore reasonable.

Figures 6, 9, 12, and 15 show the 5-year treatment performance versus the 5-year performance of control sections by environmental region. Relative performance relationships above the equality line (dashed line) indicate that improved performance was obtained with the treatment identified for the environmental region or specified zone.

The histograms include information on the number of sections and data pairs used in calculating or formulating the graphs. Discrepancies that appear in the number of sections between the different graphs are due to the number of individual treatment sections that actually exist in the field. All available data were used in generating the material shown.

The 1995 site evaluations visited 57 SPS-3 sites nationwide. If State supplemental sections are not included, the SHRP experiment alone would have resulted in a total of 290 individual sections (5 treatments x 57 sites). However, there were data for only 259 sections provided from the site visits. This is due to a variety of reasons as previously discussed. In some cases, the ETGs considered the application of the treatment inappropriate so no rating was provided. Not all treatments within each site have survived for the 5 years they have been in place. Some treatments failed immediately, while others were removed over time. The breakdown by treatment for survivors at the 57 sites visited is as follows:

Control	55
Crack Seal	40
Slurry Seal	56
Chip Seal	51
Thin Overlay	57
Total	259

For crack-sealed sections, only 40 ratings were obtained out of the 57 sites visited. This was due primarily to the inappropriateness of the application in some regions. In the Southern region, for example, there were nine sites where there were no cracks to be sealed within the crack seal sections. Neither were the crack-sealed sections maintained at many sites as originally intended.

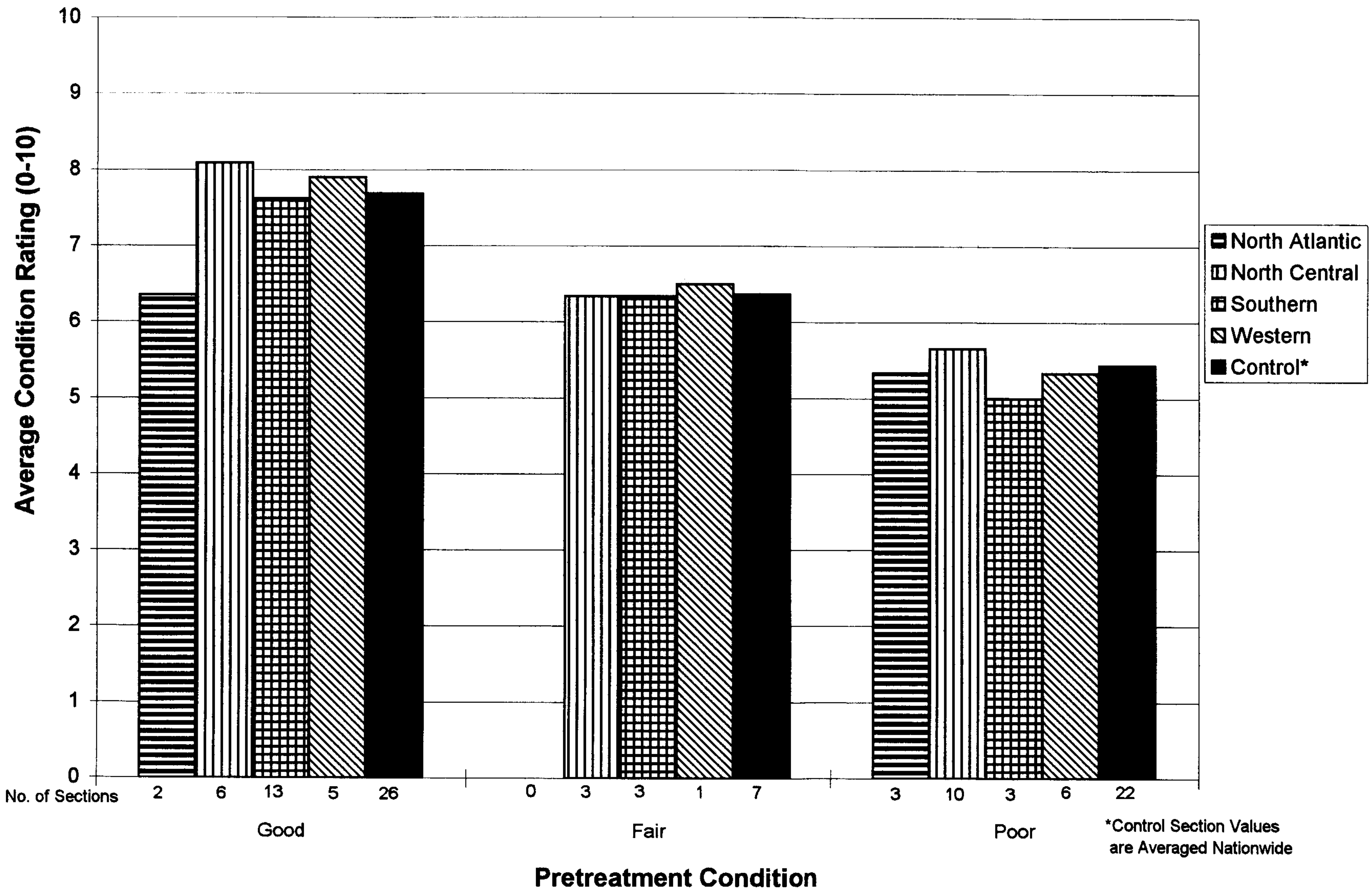

Figure 4. Average overall pavement condition by LTPP region for control sections.

Performance Life Estimates

Estimates of remaining test section performance life were provided by the ETG groups for all test sections. These estimates were based on the condition of the sections 5 years after placement. A number of other factors influenced the determination of the estimates, in addition to the condition of the pavement.

The first factor is the composite past experience of the group members. Normally, with these groups there is an initial divergence of opinion. However, after several sites, the members became calibrated to each other and consensus estimates were consistently obtained. The past experience of the individual members is strongly influenced by their experience in their own State. This experience includes factors for environmental differences and State practices. In addition, not all States use all the treatments, and consequently, some of the members are not very familiar with these treatments.

Once a group develops a consensus in making performance estimates, they remain fairly consistent. However, each regional group does this individually, with no relationship to how it is accomplished in the other regional groups. Reviewing the performance life estimates, it becomes evident that there is poor agreement between predicted performance life estimates and the subjective and numerical rating scores provided in some instances.

Figures 7, 10, 13, and 16 summarize the expectations of performance life–without additional maintenance–provided by the ETG groups. For example, the estimates shown in figure 7 represent the average performance life estimates for the crack seal treatment provided by the ETGs. This figure represents the estimates of the remaining life of the test section, with no further maintenance, and with the 5 years since construction added on. The range bars representing plus or minus one standard deviation from the mean value indicate the variability present in these estimates. The numbers below the histograms indicate the number of sections represented. Where no sections were reviewed in a region that fell within a given condition level, a zero appears. No range bars appear when the number of sites was one or all site estimates were the same.

This information is provided to give maintenance practitioners in the various regions a feel for what they can expect in terms of performance from properly applied maintenance treatments in their area. The information represents subjective opinions and should be considered representative of a region and not site-specific.

The data contained in figures 4 through 16 were developed to evaluate the subjective opinions of the tour groups as expressed in the tour reports.[8-11] Additional analyses are being performed on the numeric ratings provided by the tour members and will be included in the final report for the project.

TREATMENT PERFORMANCE

The following section of this report discusses results by treatment type: crack seal, slurry seal, chip seal, and thin hot-mix asphalt overlay. The general performance results by LTPP region, together with the influence of initial pavement condition and environment or climate, are included. Performance life estimates are summarized.

Crack Seal Treatment

Results of Reviews

Figures 5 through 7 present ETG evaluation data for crack seal treatments in terms of pre-treatment condition, climatic region, and predicted performance life. The SHRP test sections in the North Atlantic and North Central LTPP regions utilized a 38-mm-wide by 9.5-mm-deep reservoir. Although the North Central regional construction contractor reportedly did not control the routed depth well and frequently produced a 16-mm-deep reservoir, the wide, shallow crack seal design performed well on pavements in all conditions. The treatment was observed to have slowed the rate of pavement deterioration in several cases. This crack seal treatment design was effective in the wet-freeze environmental zone.

The wet-no freeze region also experienced good performance from the crack seal treatment using an overband design. Although the ETG hypothesized that in some cases, routing would have improved section performance where larger cracks existed, the crack sealing worked well. In this region, crack sealing was not effective on fatigue-cracked pavements.

The crack seal treatment did not perform well in the dry regions of the country, as reported by the Western LTPP Region ETG. The routed crack sealing applied in the dry regions utilized a 1-by-1 reservoir shape factor. This application has evidenced a propensity toward adhesion failure after 5 years, although the sealant material itself remained functional. The performance of these test sections has deteriorated accordingly.

Effect of Initial Pavement Condition

The wide shallow sealant reservoirs used in the North Atlantic and North Central regions appear to be most effective for pavements in poor condition (figure 5). They also contributed to the performance of good pavements, but not significantly (figure 5). The overband design used in the Southern region performed similarly on good, fair, and poor pavements (no fair sections were reviewed). The 1-by-1 reservoir used in the Western region contributed only to the performance of fair pavements based on a limited number of sites (two).

Effect of Climatic Region

Treatment performance trends for all the regions are similar for the crack seal treatment. Of great significance is the consistency among the LTPP regional groups for each level of pavement condition demonstrated in the control section evaluations (figure 4). This

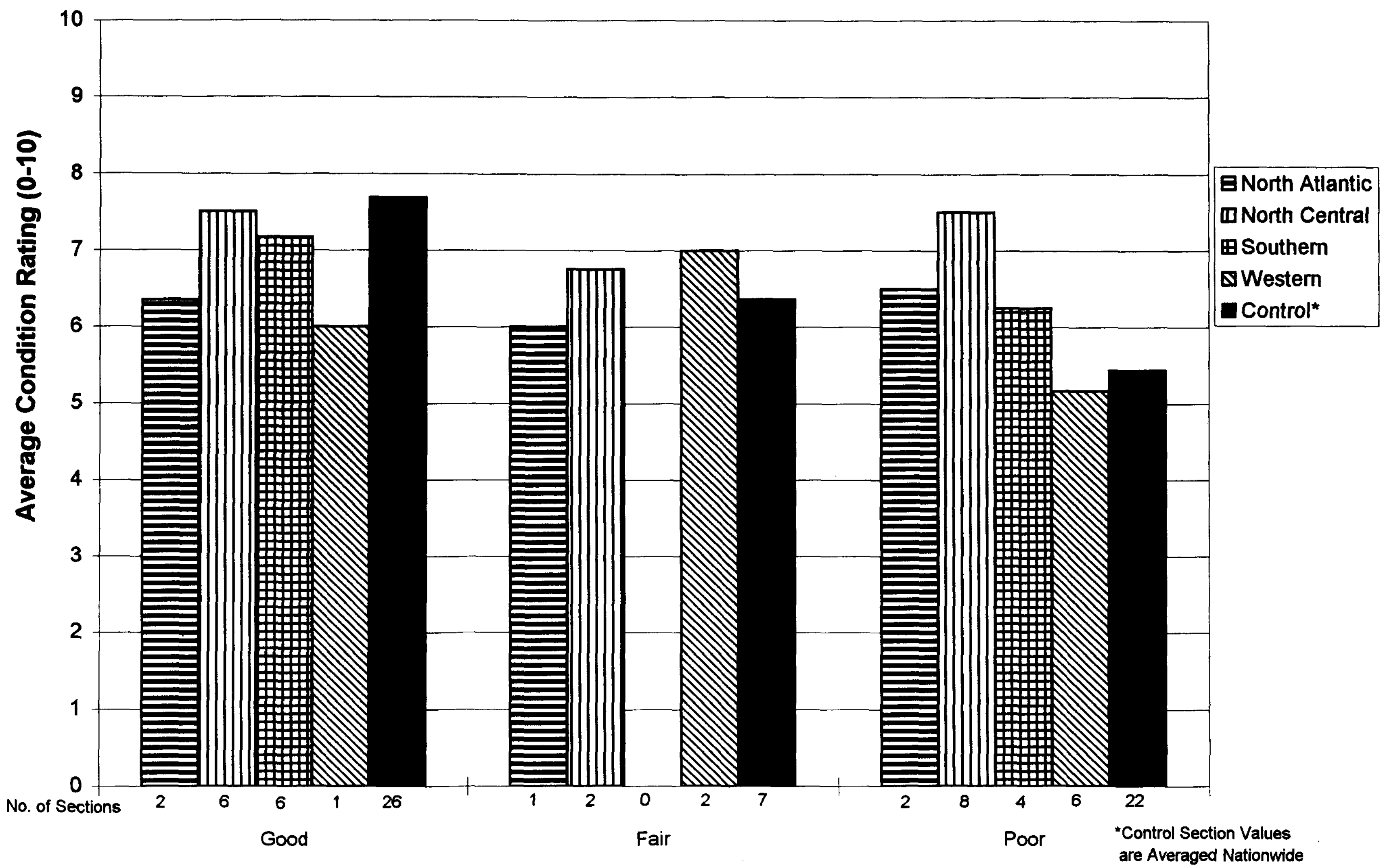

Figure 5. Average overall pavement condition by LTPP region for crack seal sections.

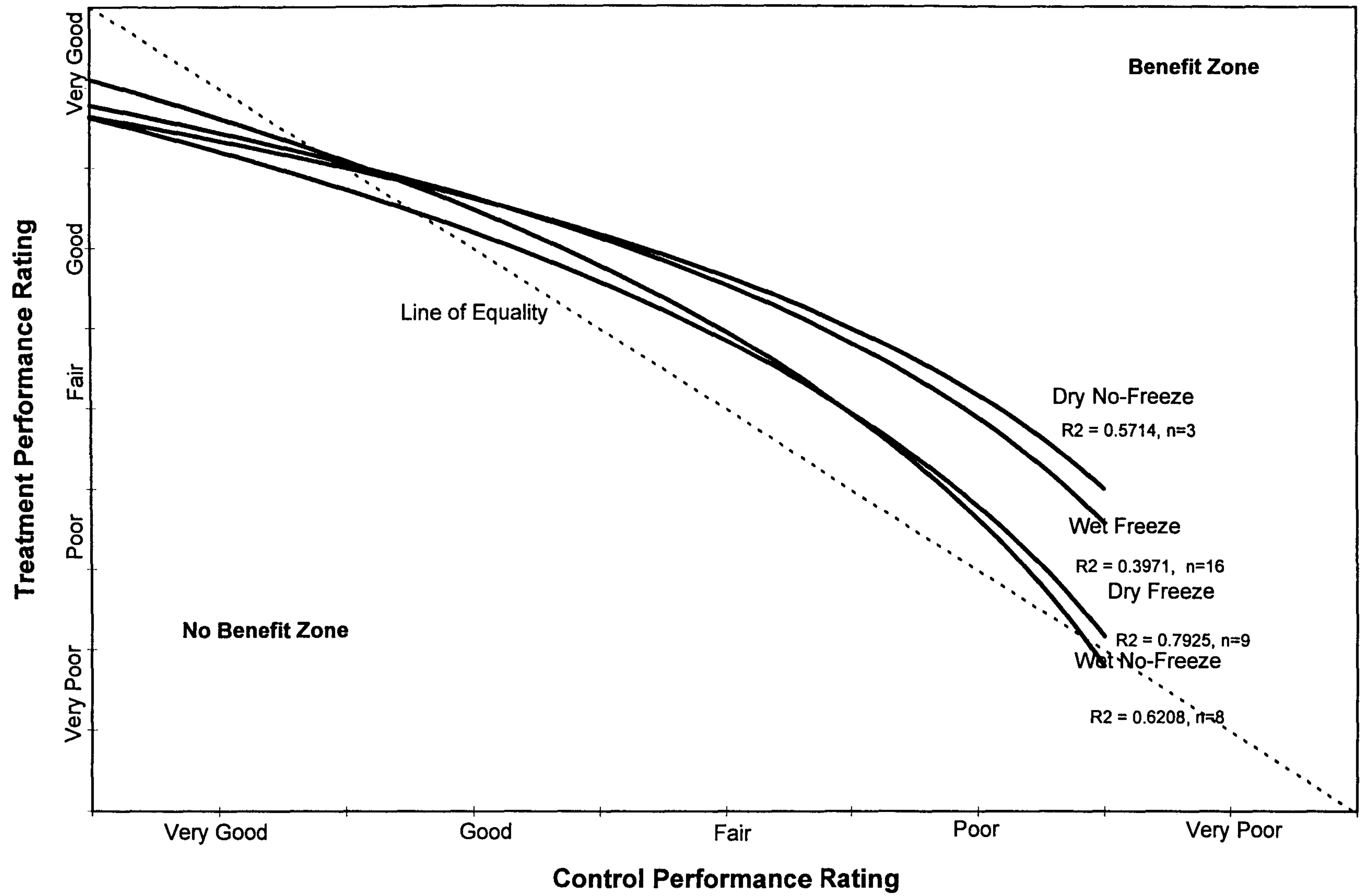

Figure 6. Treatment vs. control performance for crack seal sections.

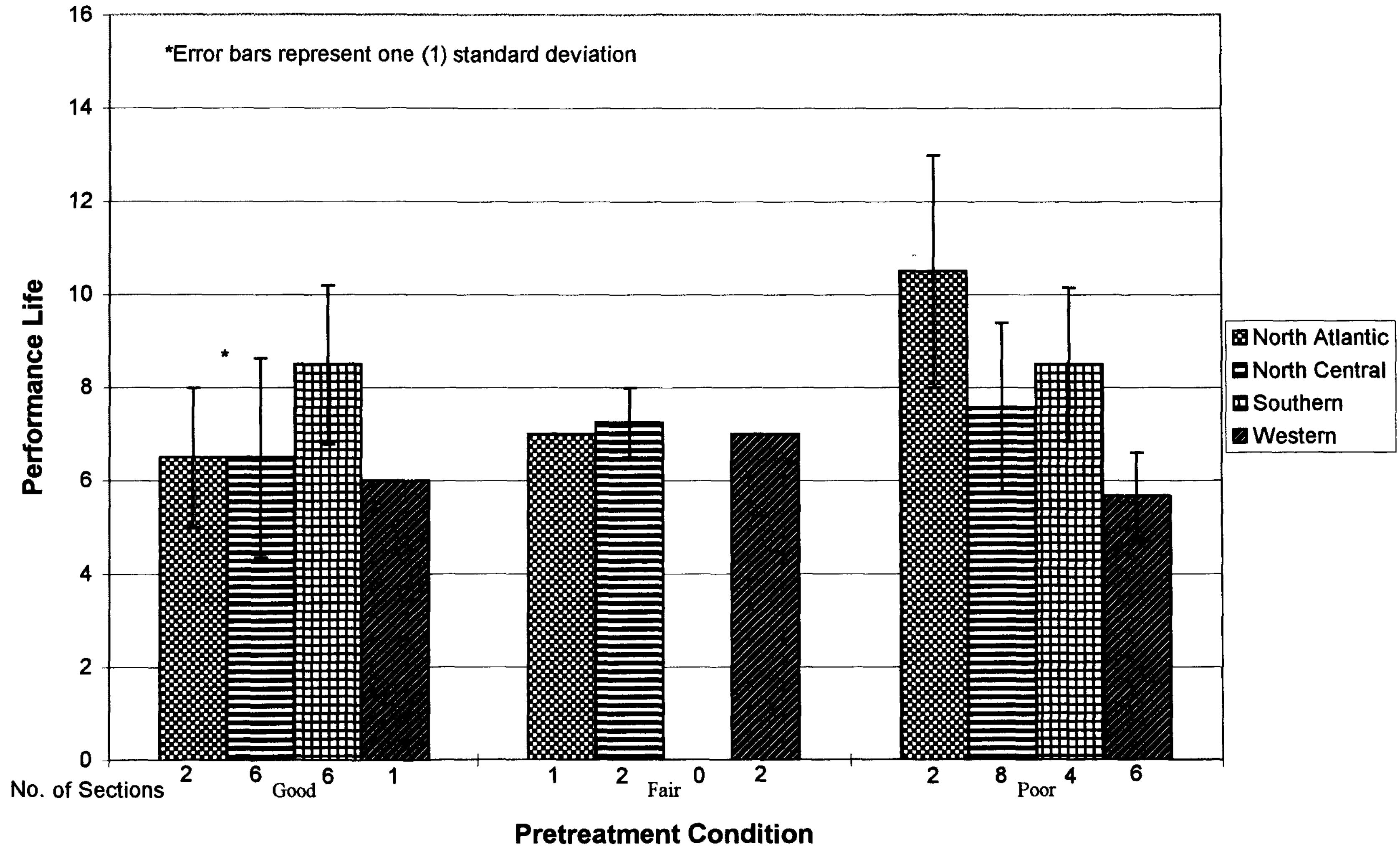

Figure 7. Performance life by LTPP region and pretreatment condition for crack seal sections.

consistency provided a sound platform for comparing the sections across LTPP regional boundaries and making climatic groupings of the data for discussion. The performance evaluations represented in figure 6 reflect the contribution of crack sealing to pavement performance by environmental regions. The figure provides curves representing the performance of the crack seal treatment sections after 5 years compared with the performance of the control sections after 5 years in each climatic region. These curves represent a composite plot of the performance at the three initial condition levels of good, fair, and poor. They were generated using a quadratic regression of these data. Although there is little spread in the regional performance data when applied to good condition pavements, the distinctions are better defined when applied to poor pavements. In considering the performance of the crack seal treatments, several factors must be recognized. Unlike the other maintenance treatments, a new surface is not applied to the pavement. Crack sealing is intended to reduce the infiltration of water into the pavement structure and thereby improves performance. A method for evaluating the effectiveness of crack sealing is to compare the performance of the crack-sealed section with an unsealed control section over a period of years. If the crack sealing is truly effective at slowing the rate of deterioration, the condition of the sealed section will show improvement relative to the control section after several years. Unfortunately, the fact that the crack sealing was not maintained at most of the SPS-3 sites clouds even the evaluation of the change in pavement condition over time, since this permitted the entry of water into the pavement.

Figure 6 indicates that the crack-sealed sections in the dry-no freeze and wet-freeze environments performed similarly. Those pavements with control sections in poor condition are better than the controls. This trend is also true for the sections with fair control section conditions. As expected, when the control sections are in good condition, little change is seen in the performance of the crack-sealed pavement sections. To effectively prevent water from entering and damaging the pavement structure, crack sealing must be undertaken early with the onset of cracking.

The crack-sealed sections performed similarly in the dry-freeze and wet-no freeze environments. For the good condition control sections, the results are very similar to those noted for the other climates; however, when the control sections are poor, so are the crack-sealed sections. When control sections are fair, the treated sections are slightly better.

It is interesting to note that the pavement sections in the dry-no freeze and dry-freeze climates resulted in very different performance, even though the cracks in these regions were routed and sealed in the same manner and they were evaluated by the same review team. This reflects the effect of a freezing climate vs. a no-freeze climate on the performance of crack seals. Again, the better performance of the wide, shallow crack seal reservoir is evident in the wet-freeze climate.

Although a marginal benefit is seen from the crack seal treatment in several cases, it is reasonable to expect that the observed performance would have been better had the crack seal been maintained. Specific examples of this were found at sites in Minnesota[9] in the wet-freeze climate.

Performance Life

Although the crack sealing treatment was applied in accordance with three different specifications, ETG remaining life estimates typically fall within a 2-year range. The performance of the North Atlantic region sites for pavements in initially poor condition represents the outstanding exception to this observation (figure 7). The higher performance expectation for these pavements reflects the observation that the wide shallow crack seal reservoir design used in the North Atlantic region performed very well on these sections.

The expected remaining life for crack sealing varies from 6 years to just over 8 years for pavements in good condition. For those in fair condition, the variation is about 1½ years–from 6 to 7½ years. The greatest variation exists for the poor condition pavements. In this case, the performance estimates vary from less than 6 years to more than 10 years (figure 7).

Slurry Seal Treatment

Results of Reviews

Figures 8 through 10 present ETG evaluation data for slurry seal treatments in terms of pre-treatment condition, climatic region, and predicted performance life. Slurry seals have improved pavement performance relative to the control sections at all levels of initial pavement condition in the dry-no freeze environment. In all climatic regions, slurry seals performed well on pavement sections with little initial cracking.

Moisture sensitivity problems were observed in the dry-freeze and wet-no freeze environments. Accelerated fatigue cracking and severe wheel path rutting of the hot-mix pavements developed in some of the slurry seal sections in these two climates. This issue is discussed in detail in the section on moisture sensitivity.

Effect of Initial Pavement Condition

Figure 8 shows the effectiveness of slurry seals as compared to control sections by initial condition of the pavement and by LTPP region. For pavements in initially good condition, the benefits of slurry seals as compared to control sections are minor. For pavements in initially fair and poor conditions, improvements in pavement performance are noted primarily in those sections in the southeast and west.

Effect of Climatic Region

Figure 9 shows the relative performance of slurry seals versus control sections after 5 years of service. Slurry seals placed in the dry-no freeze region performed well regardless of the condition of the control section.

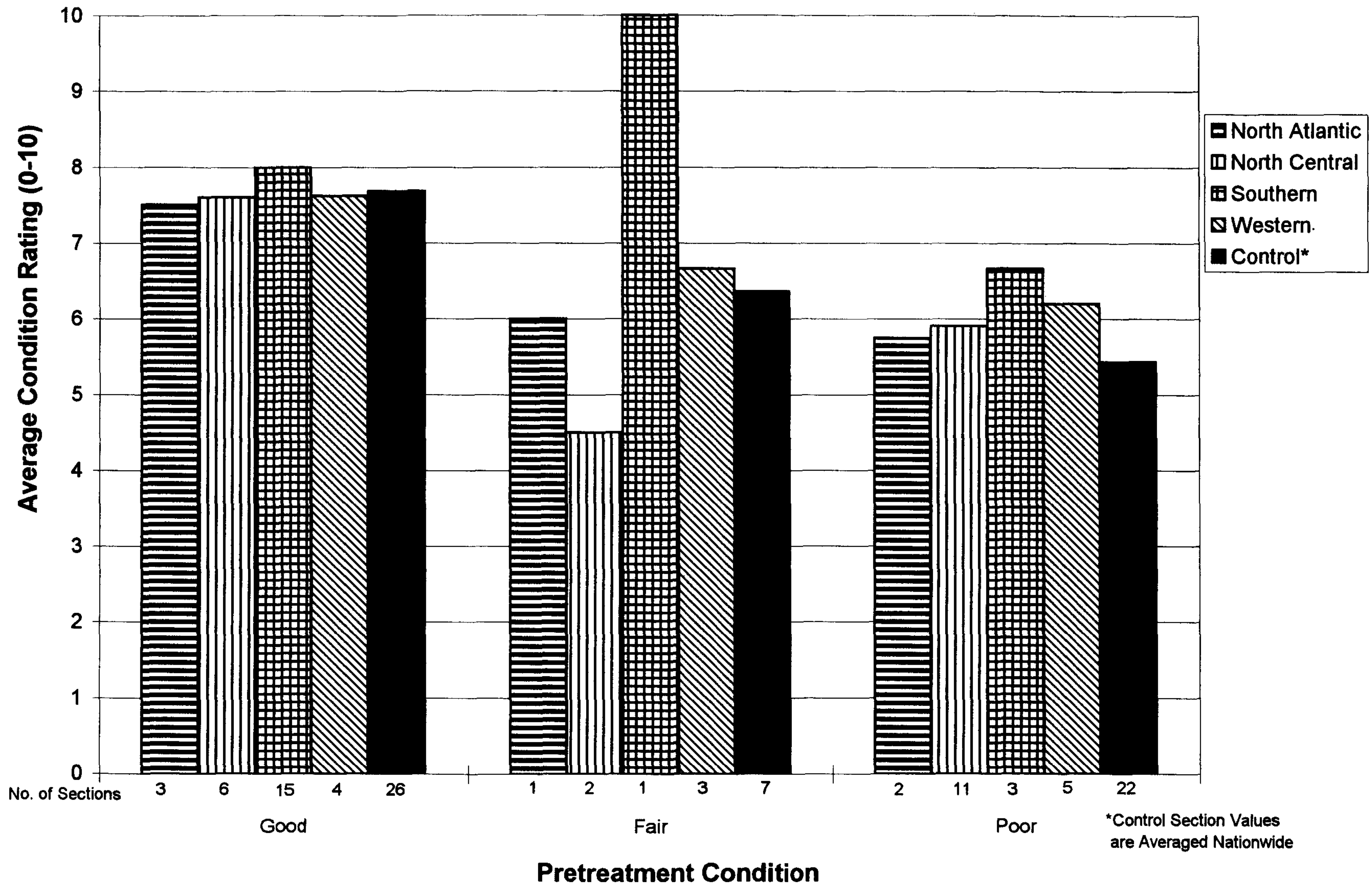

Figure 8. Average overall pavement condition by LTPP region for slurry seal sections.

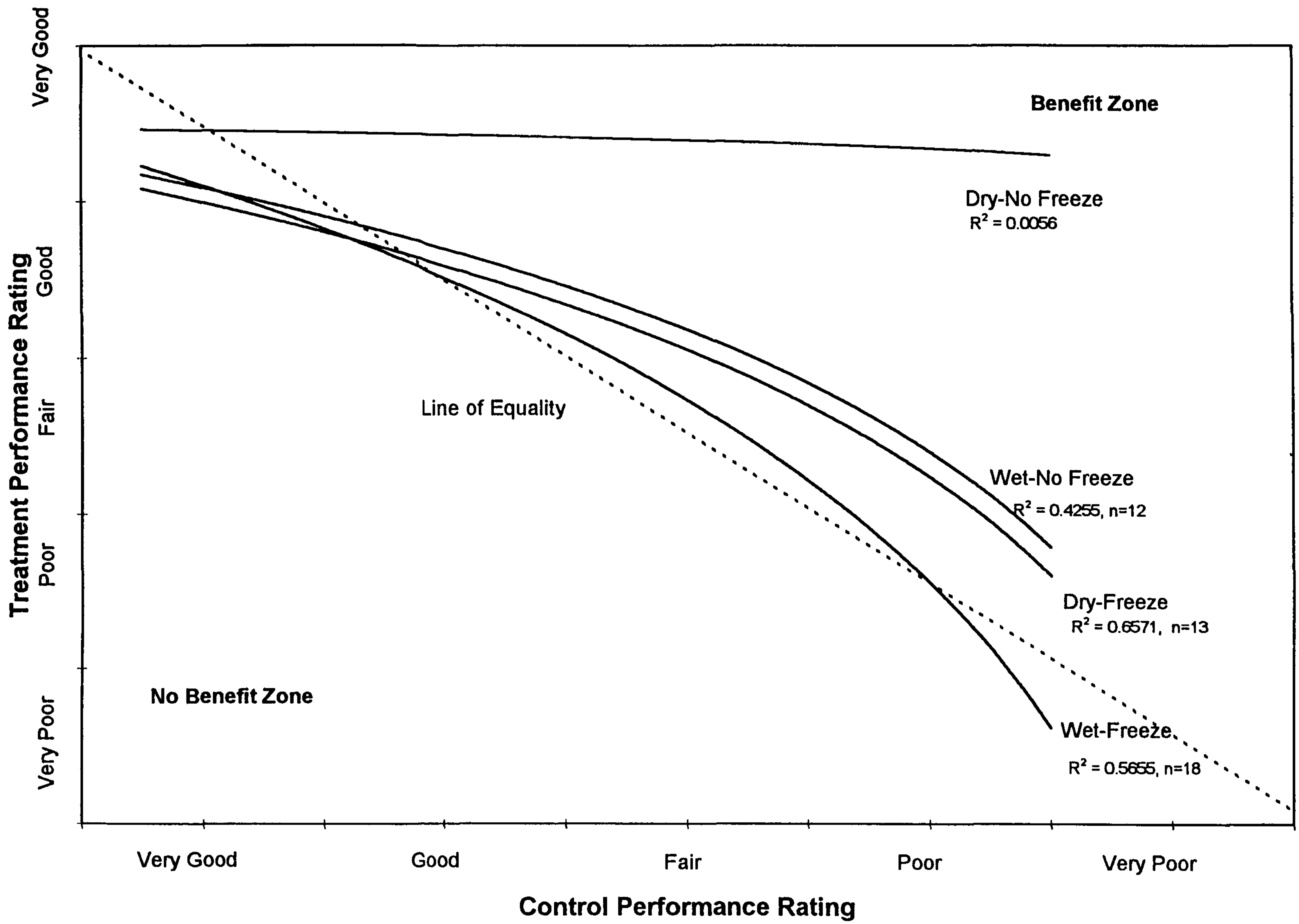

Figure 9. Treatment vs. control performance for slurry seal sections.

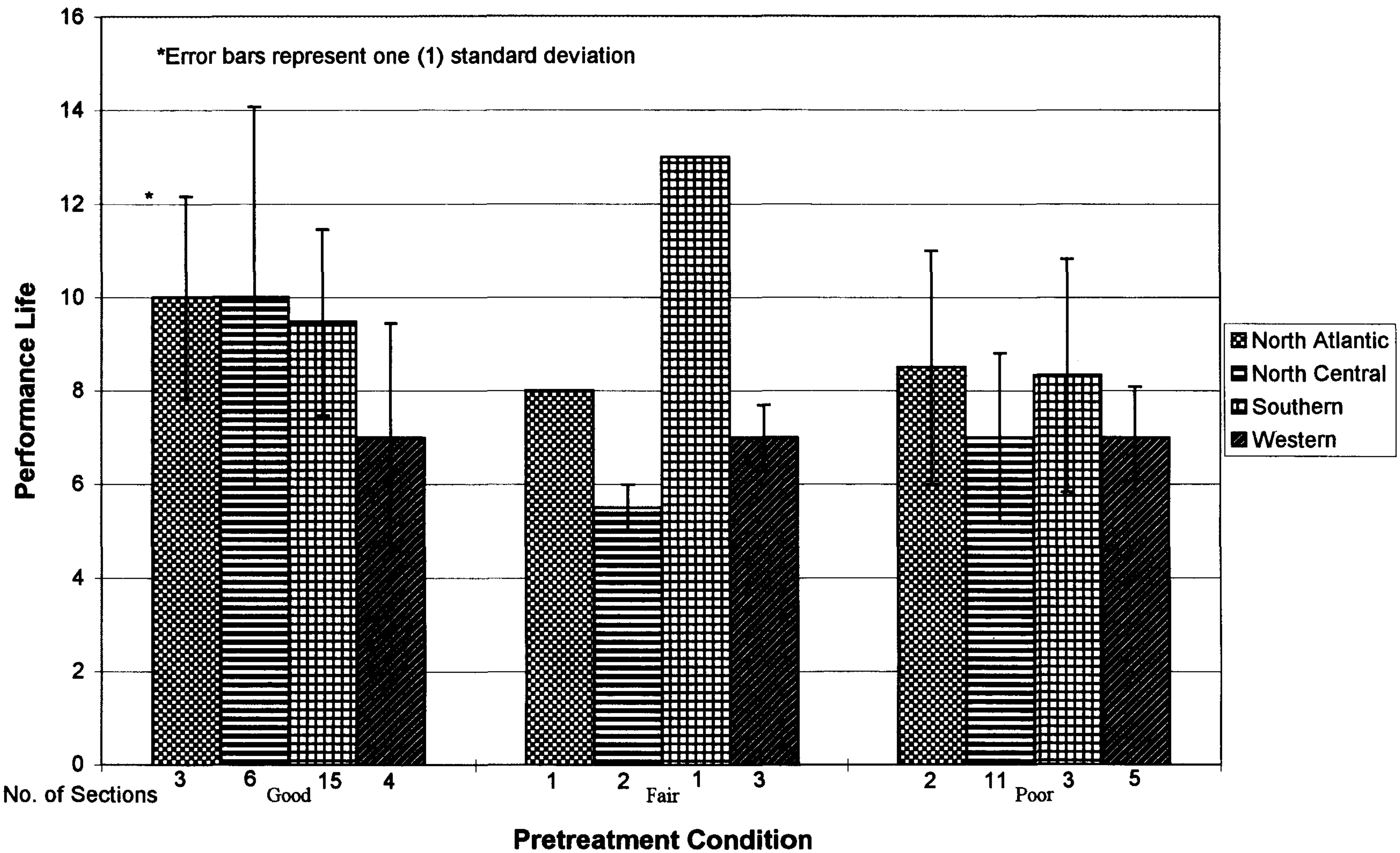

Figure 10. Performance life by LTPP region and pretreatment condition for slurry seal sections.

The wet-freeze climate, again, is most severe in terms of the benefits provided to the pavement by a treatment. Only marginal benefit is provided in this climate for pavements with control sections varying from good to poor conditions (figure 9).

Slurry seal performance in the wet-no freeze and dry-freeze regions is quite similar (figure 9). In these environmental regions for pavements with control sections now in poor condition, the test section condition remains fair. Those pavements with control sections in fair condition remain slightly better than fair. Pavements with control sections in good condition after 5 years have received little benefit from the treatment application.

In summary, there is a wide variation in the benefits derived in the four climatic zones. These trends suggest selective application of the slurry seal treatment, depending on the local environment and pavement conditions.

Performance Life

Figure 10 provides the performance life estimates for the slurry seal treatment. Slurry seals placed on pavement sections in good condition are expected to last from 7 years in the Western region to around 10 years in the other regions. Considerable variation is present in the estimates of performance life when placed on fair condition pavement sections. Note that only eight sections with fair condition pavements were reviewed, with only one in the Southern region and two each in the North Atlantic and North Central regions. Excluding the stellar estimate for the single Southern region site, the slurry seal when placed on fair condition pavements is expected to perform for 6 to 8 years. When placed on pavement sections in poor condition, the slurry seal treatment is estimated to perform for 7 to 8 years.

Chip Seal Treatment

Results of Reviews

Figures 11 and 12 present ETG evaluation data for chip seal treatments in terms of initial condition, climatic region, and predicted performance life. The chip seal treatment performed well throughout all of the environmental regions of the country. In the wet-no freeze region, performance was quite good. In the dry-no freeze and dry-freeze regions, chip seals consistently performed well. In the wet-freeze region, chip seals performed well on good and fair pavements.

As discussed in the section on construction lessons, some application problems were encountered in the Western and North Atlantic LTPP Regions as a result of excessive hauling and storing of emulsions. Snowplow damage was observed at some sites in areas where plowing is common.

In the Southern region, two site observations of special note were forthcoming. First, near Freer, TX, a severely fatigue-cracked test section was successfully held together with a chip seal. Distress had not developed after 5 years. This lends itself to an observation that in

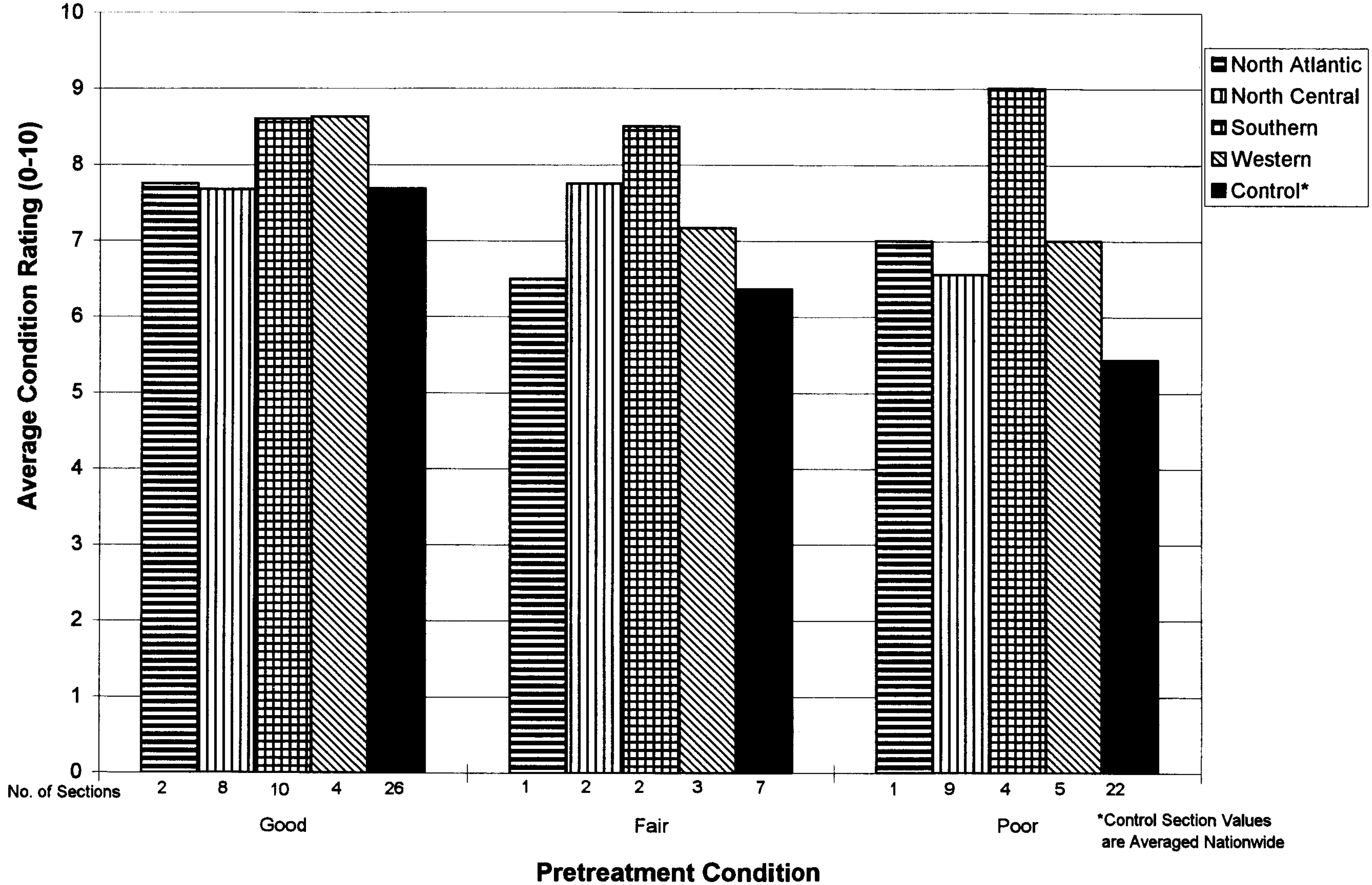

Figure 11. Average overall pavement condition by LTPP region for chip seal sections.

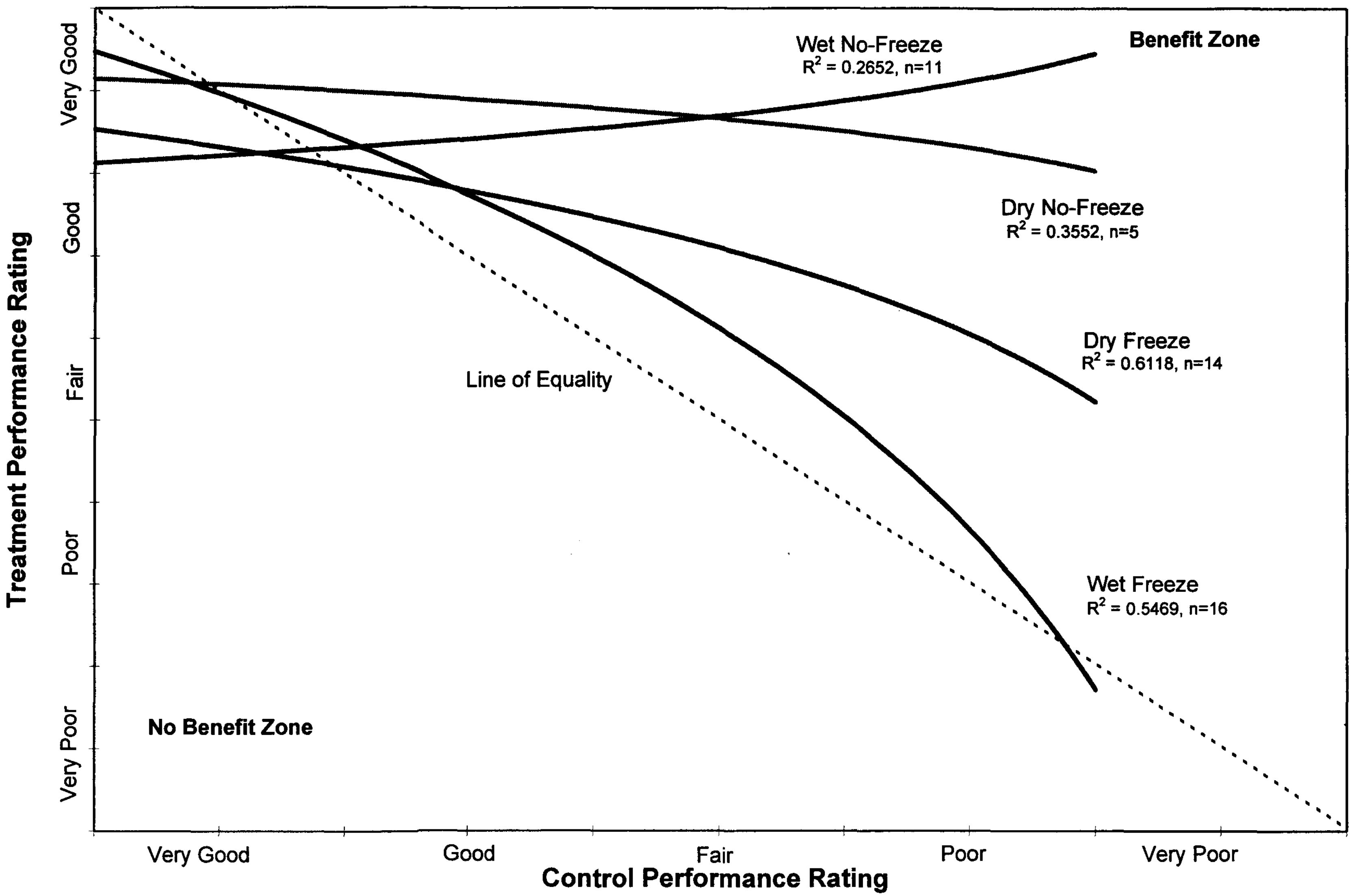

Figure 12. Treatment vs. control performance for chip seal sections.

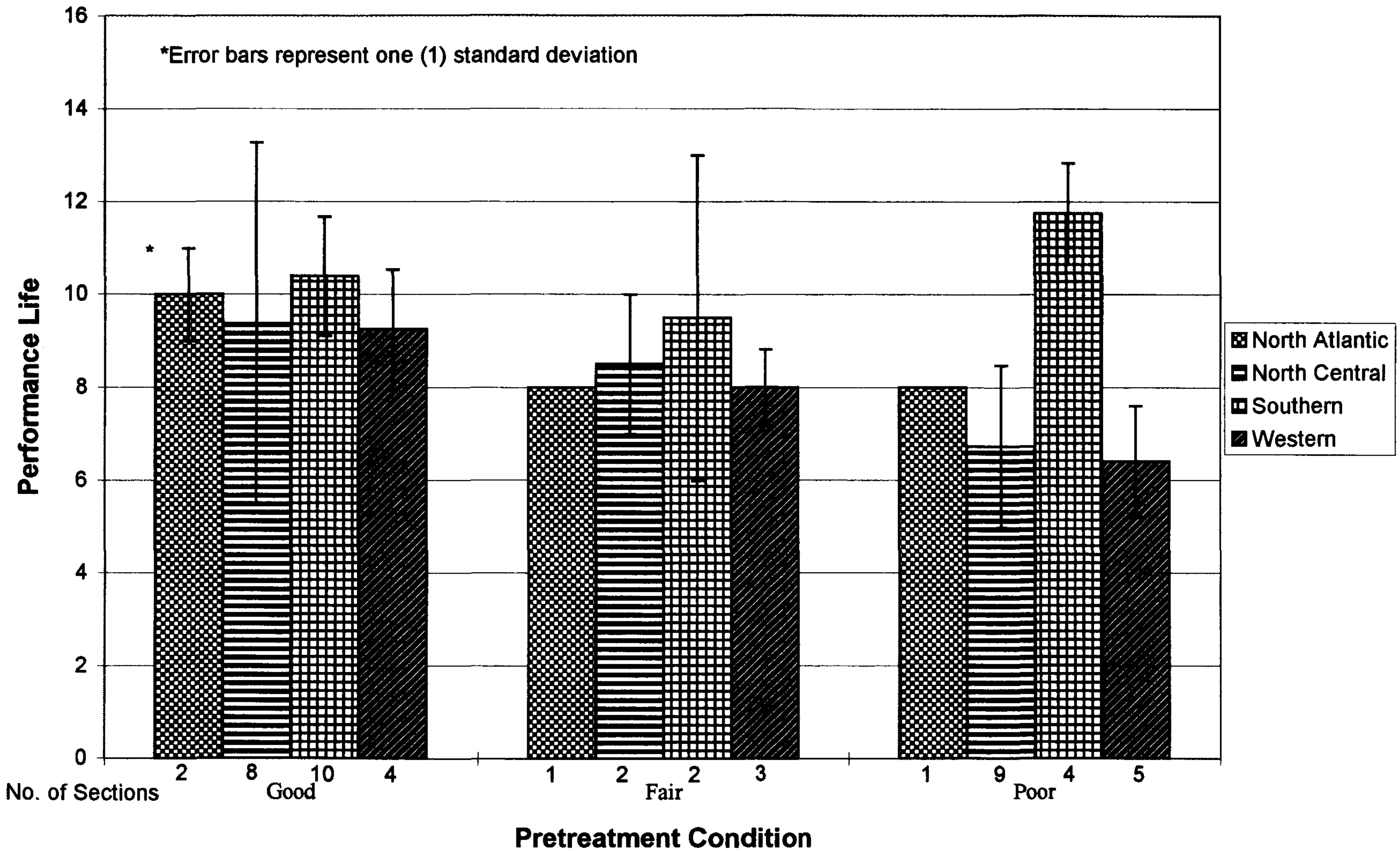

Figure 13. Performance life by LTPP region and pretreatment condition for chip seal sections.

warmer climates, chip seals can be effective in reducing the further development of fatigue cracking. Second, at a sight near Colorado City, TX, it was noted that a deteriorating open-graded friction course was maintained by the application of a chip seal. In this case, loss of the open-graded friction course was halted. Both of these observations identify further benefits of chip seal applications.

The chip seal treatment was observed to have accelerated stripping of pavements in the dry-freeze, wet-no freeze, and dry-no freeze climates. This has been observed at six sites and confirmed at two sites in Arizona by testing. It is likely that this moisture-related phenomenon will occur in the wet-freeze region as well, if stripping potential materials are present. The section discussing moisture sensitivity addresses this phenomenon in more detail.

Effect of Initial Pavement Condition

Figure 11 reflects chip seal performance by pavement condition level prior to applying the treatments. The application of chip seals resulted in average performance ratings across all pavement conditions that were better than the associated control sections. Benefits are evident for pavements in nearly all conditions and regions.

Effect of Climatic Region

As figure 11 shows, once again, the freeze environments have a more severe effect on the pavement section performance, with the wet-freeze climate being the most severe. In the wet-freeze environment, pavements with control sections in fair and poor condition remain slightly better than the control sections. In the dry-freeze region, slightly greater benefit is obtained. Pavements with fair condition control sections remain in good condition, and those with controls in poor condition remain in fair condition.

In the wet-no freeze climate, the benefit to the pavement appears to increase as pavement condition gets worse (figure 12). This trend is based on site observations and demonstrates some inconsistency in the ETG ratings and that distress has not become apparent at any condition level in this climate. Likewise, in the dry-no freeze climates, the benefit of chip seals is good for fair and poor condition pavements (figure 12). In the dry-freeze environment, there is significant benefit to pavements in the poor and fair conditions (figure 12). The benefits of the chip seal treatment are certainly greatest in the no-freeze environments, but can also be seen in the freeze environments.

Performance Life

Figure 13 provides the performance life estimates for the chip seal treatment. It can be seen that the estimates decrease with decreasing initial pavement condition. The outstanding exception to this is the performance estimate for the chip seal treatment in the Southern region. Note that a limited number of sites in the North Atlantic region are represented.

Performance expectations for the chip seal when applied to good pavement sections are 9 to 10 years. For pavement sections in fair condition, the performance expectations are 8 to 9 years. For pavement sections in poor condition, performance expectations are from 6 to 8 years. As previously stated, the Southern region represents an exception. At all levels of pavement condition, the Southern region expectations are highest (figure 13).

Thin Hot-Mix Overlay Treatment

Results of Reviews

Figures 14, 15, and 16 present ETG evaluation data for thin hot-mix overlay treatments in terms of initial condition, climatic region, and predicted performance life. The thin overlay sections were considered to have performed well by all the regional groups. Although there were specific sections that provided performance anomalies, the thin overlays were reported as improving ride quality, reducing rutting, and often reducing the severity of reflective cracking.

Effect of Initial Pavement Condition

The good performance of the thin overlays across all pavement condition levels is shown in figure 14. In all cases, the average section condition is significantly better than the associated control sections, indicating a benefit from the treatment. Note that there were no fair condition pavements reviewed in the Southern region with thin overlays.

Effect of Climatic Region

Examining the ETG ratings for the thin overlay treatment, the environmental trends previously discussed hold true. As shown in figure 15, the benefit of the overlays compared with the control sections is evident. In the freeze environments, pavements with control sections in poor condition have remained in fair condition. Similarly, pavements with control sections in fair condition remain in good condition; those with a good control section have performed only slightly better than the controls.

In the no-freeze environments, even greater benefit is evident. After 5 years, the sections with control sections in fair and poor condition remain in good condition. At the same time, the sections with good control condition remain very good.

These trends clearly show the benefits of the thin overlay after 5 years of performance with respect to pavement condition level. The benefit to poor condition pavements in the no-freeze climates is almost two times the benefit received in the freeze climates.

Performance Life

Figure 16 shows the performance life estimates for the thin overlay treatment. Only a slight difference is seen between estimates for the treatment placed on good and poor sections. Estimates for sections placed on fair pavements are somewhat lower.

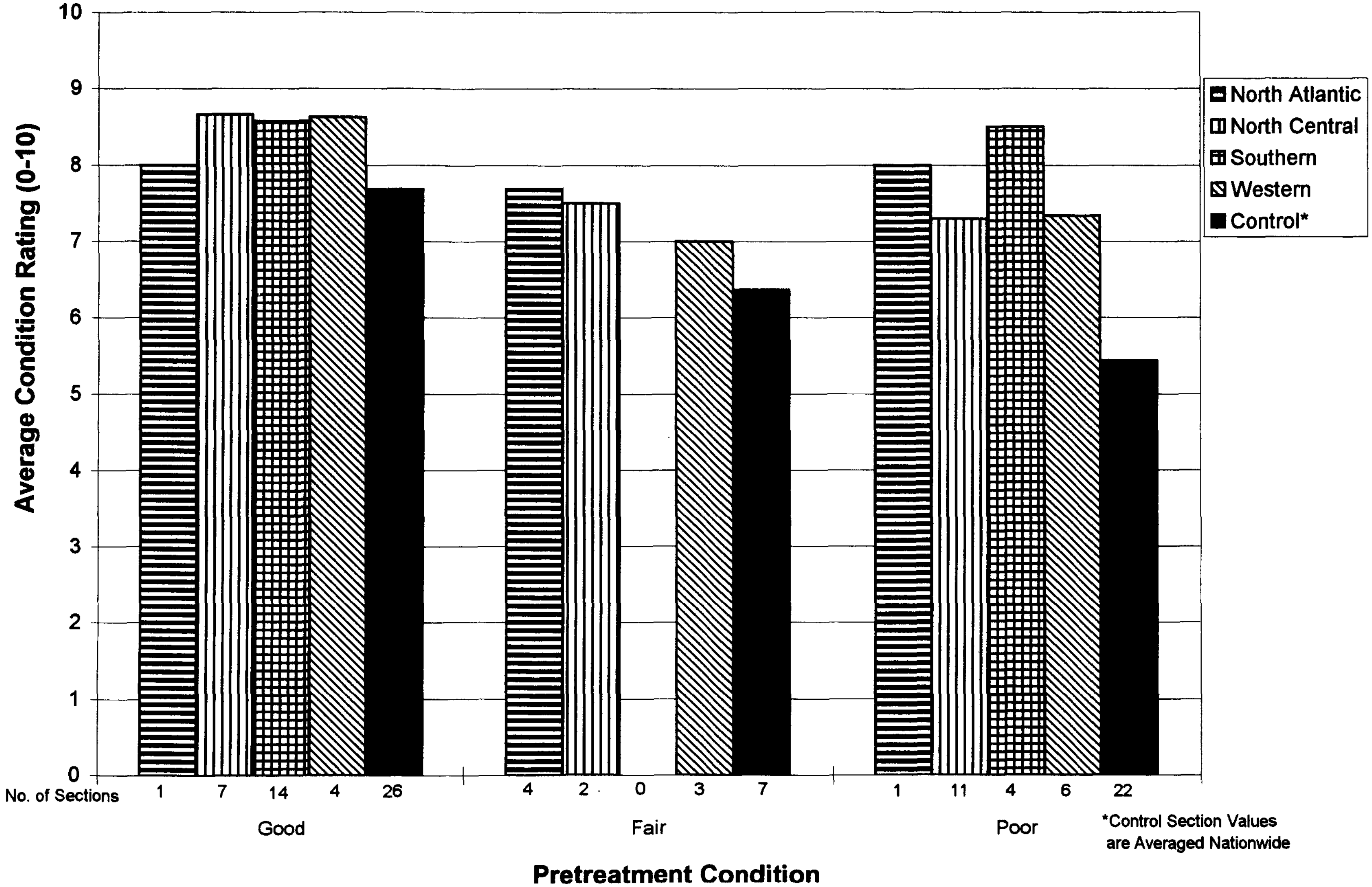

Figure 14. Average overall pavement condition by LTPP region for thin overlay sections.

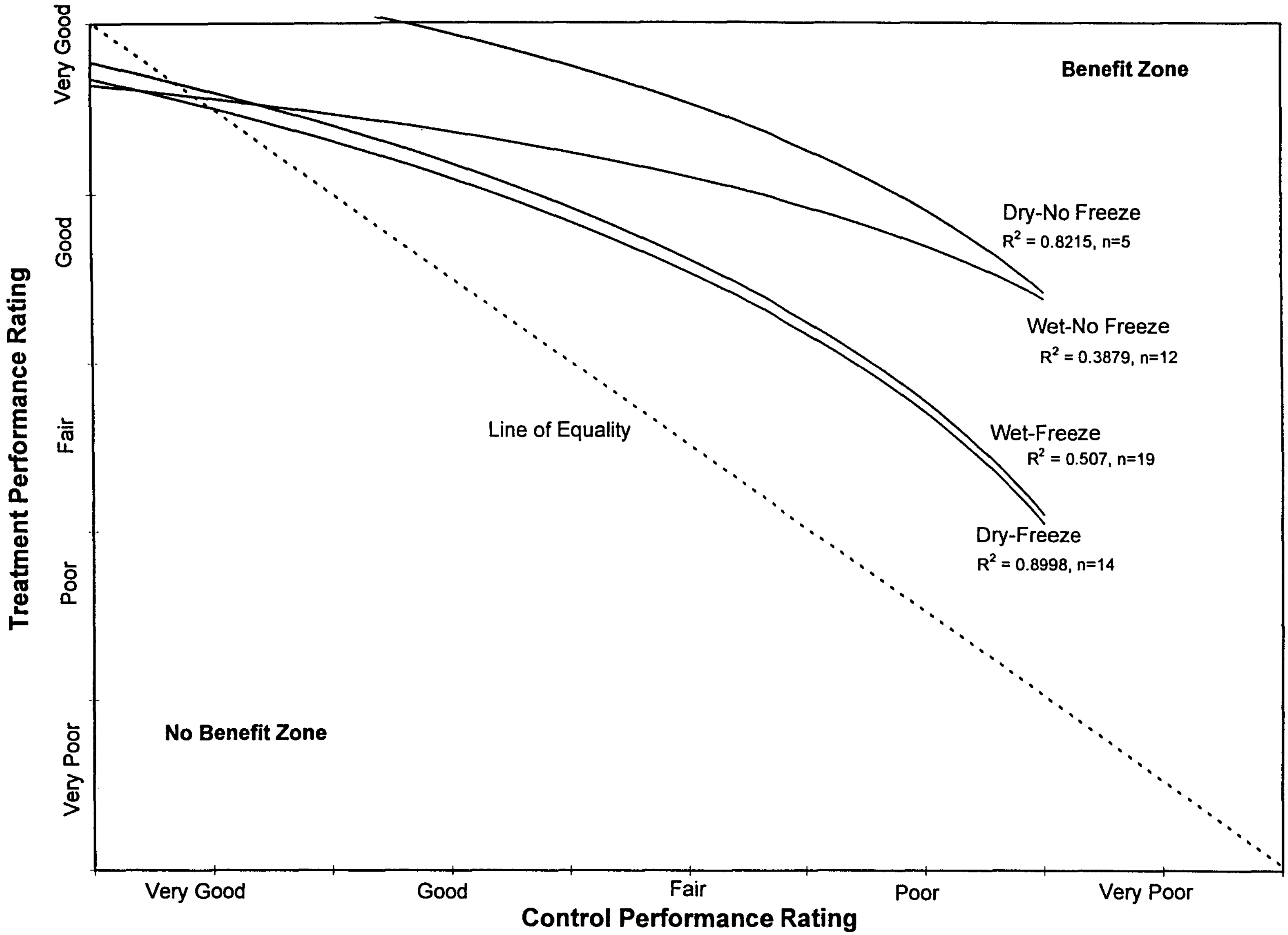

Figure 15. Treatment vs. control performance for thin overlay sections.

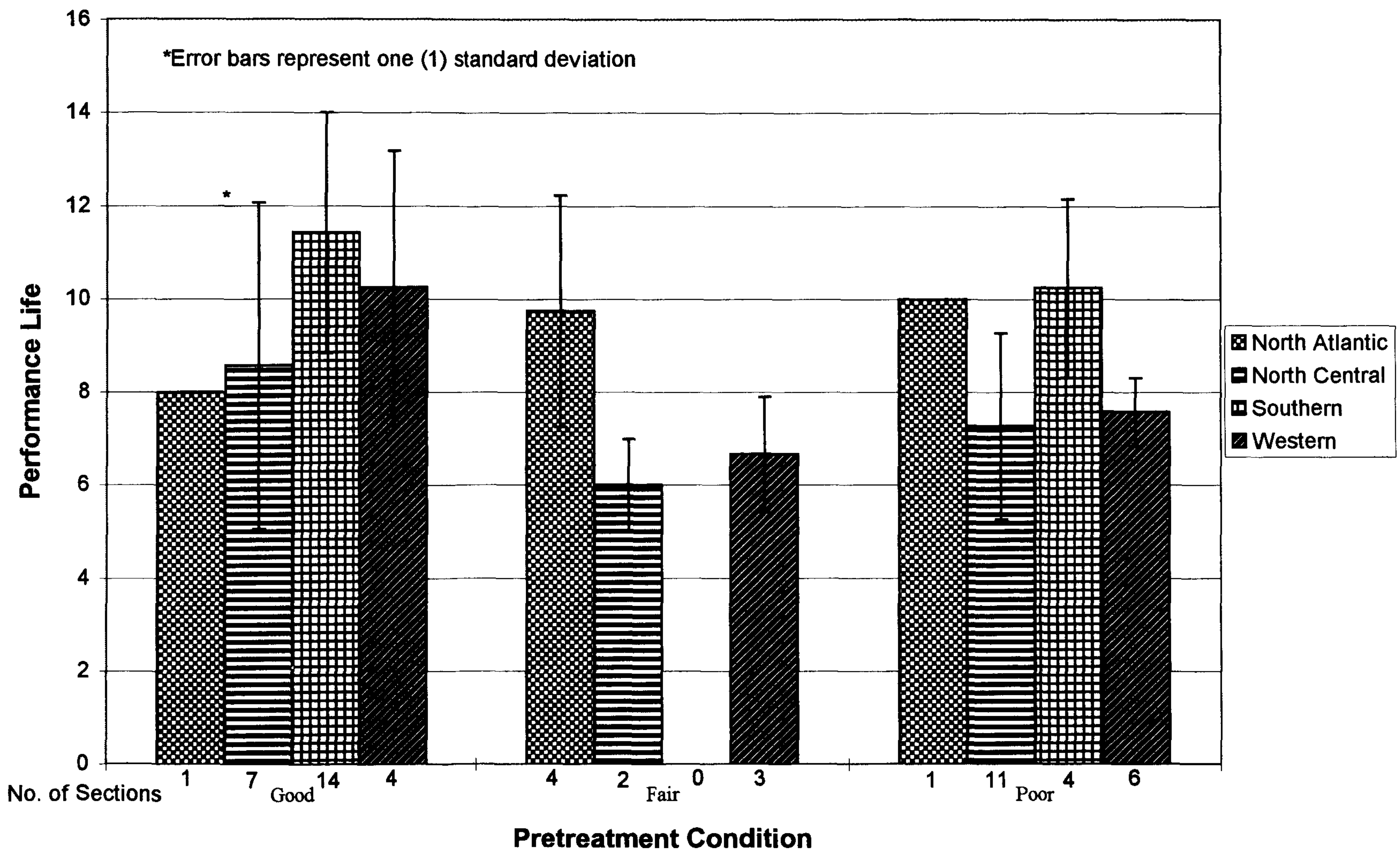

Figure 16. Performance life by LTPP region and pretreatment condition for thin overlay sections.

For pavement sections in good condition, the performance estimates for the thin overlay are from 8 to 11 years. For pavement sections in poor condition, the estimates vary from 7 to 10 years. For those sections in fair condition, estimates are from 6 to 9 years. In all but the North Atlantic region, a limited number of fair condition pavement sections are represented.

Observations Related to Specific Pavement Distress Types

Information was collected by the ETGs regarding the influence of the treatments in improving specific distress types. These specific distress types were selected to provide more detailed information about the effect of the maintenance treatments on the deterioration of the pavement. The distress types included were: longitudinal, transverse, and fatigue cracking. Along with these were bleeding, raveling, and snowplow damage. The summary of ETG performance ratings with respect to these distress types is provided in appendix E. The following discussion summarizes the performance of the treatments with respect to these distress types.

Crack Seal

The effect of the crack seal treatment in reducing the three types of cracking is marginal. This is reflective of the fact that sealed cracks continue to be counted as distress in the LTPP distress survey procedures.

The crack seal treatment has little effect on snowplow damage to the pavement. The same is true of bleeding. The treatment is seen to have a positive effect on pavement raveling.

Slurry Seal

The slurry seal treatment appears to result in some improvement in the presence of the cracking distresses. Forty percent of the sections have less cracking than the associated control sections.

The slurry seal treatment also shows some benefit in reducing pavement raveling. No real change is seen in bleeding or snowplow damage, as compared with the associated control sections.

Chip Seal

The chip seal treatment significantly reduces the occurrence of cracking in the pavement surface, with more than 60 percent of the sections having less cracking than the associated controls.

The chip seal treatment provides some benefit in relieving pavement raveling in 36 percent of the test sections. However, there is no clear trend in this area since the visual observations provided by the ETGs indicate a greater number of sections with raveling after treatment.

This trend of having more sections distressed also holds true for bleeding and snowplow damage.

Thin Overlay

The thin overlay treatment sections reduced the three types of cracking distress at more than 60 percent of the sites, as compared with the associated control sections.

The thin overlay treatment also has been of benefit in reducing raveling in 45 percent of the test sections, relative to the associated control sections. It has improved bleeding in 38 percent of the sections, and snowplow damage in 27 percent of the sections.

Assessment of SPS-3 Supplemental Sites

Data for the supplemental sites that were collected during the field reviews have been compiled in appendix F. The evaluation of the data was performed by recording the pavement performance ratings assigned to the supplemental, control, and companion sections at each site. The companion sections are identified as the standard SHRP experimental section, which is similar to the supplemental section. For example, the companion section for a microsurfacing section is the standard SHRP slurry seal.

Since there are a limited number of supplemental sections, and an even greater limit on the number of sites of the same type that were actually constructed, it became necessary to look at individual sites. Where possible, similar treatment types are grouped together for commentary about relative performance.

This assessment is limited to the supplemental sites that were reviewed in the field. Reviews were made of supplemental sections that can be compared with the slurry seal, chip seal, and thin overlay sections. In addition, the relative performances of the supplemental and companion sites are each compared with the performance of the site control section. The last two columns at the right of appendix F present the difference in the section performance rating and the control section performance rating. Comparing these two columns provides a relative performance comparison between the supplemental and companion sections.

Slurry Seals

Supplemental sites using microsurfacing as a treatment were constructed in Florida, New York, and Oklahoma. Of these, two were rated slightly higher than, one equal to, and one lower than the companion slurry seal. The margin of difference in performance rating does not appear to be significant in any of these cases.

Other State supplemental slurry seals were constructed by Michigan and Virginia. Again, no major difference is seen in the performance ratings, with one being slightly better and the other slightly worse than the standard slurry seals.

Chip Seals

Supplemental chip seal sections were constructed in three generic categories: those including modified asphalts, standard State materials, and graded aggregates. In addition, Ontario constructed two Dynapatch sections. One was a full surfacing and the other was applied only in the wheel paths. The performance of these sections is discussed below.

Supplemental chip seal sections using modified asphalt materials were reviewed at six locations in three States–California, Minnesota, and Texas (appendix F). Three of these sites were rubber-modified and three were polymer-modified. Again, there is not a clear-cut trend in the evaluation. The rubber-modified chip seal in Minnesota appears to be performing better than the associated chip seal section. The two rubber-modified sites in California and Texas, however, are not perceived as well as the associated chip seal section.

California constructed three chip seal sections with various polymer modifications. One of these appears to be performing slightly better than the companion chip seal sections. These three sections are all at one site.

Twelve supplemental sites were constructed with the standard State procedures, or some variation thereof. Of these, four of the companion sections were evaluated as performing better than the supplemental section, while three were rated as being the same. The remaining five supplemental sites were rated as slightly outperforming the companion chip seal sections.

The two Dynapatch sections constructed in Ontario performed well relative to the control section. The chip seal section at that site failed during construction, so there was no companion section for comparison.

Finally, six chip seal supplemental sites were constructed using graded aggregate. Of these, the companion chip seal section outperformed the supplemental section at two sites. At one location, the two sections were rated equally. Three of the sections in New York were rated as slightly outperforming the standard chip seal. All three New York sections were at one location.

Thin Overlays

Several thin overlays that included thickness variations or mixture additives were reviewed in the field. One section that included Bonifibers was constructed in California. This section was rated slightly better than the companion thin overlay section.

Of three supplemental thin overlay sections in Utah, two were rated slightly better than the standard thin overlay, and one was rated as worse. These sections were a standard Utah Department of Transportation overlay thickness (37 mm) and were all at different locations.

Neither a gap-graded rubber-modified section nor an adjacent open-graded section was rated as well as the companion overlay at a California site.

A double overlay in Ontario experienced problems and was rated lower than the standard overlay at that location.

SPS-4 ETG REVIEW RESULTS

Observations related to the performance of the SPS-4 projects were relatively limited after 5 years. There were significantly fewer sites constructed and only a sampling of these were reviewed in the field. Based on the limited number of sites reviewed, the findings are:

- Unsealed joints in the control sections contain significantly more debris than sealed joint sections.
- Unsealed joint sections have significantly more joint spalling than the sealed joint sections.
- Minor amounts of debris have lodged in the sealed joint sections, with little or no effect on pavement performance to date.
- No conclusions are evident regarding the performance of the undersealed sections after 5 years. The sections continue to perform consistently well. Only eight test sections that included this factor were originally constructed nation-wide.

SPS-4 Supplemental Sections

The performance of supplemental SPS-4 sections was only reviewed in the field by the ETGs at a site in Arizona and a site in South Dakota. Four joint sealant materials and five joint reservoir sizes were constructed at the Arizona site. Joint reservoirs ranged from 3 mm to 9 mm in width. Joint sealants included silicon, compression seals, ASTM 3405, and ASTM 3406 materials. All sections are performing well to date. Observations from the South Dakota site indicate that diamond grinding, dowel insertion, and edge drains have all reduced pavement pumping at transverse joints.[9]

OTHER FINDINGS

Construction Lessons

Several valuable lessons regarding construction of the preventive maintenance treatments have been identified from the SPS-3 and SPS-4 experiment reviews. While some of these issues may not be new, they are repeated here to emphasize their importance.

Asphalt Emulsion Handling

The construction of the SPS-3 sections identified definite problems with the placement of chip seals that were related to handling and storage of emulsified asphalts. It is likely that these observations are not exclusively applicable to chip seals, but warrant consideration whenever these materials are being used.

The specific lesson learned is not to attempt to transport emulsions for excessive distances or to expect to store them for long periods of time. Both the Western and North Atlantic LTPP regional construction contracts experienced problems with chip seals that directly resulted from unusual emulsion handling practices.

Crack Routing Reservoirs

Most recognizable among the "construction" lessons is the exceptional performance of the wide shallow crack seal reservoir. This shape factor far outperformed the other crack sealing techniques evaluated under the SPS-3 experiment.

Crack Seal Blotting

In the North Central region, tissue paper was used during SPS-3 construction to blot crack seal material. This treatment was sufficiently effective and it has been adopted by the Kansas DOT.

Aggregate Characteristics

Also of importance are the improved aggregate and construction specification requirements used for the SPS-3 sections, as compared with common agency specifications. Better requirements for aggregate durability and quality control of construction operations, such as minimal time requirements between emulsion and aggregate applications and rolling, contributed to the success of the SHRP chip seal test sections.

The use of the coarser (Type III) slurry seal aggregates contributed to the performance characteristics of the slurry seal treatment. Among these is the high level of friction quality provided by the slurry seals nationwide.

Moisture Sensitivity

Some problem cases have been identified when surface seals are applied to pavements containing moisture-sensitive aggregates. Specifically, chip seals and slurry seals have been observed at SPS-3 test sites to have accelerated stripping action in asphalt pavements that incorporate the potential for water sensitivity.

The application of seals to pavements produces a relatively impermeable membrane in the pavement structures. This relatively impermeable membrane stops or slows down the movement of water (solid or vapor) from the subgrade and base course through the hot-mix asphalt. The amount of water moving from the natural soil and base course through the hot-mix asphalt to the atmosphere is largely controlled by the level of the water table, the nature of the natural soil and base course, and the temperature. Substantial quantities of water move through pavements during the spring and early summer months.

The application of a seal to the pavement surface traps moisture in the hot-mix asphalt and other layers. With the placement of the seal, the water content in the hot-mix asphalt is higher and remains in the pavement over a longer period of time than the pavement ever experienced in its previous history. High temperatures and high traffic accelerate the effect of the moisture on the hot-mix asphalt. Moderately susceptible hot-mix asphalt, while not stripping in pavements without seals, will strip in a few weeks with the placement of seals in the spring or summer months. The sudden and extensive pavement failures resulting from the phenomena are expensive to repair.

The ETGs recommend that a method be developed for identifying pavements that are potentially susceptible to moisture damage in the form of stripping. This can be done by evaluating the existing pavement materials by performing stripping tests on existing pavement materials prior to making a decision regarding the application of a maintenance treatment. Further determination of the potential for stripping problems can be made by assessing the likely impact of traffic level on potentially stripping pavements.

Procedures for performing this evaluation are discussed in a report prepared for the Nevada Department of Transportation, entitled *Chip Seal Induced Rutting*.[10] Identification of potential problems that can arise from placing a tight seal (either a slurry or chip seal) under the wrong conditions can prevent serious accelerated pavement damage.

Reflection Cracking

One of the primary objectives for applying preventive maintenance treatments is to prevent the intrusion of excessive moisture into the pavement structure by sealing the pavement surface.

The ability of a chip seal, slurry seal, or thin overlay to maintain a well-sealed surface has been found to be marginally effective in eliminating reflective cracking. The performance evaluations of the treatments applied to pavements in good, fair, and poor initial pavement conditions indicate that reflective cracking returns to the surface within 1 year under most conditions. This is evident from looking at the amount of cracking that is masked by the treatments initially, and by the fact that most of the cracking has returned by the first annual distress survey. A typical example is provided in figure 17, which shows that much of the original cracking has returned within the first year after treatment. The figure reflects only the extent of cracking, not the severity level.

In the wet-no freeze environment, the thin overlay treatment reduced the severity of reflective cracking after 5 years. Similarly, the chip seal treatment reduced the extent of reflective cracking after 5 years. Several test sections were crack sealed prior to application of a surface treatment. These performed well in keeping the pre-existing pavement cracks sealed.

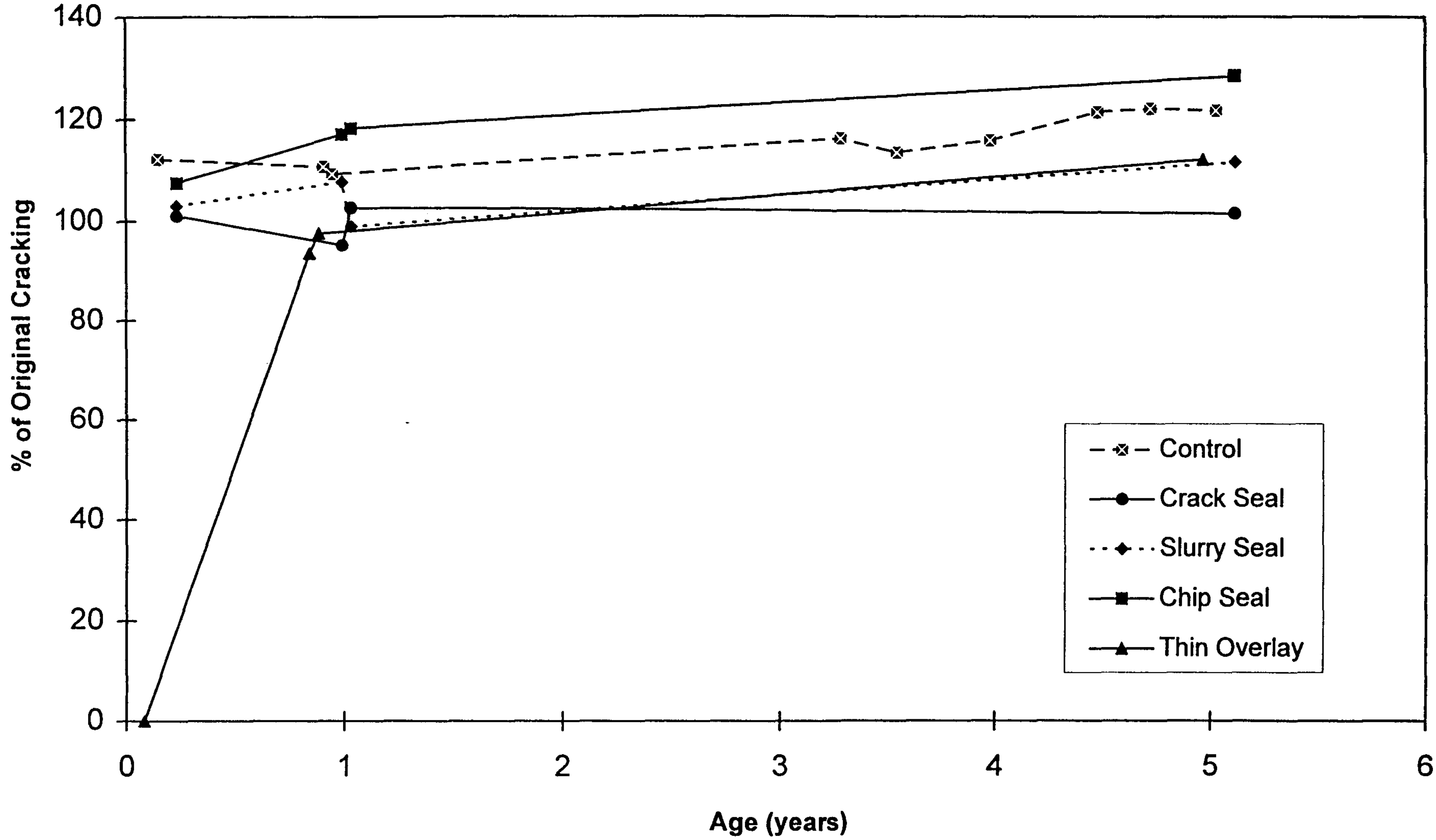

Figure 17. Transverse reflection cracking for Idaho section 16C300.

Treatment Timing

SPS-3 Treatments

One of the most critical and difficult questions regarding the application of maintenance treatments is when (during the life of the pavement) to apply the treatment for best results. Figures 5, 8, 11, and 14 indicate the relationships between treatment performance after 5 years and the initial condition (condition of the pavement prior to placement of treatment) of the pavement. Figure 4 suggests that the control sections in pavements in initially good condition have largely remained in good condition without preventive maintenance. Similarly, the control sections in pavements in initially fair or poor condition have, on average, remained in fair or poor condition. On average, the ETGs evaluation has suggested that the control sections in the pavements have experienced few changes from their initial conditions after 5 years.

Climatic effects on treatment timing are evident with respect to certain treatments in specific environments. Examples of this are the far better performance of the chip seal treatment in the no-freeze climates and the slurry seal in the dry-no freeze climate across all three levels of pavement condition.

Crack Seal

The benefit to pavement performance is greatest when this treatment is applied while the pavement is in good condition and the cracking distress is minimal. The wide shallow sealant reservoir used in the wet-freeze climate provided greater benefit to fair and poor pavements than the other crack sealing specifications used. Only the performance ratings of crack seals in the dry-no freeze climate compared well for sections with more extensive cracking.

Slurry Seal

This treatment was observed to have performed best when applied to pavements in better condition–before extensive cracking distress develops. The outstanding exception to this was also observed in the dry-no freeze climate where the slurry seal performed very well across all three levels of pavement condition.

Chip Seal

The application of the chip seal treatment was observed to provide good pavement performance for all levels of pavement condition in all climatic regions, except for the wet-freeze climate. In the wet-freeze climate, chip seals worked best on pavement sections in good or fair condition.

Thin Overlay

After 5 years of performance, the thin overlay treatment has been observed to provide benefits at all three levels of pavement condition. These ETG observations indicate that thin overlay performance is better in the no-freeze climates than in the freeze climates. However, benefits exist in all four climatic regions. Since the thin overlays continue to perform well, the end of their performance life cannot yet be accurately anticipated.

SPS-4 Treatments

Based on the performance observations made by the ETGs, no conclusions are forthcoming with regard to application timing for the SPS-4 maintenance treatments. The larger set of data from all 31 SPS-4 sites will be evaluated as part of the final project report.

SUMMARY

SPS-3 Experiment

The observations presented in this report summarize the performance of the 57 SPS-3 and 8 SPS-4 test sections reviewed during 1995 by the Highway Operations ETG. Observations after 5 years have provided some information about the effect of the four preventive maintenance treatments being studied and an estimate of their expected performance lives.

The materials and construction specifications used in placing the SPS-3 sections have resulted in better maintenance treatment performance than is normally achieved using existing practices. When the pavement performance of the standard treatments was compared with those of the supplemental sections after 5 years, the performance was found to be similar. On average, the SHRP sections performed as well as the supplemental sections, many of which cost more than the standard sections. Since the usual expectations of flexible pavement performance fall in the 6- to 10-year range, and since the majority of the test sections have not reached the end of their performance life, further evaluation of these test sections appears warranted. It is recommended that further assessment of the test sections be made at 7 and 9 years after placement. This will ensure that information is gathered as the sections near or reach the end of their performance lives.

SPS-4 Experiment

More time is required to obtain meaningful results from the SPS-4 sections. To date, sealed joints have incurred less distress than unsealed joints, and supplemental sections of diamond grinding, load transfer, and pavement edge drains appear to be helpful in maintaining good pavement performance.

APPENDIX A. TEST SECTION INFORMATION

Table 1. Number of test sections visited by LTPP region.

Projects Visited

Region	SPS-3	SPS-4	SPS-1	SPS-2	SPS-5	SPS-6	SPS-9
North Atlantic	7	1	0	0	0	0	0
North Central	18	1	0	0	1	0	0
Southern	19	3	0	0	2	0	0
Western	13	4	2	1	1	1	1
Totals	57	9	2	1	4	1	1

Table 2. Test sections removed from experiment.

SECTIONS REMOVED FROM SERVICE TO CORRECT DISTRESS

State/Province	SHRP ID	Reason for Removal From Service as Reported by LTPP Regional Office Personnel
Arizona	04B300	Extensive cracking, section worn out.
Arizona	04C320/350	Stripping problem.
Arizona	04D320/350	Stripping problem.
Colorado	08B300	Chip seal section rutted very early. Other sections rutted within a couple of years. Stripping is suspected.
Florida	12A300	Had extensive fatigue cracking before treatment and is worn out now.
Indiana	18A300	Mill and overlay due to rutting.
Iowa	19A340/350	Sections were overlaid in 1995 due to fatigue and block cracking.
Kansas	20B300	Overlay planned for 1996. 3.5-m lanes have resulted in edge fatigue.
Kentucky	21A340	An asphalt skin patch was placed because of fatigue cracking.
Minnesota	27A300	All sections are fatigue cracked; no work yet.
Nebraska	31A300	All sections have rutting and fatigue cracking, no work yet.
Nevada	32C300	Overlaid due to rutting.
New York	36B300	Scheduled for overlay this summer.
Oklahoma	40C300	25- to 50-mm transverse cracks and fatigue cracking.
Ontario	87A320/330 /340	Overlaid due to severe rutting.
Pennsylvania	42A300	Sections were overlaid because of severe rutting. Rutting existed prior to treatment and continued to progress.
Saskatchewan	90B300	Medium and high transverse fatigue cracks, localized low severity.

Table 2. Test sections removed from experiment
(continued).

SECTIONS REMOVED FROM SERVICE TO CORRECT DISTRESS

State/Province	SHRP ID	Reason for Removal From Service as Reported by LTPP Regional Office Personnel
Saskatchewan	90A330	Milled and overlaid in 1993 as a result of rutting and fatigue and block cracking.
Texas	48E300	Sections developed excessive fatigue.
Texas	48F350	Section developed stripping after treatment.
Washington	53A300	All sections, except the control, were overlaid due to extensive cracking. Other sections are still pending removal from service.

APPENDIX B. CRACK SEALING SPECIFICATIONS[1]

Section 409. CRACK SEALING - North Atlantic/North Central Regions

Description

409.01. This work consists of furnishing all materials, equipment, and labor for sealing cracks in the existing pavement in the treatment areas. Crack sealing shall be in accordance with these specifications and in conformance with details and at the locations shown on the plans. There is one treatment area for crack sealing at each project site and the demonstration site.

Equipment

409.02. The equipment used by the Contractor shall include, but not be limited to, the following:

(a) Hot-Compressed Air-Lance (HCA). The hot-compressed air-lance shall provide clean, oil-free compressed air at a volume of 100 cubic feet per minute at a pressure of 120 pounds per square inch and at a temperature of 2000 degrees F.

(b) Application Wand. The crack sealant applicator wand shall be attached to a heated hose, attached to a heated sealant chamber. Temperature controls shall be capable of maintaining the temperature of the sealant within manufacturer's tolerances.

(c) Heating Kettle. The equipment for heating the sealant materials shall be constructed as an indirect heating-type double-boiler using oil or other heat transfer medium and shall be capable of constant agitation. Additionally, the heating equipment shall be capable of controlling the sealant material temperature within the manufacturer's recommended temperature range and shall be equipped with a calibrated thermometer capable of ±5°F accuracy from 200°F to 600°F. This thermometer shall be located such that the Engineer may safely check the temperature of the sealant material.

(d) Router. A hand-controlled mechanical router specifically designed for routing cracks in pavements. The router shall have the ability to rout random cracks to the cross section specified at a minimum rate of 1,000 linear feet per hour.

[1]Specification materials were taken from reference 13.

Materials

409.03. The crack sealant shall conform to the requirements of Subsection 705.01.

Acceptance of crack sealant is specified in Subsection 106.06.

Construction Requirements

409.04. Preparation of Cracks. The pavement area to be treated shall be clean and dry with no standing or flowing water on the surface.

All cracks greater than 12 inches in length, and greater than 1/8 inch width shall be sealed.

Cracks less than 1/8 inch in width shall be routed to 1-½ inch wide and 3/8 inch deep. Sides of the routed cracks shall be vertical. The router shall be guided so that the crack lies entirely within the routed channel. The bits used to rout the cracks must be kept sharp and replaced when dull. All cracks shall be thoroughly cleaned of all foreign material.

All cracks shall be blown clean and dry using the HCA lance. Care shall be exercised to keep the HCA lance moving at a pace that will avoid burning the surrounding pavement.

409.05. Sealing the Crack. For each crack, the crack sealant shall be placed and finished within 2 minutes after heating with the HCA lance. Each crack shall be slightly overfilled.

409.06. Acceptance. Following the application of the crack sealant and before opening the roadway to traffic, the job will be visually inspected by the Engineer for area exhibiting adhesion failure, damage to the sealant from construction equipment or personnel, missed cracks, foreign objects in the sealant, or other problems that will accelerate failure or indicate the job is not acceptable. Portions of the job identified by the Engineer that do not meet these acceptable criteria will be prepared and resealed until satisfactory to the Engineer.

Method of Measurement and Basis of Payment

409.07. All materials and work required by this Section will be measured and paid for in accordance with Section 410.

Section 409. CRACK SEALING - Southern Region

Description

409.01. This work consists of furnishing all materials, equipment, and labor for sealing cracks in the existing pavement in the treatment areas. Crack sealing shall be in accordance with these specifications and in conformance with details and at the locations shown on the plans. There is one treatment area for crack sealing at each project site and the demonstration site.

Equipment

409.02. The equipment used by the Contractor shall include, but not be limited to, the following:

(a) Hot-Compressed Air-Lance (HCA). The hot-compressed air-lance shall provide clean, oil-free compressed air at a volume of 100 cubic feet per minute at a pressure of 120 pounds per square inch and at a temperature of 2000 degrees F.

(b) Application Wand. The crack sealant applicator wand shall be attached to a heated hose, attached to a heated sealant chamber. Temperature controls shall be capable of maintaining the temperature of the sealant within manufacturer's tolerances.

(c) Heating Kettle. The equipment for heating the sealant materials shall be constructed as an indirect heating-type double-boiler using oil or other heat transfer medium and shall be capable of constant agitation. Additionally, the heating equipment shall be capable of controlling the sealant material temperature within the manufacturer's recommended temperature range and shall be equipped with a calibrated thermometer capable of ±5°F accuracy from 200°F to 600°F. This thermometer shall be located such that the Engineer may safely check the temperature of the sealant material.

(d) Squeegee. A hand-held squeegee shall be used to ensure that the crack is filled to the existing surface. The squeegee shall be of the size and shape to ensure that a 3-inch-wide band is centered on the finished sealed crack.

Materials

409.03. The crack sealant shall conform to the requirements of Subsection 705.01.

Acceptance of crack sealant is specified in Subsection 106.06.

Construction Requirements

409.04. Preparation of Cracks. The pavement area to be treated shall be clean and dry with no standing or flowing water on the surface.

All cracks greater than 12 inches in length, and greater than 1/8 inch width shall be sealed.

All cracks shall be blown clean and dry using the HCA lance. Care shall be exercised to keep the HCA lance moving at a pace that will avoid burning the surrounding pavement.

409.05. Sealing the Crack. For each crack, the crack sealant shall be placed and finished within 5 minutes after heating with the HCA lance. Each crack shall be filled flush and squeegeed so that the finished sealed crack is approximately 3 inches wide and centered on the existing crack.

409.06. Acceptance. Following the application of the crack sealant and before opening the roadway to traffic, the job will be visually inspected by the Engineer for areas exhibiting adhesion failure, damage to the sealant from construction equipment or personnel, missed cracks, foreign objects in the sealant, or other problems that will accelerate failure or indicate the job is not acceptable. Portions of the job identified by the Engineer that do not meet these acceptable criteria will be prepared and resealed until satisfactory to the Engineer.

Method of Measurement and Basis of Payment

409.07. All materials and work required by this Section will be measured and paid for in accordance with Section 410.

Section 409. CRACK SEALING - Western Region

Description

409.01. This work consists of furnishing all materials, equipment, and labor for sealing cracks in the existing pavement in the treatment areas. Crack sealing shall be in accordance with these specifications and in conformance with details and at the locations shown on the plans. There is one treatment area for crack sealing at each project site and the demonstration site.

Equipment

409.02. The equipment used by the Contractor shall include, but not be limited to, the following:

(a) Hot-Compressed Air-Lance (HCA). The hot-compressed air-lance shall provide clean, oil-free compressed air at a volume of 100 cubic feet per minute at a pressure of 120 pounds per square inch and at a temperature of 2000 degrees F.

(b) Application Wand. The crack sealant applicator wand shall be attached to a heated hose, attached to a heated sealant chamber. Temperature controls shall be capable of maintaining the temperature of the sealant within manufacturer's tolerances.

(c) Router. A hand-controlled mechanical router specifically designed for routing cracks in pavements. The router shall have the ability to rout random cracks to the cross section specified at a minimum rate of 1,000 linear feet per hour.

Materials

409.03. The crack sealant shall be a polymer-modified rubber asphalt and shall conform to the requirements of ASTM Designation D3405 when tested in accordance with ASTM Designation D3407. Crack sealant shall be obtained from a source selected by the Contractor in accordance with the requirements of Subsection 106.01. Crack sealant material shall be furnished from one production lot.

Acceptance of crack sealant is specified in Subsection 106.06.

Construction Requirements

409.04. Preparation of Surface, General. The pavement area to be treated shall be clean and dry with no standing or flowing water on the surface.

409.05. Cracks to be Treated. All cracks greater than 12 inches in length, and greater than 1/8 inch width shall be treated.

409.06. Preparation of Cracks. Cracks less than 3/4 inch in width shall be routed to 3/4 inch wide and 1 inch deep. Sides of the routed cracks shall be vertical. The bits used to rout the cracks must be kept sharp and replaced when dull. All cracks larger than 3/4 inch shall be thoroughly cleaned of all foreign material.

409.07. Cleaning the Crack. All cracks shall be blown clean and dry using the HCA lance. Care shall be exercised to keep the HCA lance moving at a pace that will avoid burning the surrounding pavement.

409.08. Sealing the Crack. For each crack, the crack sealant shall be placed and finished within 5 minutes after heating with the HCA lance. Each crack shall be filled to within ¼ inch of the existing surface.

409.09. Acceptance of Crack Sealing. Following the application of the crack sealant and prior to the Government opening the roadway to traffic, the job will be visually inspected by the Engineer for areas exhibiting adhesion failure, damage to the sealant from construction equipment or personnel, missed cracks, foreign objects in the sealant, or other problems that will accelerate failure or indicate the job is not acceptable. Portions of the job identified by the Engineer that do not meet these criteria will be prepared and resealed until satisfactory to the Engineer.

Method of Measurement

409.10. Crack sealant will be measured in pounds determined by the count of containers and partial containers actually used and the weight of each.

Crack sealing will be measured by the each for the actual number of test sections completed and accepted.

Basis of Payment

409.11. The accepted quantities, determined as provided above, will be paid for at the contract price per unit of measurement, respectively, for each of the particular pay items listed below and show in the bid schedule.

The unit contract price per pound for "Crack sealant for sealing" shall be full payment for all costs for labor, tools, equipment, and materials necessary for furnishing the sealant to the project site.

The unit contract price per each for "Crack sealing per site" shall be full payment to complete the work as specified, including all costs for labor, tools, equipment, and materials. This includes, but is not limited to, the following:

(a) Brooming the base surface.
(b) Routing.

(c) Cleaning and drying the cracks.
(d) Placement of materials.

Payment will be made under:

Pay Item	Pay Unit
409(1) Crack sealant for sealing	Pound
409(2) Crack sealing per site	Each

[Metric Equivalents: 1 in = 25.4 mm; 1 ft = 0.305 m; 1 ft^3 = 0.028 m^3; 1 psi = 6.89 kPa; (F-32)/1.8 = °C]

APPENDIX C. FIELD REVIEW TRIP PARTICIPANTS AND HIGHWAY OPERATIONS TASK GROUP

Field Review Trip Participants

WESTERN REGION

Participants - Complete Tour

Michael Ray Smith, FHWA[1]
Arnold Korynta, Washington State DOT
Darrell Giannonatti, Utah DOT
Scott Gibson, Nichols Consulting Engineers
James Stevenson, Montana DOT[1,2]
Pete Pradere, Nichols Consulting Engineers[1]
Ahmad Ardani, Colorado DOT[1]
Gray Hildebrand, Caltrans

Additional Participants - Specific State Sites

California Sites
Dennis Jackson, Washington State DOT[1]
Jim Sorenson, FHWA[1]

Arizona and Utah Sites
John Zaniewski, Arizona State University

Arizona Sites
Larry Scofield, Arizona DOT[1]

SOUTHERN REGION

Participants - Complete Tour

Bruce Thomasson, Alabama DOT[1]
Harold Beaver, Arkansas SHTD[1,2]
Don Quilio, Florida DOT[1]
Thomas Bohuslav, Texas DOT[1]
Jack Hardin, Mariani Asphalt[1]
Pete Pradere, Nichols Consulting Engineers[1]
Patrick Bauer, FHWA[1]
Jerry Deleiden, Brent Rauhut Engineering

Additional Participants - Specific State Sites

All Alabama Sites
Lynn Wolfe, Alabama DOT
John Sullivan, FHWA/Alabama Division
Gordon Brown, FHWA/Alabama Division

Dothan, Alabama
Coleman Hatcher, Alabama DOT

Mobile, Alabama
Don George, FHWA/Alabama Division

Laurel, Mississippi
Al Crawley, Mississippi DOT

All Oklahoma Sites
David Ooten, Oklahoma DOT
Ginger McGovern, Oklahoma DOT
Chuck Donovan, Oklahoma DOT
Bill Barton, FHWA/Oklahoma Division

Seminole, Oklahoma
Paul Rachael, Oklahoma DOT
Johnny Hayden, Oklahoma DOT

Colorado City, Texas
Doug Eichorst, Texas DOT

Notes: [1]Expert Task Group
[2]Lead States

Mullin, Texas

Cathy Griffith, Texas DOT

Crandeil, Texas

Jerry Jones, FHWA/Region 6

NORTH ATLANTIC REGION

Don Wide, Pennsylvania DOT
Jim McDougall, Ontario Ministry of Transportation[1]
John Scalla, Maryland DOT
John Rondinaro, New York State DOT[2]
Ed Lesswing, Pavement Management Systems
Michael Ray Smith, FHWA[1]
Pete Pradere, Nichols Consulting Engineers[1]
Jose Garcia, FHWA
Bill Bellinger, FHWA

New York Sites

Ed Denehy, New York State DOT
Ron Brown, New York State DOT
Jack Hill, Midland Asphalt

NORTH CENTRAL REGION

Southern Part

Stan Hilderman, Manitoba Highways & Transportation[1]
Norman Humphrey, South Dakota DOT (TWG)
Herb Linne, Michigan DOT[1]
Bill Monhollon, Kentucky Department of Highways[1]
John Selmer, Iowa DOT[1]
Ron Shuberg, Kansas DOT[1,2]
Jason Harrington, FHWA
Pete Pradere, Nichols Consulting Engineers[1]
Ron Urbach, Braun Intertec
W. Allen Palmer, Asphalt Institute
Noel Schultz, Jebro, Inc.

Northern Part

Stan Hilderman, Manitoba Highways & Transportation[1]
Herb Linne, Michigan DOT[1]
Bill Monhollon, Kentucky Department of Highways[1]
John Selmer, Iowa DOT[1]
Ron Shuberg, Kansas DOT[1,2]
Patrick Bauer, FHWA[1]
Pete Pradere, Nichols Consulting Engineers[1]
Ron Urbach, Braun Intertec
Abdul Qayyum, Saskatchewan Highways & Transportation
Blaine Morien, Pounder Emulsions

Notes: [1]Expert Task Group
[2]Lead States

HIGHWAY OPERATIONS
EXPERT TASK GROUP

Western Region

James (Jim) Stevenson
Montana DOT

Dennis Jackson
State Materials Engineer
Washington State DOT

Ahmad Ardani
Colorado DOT

Larry Scofield
Arizona DOT

Cal Berge
LTPP Regional Engineer

North Atlantic Region

Edward Denehy
New York State DOT

Amar Bhajandas
Pennsylvania DOT

Gail Courtney
Maryland DOT

James I. McDougall, P.E.
Ontario Ministry of Transportation

Ivan Pecnik
LTPP Regional Engineer

Southern Region

Thomas Bohuslav
Texas DOT

Bruce Thomasson
Alabama DOT

A.F. (Don) Quilio
Florida DOT

Morris Reinhardt
LTPP Regional Engineer

North Central Region

Herb Linne
Michigan DOT

John Selmer
Iowa DOT

Ron Shuberg
Kansas DOT

Stan Hilderman
Manitoba Highways & Transportation

Norman Humphrey
South Dakota DOT

Dick Ingberg
LTPP Regional Engineer

University/Industry

Dr. Roger Smith
Texas A&M University

Dr. Jon Epps
University of Nevada

Larry Day
International Slurry Seal Association

Bill Ballou
International Slurry Seal Association

Jack Hardin
Asphalt Emulsion Manufacturer's Association

Pete Pradere
Consultant

Sanford LaHue
American Concrete Pavement Association

Clint Solberg
American Concrete Pavement Association

To Be Named
The Asphalt Institute

Federal Highway Administration

Jim Sorenson
Pavement Division

Michael Smith
Pavement Division

Patrick Bauer
Highway Operations Division

Bill Bellinger
LTPP Division

APPENDIX D. FIELD SURVEY FORMS

SPS-3 Site Visit Test Section Summary

Section ID: ______________________ Date: ______________

Treatment Type: ______________________ Recorder: ______________

Current Section Condition

Overall Pavement Condition

(Independent of Treatment)

Very Poor	Poor	Fair	Good	Very Good
0	2	4	6	8 — 10

Comments ____

____

Overall Treatment Condition

(Has the treatment held up and remained in place?)

Very Poor	Poor	Fair	Good	Very Good
0	2	4	6	8 — 10

Comments ____

____

Overall Treatment Effectiveness

(Has the treatment improved the pavement condition and/or extended the pavement life?)

Very Poor	Poor	Fair	Good	Very Good
0	2	4	6	8 — 10

Has the treatment improved the pavement condition? **Yes/No** __________

Has the treatment extended the pavement life? **Yes/No** __________

SPS-3 Site Visit Test Section Summary (continued)

Future Performance Predictions

Time to Next Maintenance Treatment
(How long before a maintenance treatment is required?)

Time (Years)
0 — 2 — 4 — 6 — 8 — >10

Type of Treatment Recommended ____________________
(Thin OL, Chip Seal, Slurry Seal, Crack Seal, None, Other)

Time to Next Rehabilitation With Maintenance Treatment
(How long before rehab if a future maintenance treatment is applied before end of service life?)

Time (Years)
0 — 2 — 4 — 6 — 8 — >10

Time to Rehabilitation Without Treatment
(How long before rehab if no future maintenance treatment is applied before end of service life?)

Time (Years)
0 — 2 — 4 — 6 — 8 — >10

Was this treatment appropriate for this pavement? **Yes/No** __________

Would any maintenance treatment have been appropriate? **Yes/No** __________

What would have been the most appropriate treatment? ____________
(Thin OL, Chip Seal, Slurry Seal, Crack Seal, None, Other)

General Comments: ______________________________

____

____

SPS-3 Distress Evaluations

Section Identification Number: ______________________ Date: ____________

Evaluator: ______________________

Performance Overall

	Very Poor	Poor	Fair	Good	Very Good
Thin Overlay	0	2	4	6	8 10
Chip Seal	0	2	4	6	8 10
Slurry Seal	0	2	4	6	8 10
Crack Seal	0	2	4	6	8 10
Control	0	2	4	6	8 10

Longitudinal Cracking

	Very Poor	Poor	Fair	Good	Very Good
Thin Overlay	0	2	4	6	8 10
Chip Seal	0	2	4	6	8 10
Slurry Seal	0	2	4	6	8 10
Crack Seal	0	2	4	6	8 10
Control	0	2	4	6	8 10

Transverse Cracking

	Very Poor	Poor	Fair	Good	Very Good
Thin Overlay	0	2	4	6	8 10
Chip Seal	0	2	4	6	8 10
Slurry Seal	0	2	4	6	8 10
Crack Seal	0	2	4	6	8 10
Control	0	2	4	6	8 10

Fatigue Cracking

	Very Poor	Poor	Fair	Good	Very Good
Thin Overlay	0	2	4	6	8 10
Chip Seal	0	2	4	6	8 10
Slurry Seal	0	2	4	6	8 10
Crack Seal	0	2	4	6	8 10
Control	0	2	4	6	8 10

SPS-3 Distress Evaluations (continued)

Bleeding

	Very Poor	Poor	Fair	Good	Very Good	
Thin Overlay	0	2	4	6	8	10
Chip Seal	0	2	4	6	8	10
Slurry Seal	0	2	4	6	8	10
Crack Seal	0	2	4	6	8	10
Control	0	2	4	6	8	10

Raveling or Aggregate Retention

	Very Poor	Poor	Fair	Good	Very Good	
Thin Overlay	0	2	4	6	8	10
Chip Seal	0	2	4	6	8	10
Slurry Seal	0	2	4	6	8	10
Crack Seal	0	2	4	6	8	10
Control	0	2	4	6	8	10

Snowplow Damage

	Very Poor	Poor	Fair	Good	Very Good	
Thin Overlay	0	2	4	6	8	10
Chip Seal	0	2	4	6	8	10
Slurry Seal	0	2	4	6	8	10
Crack Seal	0	2	4	6	8	10
Control	0	2	4	6	8	10

SPS-4 Joint Seal Evaluation Form

Date: ____________________

Section ID Number: ____________________

ETG Evaluator: ____________________

Overall Section Condition

Very Poor	Poor	Fair	Good	Very Good
0 – 2	2 – 4	4 – 6	6 – 8	8 – 10

Condition Near Joint

Very Poor	Poor	Fair	Good	Very Good
0 – 2	2 – 4	4 – 6	6 – 8	8 – 10

Sealant Condition

Very Poor	Poor	Fair	Good	Very Good
0 – 2	2 – 4	4 – 6	6 – 8	8 – 10

Excess Sealant Material

Very Poor ... Very Good

0 2 4 6 8 10

Way Too Much ... Just Right

Insufficient Sealant Material

Very Poor ... Very Good

0 2 4 6 8 10

Way Too Little ... Just Right

Adhesion

Very Poor	Poor	Fair	Good	Very Good
0 – 2	2 – 4	4 – 6	6 – 8	8 – 10

Permeability

Very Poor	Poor	Fair	Good	Very Good
0 – 2	2 – 4	4 – 6	6 – 8	8 – 10
High				Low

Joint Debris

Very Poor	Poor	Fair	Good	Very Good
0 – 2	2 – 4	4 – 6	6 – 8	8 – 10
Full of Material				No Debris, Seal Intact

General Comments: ____________________

APPENDIX E. SUMMARY OF ETG DISTRESS RATINGS

Crack Seal

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
NA	G	24	A330	330	-0.10	-1.20	-0.70	-0.60	0.20	0.20	-0.40
NA	P	36	A330	330	2.00	2.50	2.50	2.00	1.00	2.00	0.00
NA	F	36	B330	330	2.00	1.20	2.00	0.00	0.00	0.30	0.00
NA	G	51	A330	330	-0.50	-1.60	-0.30	1.00	0.70	0.80	-0.40
NA	P	87	B330	330	1.50	4.00	0.50	2.00	0.00	0.00	0.00
NC	P	17	B330	330	0.40	0.00	0.00	-0.10	0.00	-0.10	0.50
NC	P	19	A330	330	0.50	2.00	1.00	1.50	0.50	0.00	0.00
NC	P	20	A330	330	0.50	1.00	0.00	0.50	0.00	1.00	-0.50
NC	G	20	B330	330	0.00	-2.00	1.40	0.00	-3.00	0.00	0.00
NC	G	21	B330	330	0.90	0.00	0.00	0.00	0.00	0.00	0.00
NC	G	26	A330	330	2.90	1.00	3.00	1.00	0.00	1.00	0.40
NC	G	26	B330	330	0.50	1.00	0.50	0.00	0.00	1.10	0.00
NC	G	26	C330	330	0.50	1.00	2.50	0.50	0.00	0.50	0.00
NC	F	26	D330	330	2.00	0.80	1.50	1.00	0.00	1.00	-9.00
NC	F	27	A330	330	6.00	4.00		4.00	0.00	1.00	0.00
NC	P	27	B330	330	2.00	4.00	0.00	3.00		3.00	0.00
NC	P	27	C330	330	5.00	4.50	6.00	6.00	0.00	3.00	0.00
NC	P	29	A330	330	1.50	2.00	3.00	1.50	-1.50	1.50	0.00
NC	G	31	A330	330	-0.20	1.50	0.00	0.90	-0.10	0.00	-0.90
NC	P	83	A330	330	0.00	0.00	1.99	0.50	0.00	0.00	0.00
NC	P	90	B330	330	2.00	4.00	3.00	3.00	1.00	3.00	0.00
S	G	01	A330	330	0.00	-1.00	-1.00	-3.00	0.00	0.00	
S	P	01	C330	330	5.00	2.00	4.00	4.00	0.00	0.00	
S	G	12	A330	330	-4.00	-1.00	-3.00		0.00	0.00	
S	P	12	C330	330	-1.00	1.00	2.00	2.00	0.00	0.00	-10.00
S	P	28	A330	330	0.00	0.00	-3.00	0.00	0.00	0.00	
S	G	40	B330	330	-1.00	-1.00	-2.00	-2.00	3.00	-1.00	0.00
S	P	48	B330	330							
S	G	48	D330	330	1.00	0.00	0.00	1.00	0.00	1.00	0.00
S	G	48	H330	330	1.00	0.00	1.00	-2.00	0.00	0.00	0.00
S	G	48	Q330	330	-1.00	3.00	3.00	0.00	0.00	0.00	0.00
W	P	04	A330	330							
W	P	06	A330	330	2.50	3.00	3.50	2.00	0.00	3.00	1.50
W	P	16	C330	330	1.00	1.50	1.50	1.50	-1.50	1.00	1.00
W	F	30	A330	330	-1.00	-1.30	-1.00	-0.50	-0.50	-1.00	-0.50
W	P	32	A330	330	1.00	1.00	0.50	3.50	0.00	0.00	0.00
W	P	49	A330	330	1.00	0.00	1.00	-0.50	-6.00	-1.00	-1.00
W	P	49	B330	330	0.00	-0.50	-2.00	-1.00	2.00	0.00	0.00
W	F	56	A330	330	-1.00	-0.50	-1.50	-0.50	0.00	1.00	1.00
W	G	56	B330	330	0.00	-1.00	0.00	-0.50	0.00	0.00	0.00
				Average	0.87	0.92	0.83	0.86	-0.11	0.59	-0.54

Slurry Seal

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
NA	G	24	A320	320	-0.40	0.10	0.10	0.50	0.30	1.20	-0.40
NA	F	36	A320	320	1.00	2.00	1.50	2.00	0.00	2.00	-0.50
NA	G	36	B320	320	1.00	1.00	1.20	1.00	0.00	1.50	-3.10
NA	G	51	A320	320	-0.50	-0.70	-0.50	2.50	0.90	0.70	-0.40
NA	P	87	A320	320							
NA	P	87	B320	320	1.50	2.00	0.50	1.50	0.00	1.00	-2.00
NC	G	17	A320	320	0.00	0.30	0.00	0.20	0.00	0.60	0.00
NC	P	17	B320	320	-0.60	-2.50	0.00	-1.60	-2.00	-2.60	-2.50
NC	P	19	A320	320	-0.50	0.50	-0.10	1.00	0.00	0.00	-2.00
NC	P	20	A320	320	0.00	-0.50	-1.00	0.50	-1.50	0.00	-3.00
NC	G	20	B320	320	-3.00	-5.00	-4.00	-3.00	-10.00	-10.00	0.00
NC	G	21	B320	320	0.90	0.00	0.00	-0.20	0.00	0.00	0.00
NC	P	26	A320	320	1.00	-1.00	-0.90	-0.50	-1.00	-2.00	-3.30
NC	F	26	B320	320	0.50	-1.00	-1.50	-2.50	-2.00	-1.00	-0.50
NC	G	26	C320	320	0.50	0.50	2.50	1.00	0.00	0.50	0.00
NC	P	26	D320	320	0.50	0.30	-0.30	0.00	0.00	-1.00	1.00
NC	F	27	A320	320	1.00	1.00		0.00	-2.00	1.00	-2.50
NC	P	27	B320	320	0.00	0.00	0.00	0.00		0.00	0.00
NC	P	27	C320	320	0.00	0.50	1.00	0.50	0.00	2.00	0.00
NC	P	29	A320	320	0.00	0.50	0.80	0.00	0.50	2.50	-1.50
NC	G	29	B320	320	-1.00	-0.80	-0.70	-1.00	-0.90	-0.10	-0.80
NC	G	31	A320	320	-2.00	-0.30	-1.70	0.40	-0.20	-0.20	-0.90
NC	P	83	A320	320	0.00	-1.00	0.50	0.00	0.00	0.00	-0.26
NC	P	90	A320	320	0.00	1.00	0.50	2.00	0.50	-1.00	-2.00
NC	P	90	B320	320	-1.00	0.00	-2.00	1.00	1.00	3.00	-1.00
S	G	01	A320	320	-1.00	0.00	-1.00	-1.00	0.00	0.00	
S	G	01	B320	320	1.00	1.00	-2.00	1.00	0.00	2.00	
S	G	01	C320	320	3.00	-1.00	2.00	1.00	0.00	0.00	
S	G	05	A320	320	0.00	0.00	0.00	1.00	0.00	1.00	0.00
S	G	12	A320	320	-6.00	0.00	-4.00		0.00	-2.00	
S	P	12	C320	320	0.00	-1.00	2.00	1.00	0.00	0.00	-10.00
S	P	28	A320	320	2.00	3.00	-2.00	5.00	-1.00	0.00	
S	G	40	A320	320	0.00	0.00	0.00	1.00	0.00	0.00	0.00
S	G	40	B320	320	0.00	0.00	0.00	0.00	3.00	0.00	-1.00
S	G	48	A320	320	1.00	0.00	1.00	1.00	0.00	0.00	
S	P	48	B320	320							
S	F	48	D320	320	3.00	1.00	1.00	6.00	0.00	7.00	0.00
S	G	48	F320	320	0.00	-1.00	0.00	-2.00	0.00	-6.00	0.00
S	G	48	G320	320	0.00	1.00	0.00	1.00	1.00	0.00	0.00
S	G	48	H320	320	0.00	-1.00	0.00	1.00	0.00	-1.00	0.00
S	G	48	I320	320	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	G	48	K320	320	0.00	0.00	1.00	1.00	0.00	0.00	0.00
S	G	48	M320	320	1.00	-1.00	0.00	0.00	3.00	0.00	0.00

Slurry Seal (continued)

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
S	G	48	Q320	320	1.00	2.00	3.00	1.00	1.00	0.00	0.00
W	F	04	A320	320							
W	P	06	A320	320	3.00	3.00	3.50	4.50	0.00	4.50	1.50
W	G	16	A320	320	0.00	0.00	0.00	0.00	-0.50	-0.20	1.00
W	G	16	B320	320	0.00	0.00	0.00	0.00	-1.00	-1.00	0.50
W	P	16	C320	320	0.00	0.50	0.50	0.50	0.00	2.50	2.50
W	F	30	A320	320	-1.00	-0.80	-3.50	-1.00	1.50	-1.00	0.00
W	P	32	A320	320	4.50	4.50	3.00	2.00	-2.50	0.00	0.00
W	G	32	B320	320	-0.50	-2.00	0.50	-0.50	0.00	-0.50	-0.50
W	P	49	A320	320	1.50	1.00	2.00	1.50	-2.00	0.00	-1.00
W	G	49	C320	320	-0.50	-1.50	-1.00	-1.00	-1.00	1.00	0.50
W	P	56	A320	320	-1.50	-1.00	-2.00	-2.00	0.00	1.00	1.50
W	F	56	B320	320	0.00	-0.50	0.00	1.00	2.00	1.50	1.00
				Average	0.18	0.06	0.00	0.54	-0.25	0.13	-0.63

Chip Seal

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
NA	G	24	A350	350	1.00	1.30	1.70	0.60	-0.20	0.90	-1.10
NA	P	36	A350	350	2.00	0.50	1.50	1.00	2.00	3.00	0.50
NA	F	36	B350	350	1.50	1.20	1.50	0.50	-1.20	4.30	-7.00
NA	G	51	A350	350	1.20	1.00	1.70	2.00	-0.40	-0.60	-0.50
NC	G	17	A350	350	0.70	0.60	0.00	0.10	-0.60	-0.40	-2.00
NC	F	17	B350	350	0.90	1.00	0.00	0.90	-1.00	-0.10	-1.50
NC	P	20	A350	350	2.50	2.00	1.00	1.50	-2.00	1.50	-2.00
NC	G	20	B350	350	1.00	-1.00	1.00	-1.00	-3.00	-1.00	0.00
NC	G	21	B350	350	0.90	0.00	0.00	0.00	-1.00	0.00	0.00
NC	G	26	A350	350	3.00	1.00	4.00	-6.00	-4.30	1.00	-0.10
NC	G	26	B350	350	1.50	1.40	2.00	0.10	-4.00	2.00	-2.00
NC	G	26	C350	350	2.50	1.00	4.00	2.00	0.00	0.50	0.00
NC	P	26	D350	350	3.00	2.80	3.00	2.00	-1.00	0.00	1.00
NC	F	27	A350	350	1.00	1.00		1.00	-2.00	1.00	-1.00
NC	P	27	B350	350	0.00	0.00	0.00	0.00		-1.00	-5.00
NC	P	27	C350	350	3.00	1.50	5.00	2.00	-4.00	3.00	0.00
NC	P	27	D350	350							
NC	P	29	A350	350	2.50	3.00	4.00	2.00	-2.00	3.50	0.00
NC	G	29	B350	350	-1.80	-0.50	0.00	-2.00	-0.50	-0.20	-5.30
NC	G	31	A350	350	0.00	0.50	0.00	0.40	-2.70	-1.30	-3.00
NC	P	83	A350	350	0.00	-0.50	1.00	0.50	-1.00	0.00	-1.00
NC	P	90	A350	350	3.00	4.50	3.50	3.00	-3.00	0.00	0.00
NC	P	90	B350	350	0.00	1.00	0.00	2.00	1.00	2.00	-1.00
S	G	01	A350	350	2.00	1.00	1.00	1.00	0.00	-1.00	
S	G	01	B350	350	2.00	1.00	1.00	2.00	0.00	1.00	
S	P	01	C350	350	5.00	3.00	4.00	2.00	0.00	-1.00	
S	G	05	A350	350	0.00	0.00	0.00	-1.00	0.00	-2.00	-3.00
S	F	12	A350	350	-1.00	1.00	1.00		0.00	0.00	
S	P	12	C350	350	0.00	2.00	8.00	7.00	0.00	0.00	-10.00
S	P	28	A350	350	3.00	6.00	1.00	6.00	0.00	-1.00	
S	G	40	A350	350	0.00	0.00	0.00	0.00	-1.00	-1.00	0.00
S	G	40	B350	350	0.00	0.00	-1.00	-1.00	3.00	-3.00	-2.00
S	P	48	B350	350							
S	F	48	D350	350	2.00	0.00	0.00	5.00	-2.00	6.00	0.00
S	G	48	H350	350	2.00	1.00	1.00	2.00	0.00	0.00	0.00
S	G	48	I350	350	0.00	0.00	0.00	-2.00	0.00	-5.00	0.00
S	G	48	K350	350	1.00	0.00	3.00	3.00	-1.00	-1.00	0.00
S	G	48	M350	350	3.00	1.00	6.00	4.00	2.00	0.00	0.00
S	G	48	Q350	350	1.00	3.00	3.00	1.00	0.00	0.00	0.00
W	F	06	A350	350	2.50	3.00	3.50	4.00	0.00	3.00	1.50
W	G	16	A350	350	0.00	-0.50	0.00	0.00	0.00	-0.50	0.00
W	G	16	B350	350	0.00	-0.50	0.00	-0.50	0.00	-1.00	-0.50
W	P	16	C350	350	1.00	1.00	2.00	1.00	-1.50	0.00	0.00

Chip Seal (continued)

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
W	P	30	A350	350	-0.50	-1.30	-1.00	0.00	-2.00	-4.50	-2.50
W	F	32	A350	350	5.00	5.00	4.30	3.50	-3.00	0.50	0.00
W	G	32	B350	350	1.00	0.50	0.50	3.50	0.00	-1.00	-1.00
W	P	49	A350	350	1.50	1.00	2.50	1.50	-4.00	-3.00	-3.00
W	P	49	B350	350	0.00	0.00	-1.00	-0.50	-1.00	-2.00	-1.00
W	G	49	C350	350	0.00	-0.50	-1.00	-0.50	-2.00	1.50	0.50
W	P	56	A350	350	-2.00	-1.00	-2.50	-0.50	-1.50	-5.00	2.00
W	F	56	B350	350	0.00	-0.50	0.00	1.50	4.00	0.50	-0.50
				Average	1.18	0.99	1.46	1.14	-0.85	-0.03	-1.15

Thin Overlay

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
NA	F	24	A310	310	1.40	1.80	2.20	1.30	1.00	1.80	0.50
NA	F	36	A310	310	2.40	3.50	3.50	4.50	1.50	3.00	0.00
NA	F	36	B310	310	0.50	0.40	2.20	1.70	0.00	3.30	0.50
NA	G	51	A310	310	1.50	1.00	1.50	3.00	1.10	0.70	-0.30
NA	F	87	A310	310							
NA	P	87	B310	310	2.00	2.50	0.50	3.00	0.00	1.00	0.00
NC	G	17	A310	310	0.70	0.60	0.00	0.60	0.00	0.60	0.00
NC	G	17	B310	310	0.40	0.50	0.00	0.40	-0.50	1.40	0.50
NC	P	19	A310	310	1.50	2.00	2.00	2.70	0.50	0.60	0.00
NC	P	20	A310	310	3.00	2.00	1.00	2.50	0.00	1.00	0.00
NC	F	20	B310	310	0.00	-2.00	1.00	2.00	0.00	0.00	0.00
NC	G	21	B310	310	0.90	0.00	0.00	0.30	0.00	-0.40	0.00
NC	P	26	A310	310	1.20	-0.30	3.00	0.00	0.00	-8.00	-9.60
NC	G	26	B310	310	0.50	0.70	1.10	0.00	0.00	1.00	0.00
NC	G	26	C310	310	2.00	1.00	4.00	2.00	0.00	0.50	0.00
NC	P	26	D310	310	4.00	1.30	4.50	2.50	0.00	0.00	1.00
NC	F	27	A310	310	2.00	2.00		2.00	0.00	1.00	-10.00
NC	P	27	B310	310	1.00	2.00	0.00	2.00		2.00	0.00
NC	P	27	C310	310	5.00	2.50	5.00	3.00	-5.00	1.00	-1.00
NC	P	27	D310	310							
NC	P	29	A310	310	1.00	2.00	1.50	1.50	1.50	1.00	0.00
NC	G	29	B310	310	0.00	0.20	0.40	0.00	0.00	-0.40	0.00
NC	G	31	A310	310	-2.70	-1.00	-3.50	-0.10	0.40	-0.60	-0.50
NC	P	83	A310	310	0.00	-1.50	1.00	0.50	0.00	-2.00	0.00
NC	P	90	A310	310	2.00	2.50	3.00	3.00	1.00	-2.00	0.00
NC	P	90	B310	310	2.60	3.00	3.80	3.00	1.00	3.80	-1.00
S	G	01	A310	310							
S	G	01	B310	310	2.00	1.00	1.00	2.00	0.00	-1.00	
S	G	01	C310	310	2.00	-1.00	4.00	2.00	0.00	-1.00	
S	G	05	A310	310	0.00	0.00	0.00	1.00	0.00	1.00	0.00
S	G	12	A310	310	0.00	1.00	2.00		0.00	0.00	
S	P	12	C310	310	0.00	1.00	8.00	6.00	0.00	0.00	-10.00
S	P	28	A310	310	4.00	4.00	1.00	6.00	0.00	0.00	
S	G	40	B310	310	1.00	2.00	0.00	1.00	3.00	0.00	0.00
S	G	48	A310	310	2.00	1.00	3.00	3.00	0.00	0.00	
S	P	48	B310	310							
S	G	48	D310	310	1.00	-1.00	-2.00	4.00	0.00	7.00	0.00
S	P	48	F310	310	2.00	-1.00	5.00	3.00	0.00	0.00	0.00
S	G	48	G310	310	-2.00	0.00	-5.00	-1.00	2.00	0.00	0.00
S	G	48	H310	310	0.00	0.00	1.00	1.00	0.00	0.00	0.00
S	G	48	I310	310	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S	G	48	K310	310	1.00	0.00	3.00	3.00	0.00	0.00	0.00
S	G	48	M310	310	1.00	-2.00	-1.00	-3.00	3.00	-3.00	0.00

Thin Overlay (continued)

Region (LTPP)	INITIAL CONDITION	STATE	SHRP	Type	Delta Longitudinal	Delta Transverse	Delta Fatigue	Delta Overall Performance	Delta Bleeding	Delta Raveling	Delta Snowplow
S	G	48	Q310	310	1.00	3.00	3.00	2.00	-7.00	0.00	0.00
W	F	04	A310	310							
W	P	06	A310	310	3.50	4.50	4.50	5.00	0.50	4.50	1.50
W	G	16	A310	310	0.00	0.00	0.00	0.00	0.00	-0.50	0.50
W	G	16	B310	310	0.00	0.00	0.00	0.00	0.00	1.00	0.50
W	P	16	C310	310	1.00	0.70	2.50	1.50	1.00	2.00	2.00
W	F	30	A310	310	-1.00	-0.80	-2.00	-0.50	1.50	-2.00	0.00
W	P	32	A310	310	4.00	3.50	2.50	2.00	-0.50	0.00	0.00
W	G	32	B310	310	-1.00	-0.50	1.50	2.00	1.00	-1.50	-1.50
W	P	49	A310	310	1.50	1.00	2.00	2.00	0.00	-2.00	-1.00
W	P	49	B310	310	-0.50	2.50	0.50	1.00	2.00	-2.00	-1.00
W	G	49	C310	310	0.00	-0.50	-0.50	-0.50	0.50	1.00	0.50
W	F	56	A310	310	0.00	1.00	-0.50	1.50	1.00	1.50	1.50
W	P	56	B310	310	0.00	-1.50	0.00	1.50	4.00	-1.00	0.50
				Average	1.07	0.86	1.40	1.70	0.28	0.28	-0.56

APPENDIX F. SUPPLEMENTAL SITE RATINGS

Supplemental Sections on Tour by Treatment Type

Treatment Type	State	State No.	Treatment Differences	Overall Pavement Condition	Companion SPS Site	Overall Pavement Condition	Control	Supplemental Perf./Control	Companion/Control
Crack Seal	MD	24A311	State Overlay	9.3	310	9	7.5	1.24	1.20
Slurry Seal	NY	36A321	Micro Slurry	6.5	320	6	4.5	1.44	1.33
	MI	26B321	Latex-Modified Slurry	4.5	320	4	6.5	0.69	0.62
	FL	12A321	Microsurfacing	9	320	6	8	1.13	0.75
	FL	12C321	Microsurfacing	5	320	5	3	1.67	1.67
	OK	40B360	Microsurfacing	8	320	9	8	1.00	1.13
	VA	51A351	Slurry	No Info.			5		0
	VA	51A321	Slurry	7	320	7.5	5	1.40	1.50
Chip Seal	MN	27B321	Rubber Chip Seal	8	350	5	5	1.60	1.00
	CA	06A361	Rubber Chip Seal	7.5	350	8	4	1.88	2.00
	TX	48K351	Rubber Chip Seal	9	350	10	7	1.29	1.43
	CA	06A351	Polymer	8.5	350	8	4	2.13	2.00
	CA	06A352	Polymer with Hot Precoated	6.5	350	8	4	1.63	2.00
	CA	06A353	Polymer	7.5	350	8	4	1.88	2.00
State Chip Seal	MI	26D351	Regular	5	350	7	5	1.00	1.40
	TX	48H351	Regular	8	350	8	7	1.14	1.14
	UT	49A351	Regular	6.5	350	6.5	5	1.30	1.30
	UT	49B351	Regular	7.5	350	6.5	7	1.07	0.93
	UT	49C351	Regular	8.5	350	8	8.5	1.00	0.94
	TX	48Q353	Regular	8	350	9	8	1.00	1.13
	PA	42B351	Regular	6.5	350	7.5	6	1.08	1.25
	UT	49A352	State Slag Chip Seal	8	350	6.5	5	1.60	1.30
	UT	49B352	State Natural Chip Seal	7	350	6.5	7	1.00	0.93
	UT	49C352	State Slag Chip Seal	8	350	8	8.5	0.94	0.94
	WY	56A351	State Chip Seal	8	350	7	7.5	1.07	0.93

Supplemental Sections on Tour by Treatment Type (continued)

Treatment Type	State	State No.	Treatment Differences	Overall Pavement Condition	Companion SPS Site	Overall Pavement Condition	Control	Supplemental Perf./Control	Companion/Control
State Chip Seal	CA	06A363	State Emulsion with Catalyst	7.5	350	8	4	1.88	2.00
Chip Seal	UT	49A390	Graded Aggregate	5	350	6.5	5	1.00	1.30
	UT	49B390	Graded Aggregate	6	350	6.5	7	0.86	0.93
	NY	36B352	Graded Aggregate	6.5	350	6.5	6	1.08	1.08
	NY	36B353	Graded Aggregate	7.5	350	6.5	6	1.25	1.08
	NY	36B351	Graded Aggregate	8.5	350	6.5	6	1.42	1.08
	NY	36B354	Graded Aggregate	7.5	350	6.5	6	1.25	1.08
Thin Overlay	CA	06A311	Bonifibers	9.5	310	9	4	2.38	2.25
	CA	06A361	Gap Graded with Rubber	7.5	310	9	4	1.88	2.25
	UT	49A361	Plant Mix Seal	7.5	310	7	5	1.50	1.40
	UT	49B361	Plant Mix Seal	9	310	8	7	1.29	1.14
	UT	49C361	Plant Mix Seal	9	310	9	8.5	1.06	1.06
	CA	06A362	OG AC	7.5	310	9	4	1.88	2.25
	Ontario	87B311	Double Overlay	8	310	8.5	5.5	1.45	1.55
	Ontario	87B361	Dyna Patch	7.5			5.5	1.09	
	Ontario	87B362	Dyna Patch	6			5.5	1.09	

APPENDIX G. ETG RECOMMENDATIONS

North Atlantic:

- Develop a user's manual documenting various treatments that are available.

  The manual should be structured in a simple format that could be used at the operational and individual project level. It should also clearly show under what conditions each individual treatment is the most appropriate. In addition, innovative agency-specific treatment would be presented for consideration.

- A Preventative Maintenance "Strategy Manual" should also be developed. This manual would focus on alternative network or system-level long-term pavement management philosophies. The manual would outline how and under what conditions various treatments could be programmed to provide for the most cost-effective pavement service life for the highway system.

- Any sites that are not taken out of service should continue to be monitored as well as the agency treatments that are performing well.

Southern Region:

- Additional time is needed to better determine the service life of many of the treatments. It is recommended that two additional field reviews be conducted at 2-year intervals (i.e., 1997 and 1999). Additional field reviews are important as the treatments are just now beginning to yield vital data as they begin to exhibit signs of distress.

- Develop a decision tree to provide guidance to maintenance personnel in the selection of cost-effective treatments for conditions encountered in the field.

- An economic analysis of the different treatments, as well as a comparison to rehabilitation (life-cycle cost). This document would support an agency's request for preventive maintenance funds.

North Central Region:

- Continue a SHRP-type research program to evaluate other maintenance treatments and other materials.

- Crack sealing is effective, and SHRP procedures and materials should be adopted by highway organizations.

- Emphasize the need to patch pavements and seal cracks prior to placing any maintenance treatment, except crack sealing.

- Something more should come out of the SHRP effort than a "how to" publication. Public transportation agencies generally know how to perform these SHRP treatments. We do not know the most effective time to apply the most appropriate treatment.

Western Region:

- Continue the expert team review of SPS-3 and SPS-4 test sections.
- Similar team should review all SPS test sections.
- An annual performance report should be developed for site and test sections.
- FHWA and States need to do a better job ensuring reports distribution.
- Continue monitoring the performance of in-service SPS-3 and SPS-4 test sections.
- Develop experiment to tie SPS-3 to SPS-5. This would allow for maintenance treatments to be placed on SPS-5 as distresses begin to appear.
- A formal continuation experiment needs to be developed to allow for the placement of a second maintenance treatment on the SPS-3 test sections. This would allow for the further use of existing test sections and data and better define when the second maintenance treatment can be effective. This experiment should also allow for the use of both local and new materials (polymers, etc.).
- FHWA, in conjunction with States, should develop a forensic evaluation procedure for the SPS test sections.
- FHWA, in conjunction with the States, should develop a national symposium on hydrogenesis and its impact on maintenance rehabilitation strategies.
- FHWA should help champion the idea that maintenance activities need to integrate pavement management, design, and evaluation.
- An in-depth forensic evaluation experiment should be required on those sites exhibiting accelerated distress to determine the cause.

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