Virginia Department of Transportation

MAINTENANCE DIVISION

STATE OF THE PAVEMENT 2009

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EXECUTIVE SUMMARY

The Virginia Department of Transportation (VDOT) is responsible for more than 125,000 lane miles of roadway. Virginia's current highway network is the result of more than 100 years of investment in infrastructure that provides for the economic activities and the mobility of people and goods throughout the Commonwealth. Preserving this investment is a core function of VDOT.

This report describes the pavement condition and ride quality on Virginia's pavements based on data collected, processed and analyzed during the early months of 2009. It also provides trend analysis over the last four years of pavement condition ratings. The information in this report is used to understand variations in pavement condition and ride quality by pavement type, highway system, maintenance district and county.

This report provides background information on the methodology of data collection, quality assurance of data, derivation of condition measures, and the use of pavement condition data to assess pavement deficiencies statewide.

The report is organized into two major areas: (i) pavement condition data collection, data processing and quality assurance, and (ii) statewide pavement condition and ride quality summary. Appendices provide detailed pavement condition and ride quality data and the distribution of key distresses by district and pavement types.

The data presented in this report comprise a "snapshot" of pavement condition during the early months of 2009. The data displayed highlights the pavement condition and ride quality summary. These results are broken down into further details in the main body of this report. Throughout this report the abbreviations in Table I are used to denote the maintenance districts. Table II below shows the mileage by system maintained by each district based on the last published mileage tables.

Table I: Abbreviations for VDOT Districts

District Number	District Name	Abbreviation
1	Bristol	1/BR
2	Salem	2/SA
3	Lynchburg	3/LY
4	Richmond	4/RI
5	Hampton Roads	5/HR
6	Fredericksburg	6/FR
7	Culpeper	7/CU
8	Staunton	8/ST
9	Northern Virginia	9/NO

Table II: Lane Mileage by District and System

District	Interstate	Primary	Secondary	Frontage	Total
Bristol	533	2,953	12,296	112	15,894
Salem	490	2,666	14,665	107	17,929
Lynchburg	0	2,798	12,362	35	15,195
Richmond	1,315	3,418	13,671	79	18,483
Hampton Roads	872	1,766	7,076	92	9,807
Fredericksburg	281	2,170	9,140	24	11,615
Culpeper	279	1,851	8,163	52	10,345
Staunton	942	2,472	10,481	76	13,971
Nova	684	1,548	10,207	81	12,520
Statewide	5,395	21,642	98,061	660	125,758

PAVEMENT DATA COLLECTION, DATA PROCESSING & QUALITY CONTROL/QUALITY ASSURANCE

The pavement condition data presented in this report were collected and processed by VDOT's contractor, Fugro-Roadware Inc., using continuous digital imaging and automated crack detection technology. For data collection purposes, Fugro-Roadware uses vehicles equipped with special cameras to capture downward pavement images for crack detection, and a forward perspective view camera for the collection of right of way images. Roughness and rutting data are also captured simultaneously with the sensors mounted on the van. Downward images collected during the survey are processed with specialized automated crack detection software for the identification of cracks and then further augmented with analysis of the digital images for the identification of other distresses.

Data were collected by the above-mentioned method on the entire Interstate and Primary highway systems, and approximately 20% of Secondary network. The distresses were interpreted according to the methodology detailed in the VDOT Distress Identification Manual[(1)], processed, and summarized in a pre-defined format. Quality Control (QC) work was conducted by the contractor and the Quality Assurance (QA) and Independent Validation and Verification (IV&V) was performed by a third party consultant - Quality Engineering Solutions (QES). This consultant independently rated and verified approximately 4% of all the data collected by the data collection contractor. The ratings on pavement sections were also compared with the previous year's ratings on the same sections. Any major differences in ratings were further investigated. The data were processed and verified in batches. VDOT then accepted the data based on predefined acceptance criteria mentioned in the quality review document. The details of the QC/QA procedures and the results can be found in the Quality Monitoring Report[(2)].

Individual distress data are aggregated into two Pavement Condition Indices. The Load-related Distress Rating (LDR) incorporates pavement distresses that are related to

vehicle load related damages (e.g. fatigue cracking, patching, rutting, etc.) to pavement. The Non-load-related Distress Rating (NDR) is comprised of distresses (e.g. transverse and longitudinal cracking, longitudinal joint separation, bleeding, etc.) considered to be primarily non-load related, i.e., caused by weathering of pavement surface or materials and/or construction deficiency. Both indices are on a scale of 0 to 100 with 100 representing a pavement with no visible distresses. The details of the index calculation methodology for asphalt surfaced pavements are provided in a VDOT report[3] published in 2002.

A third index – the Critical Condition Index (CCI) is calculated as the lower of the LDR and NDR. These indices were first derived in 1998 based on the PAVER methodology developed by the US Army Corps of Engineers, and have undergone extensive validation process using the Long Term Pavement Performance (LTPP) data collected through the Strategic Highway Research Program (SHRP) of FHWA and through a process of consensus building using numerous VDOT pavement experts. It should be noted that LDR and NDR are used only for asphalt-surfaced pavements. Slab Distress Rating (SDR) is used for jointed concrete pavement while Concrete Punchout Rating (CPR) and the Concrete Distress Rating (CDR) are used for continuously reinforced concrete pavements. However, the same concept of CCI applies to the latter two pavement types. More details about concrete pavement condition indices are documented in another published VDOT report[4].

As shown below in Table III, CCI values are grouped into five ranges corresponding to condition categories: excellent, good, fair, poor and very poor. In general, pavement sections with a CCI value below 60 (poor and very poor) are considered 'deficient' and should be further evaluated for maintenance and rehabilitation actions.

Table III : Pavement Condition Category Based on CCI

Pavement Condition	Index Scale (CCI)
Excellent	90 and above
Good	70-89
Fair	60-69
Poor	50-59
Very Poor	49 and below

Pavement roughness or ride quality, expressed in the International Roughness Index (IRI), is derived from sensor data collected by the van simultaneously with the video images. IRI data has been analyzed and reported separately in this report. Table IV below contains a qualitative pavement ride quality term and corresponding quantitative IRI values. VDOT uses the categories summarized in Table IV below for its Interstate, Primary, and Secondary systems.

Table IV : Pavement Ride Quality Based on IRI

Ride Quality	IRI Rating (inch/mile)	
	Interstate & Primary	Secondary Roads
Excellent	< 60	< 95
Good	60 to 99	95 to 169
Fair	100 to 139	170 to 219
Poor	140 to 199	220 to 279
Very Poor	≥ 200	≥ 280

Ranges of IRI that correspond to qualitative descriptors of ride quality were built upon similar categories promulgated by FHWA[5] and incorporated consensus opinions from VDOT pavement experts regarding what thresholds were considered appropriate to represent acceptable roughness levels on Virginia highways. Similar to pavement conditions, any Interstate and Primary pavement sections with an average IRI of 140 or more or a Secondary pavement section with an average of IRI of 220 or more are considered 'deficient' in terms of ride quality.

STATEWIDE PAVEMENT CONDITION AND RIDE QUALITY SUMMARY

For Interstate, Primary, and Secondary systems, the statewide pavement condition and ride quality summary is presented in the Figures I, II and III. Tables III and IV above provided definitions of the pavement condition and ride quality categories shown in the figures.

Figure I : Pavement Condition and Ride Quality - Interstate

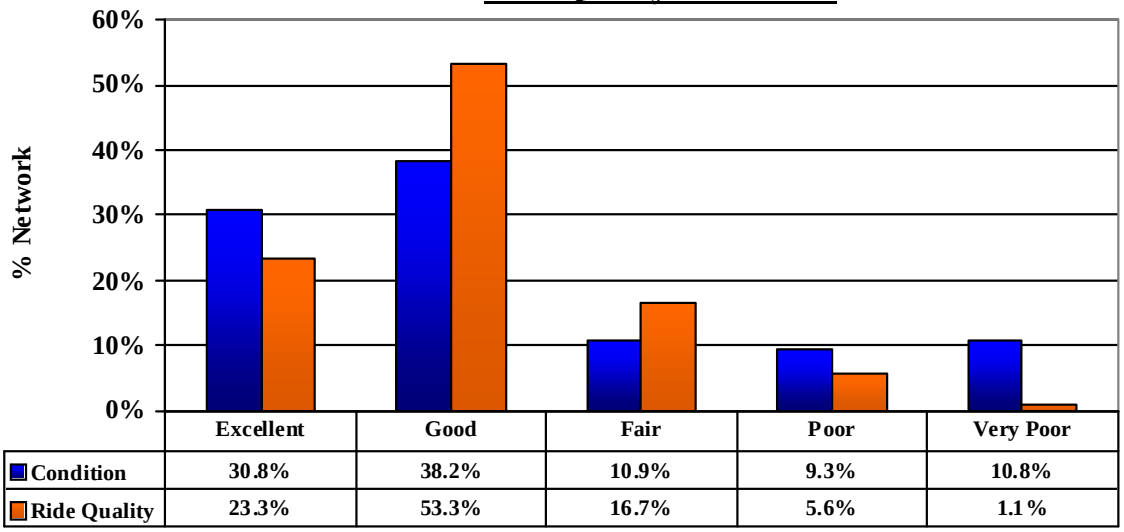
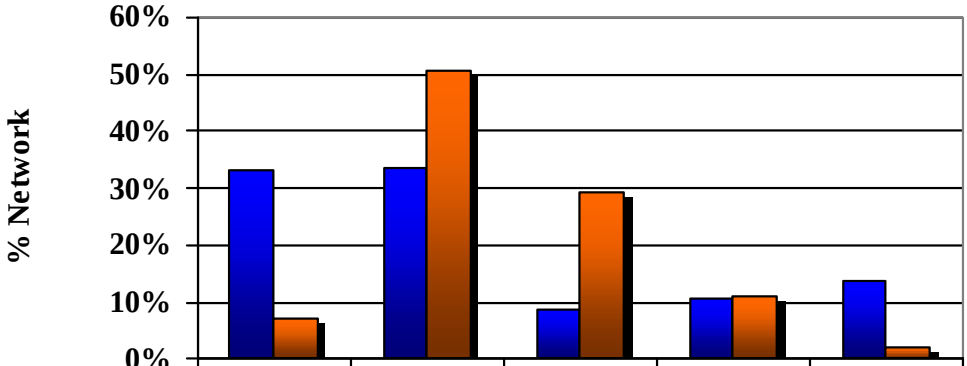
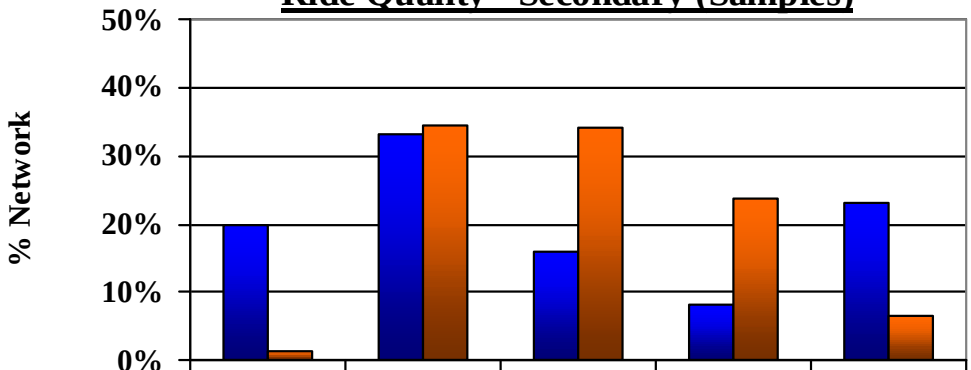


Figure II : Pavement Condition and Ride Quality - Primary



	Excellent	Good	Fair	Poor	Very Poor
Condition	33.3%	33.6%	8.8%	10.7%	13.6%
Ride Quality	7.1%	50.7%	29.2%	11.0%	2.0%

Figure III : Pavement Condition and Ride Quality - Secondary (Samples)



	Excellent	Good	Fair	Poor	Very Poor
Condition	19.9%	33.1%	15.9%	8.1%	23.0%
Ride Quality	1.5%	34.4%	34.0%	23.7%	6.4%

Interstate Pavement Condition and Ride Quality by District

The following graphic shows the pavement ratings for the Interstate pavement system. Following this graphic, the detailed ratings for the system are reported.

The statewide performance target for percentage of Interstate pavements rated deficient, i.e., in poor or very poor condition, is 18% or less. Similarly, the performance target for statewide deficient ride quality on the Interstate systems is 15% or less.
Figure IV shows the percent deficiency on the Interstate system by district based on pavement condition and ride quality. Approximately 20.1% of the Interstate network has been rated to be in 'deficient' condition and 6.7% has deficient ride quality.
These are illustrated in Figure IV with each district's pavement condition and ride quality along with statewide statistics. Figure V presents the total number of deficient, Interstate lane miles in each district.

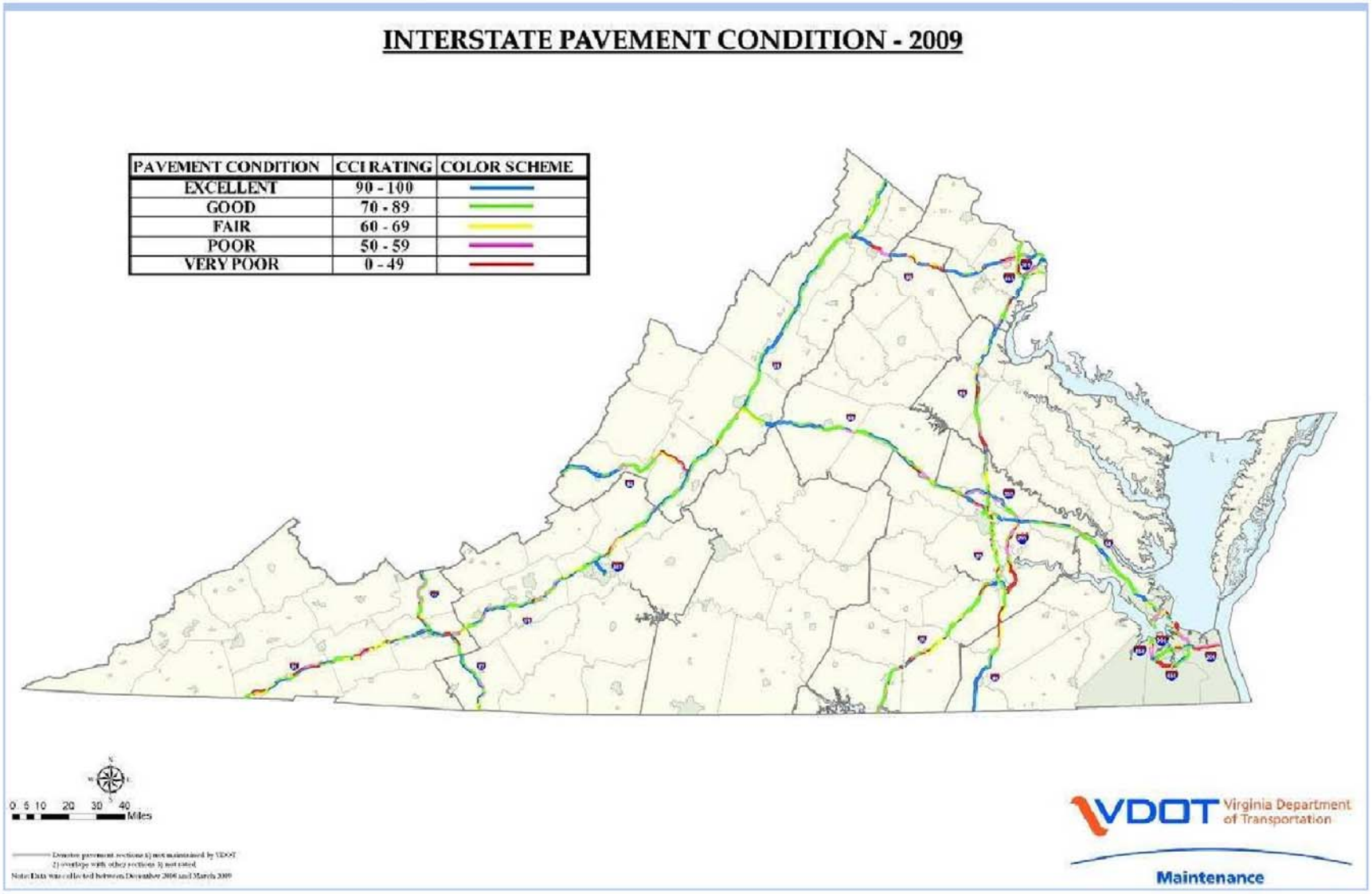
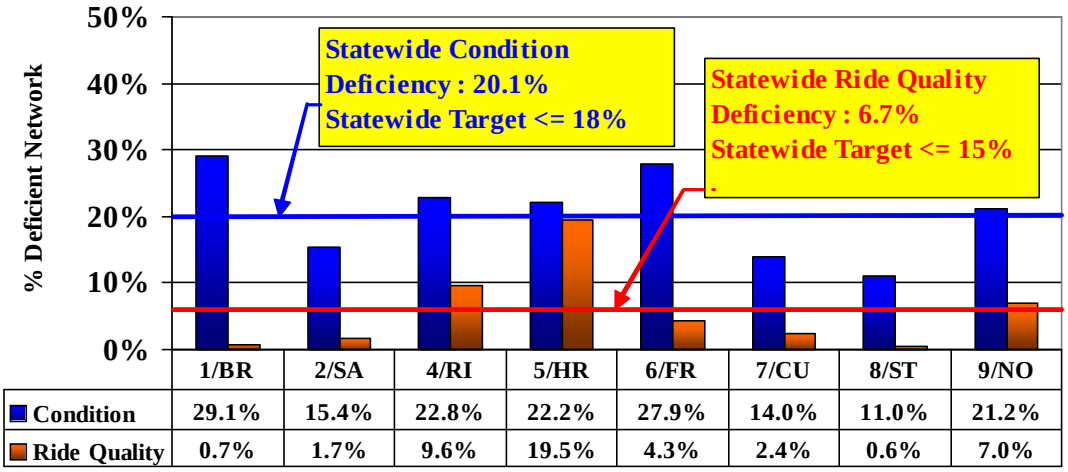
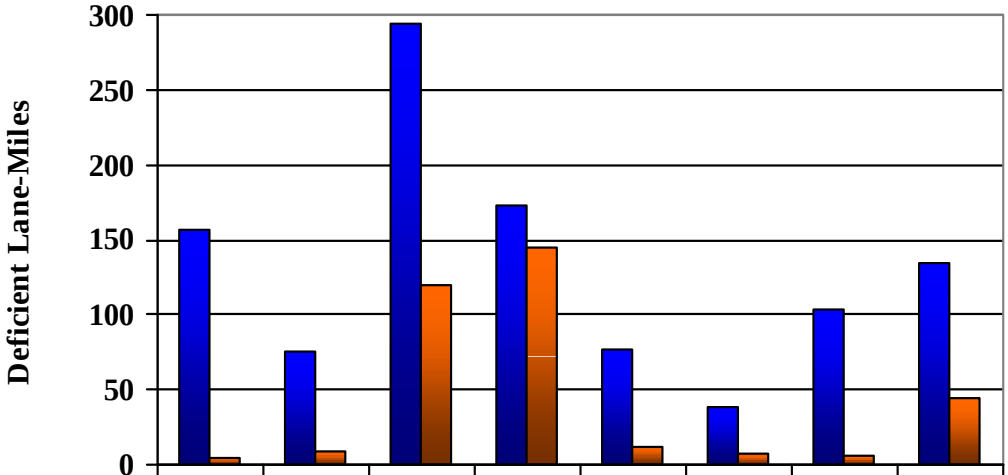

INTERSTATE PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 5 10 20 30 40 Miles
VDOT Virginia Department of Transportation
Maintenance

Figure IV: Percent Deficiency by District - Interstate



	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Condition	29.1%	15.4%	22.8%	22.2%	27.9%	14.0%	11.0%	21.2%
Ride Quality	0.7%	1.7%	9.6%	19.5%	4.3%	2.4%	0.6%	7.0%

Figure V: Deficient Lane Miles by District - Interstate

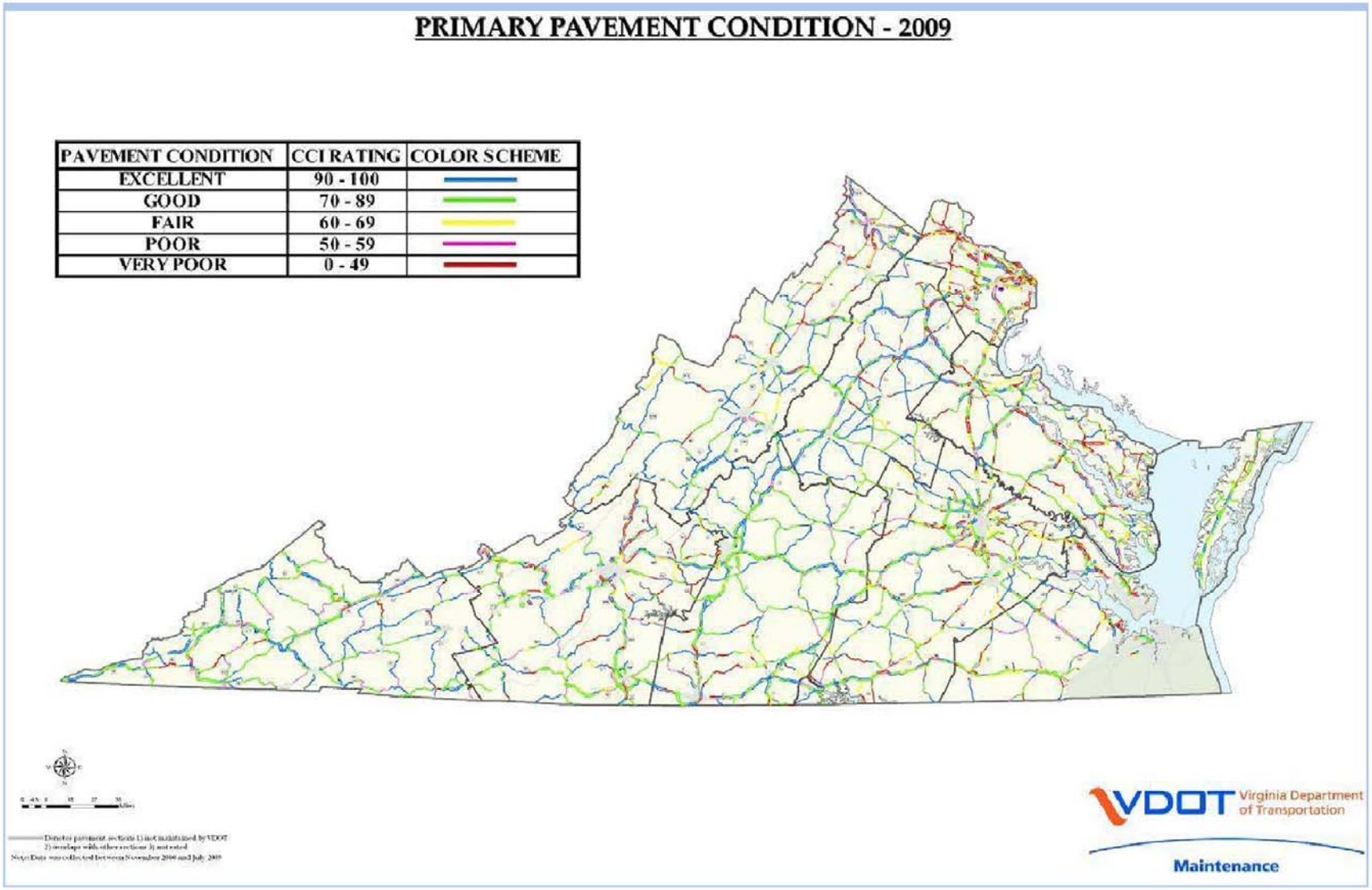


	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Condition	157	76	294	173	77	39	104	134
Ride Quality	4	8	120	145	12	7	5	44

The number of miles maintained by each district varies considerably, therefore, one district may have a smaller percentage of miles in deficient condition but more lane miles deficient than another. The percent of lane miles rated deficient varies from as low as 11.0% in Staunton District to as high as 29.1% in Bristol District. Richmond District maintains the largest number of Interstate lane miles while Lynchburg District does not maintain any Interstate pavements. On the Interstate system, the ride quality deficiencies vary from as low as 0.6% in Staunton District to as high as 19.5% in Hampton Roads District.

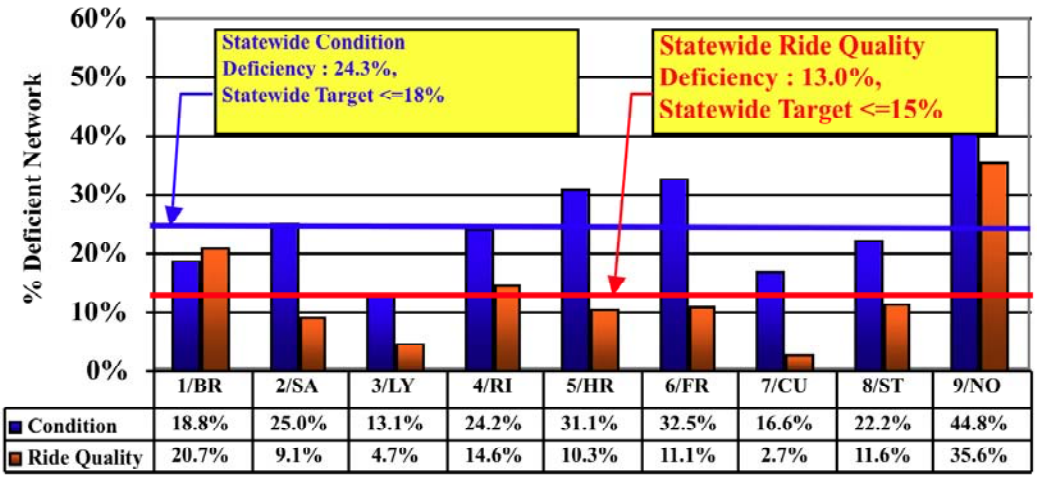
Primary Pavement Condition and Ride Quality by District

The following graphic shows the pavement ratings for the Primary pavement system.


PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION
CCI RATING
COLOR SCHEME
EXCELLENT
90 - 100
GOOD
70 - 89
FAIR
60 - 69
POOR
50 - 59
VERY POOR
0 - 49
VDOT Virginia Department of Transportation
Maintenance

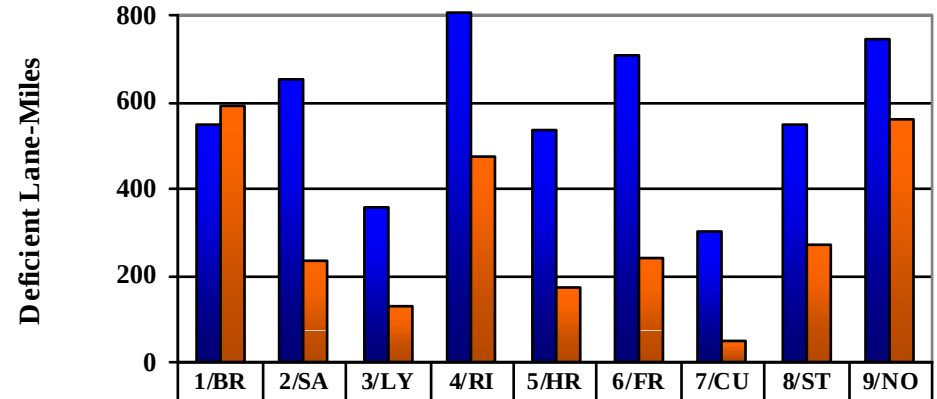
Figures VI and VII show pavement condition and ride quality summaries for the Primary pavement network. Figure VI shows the percent of deficiencies by district based on pavement condition and ride quality along with statewide figures. Figure VII shows the number of deficient lane-miles in each district. Current VDOT performance targets are that no more than 18 percent of pavements to be in deficient condition and no more than 15 % have a deficient ride quality.

Figure VI: Percent Deficiency by District - Primary



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Condition	18.8%	25.0%	13.1%	24.2%	31.1%	32.5%	16.6%	22.2%	44.8%
Ride Quality	20.7%	9.1%	4.7%	14.6%	10.3%	11.1%	2.7%	11.6%	35.6%

Figure VII: Deficient Lane Miles by District - Primary



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Condition	546	650	359	804	538	706	302	549	742
Ride Quality	594	234	129	474	174	238	50	273	562

Based on the data, approximately 24.3% of the Primary network has been rated to be in deficient condition and 13.0% has deficient ride quality. Therefore, the Primary system is currently not meeting its pavement condition performance target of 18 percent or less rated deficient; however, it is meeting the ride quality target of 15 percent or less rated deficient in ride quality.

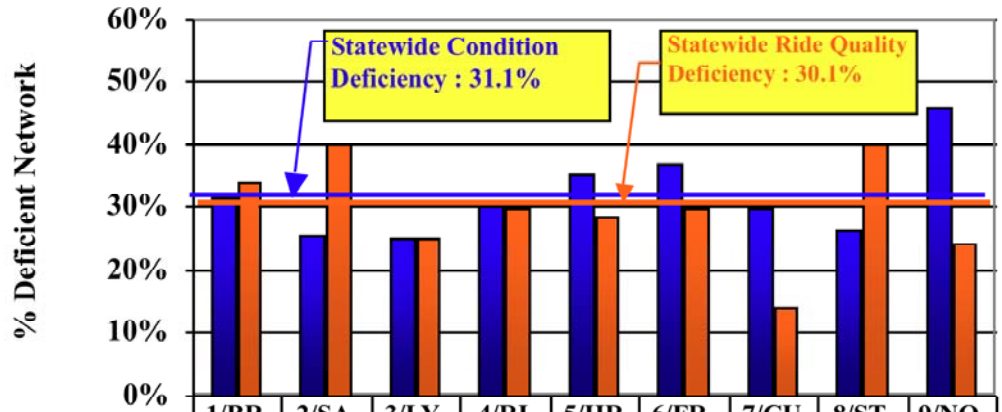
Secondary Pavement Condition and Ride Quality by District

As previously mentioned the Secondary pavement network was not surveyed in its entirety. In 2009, data in each county was collected and processed for a total of about 15,398 lane miles of the VDOT maintained hard-surfaced Secondary network. VDOT maintains approximately 79,036 lane miles of hard surfaced Secondary pavements.

Figure VIII shows the percent deficiencies by district based on pavement condition and ride quality. Figure IX represents the number of lane miles surveyed and the number of deficient lane miles in terms of condition and ride quality. Since samples for Secondary pavements were selected from every county of the state, this figure, although not based on the survey of the entire network, is a good representation of the Secondary pavement condition across the state. Based on these figures, Northern Virginia District has the highest percentage of its Secondary rated as deficient (46.1%), followed by Fredericksburg and Hampton Roads Districts. Lynchburg District has the lowest percent of deficient Secondary pavements. Statewide, 31.1% of the sampled Secondary system was found to have deficient pavement condition.

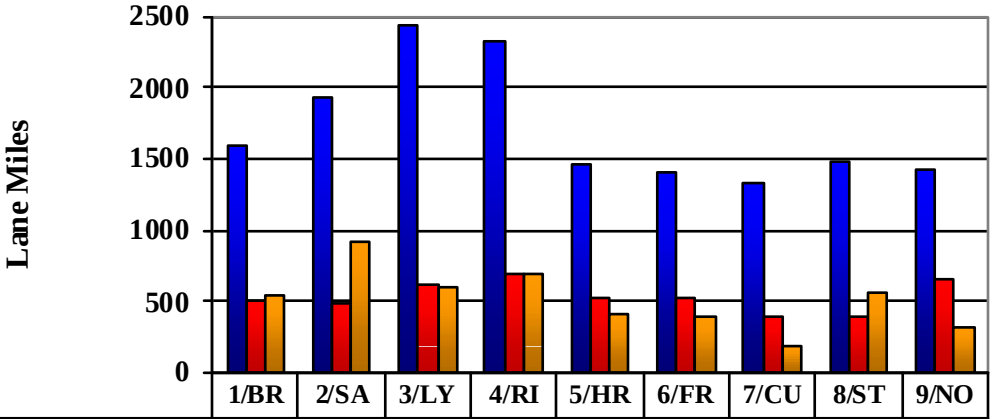
Based on ride quality, the deficiency ratings range from a low of 14.0% deficient in Culpeper district to a high of 40.2% in Salem district. Statewide 30.1% of the rated samples on the Secondary system were found to have deficient ride quality.

Figure VIII: Percent Deficiency by District - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Condition	31.6%	25.6%	25.0%	30.0%	35.2%	37.1%	30.0%	26.5%	46.1%
Ride Quality	34.1%	40.2%	25.2%	30.0%	28.4%	29.9%	14.0%	39.9%	24.2%

Figure IX: Surveyed, Deficient Condition and Deficient Ride Quality Lane Miles by District - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Surveyed	1601	1928	2441	2327	1469	1398	1334	1475	1425
Deficient Condition	506	493	610	699	516	518	400	390	657
Deficient Ride Quality	541	927	604	685	411	386	184	563	324

Statewide Pavement Deficiency Trends

The trends over recent years in Interstate and Primary percent deficiencies are shown in Figure X; trends for the Secondary pavements are shown in Figure XI. The lower the percentage of deficient pavements, the better is the pavement network condition. In Figure X, the statewide performance targets of 18% deficient are shown for Interstate and Primary pavements.

Figure X: Trend in Percent Deficiency - Interstate and Primary

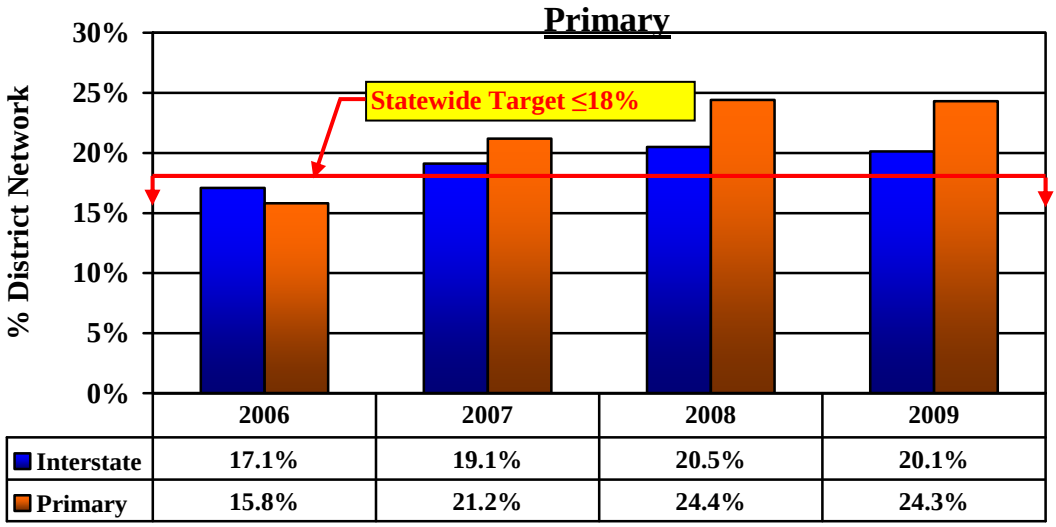
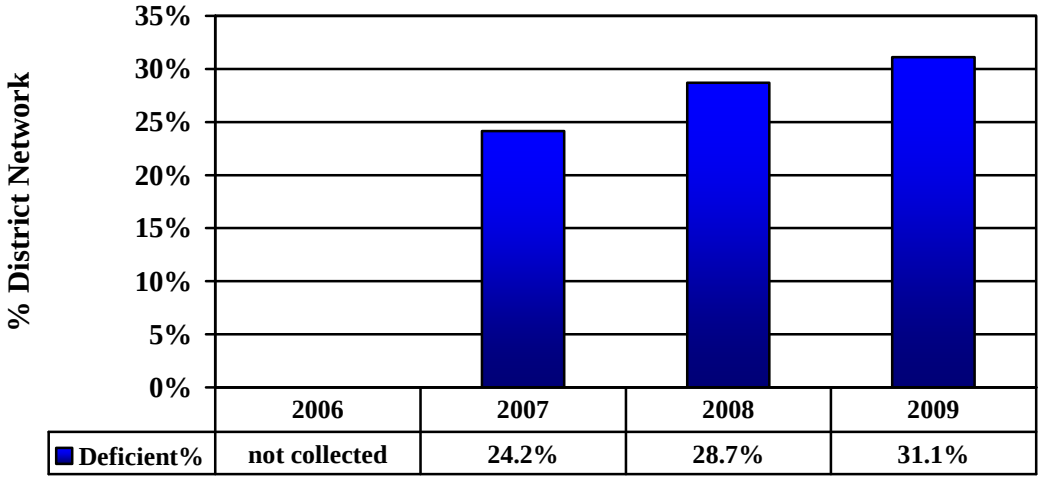


Figure XI: Trend in Percent Deficiency - Secondary (Samples)



Current and Future Uses of the Data

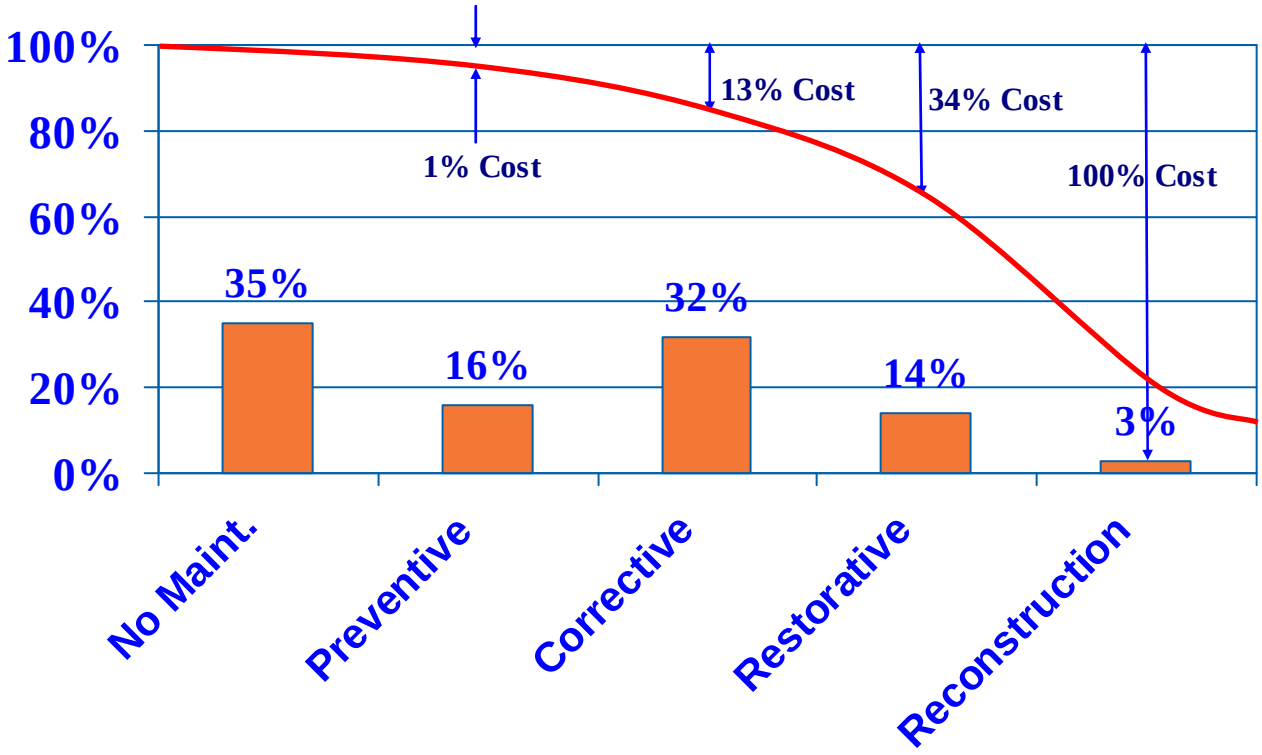
Pavement condition data presented in this report are used for multiple purposes – both internal and external to VDOT, including:

1. Needs-Based Budgeting. Pavement condition data are used to estimate the cost to achieve and sustain pavement performance targets, and to recommend allocation of available maintenance funds across districts. Thus, the pavement condition data are an important input into the Pavement Management System (PMS) to develop estimates of pavement maintenance and rehabilitation needs based on an optimization analysis. These needs are subsequently used for the development of the biennial maintenance budget and the work plan generated by the optimization serves as a guide to district personnel for the selection of pavement maintenance strategy for the yearly pavement maintenance schedules. Once a particular section of pavement is selected for maintenance, a detailed project level analysis is conducted to determine the specific treatment.

The maintenance activities recommended by the optimal work plan are arrived at through decision trees that utilize the pavement type, predicted surface condition, roughness and rutting. The predicted surface condition is based on an actual surface condition collected through VDOT's annual pavement condition survey prior to the analysis, which is "deteriorated" along performance prediction models in each of year of the analysis.

The data are also used to feed the automatic maintenance decision trees to determine the unconstrained maintenance needs for the pavement assets in the Maintenance Division's needs-based analysis process. Unconstrained needs analysis establishes the maintenance and rehabilitation needs to appropriately correct the existing pavement conditions where money would not be considered a constraint. It provides an idea of the amount and type of work needed on the whole network. For the determination of the needed treatment for a particular section the decision trees are used with distress quantity and severity, and condition index as input from the condition survey data[(6)]. Also, for the selection of the treatment traffic level, structural condition, and maintenance history are provided as additional inputs wherever these are available. Figure XII shows the percentage of pavements that need various maintenance treatments from unconstrained needs analysis in the form of bar chart. A typical pavement deterioration curve is also presented in the chart with the percentage unit costs of various treatments compared to reconstruction/major rehabilitation. Unconstrained needs are also used in many cases as the first indicator of the needed treatment which is further refined by field inspections, detailed project level analysis, overall needs of the network and available budget.

Figure XII : Pavement Deterioration and Cost (IS+PR)



2. Planning for Preventive Maintenance and Resurfacing. The surface distress condition data have been used to identify and prioritize recommended candidate pavement sections for preventative maintenance activities. These recommendations are based on decision trees developed for the needs analysis, as described above.

The pavement data are used for selection of pavement sections and maintenance strategies for yearly pavement maintenance schedule. Automated data that provide high consistency and efficiency have been used to aid in prioritizing Maintenance Resurfacing by the districts. Typically, the districts have used the data in combination with their local knowledge of pavement conditions to select pavement projects.

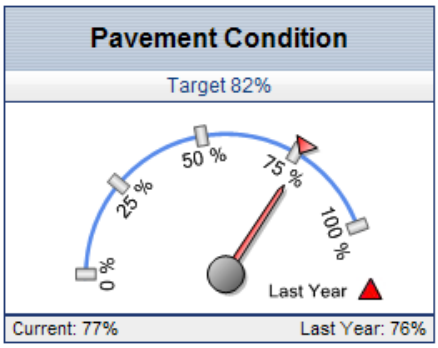
Information about specific distresses can be used to determine appropriate maintenance and rehabilitation actions for consideration. For example, a pavement with serious load related distress would typically require a resurface or "mill and fill" treatment, whereas a preventive maintenance treatment would be more appropriate for a pavement with primarily non-load related distresses.

3. Pavement Performance Reporting. The pavement condition data play a major role in preparation of two legislatively mandated reports. One report is the biennial infrastructure condition report required by Section 33.1-23.02(B) 3. The second report is on the condition of and needs for maintaining and operating the existing transportation infrastructure to meet the performance targets with an estimate of the budget required for the upcoming biennium required by Section 33.1-13.02.

The data are also used for tracking performance measures on the dashboard and reported to the Commonwealth Transportation Board (CTB) yearly. The dashboard uses the condition data to display the percent of pavement in fair or better condition for each district, county and system in the form of a gauge, and also in a bar chart form. The gauge points to the percent of pavement in non-deficient condition, with a tic mark to show the last year's results. All pavements on the Interstate and Primary road systems in Virginia are assessed each year and rated in one of the following categories: Excellent, Good, Fair, Poor, or Very Poor. Segments of pavement classified as Poor and Very Poor are considered deficient, all others are non-deficient. VDOT's goal is to have a minimum of 82% of Interstate and Primary pavement in Excellent, Good, or Fair condition. 82% or better in these conditions is considered 'green' status, from 70% to 82% is yellow, and less than 70% is red status.

The percent of pavement with fair or better ride quality is also displayed in a separate gauge. Performance target for deficient ride quality is 85% for Interstate and Primary pavements, i.e., VDOT's goal is to have at least 85% of the pavements with fair or better ride quality.

Figure XIII. Gauges from the VDOT Dashboard



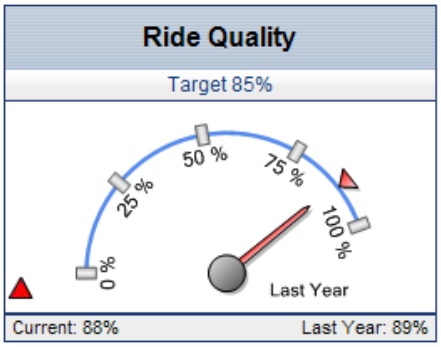
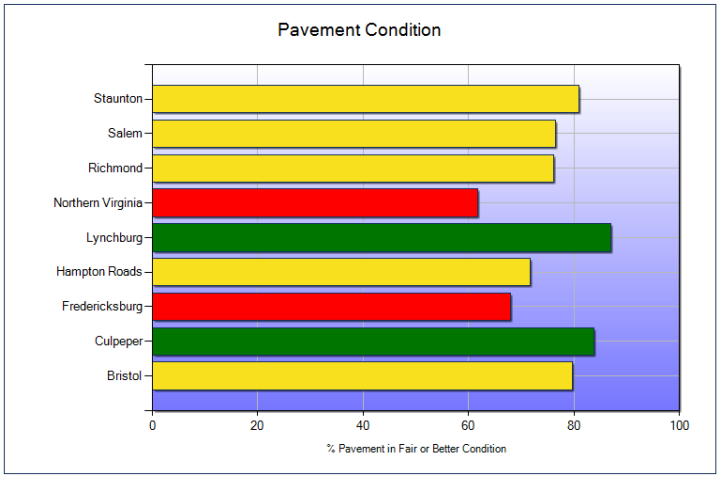


Figure XIV. Barchart from the VDOT Dashboard



4. Federal HPMS Reporting. Pavement condition data are included in VDOT's Highway Performance Monitoring System (HPMS) data submission to FHWA. This report is the basis for the federal apportionment of Virginia's share of federal funds. VDOT provides the FHWA with the length, roughness and lane-miles on state maintained roads in various functional systems for assessing and reporting highway performance. HPMS data are also used for assessing and reporting highway system performance under FHWA's strategic planning process and are the source for a substantial portion of the information published in Highways Statistics and in other FHWA publications and media. Finally, the HPMS data are widely used throughout the transportation community, including other governmental interest, business and industry, institutions of higher learning, the media and general public. More details can be found in the HPMS Field Manual[(7)].

Starting with the 2010 submission, HPMS data specifications will expand to include requirements to report surface distress quantifications as well as additional pavement structural information for a statistical sample of highway sections. The data collected in the annual pavement condition survey will be used to meet many of the new reporting requirements.

5. Research Needs. Pavement data are made available to a variety of divisions within VDOT and externally as well to meet research, analysis and planning needs. It is also used for other purposes including determination of performance of various types of asphalt mixes. Initial steps, needed to identify detailed project level analysis, are determined using the pavement condition data.

Accumulation of consistent and quality pavement condition data over time will also allow VDOT predict future pavement performance trends more accurately, enabling VDOT to more efficiently manage the pavement assets. It will also help the agency measure maintenance cost effectiveness, study the influence of new construction materials on pavement performance, and can serve as a basis for future vehicle cost responsibility studies.

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BACKGROUND

The Virginia Department of Transportation (VDOT) maintains the third largest public road network in this country, covering a total of about 57,920 miles consisting of about 1,119 miles of Interstate highways, 8,324 miles of Primary highways and 48,477 miles of Secondary roads. The pavement management program in Virginia began with the establishment of a pavement inventory. That phase took place in the 1970s with the manual gathering of pavement records including those of construction history and rehabilitation projects. The merging of those early pavement records and the then existing highway inventory eventually evolved into what is now known in VDOT as the Highway Traffic Records Information/Inventory System (HTRIS). While, as the name implies, HTRIS is heavily oriented toward traffic engineering needs, it also was the first repository for pavement construction and rehabilitation records or pavement inventory. The system was developed and remains a mainframe computer application widely accessible throughout VDOT.

A second stage of pavement management activity in the state took place in the early 1980s and involved the development of a first generation pavement condition assessment methodology. This methodology, used throughout most of the 1980s and early 1990s, was a windshield survey based index procedure called the distress maintenance rating (DMR) with a rating scale of 0 to 100, with 100 being a pavement with no visual surface distress. The procedure gave consideration only to pavement surface distresses with heavy emphasis on cracking and patching. In the mid-1990s VDOT began to collect pavement distress data through the use of videotaped images. To make use of data collected from those tapes, VDOT also made interim use of the pavement condition index (PCI) defined and used by the U.S. Army Corps of Engineers[8]. After several trial years, the PCI was deemed too general for Virginia conditions and a VDOT specific method was developed. Briefly, that system recognizes that pavement distresses fall into two basic categories; they are either load related (caused by the application of vehicular loadings) or they are not load related (caused by the exposure of pavement elements to the environment). This realization gave rise to the development of two separate indices to describe pavement surface distresses. These are the load related distress rating (LDR) and the non-load related distress rating (NDR). These two indices also use 0 to 100 scales and are the basis for asphalt pavement surface condition evaluation in VDOT.

The advent of pavement data collection through contracted, automated means led to a need to standardize the procedures for the purposes of consistency and as a contractual instrument for bidding purposes. The document providing this standardization, *A Guide To Evaluating Pavement Distress Through The Use Of Digital Images* [1], was developed and made available to vendors bidding on contract data collection.

Pavement distress condition throughout the state is crucially important information and one of the most important products of the Pavement Management Program. Dissemination of that product throughout the agency is a major reason the 1998 condition report [9], the 2002 report [10], the 2003 report [11], the 2004 report [12], the 2006 [13] report and the 2008 report [14] were assembled. One of the uses of this information is to aid in the maintenance activities of the agency. Another value of disseminating this information is to receive feedback from users on the pavement management and the asset management systems. This feedback will be used to identify and address changes that may enhance the continued implementation of the Pavement Management System.

PURPOSE AND SCOPE

The present document is more of a "fact sheet" than an in-depth research report; the intention is to provide the reader with an overall assessment of the condition of pavements throughout the Commonwealth. The condition of pavements in terms of condition states, deficient pavement network, summaries of key distresses, and ride quality are included in this report.

Previously, only the surface distress, roughness and rutting data were collected, which had limitations. Any consideration of the structural integrity of the pavements had to be deduced from the nature of the distresses (e.g., early alligator or fatigue cracking would suggest a pavement is subject to loadings in excess of its design capacity).

The surface distress data are collected and analyzed on a lane mile basis on all of the Interstate and Primary pavements, and a 20-25% of the hard-surfaced Secondary pavement network. In addition, the FWD data are collected, as an initial effort as part of a different project, on the entire Interstate system. Results of FWD data analysis have been published in a VTRC research report [15] and will not be included in this report.

PAVEMENT DATA COLLECTION, DATA PROCESSING & QC/QA

The pavement condition data presented in this report were collected and processed by a contractor (Fugro-Roadware Inc.) using continuous digital imaging and automated crack detection technology. For data collection purposes, Fugro-Roadware uses vehicles equipped with special cameras to capture downward pavement images for crack detection, and a forward perspective view. Roughness and rutting data are also captured simultaneously with the sensors mounted on the van. The data were collected at highway speeds as the vans were driven along the pavement. Downward images collected during the survey are processed with specialized automated crack detection software (Wise-Crax) for the identification of cracks and then further augmented with distress survey of digital images for the identification of other distresses. The following sections describe the major data items that were collected, and the results of the 2009 surveys.

DISTRESS DATA ELEMENTS COLLECTED

Distresses were collected for various pavement types following the protocols specified in the distress data collection manual: "A Guide to Evaluating Pavement Distress Through the Use of Digital Images[1]." The data elements collected are provided in Appendix B for all of the following pavement types: continuously reinforced concrete pavement (CRCP), jointed concrete pavement (JCP) and asphalt-surfaced concrete pavement (ACP) that further includes bituminous (BIT), bituminous over jointed concrete (BOJ), and bituminous over continuously reinforced concrete (BOC) pavements. Detailed distress data in terms of extents and severities are collected and summarized for each 0.1 mile as well as for each homogeneous section. For ease of interpretation, the data are also summarized in the "ACP-INPUT" format which is used in the decision matrices to determine maintenance and rehabilitation recommendations. This is also similar to the "windshield" data format, which is the data format obtained while collecting data by windshield surveys. The details of the various formats of the data for different types of pavements are provided in Appendix A, and the distribution of key distresses in Appendix B.

QUALITY ASSURANCE

An independent QA process is an important consideration for quality data. For 2009 data collection, the QA process began with evaluation of control sections comprised of ACP, CRCP and JCP for Interstate, Primary and Secondary systems. Image evaluations were completed on 12 control sections distributed over the system and pavement types. The control sections were used to calibrate the pavement distress rating process and also to establish the precision and bias values for the roughness and rutting measurements.

For the rutting and roughness comparison, the precision (repeatability), as specified in the terminology of ASTM E177[16] and the bias, based upon the average value or "ground truth", were used for QA checks. A data-collection vehicle is considered to have passed the QA checks if it is capable of collecting rutting and roughness data within the specified repeatability limits.

For the production ratings, batches of data, including Interstate, Primary and Secondary system ACP, JCP and CRCP pavements, were delivered to, and reviewed by the Independent data Verification and Validation (IV&V) contractor. Four percent of the data delivered in each batch were randomly chosen for QA and rated independently by the IV&V contractor. A batch is considered to have passed the QA checks when the CCI index values from the production data fall within 10 points of the CCI values from the IV&V ratings for 90% of the pavement length. In addition to the random 4% QA checks, a "high-level" data review consisted of reasonableness and a completeness check was also conducted for each delivery table. The ratings on pavement sections were also compared with the previous year's ratings on the same sections. Any major differences in ratings were further investigated.

A comparison of data summaries from the data obtained on these sections by the data collection contractor, and the IV&V contractor showed good match in the results as specified in the data collection Request for Proposal (RFP). The QA procedures and the results are described in detail in the Quality Monitoring Report [(2)].

PAVEMENT INVENTORY EVALUATED

The 2009 automated condition surveys began in November, 2008 and were completed, including the QA evaluations, by late July of 2009. The following sections summarize the inventory evaluated and the results of those surveys, including the establishment of a scale of relative condition evaluation.

The surveys were conducted in the rightmost traffic lane, usually designated lane 1 in the VDOT pavement inventory, while the tabulations, graphs, and discussions below were extended to a lane mile basis. For example, a one-mile long pavement section with three lanes in the direction of rating would be reported as three lane miles. Using the method described above, about 5,233 lane miles on Interstate and 21,424 lanes miles on Primary (25,546 lanes miles of ACP pavements and 1,111 lanes miles of JCP and CRCP pavements) are accounted for in 2009 surveys.

Because of the size of the Secondary system, it was planned to complete the entire condition data collection in a four to five-year time window, starting from the year 2007 and with a different 20-25% portion of the network each consecutive year. For this purpose, 20-25% of the lane miles are chosen for survey in each county, and approximately 15,398 lane miles of Secondary pavements were surveyed in 2009.

PAVEMENT CONDITION - 2009

The 2009 automated condition surveys began in November, 2008 and were completed, including the QA evaluations, by late July. The following sections summarize the inventory evaluated and the results of those surveys, including the establishment of a scale of relative condition evaluation.

CONDITION EVALUATION CRITERIA

Table 1 provides a scale for evaluation for the 2009 pavement surface distress condition survey results. The index scale provided in that table is the result of experience with previous windshield surveys and reflects earlier action of the VDOT Pavement Management Engineering Team (PMET). The PMET action was a decision that pavements with a condition index of less than 60, referred to as the deficient pavements, would be evaluated further for possible higher types of maintenance and rehabilitation.

The condition state of pavement shown in Table 1 is based on CCI values. For asphalt surfaced pavements LDR and NDR are used and CCI is defined as the lower of the two values. The slab distress rating (SDR) is used instead for JCP pavements and the Concrete Punchout Rating (CPR) and the Concrete Distress Rating (CDR) are for CRCP pavements. However, the same concept of CCI and the same scale in Table 1 apply to the latter two pavement types as well: SDR is directly equivalent to CCI for JCP pavements; and the lower of CDR and CPR is equivalent to CCI for CRCP pavements. More details about these concrete pavement condition indices are documented in another VDOT report[4]. In general, pavements rating less than 60 by either index are considered to be deficient, i.e., they need some kind of attention, more specifically, some heavier type of maintenance/rehabilitation actions. The deficient pavement in each county and district for Interstate and Primary pavements is presented in Appendix C. Appendix D shows that maps of condition of Interstate and Primary pavements.

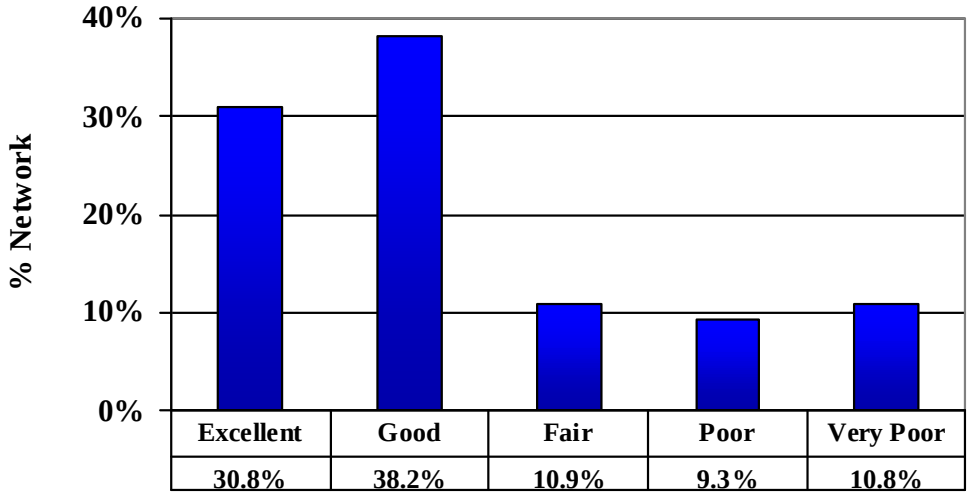
Table 1: Pavement Condition Definition

Pavement Condition	Index Scale (CCI)
Excellent	90 and above
Good	70-89
Fair	60-69
Poor	50-59
Very Poor	49 and below

THE CONDITION OF INTERSTATE PAVEMENT

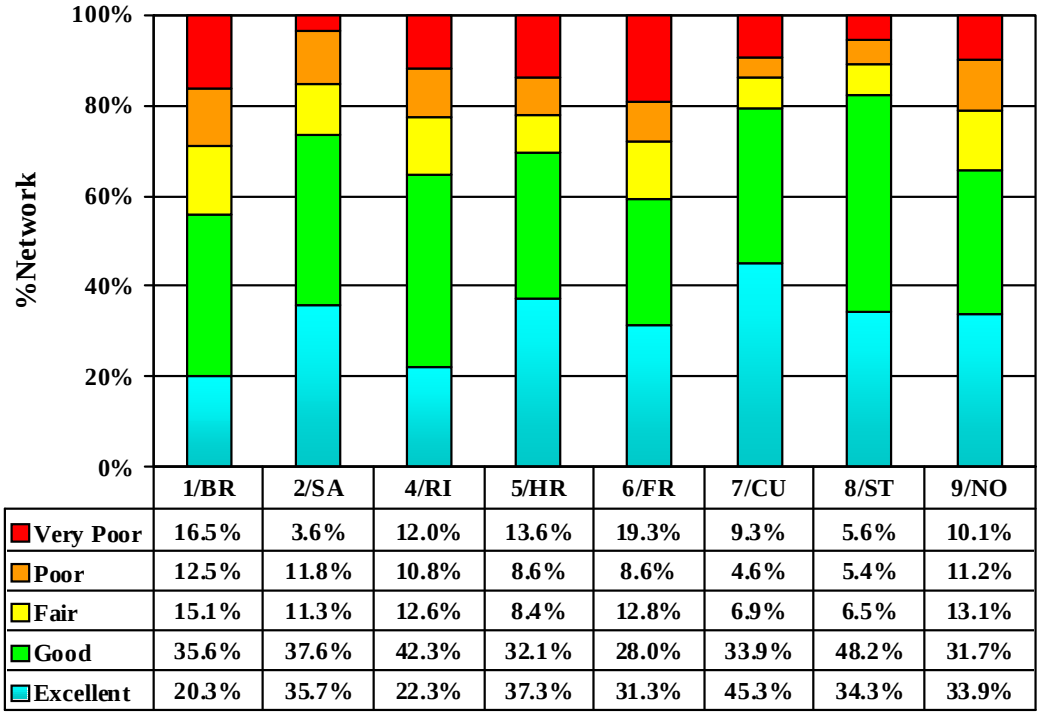
The percentage of pavements in different condition states is shown in Figure 1 for the Interstate system. It shows that more than 79 percent of the Interstate pavements are in fair or better condition on statewide basis.

Figure 1 : Pavement Condition - Interstate



The distribution of condition states on district basis is presented in Figure 2 for Interstates. Here all of the condition states are represented as percentages in the chart along with numerical values.

Figure 2 : Pavement Condition by District - Interstate

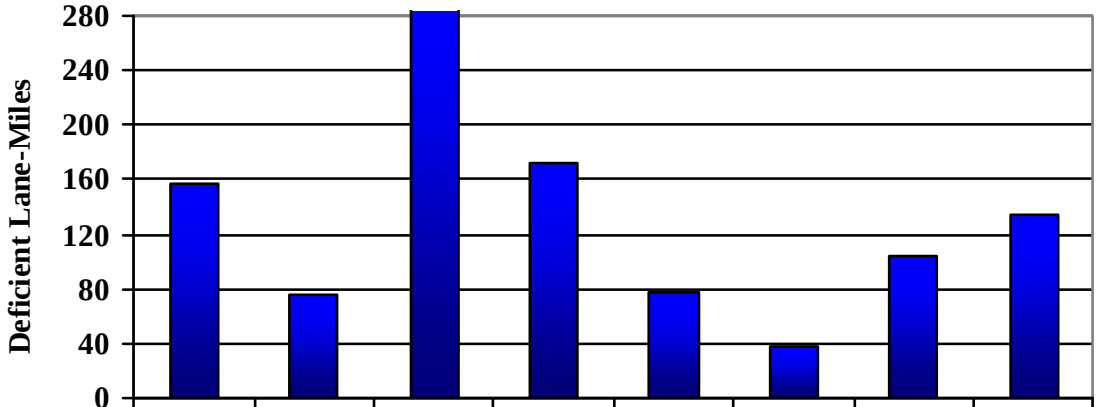


	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Very Poor	16.5%	3.6%	12.0%	13.6%	19.3%	9.3%	5.6%	10.1%
Poor	12.5%	11.8%	10.8%	8.6%	8.6%	4.6%	5.4%	11.2%
Fair	15.1%	11.3%	12.6%	8.4%	12.8%	6.9%	6.5%	13.1%
Good	35.6%	37.6%	42.3%	32.1%	28.0%	33.9%	48.2%	31.7%
Excellent	20.3%	35.7%	22.3%	37.3%	31.3%	45.3%	34.3%	33.9%

Figure 3 presents the Interstate deficient lane miles in each district in the form of bar chart. The numerical values are also presented which split the deficient lane miles among different pavement types: Asphalt Concrete (AC), Continuously Reinforced Concrete (CRC) and Jointed Reinforced Concrete (JRC) in each district. Deficient pavements typically need some type of higher maintenance and rehabilitation treatments. Since the deficient lane miles presented in Figure 3, are part of different Interstate network sizes in different districts, the percentage of deficient pavements is presented in Figure 4.

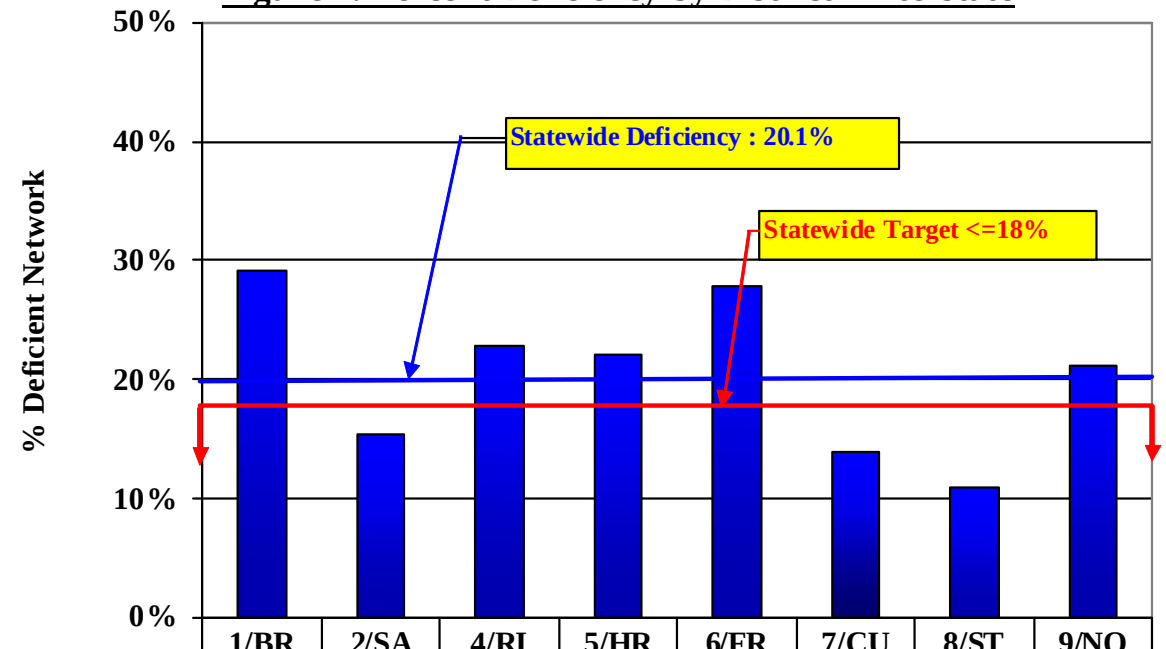
A performance target of a maximum of 18% deficient pavements is established for Interstate pavements. A lower value of percent deficient is preferred since it indicates lower percentage of pavements in poor and very poor condition, i.e., higher percentage of pavements in fair or better condition. In Figure 4 the statewide performance target of 18% deficient is represented by a line, and the current percent deficient of 20.1% for Interstate pavements is represented by another line. It can be seen that three districts are below performance target of maximum 18% deficiency. District 8 shows the lowest percentage deficient, about 11%, whereas the highest percentage deficiency is found in District 1 of about 29%.

Figure 3: Deficient Lane Miles by District - Interstate



	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Total	157	76	294	173	77	39	104	134
ACP	157	76	170	64	77	39	104	107
CRCP	-	-	117	45	-	-	-	-
JRCP	-	-	7	63	-	-	-	27

Figure 4: Percent Deficiency by District - Interstate



	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
% Deficient	29.1%	15.4%	22.8%	22.2%	27.9%	14.0%	11.0%	21.2%

ASPHALT SURFACED PAVEMENT

For asphalt surfaced pavements some of the key distresses are presented in Table 2 for each district. Alligator cracking and patching area are presented as percentages of the total area of pavement. Rutting is presented in terms of average value while transverse and longitudinal cracking are presented in terms of linear feet per lane mile. Distress types, quantities and severities are important factors in recommending maintenance and rehabilitation actions. Also, these distresses provide an indication of the type of damage to the pavements. Alligator cracking and rutting are induced by traffic loads while longitudinal and transverse cracking are typically caused by environmental effects, use of improper materials, construction deficiencies, etc.

Table 2, below, quantifies certain key distresses found on the Interstate Asphalt Pavements by district. For example, the table shows that the percentage of alligator cracking varies from a low value of 1.5% in Staunton District to a high of 4.4% in Bristol district. Also, it can be seen that, by district, the variation of average rutting values is relatively small from a lowest value of 0.15 inch to a highest value of 0.19 inch.

Table 2: Major Distresses on Interstate Asphalt Pavement

Key Distresses	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Alligator Cracking (% total area)	4.4%	1.9%	2.9%	2.5%	3.0%	2.0%	1.5%	1.7%
Patching (% total area)	0.6%	0.7%	0.6%	0.1%	1.5%	0.4%	0.9%	0.1%
Rutting (inches)	0.19	0.19	0.18	0.17	0.18	0.15	0.17	0.17
Transverse Cracking (ft/lane mile)	504	512	943	735	1136	556	400	683
Longitudinal Cracking (ft/lane mile)	2174	1309	1182	1022	901	769	1605	733

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

For CRC pavements the percentage of asphalt patching, punchout area, PCC patching, and transverse cracking are presented in Table 3. Punchout is a serious distress that occurs in a CRC pavement constituting structural failure, and asphalt patch on concrete pavement is considered temporary in nature till a more permanent concrete patch can be applied. Punchout, asphalt patching, and concrete patching are presented in terms of percent area of pavement. In case of transverse cracking, both average length per mile and average spacing between transverse cracking are presented. It should be noted that the areas where the cluster cracking occurs are excluded for the determination of average spacing between transverse cracks. Richmond and Hampton Roads are the only two districts with CRC pavements on the Interstate system.

Table 3: Major Distresses on Interstate CRC Pavement

Key Distresses		4/RI	5/HR
Asphalt Patching (% total area)		2.0%	0.6%
Punchout (% total area)		0.2%	0.2%
PCC Patching (% total area)		2.8%	5.1%
Transverse Cracking	ft/lane mile	8617	5928
	Spacing (ft)	5.9	8.0

JOINTED REINFORCED CONCRETE PAVEMENT

The percent of slabs of jointed concrete pavements with transverse cracks, corner breaks, PCC patching, and asphalt patching are presented in Table 4. On the Interstate system, JRC pavements are present only in Richmond, Hampton Roads, and Northern Virginia districts. Corner breaks and transverse cracks are some of the distresses that help in the determination of the required treatment type. Asphalt and PCC patching on jointed concrete pavements indicate the areas of deterioration of the slabs. Shattered slabs indicate severe damage to slabs, and they are not included in the table since the percentage of their occurrence is very low.

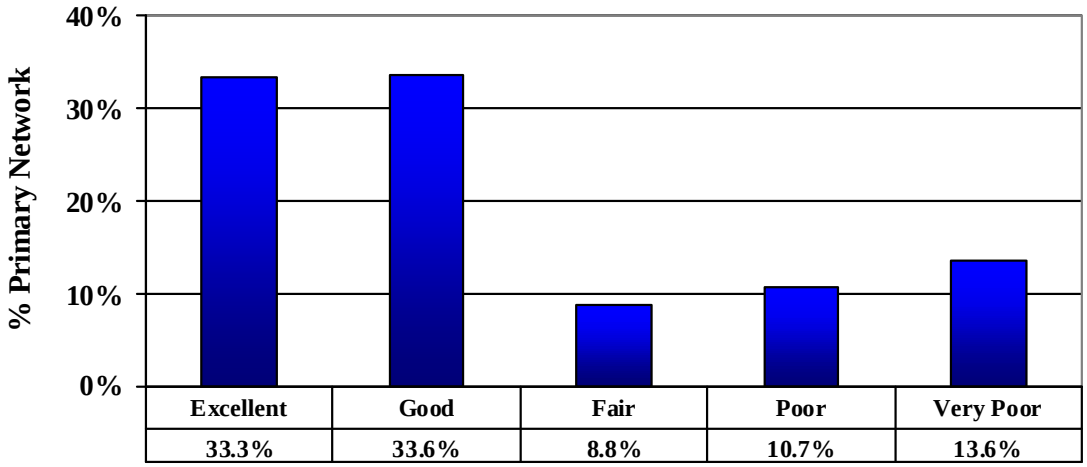
Table 4: Major Distresses on Interstate JRC Pavement

Key Distresses	4/RI	5/HR	9/NO
Transverse Cracking (% slabs)	12.0%	9.4%	2.9%
Corner Breaks (% slabs)	2.5%	1.7%	2.4%
PCC Patching (% slabs)	10.4%	1.3%	8.6%
Asphalt Patching (% slabs)	29.0%	6.0%	8.4%

CONDITION OF PRIMARY PAVEMENT

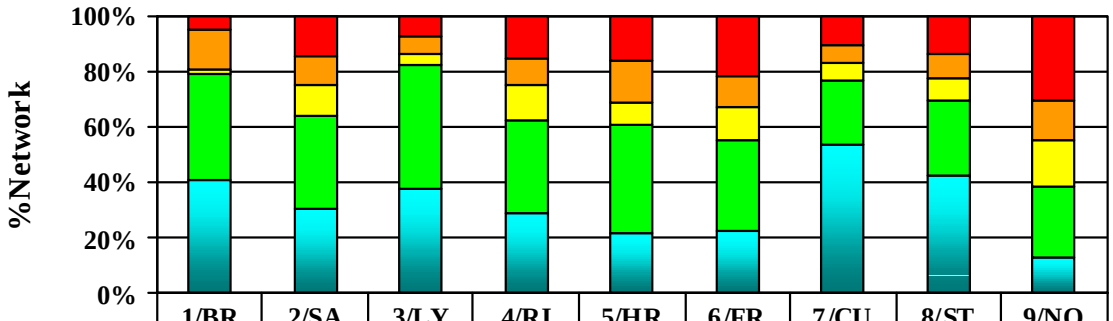
The statewide distribution of pavement condition on the Primary system is presented in Figure 5. It can be seen that the percentage of pavements in fair or better condition is 75.7%.

Figure 5: Pavement Condition - Primary



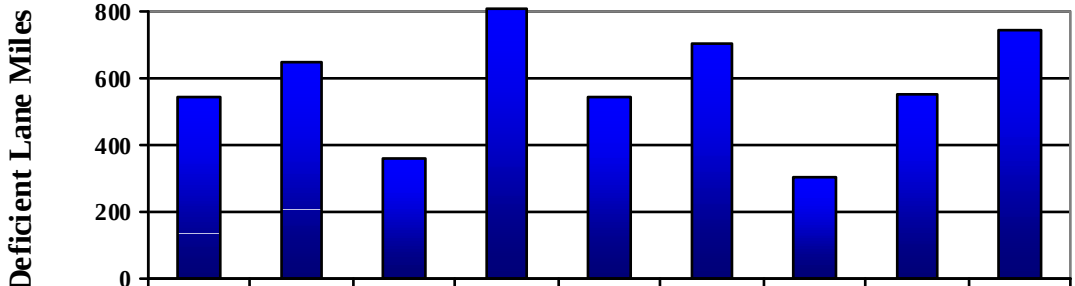
The distribution of pavement condition states on Primary system by district is shown in Figure 6. From the chart it can be seen that the overall pavement condition distribution is best in Lynchburg district with the worst conditions observed in Northern Virginia

Figure 6 : Pavement Condition by District - Primary



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Very Poor	4.6%	14.0%	6.8%	14.9%	15.4%	21.5%	9.9%	13.3%	30.1%
Poor	14.2%	10.9%	6.3%	9.4%	15.7%	11.0%	6.8%	8.9%	14.7%
Fair	2.1%	10.6%	4.7%	13.0%	8.0%	12.3%	6.1%	8.2%	16.6%
Good	37.7%	34.2%	44.4%	33.3%	38.7%	32.8%	23.1%	26.9%	25.3%
Excellent	41.4%	30.3%	37.8%	29.4%	22.2%	22.4%	54.1%	42.7%	13.3%

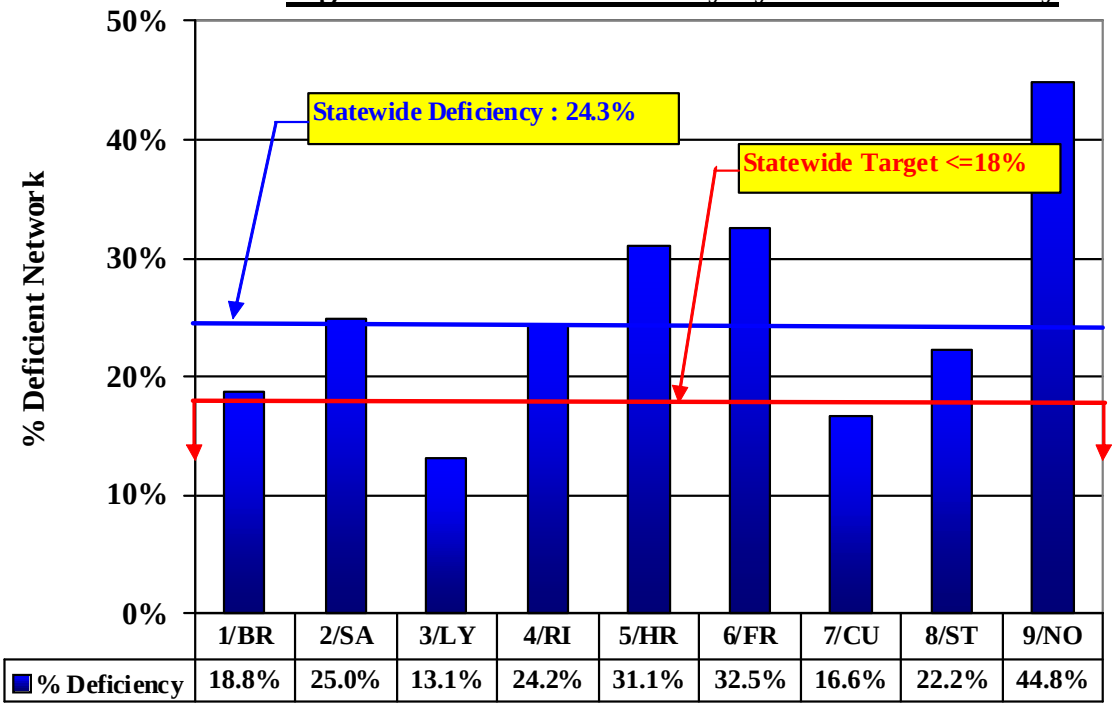
Figure 7: Deficient Lane Miles by District - Primary



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Total	546	650	359	804	538	706	302	549	742
ACP	546	650	358	758	514	706	302	549	740
CRCP	-	-	0	36	19	-	-	-	-
JRCP	-	-	1	9	4	-	-	-	2

Figure 7 presents the deficient lane miles in each district, with numerical values by pavement type. Again, the deficient lane miles are part of different pavement network sizes in different districts. For Primary pavements, Culpeper District has the least number of deficient lane-miles (302) while Richmond District has the highest (804) closely followed by Northern Virginia and Fredericksburg Districts with 742 and 706 lane miles, respectively.

Figure 8: Percent Deficiency by District - Primary



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
% Deficiency	18.8%	25.0%	13.1%	24.2%	31.1%	32.5%	16.6%	22.2%	44.8%

The percent deficient lane mile in each district is presented in Figure 8. The performance target of a maximum of 18% pavement rated as deficient as well as the statewide average percent deficiency of 24.3% are also shown on the figure. Only Districts 3 and 7 are below the target, all other districts are above the target. The percentage of deficient pavements varies from a low of about 13% in District 3 to a maximum of 44.8% in District 9.

ASPHALT SURFACED PAVEMENT

Some of the key distresses for asphalt surfaced pavements are presented in Table 5. These include percentage of alligator cracking, patching, rutting, transverse cracking and longitudinal cracking. Distress types, severities, and quantities constitute important inputs in the determination of maintenance/rehabilitation types needed.

Table 5: Major Distresses on Primary Asphalt Pavement

Key Distresses	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Alligator Cracking (% total area)	2.2%	3.9%	3.7%	5.9%	6.1%	6.4%	4.2%	3.7%	9.6%
Patching (% total area)	1.2%	1.9%	0.9%	0.8%	0.3%	0.8%	0.5%	2.3%	1.7%
Rutting (inches)	0.15	0.14	0.12	0.11	0.13	0.14	0.11	0.12	0.14
Transverse Cracking (ft/lane mile)	318	961	797	1,483	1,477	1,740	591	570	1,478
Longitudinal Cracking (ft/lane mile)	710	1,273	757	1,114	820	1,015	775	527	1,884

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

Some of the key distresses in CRC pavements that include: asphalt patching, punchout, PCC patching, and transverse cracking are presented in Table 6. In the case of transverse cracking, both the average length per mile and average spacing between the cracks are presented. For the determination of average spacing between the transverse cracks, the area of cluster cracking is excluded. Smaller quantities of transverse cracks per lane mile imply that the spacing between the cracks would be larger. Lynchburg, Richmond, and Hampton Roads are the only three districts with CRC pavements on the Primary system.

Table 6: Major Distresses on Primary CRC Pavement

Key Distresses		D3 LY	D4 RI	D5 HR
Asphalt Patching (% total area)		0.0%	0.6%	0.1%
Punchout (% total area)		0.1%	0.4%	0.7%
PCC Patching (% total area)		0.5%	3.6%	12.0%
Transverse Cracking	ft/lane mile	9,530	6,960	7,228
	Spacing (ft)	6.2	7.8	7.9

JOINTED REINFORCED CONCRETE PAVEMENT

The percentage of slabs with transverse cracks, corner breaks, PCC patching, and asphalt patching are presented in Table 7. As expected, it can be seen from the tables that transverse cracking and PCC patching are common distresses on JRC pavements. Only four districts have JRC pavements on the Primary system.

Table 7: Major Distresses on Primary JRC Pavement

Key Distresses	D3 LY	D4 RI	D5 HR	D9 NO
Transverse Cracking (% slabs)	21.8%	9.2%	10.0%	6.1%
Corner Breaks (% slabs)	0.5%	3.0%	3.3%	10.6%
PCC Patching (% slabs)	0.1%	2.8%	6.5%	10.6%
Asphalt Patching (% slabs)	0.0%	4.2%	5.8%	41.7%

CONDITION OF SECONDARY PAVEMENT

The Secondary pavement network was not surveyed in its entirety due to the size of the Secondary network in the state, time required to collect the data, and the cost of data collection. In this case, data for approximately 20 to 25 percent of the VDOT maintained Secondary network, in every county, were collected and processed this year; all of the statistics in the charts and tables are based on this sample. Since samples for Secondary survey were selected from every county of the state, the charts and tables presented here, although not based on the survey of the entire network, are a good representation of the Secondary pavement condition across the state.

Figure 9 shows the statewide condition distribution of the Secondary network while Figure 10 presents the distribution on district basis.

Figure 9: Pavement Condition - Secondary (Samples)

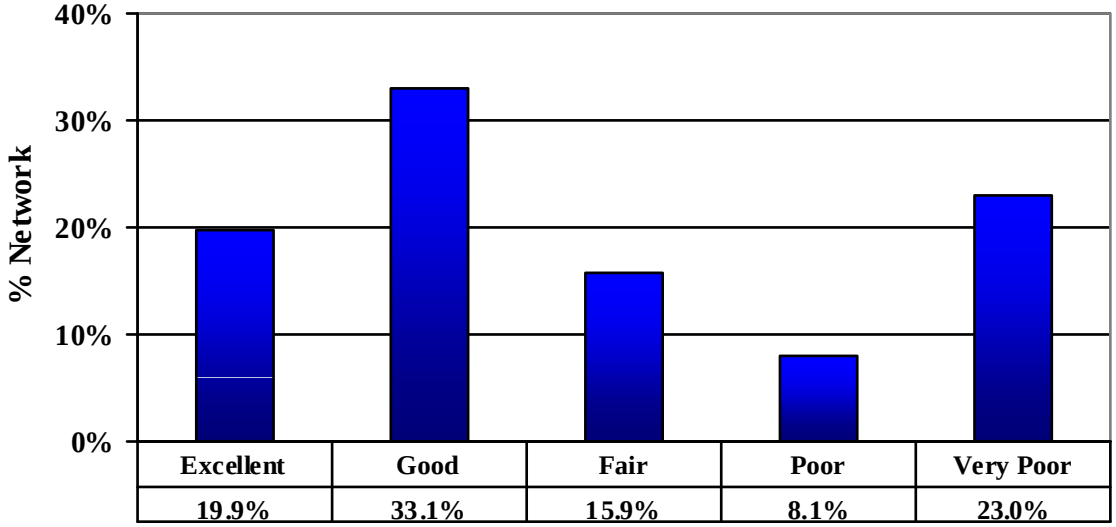
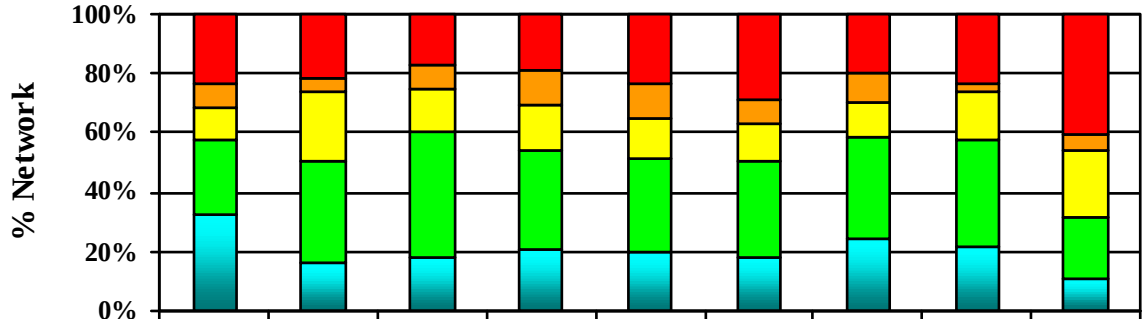


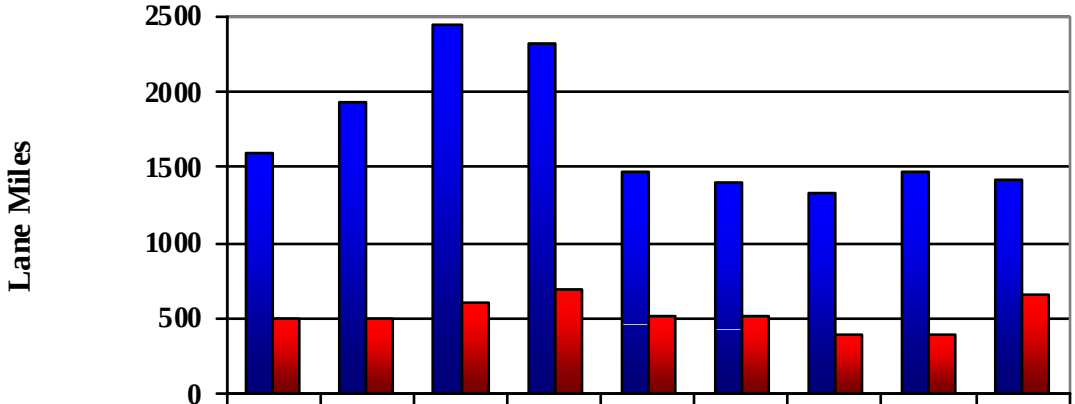
Figure 10 : Pavement Condition by District - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Very Poor	23.6%	21.4%	16.8%	18.3%	22.9%	29.2%	19.5%	23.0%	40.1%
Poor	8.1%	4.2%	8.2%	11.8%	12.2%	7.8%	10.5%	3.5%	6.0%
Fair	10.7%	23.9%	14.9%	15.9%	14.0%	12.3%	11.4%	15.9%	22.2%
Good	24.9%	34.9%	42.3%	33.5%	31.6%	32.5%	34.3%	36.2%	21.3%
Excellent	32.7%	15.6%	17.8%	20.5%	19.3%	18.2%	24.3%	21.4%	10.4%

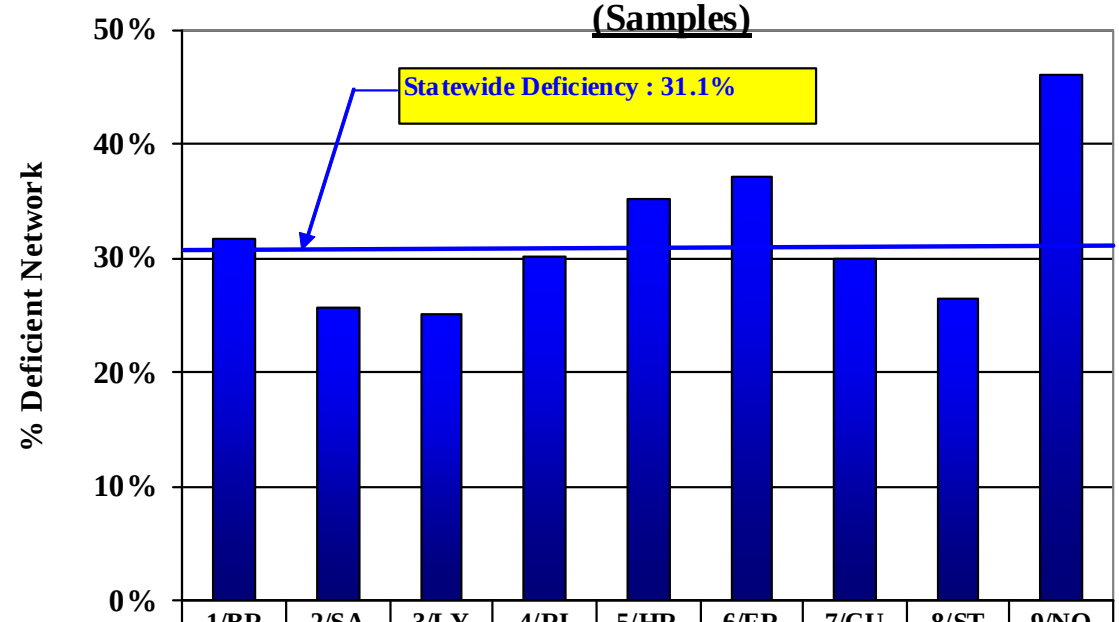
Figure 11 shows the number of lane-miles surveyed in each district as well as the number of lane-miles rated as 'deficient'. Figure 12 represents the percent deficient numbers in terms of lane miles surveyed. Based on these figures, Northern Virginia District has the highest percentage of its Secondary network rated as deficient while Lynchburg District has the lowest.

Figure 11: Surveyed and Deficient Lane Miles by District - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Surveyed	1601	1928	2441	2327	1469	1398	1334	1475	1425
Deficient	506	493	610	699	516	518	400	390	657

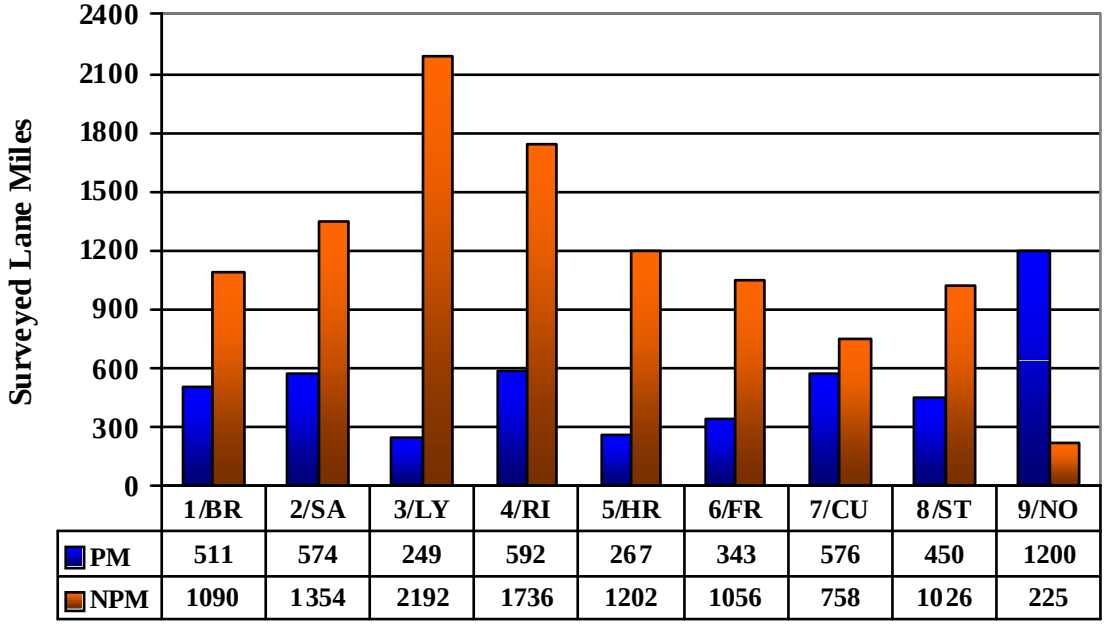
Figure 12: Percent Deficiency by District - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
% Deficient	31.6%	25.6%	25.0%	30.0%	35.2%	37.1%	30.0%	26.5%	46.1%

Within the sampled Secondary network, the rated lane miles of plant mix surfaces and non-plant mix surfaces are shown in Figure 13. On the samples surveyed, only in district 9 are there more plant mix than non-plant mix lane miles. In all other districts, the rated non-plant mix lane miles are greater than the plant mix lane miles.

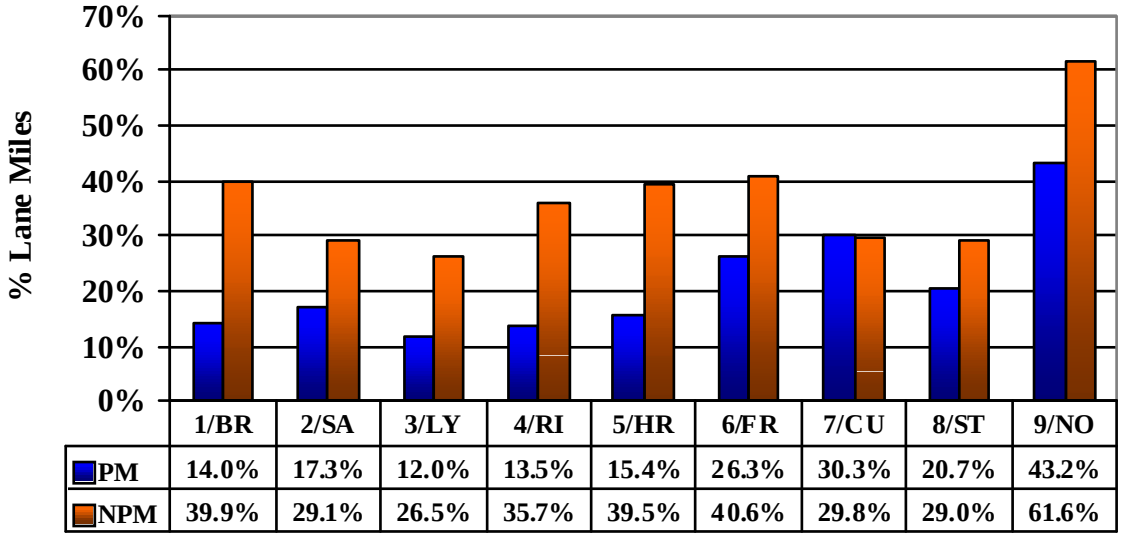
Figure 13: Surveyed Lane Miles - Secondary (Samples) with Plant Mix (PM) & Non-Plant Mix (NPM) Surface



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
PM	511	574	249	592	267	343	576	450	1200
NPM	1090	1354	2192	1736	1202	1056	758	1026	225

The percent deficient of Secondary plant mix and the percent deficient of non-plant mix lane miles are presented in Figure 14. In general, it can be seen the percent deficient of non-plant mix pavements is larger than that of plant mix. Only Culpeper district shows lower non-plant mix percent deficient than plant mix percent deficient.

Figure 14: Percent Deficiency by District and Pavement Type - Secondary (Samples)



PLANT MIX SECONDARY PAVEMENT

Some of the key distress types are shown in table 8 for plant mix surfaced pavements.

Table 8: Major Distresses on PM Surfaced Pavement

Key Distresses	D1 BR	D2 SA	D3 LY	D4 RI	D5 HR	D6 FR	D7 CU	D8 ST	D9 NO
Alligator Cracking (% total area)	2.7%	3.7%	3.1%	3.2%	3.0%	5.4%	5.1%	1.1%	7.9%
Patching (% total area)	1.6%	2.7%	1.0%	1.4%	0.6%	1.8%	1.5%	6.1%	1.4%
Rutting (inches)	0.13	0.15	0.14	0.13	0.12	0.12	0.16	0.21	0.10
Transverse Cracking (ft/lane mile)	425	979	838	663	674	1,025	847	199	2,203
Longitudinal Cracking (ft/lane mile)	415	720	360	576	613	962	752	156	2,135

NON-PLANT MIX SECONDARY PAVEMENT

Some of the key distress types are shown in table 9 for non-plant mix surfaced pavements.

Table 9: Major Distresses on NPM Secondary Pavement

Key Distresses	D1 BR	D2 SA	D3 LY	D4 RI	D5 HR	D6 FR	D7 CU	D8 ST	D9 NO
Alligator Cracking (% total area)	4.4%	3.4%	2.0%	2.3%	2.1%	3.3%	3.4%	1.6%	8.1%
Patching (% total area)	6.0%	4.1%	5.1%	4.9%	1.4%	4.1%	2.5%	5.1%	5.6%
Rutting (inches)	0.21	0.24	0.20	0.25	0.28	0.11	0.22	0.18	0.07
Transverse Cracking (ft/lane mile)	540	520	337	443	442	687	599	190	2,049
Longitudinal Cracking (ft/lane mile)	630	412	263	290	335	404	476	138	1,561

PAVEMENT RIDE QUALITY - 2009

RIDE QUALITY EVALUATION CRITERIA

Pavement roughness is an expression of irregularities in the pavement surface that adversely affect the ride quality of a vehicle and thus the user. The general public perception of a good road is one that provides a smooth ride. Ride quality is expressed in terms of International Roughness Index (IRI) measured in inches/mile.

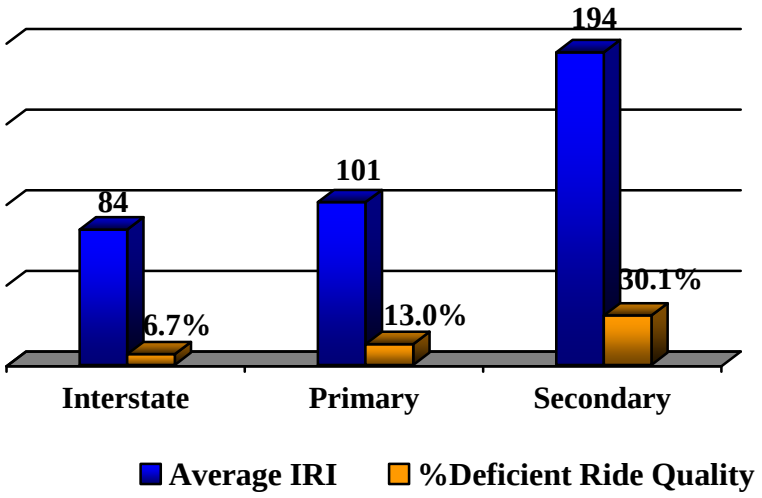
Table 10 contains two IRI scales used for evaluation of the 2009 pavement ride quality survey: one set for Interstate and Primary highways, and the other for Secondary roads. It needs to be pointed out that ranges of IRI values corresponding to qualitative descriptors of ride quality were built upon similar categories promulgated by FHWA [(5)] and incorporated consensuses from VDOT pavement experts regarding what thresholds were considered appropriate to represent acceptable roughness levels on Virginia highways. Pavements with poor and very poor ride quality are said to have deficient ride quality. The distribution of deficient ride quality in different counties is presented in Appendix E.

Table 10 : Pavement Ride Quality Definition

Ride Quality Category	IRI Rating (inch/mile)	
	Interstate & Primary	Secondary
Excellent	< 60	< 95
Good	60 to 99	95 to 169
Fair	100 to 139	170 to 219
Poor	140 to 199	220 to 279
Very Poor	≥ 200	≥ 280

The average IRI values for Interstate, Primary and Secondary system are presented in Figure 15, along with the percentage of pavement network with deficient ride quality, i.e., the ride quality is poor or very poor. On Interstate and Primary pavements the data are collected on the entire network but on the Secondary pavements the data are collected on a sampling basis.

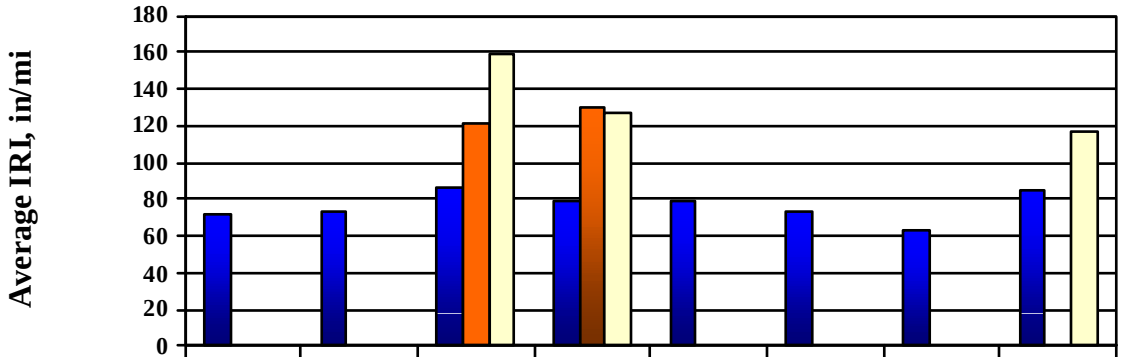
Figure 15: Statewide Ride Quality (Interstate, Primary & Secondary Pavement)



INTERSTATE PAVEMENT RIDE QUALITY

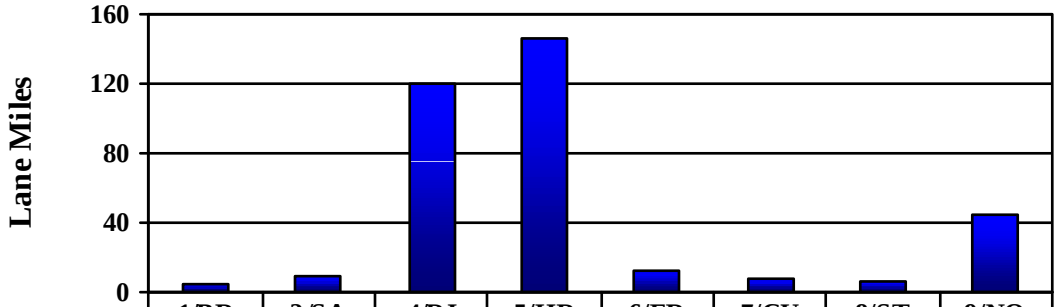
For Interstate pavements, the average IRI values are presented in Figure 16. It can be seen that typically average IRI values are the lowest for AC pavements, higher for CRC pavements, and highest for JRC pavements. Lane miles of deficient ride quality by pavement type are presented in Figure 17.

Figure 16: Average IRI by District and Pavement Type - Interstate



	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
ACP	72	74	86	78	79	73	63	85
CRCP	-	-	121	130	-	-	-	-
JRCP	-	-	159	127	-	-	-	117

Figure 17: No. of Deficient Lane Miles Due to Ride Quality by Pavement Type - Interstate

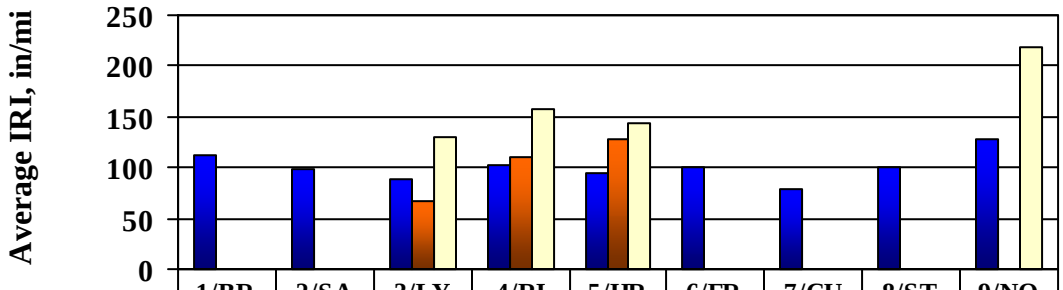


	1/BR	2/SA	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Deficient	4	8	120	145	12	7	5	44
ACP	4	8	38	16	12	7	5	24
CRCP	-	-	74	33	-	-	-	-
JRCP	-	-	8	96	-	-	-	20

PRIMARY PAVEMENTS RIDE QUALITY

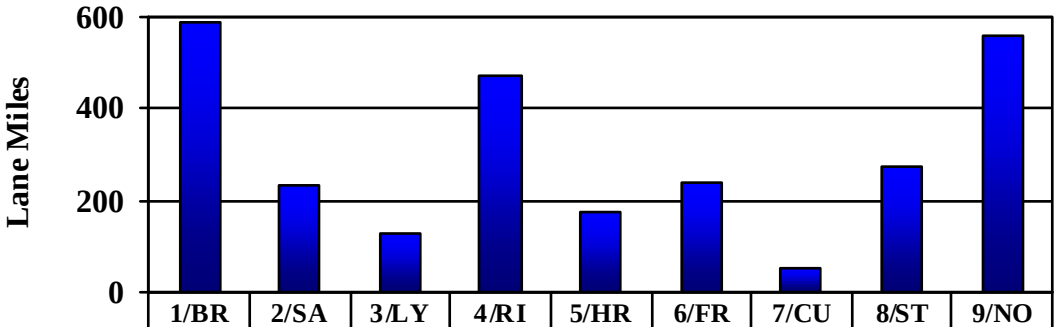
Figure 18 and Figure 19 display the average IRI values and deficient ride quality by pavement type, respectively. Again, typically, the AC pavements have the lowest IRI values, followed by CRC pavements, then JRC pavements.

Figure 18: Average IRI by District and Pavement Type - Primary



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
ACP	111	98	89	103	95	100	80	101	128
CRCP	-	-	66	111	128	-	-	-	-
JRCP	-	-	130	158	143	-	-	-	218

Figure 19: No. of Deficient Lane Miles Due to Ride Quality by Pavement Type - Primary

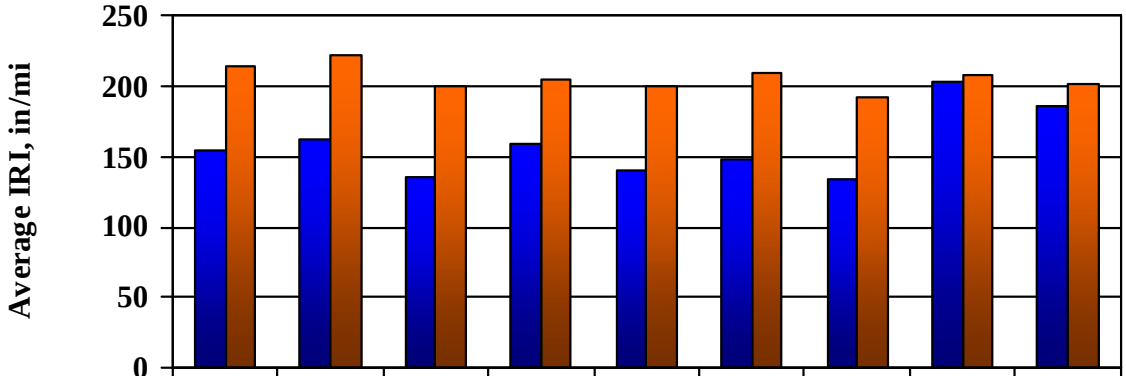


	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Deficient	594	234	129	474	174	238	50	273	562
ACP	594	234	124	408	141	238	50	273	559
CRCP	-	-	0	18	20	-	-	-	-
JRCP	-	-	6	48	14	-	-	-	3

SECONDARY PAVEMENTS RIDE QUALITY

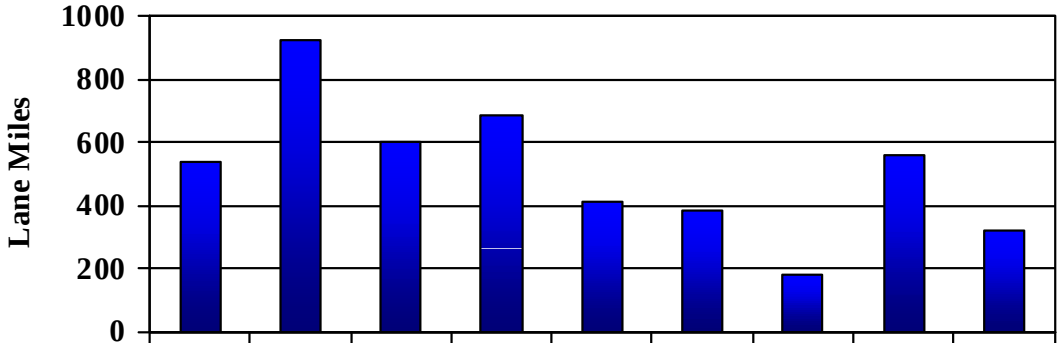
Figure 20 displays the average IRI by pavement type for Secondary pavements. It can be seen that the IRI values are higher for non-plant mix than for plant mix Secondary pavements. Figure 21 displays the deficient ride quality lane miles for plant mix and non-plant mix based on the samples.

Figure 20: Average IRI by District and Pavement Type - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
PM	155	163	135	159	141	148	134	203	186
NPM	215	223	200	205	199	209	192	208	202

Figure 21 : No. of Deficient Lane Miles Due to Ride Quality by Pavement Type - Secondary (Samples)



	1/BR	2/SA	3/LY	4/RI	5/HR	6/FR	7/CU	8/ST	9/NO
Deficient	541	927	604	685	411	386	184	563	324
PM	53	57	19	72	14	19	26	165	252
NPM	488	870	586	613	398	367	158	399	72

USES & LIMITATIONS OF 2009 PAVEMENT CONDITION DATA

This section describes a few of the uses of this data as well as some of the data limitations. In addition, future uses of this data are described here.

CURRENT USE OF THE DATA

Pavement condition data presented in this report are used by VDOT Central Office and District staff to plan, budget, prioritize and schedule pavement maintenance and rehabilitation work. Data are also used for internal and external performance reporting; and are made available to pavement researchers, safety planners and others within and external to VDOT. Major uses of this information are described below.

PAVEMENT NEEDS ANALYSIS

The pavement condition data are an important input into the Pavement Management System (PMS) to develop estimates of pavement maintenance and rehabilitation needs based on an optimization analysis. These needs are subsequently used for the development of the biennial maintenance budget and the work plan generated by the optimization serves as a guide to district personnel for the selection of pavement maintenance strategy for the yearly pavement maintenance schedules. Once a particular section of pavement is selected for maintenance, a detailed project level analysis is conducted to determine the specific treatment.

To develop the Interstate and Primary pavement needs, the pavement condition data are loaded into the Pavement Management System (PMS) which then optimizes the selection of pavement maintenance activities on the Interstate and Primary network. These needs estimates are provided through a process called multi-constraint optimization analysis, which develops an optimal work plan (a series of pavement maintenance activities applied to specific sections on the total network) to achieve a single objective (minimizing cost) against multiple condition-based constraints (performance targets) in a given year of the total six year analysis. The general constraints on these optimization analyses are:

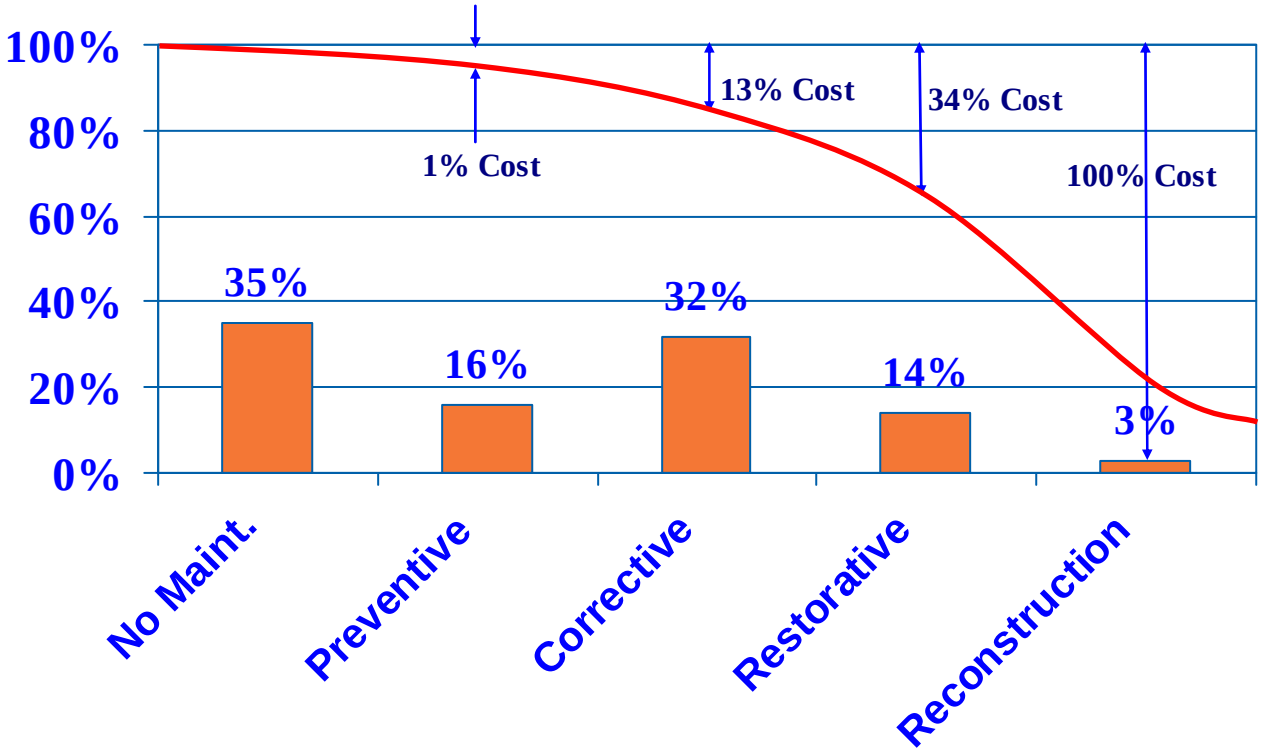
- 18% or less of the network in a deficient condition
- 10% or less of the network in need of Reconstruction (RC)
- Maintaining or improving average CCI over time

The maintenance activities recommended by the optimal work plan are arrived at through decision trees that utilize the pavement type, predicted surface condition, roughness and rutting. The predicted surface condition is based on an actual surface condition collected through VDOT's annual pavement condition survey prior to the analysis, which is "deteriorated" along performance prediction models in each of year of the analysis. For greater detail regarding pavement condition rating, please refer to the document titled "A Guide to Evaluating Pavement Distress Through the Use of Digital Images"[(1)]. For more information on the decision trees and pavement condition prediction models used by the PMS please refer to the documents titled "Development of Decision Trees for Virginia Department of Transportation Pavement Management System"[(17)] and "Development of Performance Prediction Models for Virginia Department of Transportation Pavement Management System"[(18)] respectively (Note: A separate Addendum: "Revisions to Continuously Reinforced Concrete Decision Trees

and Performance Prediction Models" should be referred to for information regarding the CRCP decision trees and prediction models).

The data are also used to feed the maintenance decision trees to determine the unconstrained maintenance needs for the pavement assets in the Maintenance Division's needs-based analysis process. Unconstrained needs analysis establishes the maintenance and rehabilitation needs to appropriately correct the existing pavement conditions where funding would not be considered a constraint. It provides an idea of the amount and type of work needed on the whole network. For the determination of the needed treatment for a particular section the decision trees are used with distress quantity and severity, and condition index as input from the condition survey data[6]. Also, for the selection of the treatment traffic level, structural condition, and maintenance history are provided as additional inputs wherever these are available. Figure 22 shows the percentage of pavements that need various maintenance treatments from unconstrained needs analysis in the form of bar chart. A typical pavement deterioration curve is also presented in the chart with the percentage unit costs of various treatments compared to reconstruction/major rehabilitation. Unconstrained needs are also used in many cases as the first indicator of the needed treatment which is further refined by field inspections, detailed project level analysis, overall needs of the network and available budget.

Figure 22 : Pavement Deterioration and Cost (IS+PR)



PLANNING FOR PREVENTIVE MAINTENANCE AND RESURFACING

The surface distress condition data have been used to identify recommended candidate pavement sections for preventative maintenance activities. These recommendations are based on decision trees developed for the needs analysis, as described above.

The pavement data are used for selection of pavement sections and maintenance strategies for yearly pavement maintenance schedule. Automated data that provide high consistency and efficiency have been used to aid in prioritizing Maintenance Resurfacing by the districts. Typically, the districts have used the data in combination with their local knowledge of pavement conditions to select pavement projects.

Information about specific distresses can be used to determine appropriate maintenance and rehabilitation actions for consideration. For example, a pavement with serious load related distress would typically require a resurface or "mill and fill" treatment, whereas a preventive maintenance treatment would be more appropriate for a pavement with primarily non-load related distresses.

PAVEMENT PERFORMANCE REPORTING

The pavement condition data play a major role in preparation of two legislatively mandated reports. One report is the biennial infrastructure condition report required by Section 33.1-23.02(B) 3. The second report is on the condition of and needs for maintaining and operating the existing transportation infrastructure to meet the performance targets with an estimate of the budget required for the upcoming biennium required by Section 33.1-13.02.

The data are also used for tracking performance measures on the dashboard and reported to the Commonwealth Transportation Board (CTB) yearly. The dashboard uses the condition data to display the percent of pavement in fair or better condition for each district, county and system in the form of a gauge, and also in a bar chart form. The gauge points to the percent of pavement in non-deficient condition, with a tic mark to show the last year's results. All pavements on the Interstate and Primary road systems in Virginia are assessed each year and rated in one of the following categories: Excellent, Good, Fair, Poor, or Very Poor. Segments of pavement classified as Poor and Very Poor are considered deficient, all others are non-deficient. The default view for this measure, until some other data filter is applied, is for Interstate and Primary lane miles combined, statewide. The lower portion of the screen shows a bar chart with each VDOT District represented. The bars show the percentage of pavement in each District that is in Fair or better condition. If a District is selected using data filters then the bar chart shows each county in the District, and that county's percentage of non-deficient pavement. VDOT's goal is to have a minimum of 82% of Interstate and Primary pavement in Excellent, Good, or Fair condition. 82% or better in these conditions is considered 'green' status,

from 70% to 82% is yellow, and less than 70% is red status. This performance target of 82% is also displayed on the gauge.

The percent of pavement with fair or better ride quality is also displayed in a separate gauge. Performance target for deficient ride quality is 85% for Interstate and Primary pavements, i.e., VDOT's goal is to have at least 85% of the pavements with fair or better ride quality. Thus the dashboard presents the information in an easy to understand form with the users being able to obtain information of the current performance and previous year's performance against the performance target. These data are available on the internet, and can be viewed by general public. The gauges and bar chart from the dashboard are shown below.

Figure 23. Gauges from the VDOT Dashboard

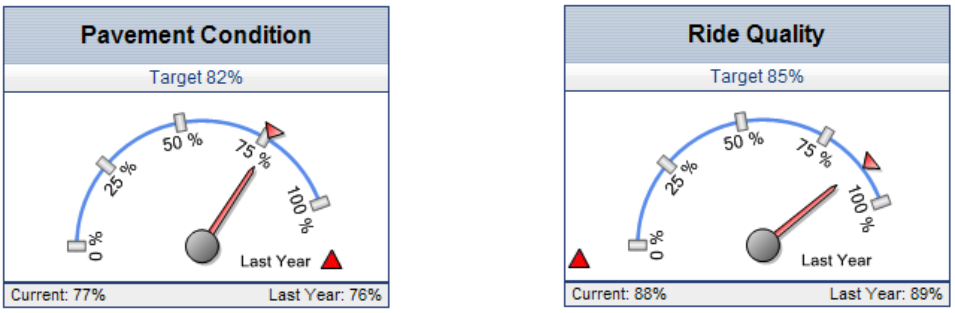
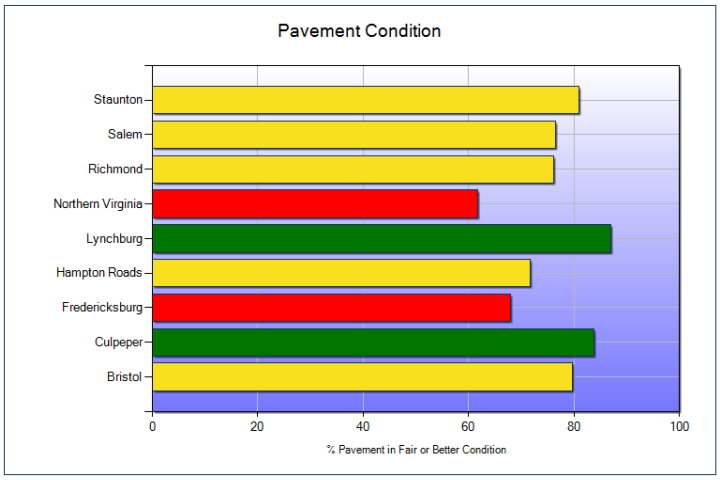


Figure 24. Barchart from the VDOT Dashboard



FEDERAL HPMS REPORTING

Pavement condition data are included in VDOT's Highway Performance Monitoring System (HPMS) data submission to FHWA. This report is the basis for the federal apportionment of Virginia's share of federal funds. VDOT provides the FHWA with the length, roughness and lane-miles on state maintained roads in various functional systems for assessing and reporting highway performance. HPMS data are also used for assessing and reporting highway system performance under FHWA's strategic planning process and are the source for a substantial portion of the information published in Highways Statistics and in other FHWA publications and media. Finally, the HPMS data are widely used throughout the transportation community, including other governmental interest, business and industry, institutions of higher learning, the media and general public. More details can be found in the HPMS Field Manual[(7)].

Current HPMS requirements are that roughness data, quantified to the nearest inch/mile using the international roughness index (IRI), are reported for all pavement on the National Highway System (which includes the Interstate System) and on all Principal Arterials. IRI data are also required for sample sections on Minor Arterials. The pavement condition data are the primary source for the IRI data; however, VDOT Materials Division's Non-Destructive Testing Unit collects the IRI data for sample sections that are not a part of the annual pavement condition surveys.

Starting with the 2010 submission, HPMS data specifications will expand to include requirements to report surface distress quantifications as well as additional pavement structural information for a statistical sample of highway sections. The data collected in the annual pavement condition survey will be used to meet many of the new reporting requirements.

RESEARCH NEEDS

The pavement condition data are used to satisfy various internal and external research needs. Frequently, there are requests for pavement condition data from various divisions within VDOT, and also research units associated with VDOT.

FUTURE USE OF THE DATA

Accumulation of consistent, quality condition data over time allows VDOT to better understand the cost-effectiveness of different pavement treatment strategies. This information enables VDOT to make investment decisions that maximize pavement life and optimize use of scarce resources. Pavement performance models are a key element of VDOTs pavement management system – they are used to predict future pavement conditions and calculate the benefits of alternative treatment strategies. Historical condition data provide the basis for improvements to these performance models which in turn enhance the accuracy, reliability and usefulness of the system's recommendations. Historical data also provide a rich base of information for research into maintenance cost effectiveness, the influence of new construction materials and techniques on pavement performance, and the performance of pavements under different traffic loading and

environmental conditions. Pavement performance research results may also be used for vehicle cost responsibility studies and the establishment of licensing fees related to pavement damage.

LIMITATIONS OF THE DATA

While surface condition data are very helpful in project selection they cannot be the only source of information used to determine what actually should be done to a pavement. Determining the appropriate action for a pavement that is not performing as well as desired may require projected traffic loads, maintenance history of the pavement, the analysis of cores, trenching, and the use of non-destructive testing procedures. In other words, surface distress (especially premature) will indicate that something is wrong but can give no more than a hint as to what is wrong. For example, excessive early fatigue cracking suggests structural inadequacy, but does not indicate where the inadequacy lies (foundation, base, surface, etc.). In this light, caution is advised whenever surface condition alone is used to trigger repair.

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APPENDIX A: DISTRESS DATA AND FORMAT

Table A1. Distress Data and Format for Asphalt Surfaced Pavement

Description	Field Name	Pavement Type	Units	Format	Comments
IRI Left WP	NIRI_L	BIT/BOJ/BOC	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
IRI Right WP	NIRI_R	BIT/BOJ/BOC	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
IRI Average	NIRI_AVG	BIT/BOJ/BOC	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
Transverse Cracking Severity 1	NT_CR1_LF	BIT/BOJ/BOC	Linear Feet	99999	A crack with the sealant in good condition such that the crack width cannot be determined, or A closed, unsealed crack.
Transverse Cracking Severity 2	NT_CR2_LF	BIT/BOJ/BOC	Linear Feet	99999	An open, unsealed crack, or Any crack (sealed or unsealed) with adjacent (within 1 foot) random cracking.
Longitudinal Cracking Severity 1	NL_CR1_LF	BIT/BOJ/BOC	Linear Feet	99999	A crack with the sealant in good condition such that the crack width cannot be estimated, or A closed, unsealed crack.
Longitudinal Cracking Severity 2	NL_CR2_LF	BIT/BOJ/BOC	Linear Feet	99999	An open, unsealed crack, or Any crack (sealed or unsealed) with adjacent random cracking.
Longitudinal Lane Joint Severity 1	NL_JT1_LF	BIT/BOJ/BOC	Linear Feet	99999	A longitudinal paving joint with the sealant in good condition such that the width cannot be estimated, or An open, unsealed joint.
Longitudinal Lane Joint Severity 2	NL_JT2_LF	BIT/BOJ/BOC	Linear Feet	99999	The longitudinal paving joint must be cracked with severe spalling or adjacent random cracking
Reflective Transverse Cracking Severity 1	NRT_CR1_LF	BOJ/BOC	Linear Feet	9999	A crack with the sealant in good condition such that the crack width cannot be determined, or A closed, unsealed crack.
Reflective Transverse Cracking Severity 2	NRT_CR2_LF	BOJ/BOC	Linear Feet	9999	A crack with width more than or equal to ¼ inches but less than ¾ inches; or A crack with width less than ¾ inches and with adjacent (within 1 foot) random cracking; and One level-1 or level-2 crack with an adjacent (within 1 foot) level-1 crack is rated as one crack of level 2.
Reflective Transverse Cracking Severity 3	NRT_CR3_LF	BOJ/BOC	Linear Feet	9999	A crack with width more than or equal to ¾ inches; or A crack with width more than ¼ inches and with deterioration for a width greater than 6 inches; and Two adjacent (within 1 foot) level-2 and/or level-3 cracks are rated as one crack of level 3.
Reflective Longitudinal Cracking Severity 1	NRL_CR1_LF	BOJ/BOC	Linear Feet	99999	A crack with the sealant in good condition such that the crack width cannot be determined, or A closed, unsealed crack.
Reflective Longitudinal Cracking Severity 2	NRL_CR2_LF	BOJ/BOC	Linear Feet	99999	A crack with width more than or equal to ¼ inches but less than ¾ inches; or A crack with width less than ¾ inches and with adjacent (within 1 foot) random cracking; and One level-1 or level-2 crack with an adjacent (within 1 foot) level-1 crack is rated as one crack of level 2.
Reflective Longitudinal Cracking Severity 3	NRL_CR3_LF	BOJ/BOC	Linear Feet	99999	A crack with width more than or equal to ¾ inches; or A crack with width more than ¼ inches and with deterioration for a width greater than 6 inches; and Two adjacent (within 1 foot) level-2 and/or level-3 cracks are rated as one crack of level 3.
Alligator Cracking Severity 1	NA_CR1_SF	BIT/BOJ/BOC	Square Feet	99999	A single sealed or unsealed longitudinal crack in the wheel path, or An area of cracks with no or few interconnecting cracks with no spalling.
Alligator Cracking Severity 2	NA_CR2_SF	BIT/BOJ/BOC	Square Feet	99999	An area of interconnecting cracks forming the characteristic alligator pattern; may have slight spalling.
Alligator Cracking Severity 3	NA_CR3_SF	BIT/BOJ/BOC	Square Feet	99999	An area of moderately or severely spalled cracks forming the characteristic alligator pattern.
Patching Area - wheel path	NPA_WP_SF	BIT/BOJ/BOC	Square Feet	999999	Area - wheel path only - Max length of patch is 1320ft
Patching Area - Non wheel path	NPA_NWP_SF	BIT/BOJ/BOC	Square Feet	999999	Area - non wheel path only - Max length of patch is 1320ft
Potholes Count	NPOT_NO	BIT/BOJ/BOC	Count	999	
Delaminations Area	NDELAM_SF	BIT/BOJ/BOC	Square Feet	9999	
Bleeding Severity 1	NBLEED1_SF	BIT/BOJ/BOC	Square Feet	9999	Pavement surface that is discolored relative to the remainder of the surface due to excessive liquid asphalt.
Bleeding Severity 2	NBLEED2_SF	BIT/BOJ/BOC	Square Feet	9999	Excessive liquid asphalt gives the pavement surface a shiny appearance; tire marks may be evident in warm weather.
Average Deeper Rut (Straight-edge)	NRUT_S_AVG	BIT/BOJ/BOC	Inch	9.99	Reject greater than 3 inches
Notes:					
** Roughness Summary Values do not include low speed or bridge, construction and lane deviation values					
***Distress Summary Values do not include Construction, Lane Deviations or Bridge values.					

Table A2. Distress Data and Format for CRC Pavement

Description	Field Name	Pavement Type	Units	Format	Comments
IRI Left WP	NIRI_L	CRCP	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
IRI Right WP	NIRI_R	CRCP	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
IRI Average	NIRI_AVG	CRCP	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
Transverse Cracking Severity 1	NT_CR1	CRCP	Linear Feet	99999	A closed transverse crack with no spalling
Transverse Cracking Severity 2	NT_CR2	CRCP	Linear Feet	99999	An open transverse crack with no spalling
Transverse Cracking Severity 3	NT_CR3	CRCP	Linear Feet	99999	Any transverse crack with spalling
Transverse Cracking Total Number	NT_CR_NO	CRCP	Count	999	
Transverse Crack Average Spacing	NT_CR_AVG	CRCP	Linear Feet	999.9	(Tenth mile - length of Cluster cracking) / Number of Trans cracks
Longitudinal Cracking Severity 1	NL_CR1	CRCP	Linear Feet	9999	A longitudinal crack with no spalling
Longitudinal Cracking Severity 2	NL_CR2	CRCP	Linear Feet	9999	A longitudinal crack with less than or equal to ¼ of the crack length containing spalling
Longitudinal Cracking Severity 3	NL_CR3	CRCP	Linear Feet	9999	A longitudinal crack with greater than ¼ of the crack length containing spalling
Clustered Cracking Severity 1	NCL_CR1_NO	CRCP	Count	9999	Clusters of three or more transverse cracks having an average spacing greater than 1 foot and less than or equal to 2 feet
Clustered Cracking Severity 2	NCL_CR2_NO	CRCP	Count	9999	Clustered cracks with an average spacing of less than or equal to 1 foot
Clustered Cracking Severity 1	NCL_CR1_SF	CRCP	Square Feet	9999	Clusters of three or more transverse cracks having an average spacing greater than 1 foot and less than or equal to 2 feet
Clustered Cracking Severity 2	NCL_CR2_SF	CRCP	Square Feet	9999	Clustered cracks with an average spacing of less than or equal to 1 foot
Longitudinal Joint Spalling	NCL_J_SP_LF	CRCP	Linear Feet	9999	
Longitudinal Joint Fully (90%) Sealed	CCL_J_SEAL	CRCP	Yes/No	x	
Punchouts and Spalled Ycracks	NPUNCH_NO	CRCP	Count	99	Add number of "NPUNCH_SF" for count
Punchouts and Spalled Ycracks	NPUNCH_SF	CRCP	Square Feet	9999	
PCC Patch Severity 1	NC_PAT1_SF	CRCP	Square Feet	9999	The patch has no distress either in the patch or around its perimeter
PCC Patch Severity 2	NC_PAT2_SF	CRCP	Square Feet	9999	The patch has any type of severity level 1 CRCP distress either in the patch or around its perimeter
PCC Patch Severity 3	NC_PAT3_SF	CRCP	Square Feet	9999	The patch has any type of severity level 2 CRCP distress either in the patch or around its perimeter
Asphalt Patching	NA_PAT_SF	CRCP	Square Feet	9999	
Notes:					
** Roughness Summary Values do not include low speed or bridge, construction and lane deviation values					
***Distress Summary Values do not include Construction, Lane Deviations or Bridge values.					

Table A3. Distress Data and Format for JRC Pavement

Description	Field Name	Pavement Type	Units	Format	Comments
IRI Left WP	NIRI_L	JRCP	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
IRI Right WP	NIRI_R	JRCP	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
IRI Average	NIRI_AVG	JRCP	inches/mile	999	Save profile data - RoadRuf, Maximum IRI is 500 inches per mile
Transverse Cracking Severity 1	NT_CR1_NS	JRCP	# of Slabs	9999	A crack that is well sealed so the width cannot be determined, or A closed crack that has no spalling.
Transverse Cracking Severity 2	NT_CR2_NS	JRCP	# of Slabs	9999	An open crack, or Any spalled crack.
Longitudinal Cracking Severity 1	NL_CR1_NS	JRCP	# of Slabs	9999	A crack that is well sealed so the width cannot be determined, or A closed crack that has no spalling.
Longitudinal Cracking Severity 2	NL_CR2_NS	JRCP	# of Slabs	9999	An open crack, or Any spalled crack.
PCC Patch Severity 1	NC_PAT1_NS	JRCP	# of Slabs	9999	The patch has no distress either in the patch or around its perimeter.
PCC Patch Severity 2	NC_PAT2_NS	JRCP	# of Slabs	9999	The patch has severity level 1, longitudinal cracking, transverse cracking (or any other severity level 1 distress) either in the patch or around its perimeter.
PCC Patch Severity 3	NC_PAT3_NS	JRCP	# of Slabs	9999	The patch has spalling, severity 2 longitudinal cracking or transverse cracking (or any other severity level 2 distress) either in the patch or around its perimeter.
Asphalt Patch	NA_PAT_NS	JRCP	# of Slabs	9999	
Number of Transverse Joints	NNO_T_JTS	JRCP	Count	999	
Average Slab Length	NSLAB_AVG	JRCP	Feet	999	(# of Joints -1) / Output summary length = Average Slab Length
Transverse Joint Spalled	NT_J_SP_NS	JRCP	# of Slabs	9999	
Transverse Joint Fully Sealed	NT_J_FS_NS	JRCP	# of Joints	9999	
Longitudinal Joint Spalled	NL_J_SP_NS	JRCP	# of Slabs	9999	
Longitudinal Joint Fully Sealed	NL_J_FS_NS	JRCP	# of Slabs	9999	
Corner Breaks Severity 1	NC_BRK1_NS	JRCP	# of Slabs	9999	The crack is spalled for no more than 1/4th of its length and the corner break is in one piece.
Corner Breaks Severity 2	NC_BRK2_NS	JRCP	# of Slabs	9999	The crack is spalled for more than 1/4th of its length, or The corner break is in two or more pieces.
Divided Slabs	NDIV_NS	JRCP	# of Slabs	9999	
Blowups	NBLOW_NS	JRCP	# of Slabs	9999	
Joint Fault Severity 1	NJFL_T1_PER	JRCP	Percent	999.9	0 - .49
Joint Fault Severity 2	NJFL_T2_PER	JRCP	Percent	999.9	.49 - 1.0
Joint Fault Severity 3	NJFL_T3_PER	JRCP	Percent	999.9	>1
Average Joint Fault in Left Wheel Path	NJFLT_LT_AVG	JRCP	Inch	9.99	
Average Joint Fault in Right Wheel Path	NJFLT_RT_AVG	JRCP	Inch	9.99	
Joint Fault None (<0.8")	NJFLTO_PER	JRCP	Percent	999.9	No faulting
Notes:					
** Roughness Summary Values do not include low speed or bridge, construction and lane deviation values					
***Distress Summary Values do not include Construction, Lane Deviations or Bridge values.					

Table A4. Distress Data in ACPINPUT Table for Asphalt Concrete Pavement

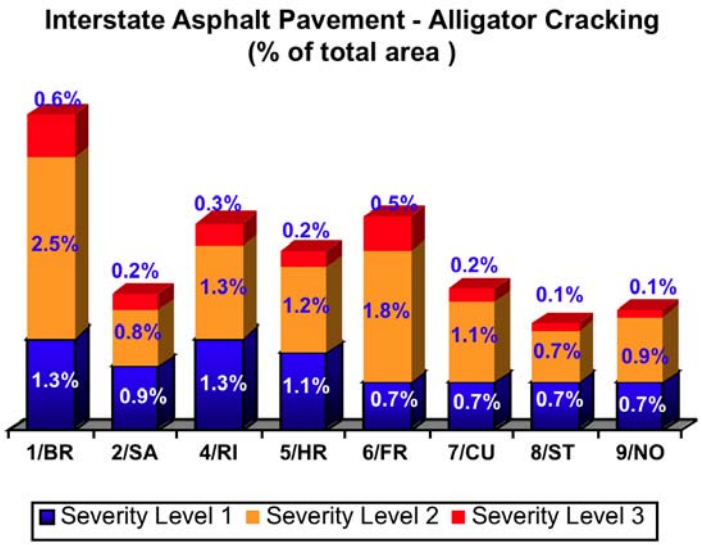
Description	Field Name	Format	Comments	Calculations
Frequency of Alligator/Fatigue cracking. This is a numeric field with values of 0, 1, 2 or 3.	la_cr_freq	9	0 is none, 1 is rare, 2 is occassional and 3 is frequent:	rare = (wheel path + non wheel path alligator cracking area in SF) / (7*length), if this quantity is > 0 to 10% : Ocassional is >10% and <=50%; : frequent is >50%. Here length is (end_mp - begin_mp). The codes are 0, 1, 2 and 3.
Severity of Alligator/Fatigue cracking. This is a numeric field with values of 0, 1, or 2.	la_cr_severity	9	0 is not severe (severity 1), 1 is severe (severity 2) and 2 is very severe (severity 3).	severity of the most prevalent type; i.e. if 10% of the cracks are not severe (severity 1), 15% severe (severity 2) and 2% very severe (severity 3) then severity for the entire section is "severe".
Total number of transverse cracks in the sections. This is a numeric field with the format 99999.	tr_cr_freq	9999999	Actual Count of Cracks in Section	Total (of all severities)Linear feet /12. This includes transverse cracks, and reflective transverse cracks.
Severity of majority of the transverse cracks in the sections. This is a numeric field with values of 0, 1, or 2.	tr_cr_severity	9	If the Pavement Type is 'BIT', transverse cracks will have two severity levels; 0 for Not Severe (severity 1) and 1 for Severe (severity 2). If the pavement type is BOJ or BOC then it will have three severity levels; 0 for Not Severe (severity 1) and 1 for Severe (severity 2) and 2 for very severe (severity 3).	severity of the most prevalent type; i.e. if 1000 LF of the cracks are not severe (severity 1), 1200 LF of cracks severe (severity 2) then severity for the entire section is "severe" (severity 2).
Frequency of Rutting in the section. This is a numeric field with values of 0, 1, or 2.	rutting_freq	9	0 is None, 1 is 'Rare' and 2 is 'Widespread'	None: If all the values from the 0.1 mile table are <0.1" rutting value for the homogeneous section. Rare: if <=10% of the readings in the sections affected, i.e., from 0.1 mile tables if <=10% of the readings(records) have a rutting value of >=0.1 and <0.5". Widespread: more than 10% of the readings affected, i.e., from 0.1 mile tables if >10% of the readings(records) have a rutting value of >=0.1 and <0.5". In case there are >0.5" rutting values, it is rare if <=10% are >0.5"; and widespread if >10% are >0.5".
Severity of rutting in the section. This is a numeric field with values of 0 or 1.	rutting_severity	9	0 is for less than half inch average for section, and 1 is for more than half inch average for section	if the average reading fo the section is >= 0.1" to 0.5" then 0; if the average for the section is >0.5" then 1
Frequency of Patching in the section. This is a numeric field with values of 0 or 1.	patches_freq	9	0 is none or no patches in the section, 1 is for yes or there are patches in the section	This includes patches in both wheel path and non-wheel path.
Severity of Patching in the section. This is a numeric field with values of 0 or 1.	patches_severity	9	0 is for less than 10% of the pavement area is patched, 1 is for more than 10% of the pavement area is patched. This includes patches in both wheel paths and non wheel paths.	The area of pavement is determined by length * 12. Here a width of 12' is considered irrespective of the widths determined by other means. Here length is (end_mp - begin_mp).
Acceptable' or 'Unacceptable' based on the quality of the ride	ride_quality	9	0 is acceptable; 1 is unacceptable where IRI>140 in/mi.	if the average of left and right IRI for the whole section is >200 then -1, otherwise 0

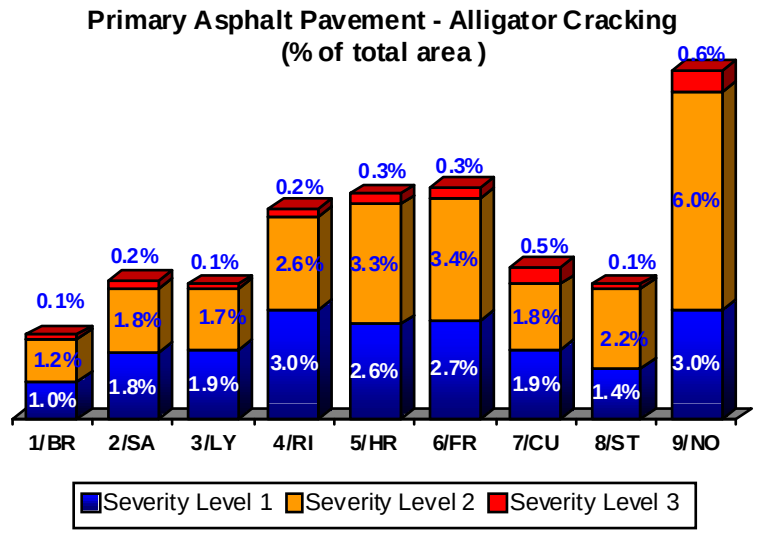
Notes:

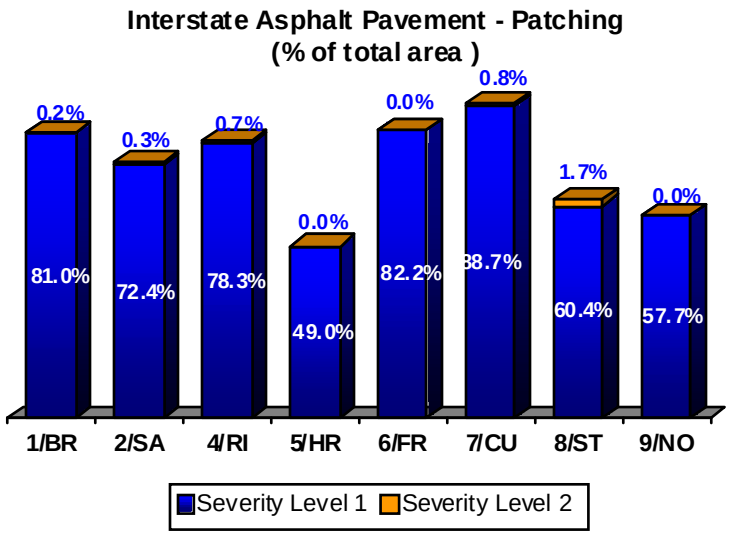
** Roughness Summary Values do not include low speed or bridge, construction and lane deviation values

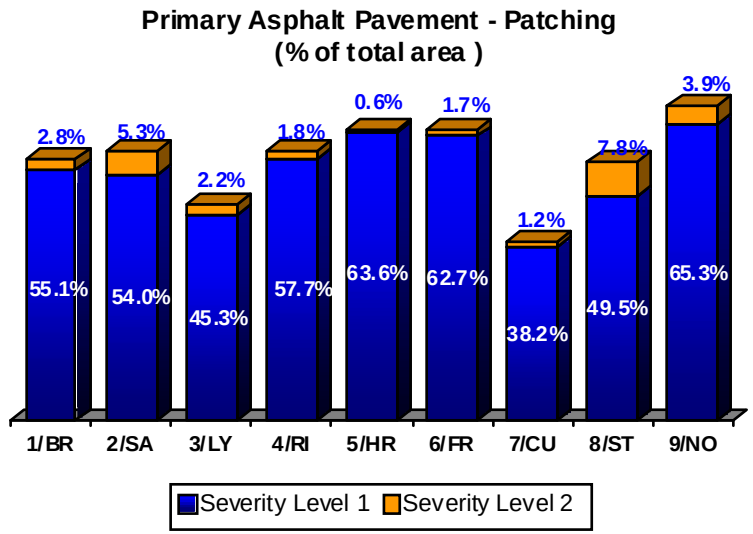
***Distress Summary Values do not include Construction, Lane Deviations or Bridge values.

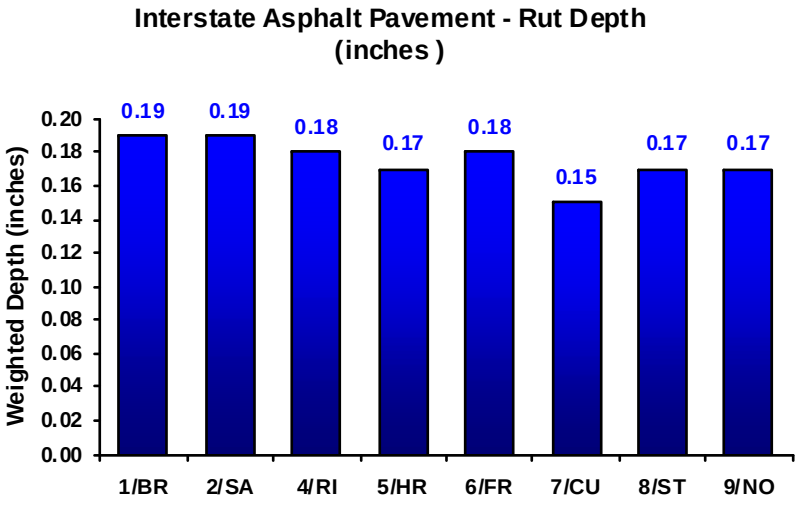
APPENDIX B: DISTRIBUTION OF KEY DISTRESSES BY DISTRICTS AND SYSTEMS

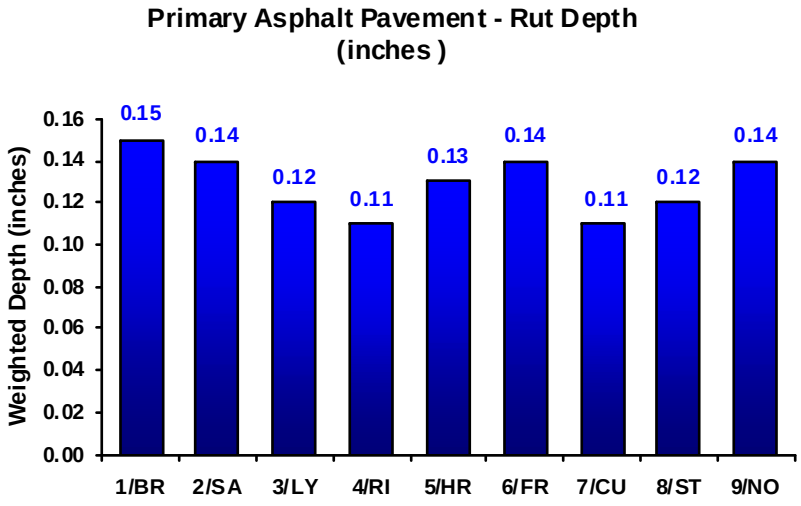

Interstate Asphalt Pavement - Alligator Cracking
(% of total area)
0.6%
2.5%
1.3%
0.2%
0.8%
0.9%
0.3%
1.3%
1.3%
0.2%
1.2%
1.1%
0.5%
1.8%
0.7%
0.2%
1.1%
0.7%
0.1%
0.7%
0.7%
0.1%
0.9%
0.7%
1/BR
2/SA
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO
Severity Level 1
Severity Level 2
Severity Level 3

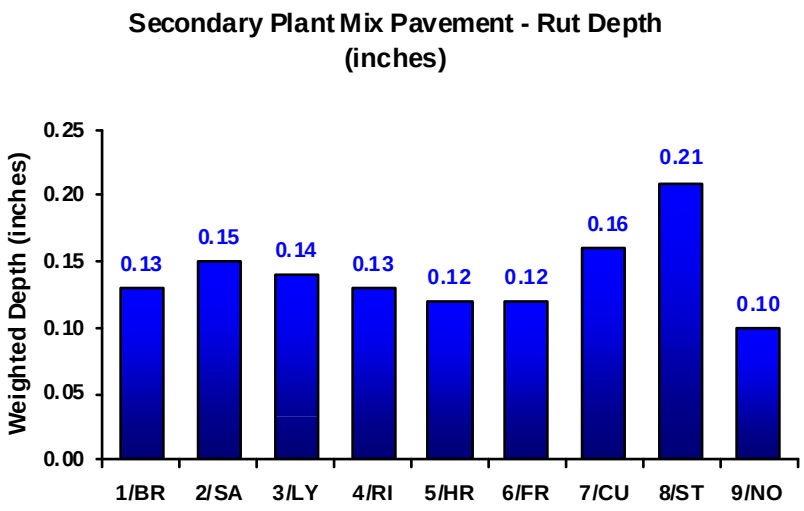

Primary Asphalt Pavement - Alligator Cracking
(% of total area)
0.1%
1.2%
1.0%
0.2%
1.8%
1.8%
0.1%
1.7%
1.9%
0.2%
2.6%
3.0%
0.3%
3.3%
2.6%
0.3%
3.4%
2.7%
0.5%
1.8%
1.9%
0.1%
2.2%
1.4%
0.6%
6.0%
3.0%
1/BR
2/SA
3/LY
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO
Severity Level 1
Severity Level 2
Severity Level 3

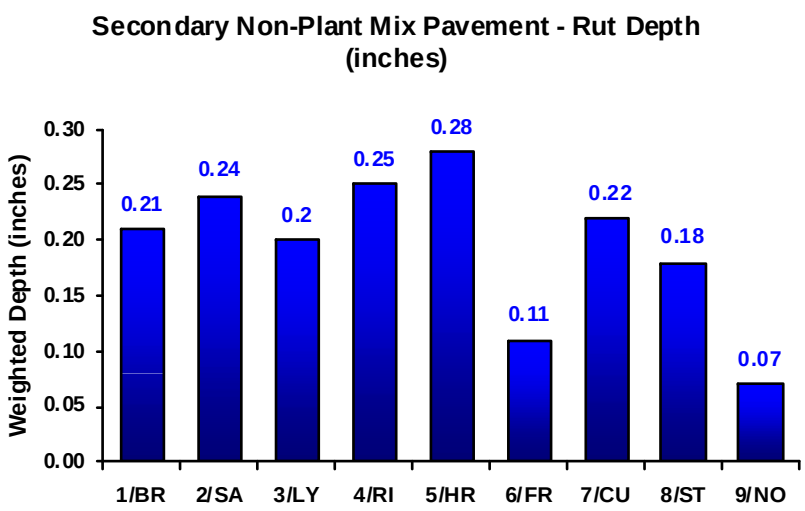

Interstate Asphalt Pavement - Patching
(% of total area)
0.2%
81.0%
0.3%
72.4%
0.7%
78.3%
0.0%
49.0%
0.0%
82.2%
0.8%
88.7%
1.7%
60.4%
0.0%
57.7%
1/BR
2/SA
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO
Severity Level 1
Severity Level 2

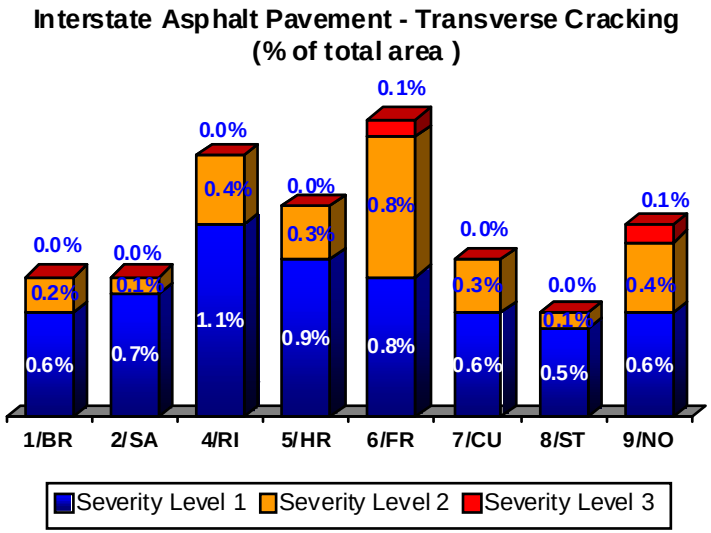

Primary Asphalt Pavement - Patching
(% of total area)
2.8%
55.1%
5.3%
54.0%
2.2%
45.3%
1.8%
57.7%
0.6%
63.6%
1.7%
62.7%
1.2%
38.2%
7.8%
49.5%
3.9%
65.3%
1/BR
2/SA
3/LY
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO
Severity Level 1
Severity Level 2

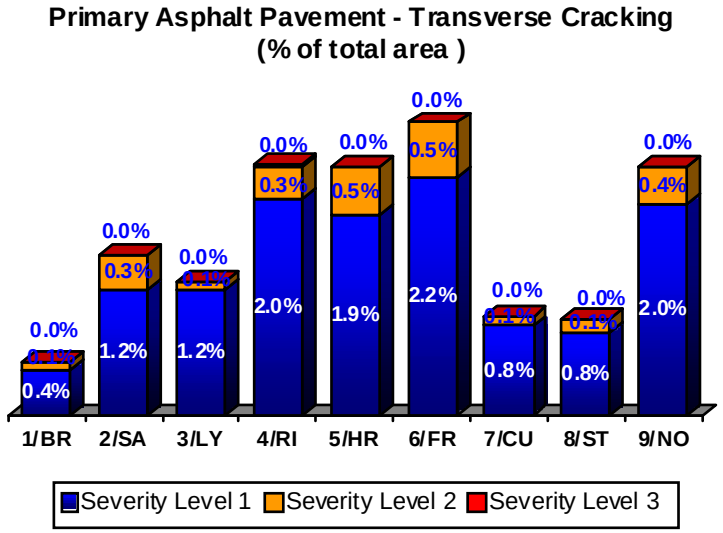

Interstate Asphalt Pavement - Rut Depth (inches)
Weighted Depth (inches)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.19
0.19
0.18
0.17
0.18
0.15
0.17
0.17
1/BR
2/SA
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO

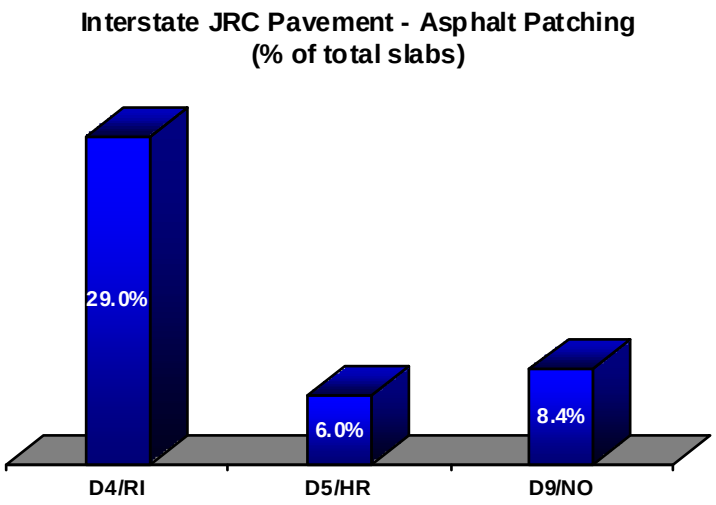

Primary Asphalt Pavement - Rut Depth (inches)
Weighted Depth (inches)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.15
0.14
0.12
0.11
0.13
0.14
0.11
0.12
0.14
1/BR
2/SA
3/LY
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO

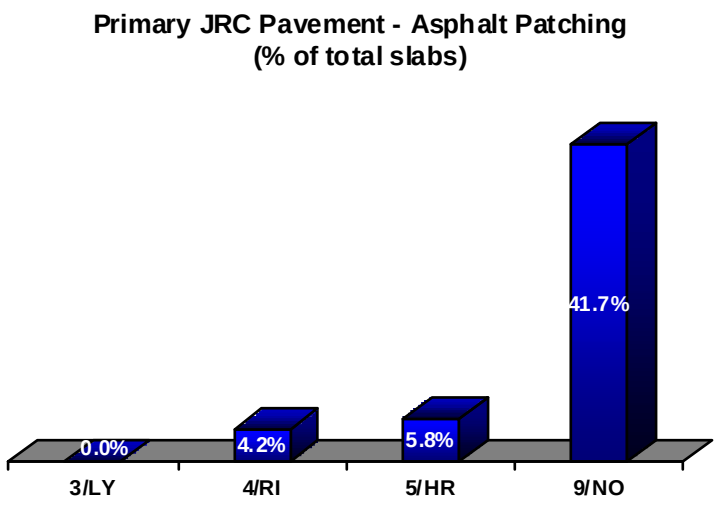

Secondary Plant Mix Pavement - Rut Depth (inches)
Weighted Depth (inches)
0.00
0.05
0.10
0.15
0.20
0.25
0.13
0.15
0.14
0.13
0.12
0.12
0.16
0.21
0.10
1/BR
2/SA
3/LY
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO


Secondary Non-Plant Mix Pavement - Rut Depth (inches)
Weighted Depth (inches)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.21
0.24
0.2
0.25
0.28
0.11
0.22
0.18
0.07
1/BR
2/SA
3/LY
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO

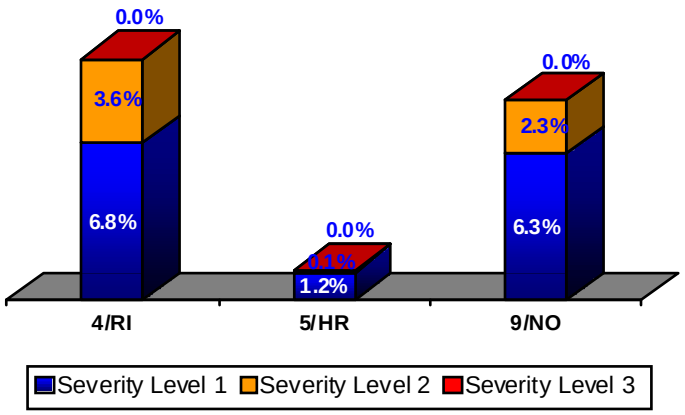

Interstate Asphalt Pavement - Transverse Cracking
(% of total area)
0.0%
0.2%
0.6%
0.0%
0.1%
0.7%
0.0%
0.4%
1.1%
0.0%
0.3%
0.9%
0.1%
0.8%
0.8%
0.0%
0.3%
0.6%
0.0%
0.5%
0.1%
0.4%
0.6%
1/BR
2/SA
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO
Severity Level 1
Severity Level 2
Severity Level 3


Primary Asphalt Pavement - Transverse Cracking
(% of total area)
0.0%
0.4%
0.0%
0.3%
1.2%
0.0%
1.2%
0.0%
0.3%
2.0%
0.0%
0.5%
1.9%
0.0%
0.5%
2.2%
0.0%
0.8%
0.0%
0.8%
0.0%
0.4%
2.0%
1/BR
2/SA
3/LY
4/RI
5/HR
6/FR
7/CU
8/ST
9/NO
Severity Level 1
Severity Level 2
Severity Level 3

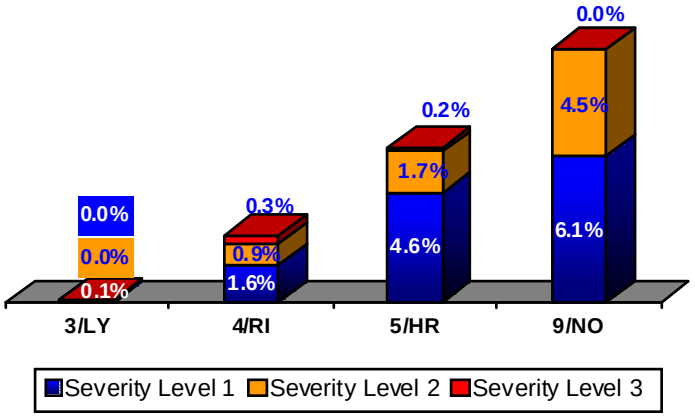

Interstate JRC Pavement - Asphalt Patching
(% of total slabs)
29.0%
6.0%
8.4%
D4/RI
D5/HR
D9/NO


Primary JRC Pavement - Asphalt Patching
(% of total slabs)
0.0%
4.2%
5.8%
41.7%
3/LY
4/RI
5/HR
9/NO

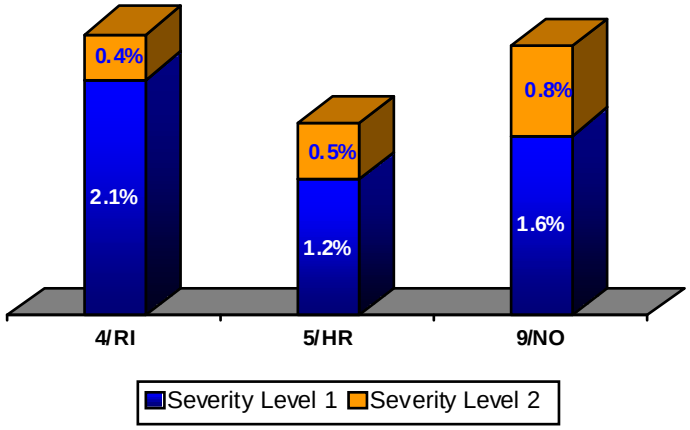
Interstate JRC Pavement - PCC Patching
(% of total slabs)



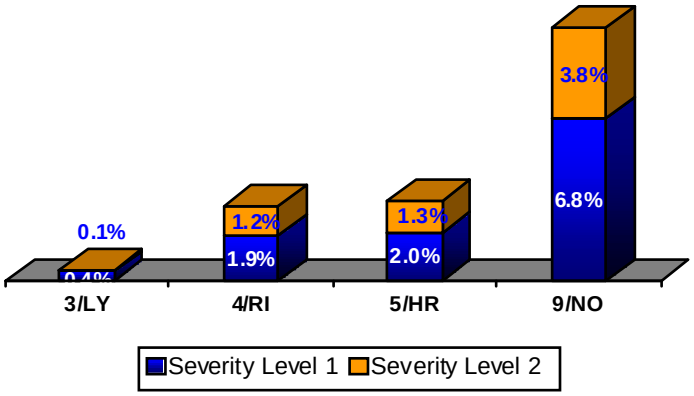
Primary JRC Pavement -PCC Patching
(% of total slabs)



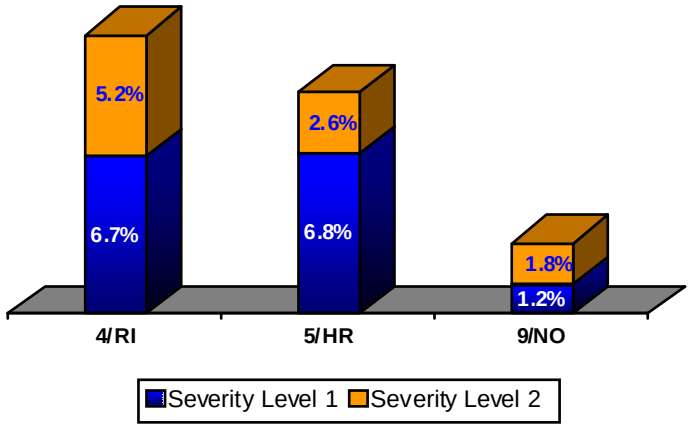
Interstate JRC Pavement - Corner Breaks
(% of total slabs)



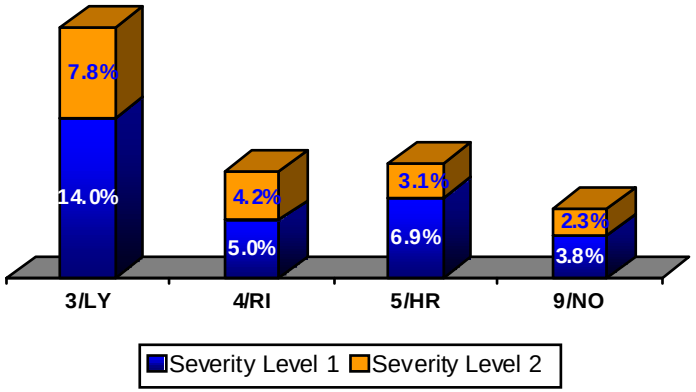
Primary JRC Pavement - Corner Breaks
(% of total slabs)



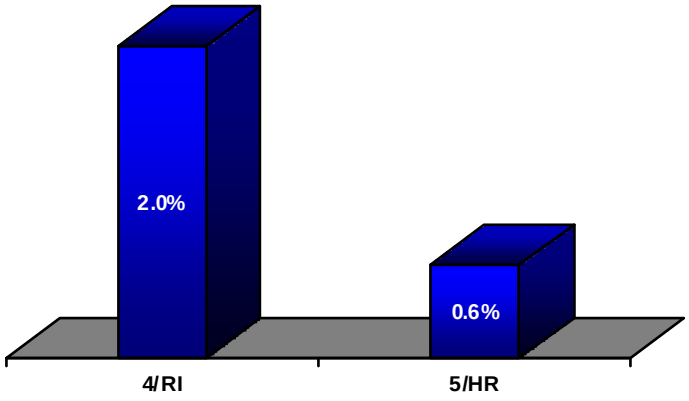
Interstate JRC Pavement - Transverse Cracking
(% of total slabs)



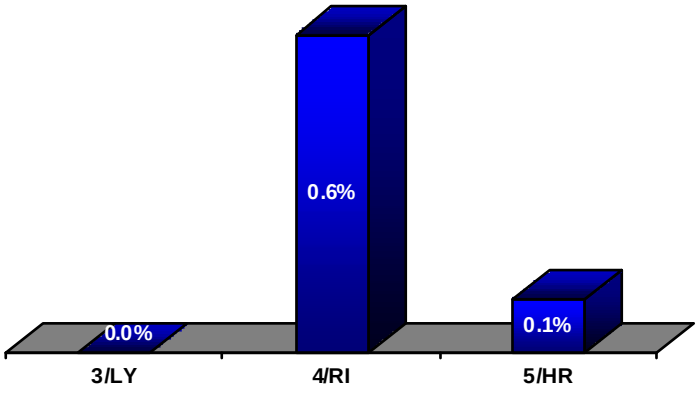
Primary JRC Pavement - Transverse Cracking
(% of total slabs)



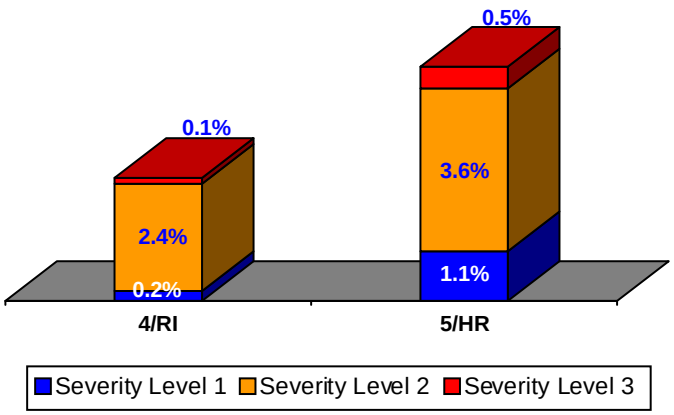
Interstate CRC Pavement - Asphalt Patching
(% of total area)



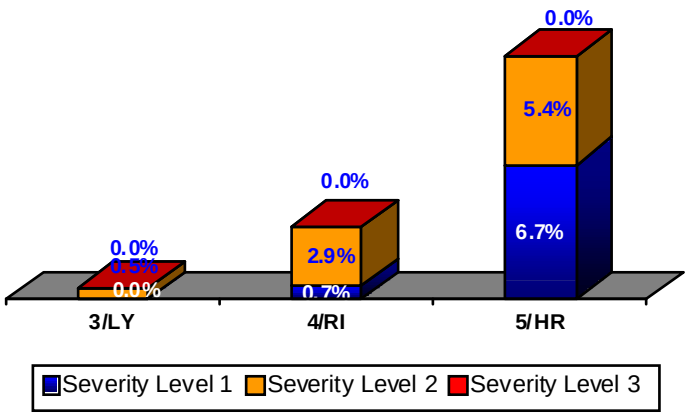
Primary CRC Pavement - Asphalt Patching
(% of total area)



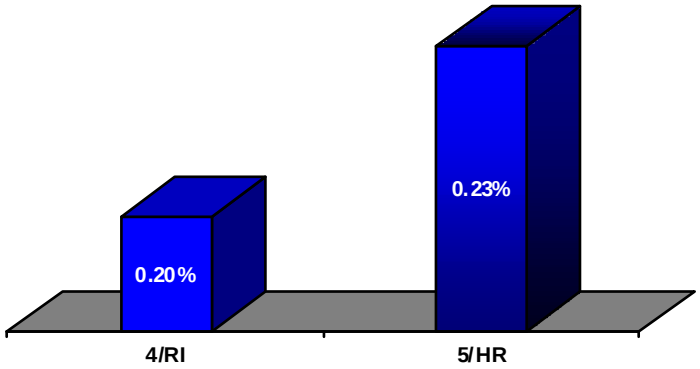
Interstate CRC Pavement - PCC Patching
(% of total area)



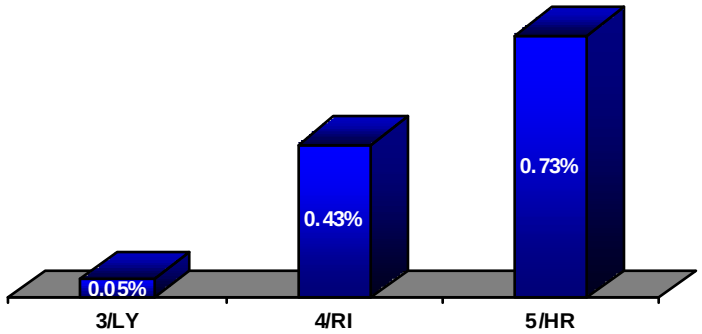
Primary CRC Pavement - PCC Patching
(% of total area)



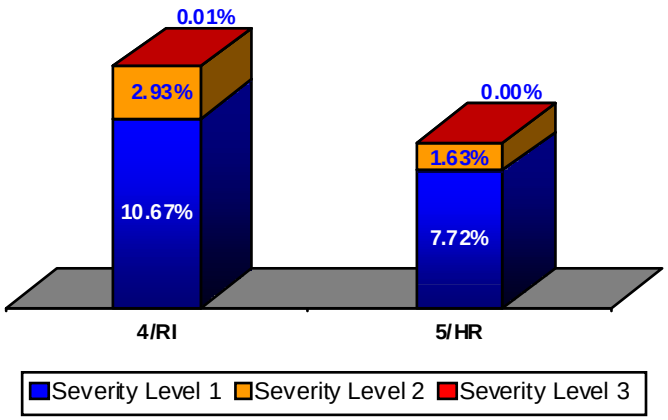
Interstate CRC Pavement - Punchout
(% of total area)



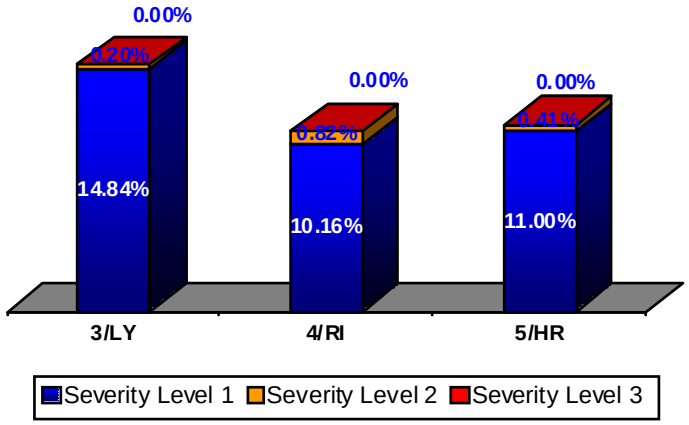
Primary CRC Pavement - Punchout
(% of total area)



Interstate CRC Pavement-Transverse Cracking
(% of total area)



Primary CRC Pavement - Transverse Cracking
(% of total area)



APPENDIX C: PAVEMENT CONDITION BY DISTRICT AND COUNTY FOR INTERSTATE AND PRIMARY SYSTEMS - 2009

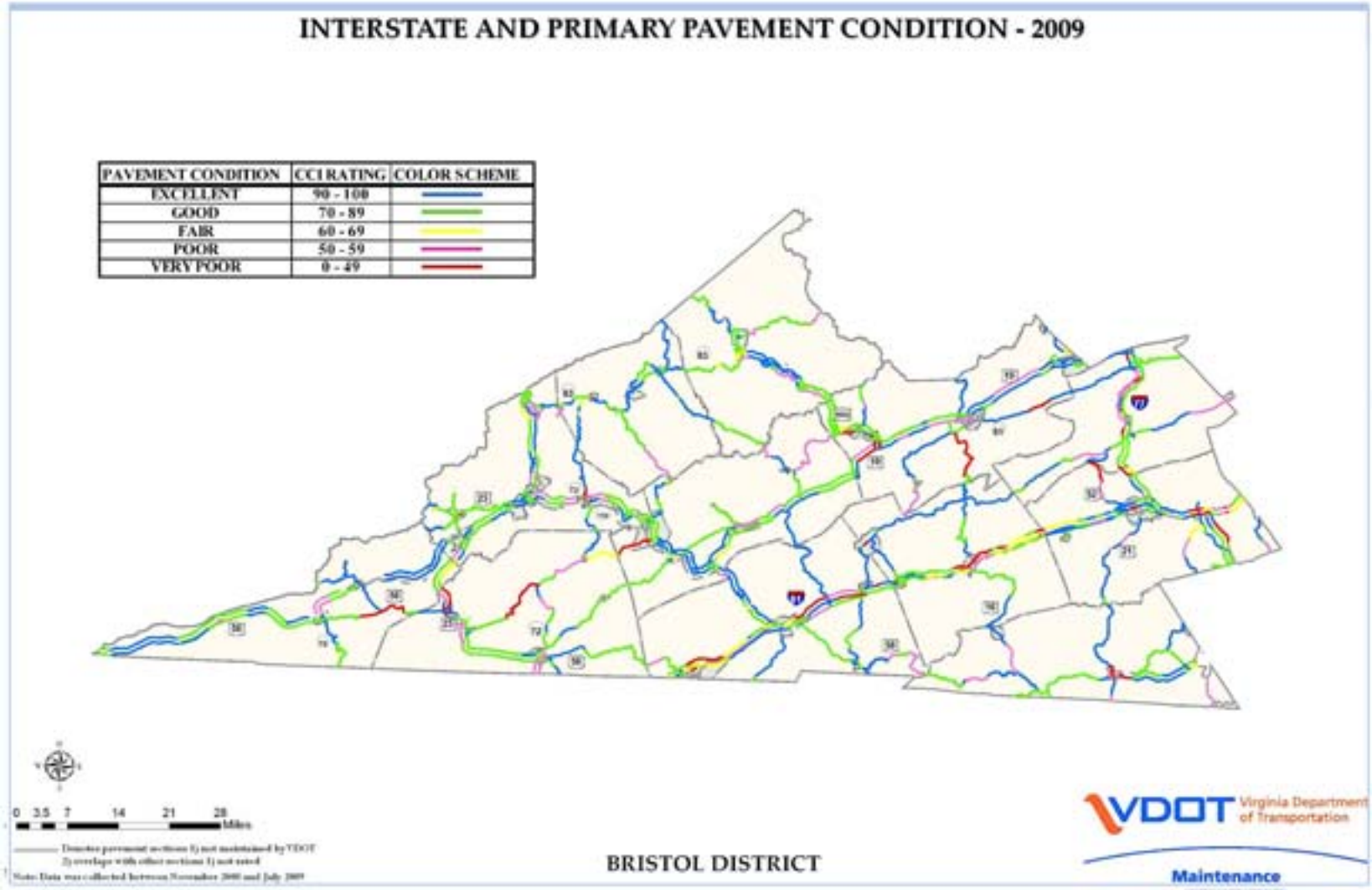
District	County No.	County Name	Lane Miles Rated	Deficient Lane Miles	% Deficient
1	10	Bland	242.42	68.80	28.38%
	13	Buchanan	187.86	29.08	15.48%
	25	Dickenson	163.16	18.70	11.46%
	38	Grayson	234.60	50.78	21.65%
	52	Lee	320.73	37.06	11.55%
	83	Russell	291.99	53.30	18.25%
	84	Scott	284.61	72.20	25.37%
	86	Smythe	273.93	45.70	16.68%
	92	Tazewell	356.08	95.74	26.89%
	95	Washington	416.84	97.08	23.29%
	97	Wise	340.91	54.76	16.06%
	98	Wythe	336.67	80.69	23.97%
District 1 Total			3449.8	703.89	20.40%
2	9	Bedford	379.78	107.38	28.27%
	11	Botetourt	361.22	153.82	42.58%
	17	Carroll	291.12	54.97	18.88%
	22	Craig	119.32	16.68	13.98%
	31	Floyd	109.60	35.18	32.10%
	33	Franklin	243.60	71.16	29.21%
	35	Giles	230.56	56.90	24.68%
	44	Henry	348.77	70.04	20.08%
	60	Montgomery	280.06	69.08	24.67%
	70	Patrick	230.07	13.78	5.99%
	77	Pulaski	182.21	25.90	14.21%
	80	Roanoke	318.21	50.69	15.93%
District 2 Total			3094.52	725.58	23.45%
3	5	Amherst	284.63	13.26	4.66%
	6	Appomattox	139.83	4.80	3.43%
	14	Buckingham	199.06	15.78	7.93%
	15	Campbell	312.69	15.53	4.97%
	19	Charlotte	259.68	30.70	11.82%
	24	Cumberland	106.08	56.34	53.11%
	41	Halifax	435.50	48.76	11.20%
	62	Nelson	257.52	14.44	5.61%
	71	Pittsylvania	537.04	145.81	27.15%
	73	Prince Edward	221.73	14.04	6.33%
District 3 Total			2753.76	359.46	13.05%

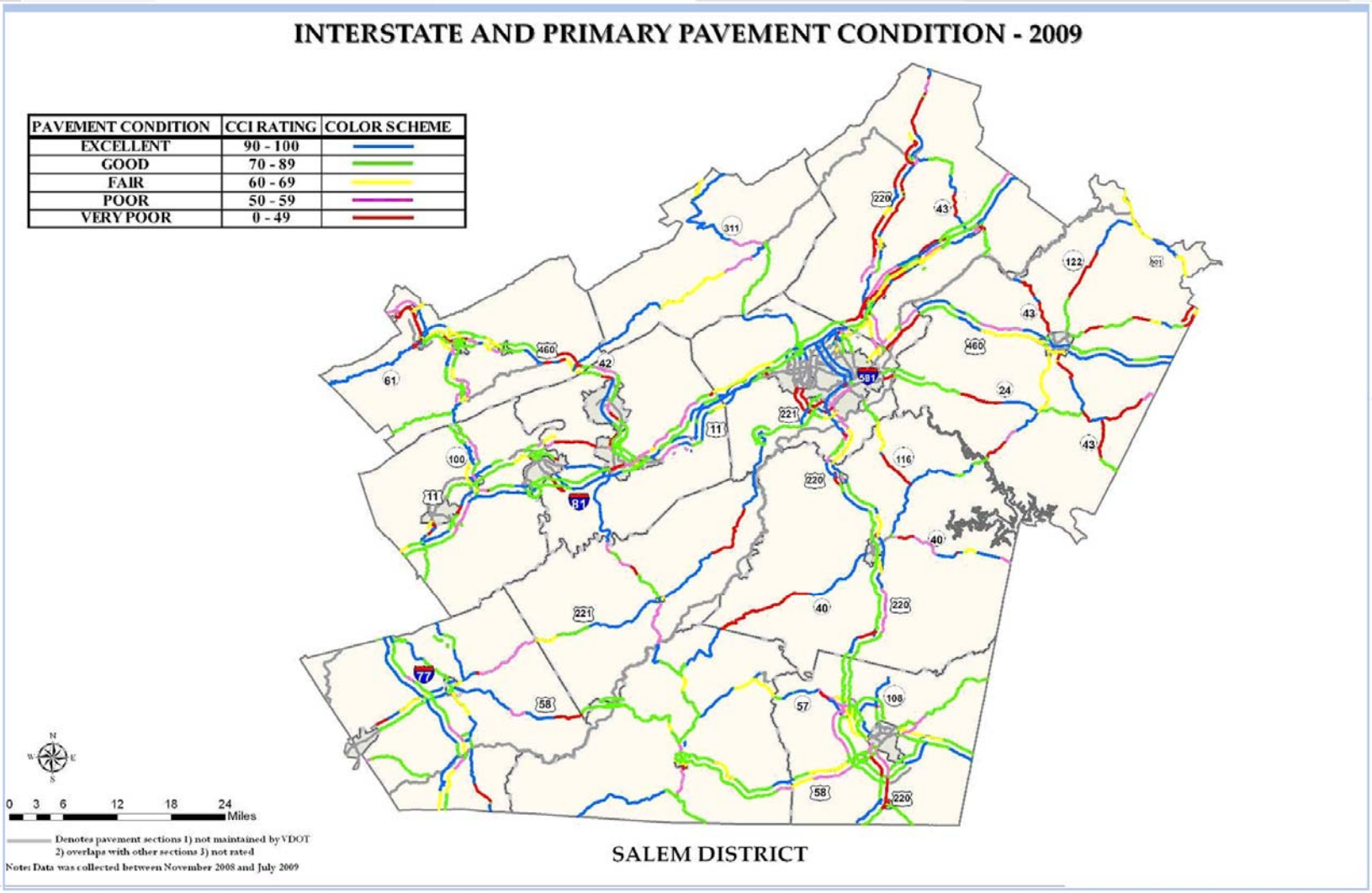
4	4	Amelia	115.16	16.56	14.38%
	12	Brunswick	337.44	68.89	20.42%
	18	Charles City	89.9	19.74	21.96%
	20	Chesterfield	667.57	174.04	26.07%
	26	Dinwiddie	346.52	92.53	26.70%
	37	Goochland	298.46	45.10	15.11%
	42	Hanover	402.08	91.07	22.65%
	43	Henrico	788.98	189.08	23.96%
	55	Lunenburg	126.92	11.72	9.23%
	58	Mecklenburg	492.97	150.63	30.56%
	63	New Kent	266.90	72.58	27.20%
	67	Nottoway	220.54	45.88	20.80%
	72	Powhatan	134.72	44.22	32.82%
	74	Prince George	319.13	75.88	23.78%
District 4 Total			4607.30	1097.91	23.83%
5	1	Accomack	284.96	61.90	21.72%
	40	Greensville	151.93	23.86	15.70%
	46	Isle of Wight	206.46	64.08	31.04%
	47	James City	224.96	97.46	43.32%
	61	Nansemond	19.31	5.88	30.44%
	64	Norfolk	334.37	101.15	30.25%
	65	Northampton	160.01	4.20	2.62%
	75	Princess Anne	88.62	35.12	39.63%
	87	Southampton	282.80	112.19	39.67%
	90	Surry	97.85	21.33	21.80%
	91	Sussex	291.96	112.64	38.58%
	99	York	369.47	70.66	19.13%
District 5 Total			2512.70	710.47	28.28%

6	16	Caroline	386.17	153.26	39.69%
	28	Essex	172.36	70.98	41.18%
	36	Gloucester	184.98	49.98	27.02%
	48	King George	208.3	42.50	20.40%
	49	King & Queen	135.42	45.72	33.76%
	50	King William	110.35	20.08	18.20%
	51	Lancaster	125.98	50.24	39.88%
	57	Mathews	66.64	2.92	4.38%
	59	Middlesex	131.92	37.20	28.20%
	66	Northumberland	113.12	43.14	38.14%
	79	Richmond	107.84	67.24	62.35%
	88	Spotsylvania	303.43	111.40	36.71%
	89	Stafford	257.39	49.59	19.27%
	96	Westmoreland	143.96	38.88	27.01%
District 6 Total			2447.86	783.13	31.99%
7	2	Albemarle	476.29	31.73	6.66%
	23	Culpeper	211.47	52.36	24.76%
	30	Fauquier	409.68	118.76	28.99%
	32	Fluvanna	102.2	8.12	7.95%
	39	Greene	86.43	6.22	7.20%
	54	Louisa	306.66	22.36	7.29%
	56	Madison	158.62	50.16	31.62%
	68	Orange	187.10	24.92	13.32%
	78	Rappahannock	155.83	26.38	16.93%
District 7 Total			2094.28	341.01	16.28%
8	3	Alleghany	323.75	36.66	11.32%
	7	Augusta	551.85	56.18	10.18%
	8	Bath	149.98	11.14	7.43%
	21	Clarke	149.62	34.66	23.17%
	34	Frederick	444.59	188.11	42.31%
	45	Highland	141.16	9.40	6.66%
	69	Page	149.48	13.92	9.31%
	81	Rockbridge	471.24	80.24	17.03%
	82	Rockingham	531.65	59.87	11.26%
	85	Shenandoah	353.80	103.29	29.19%
	93	Warren	148.88	59.54	39.99%
District 8 Total			3416.00	653.01	19.12%

9	0	Arlington	237.78	66.04	27.77%
	29	Fairfax	1161.24	389.51	33.54%
	53	Loudoun	434.63	255.13	58.70%
	76	Prince William	452.80	164.81	36.40%
District 9 Total			2286.45	875.49	38.29%
Statewide			**26662.67**	**6249.95**	**23.44%**

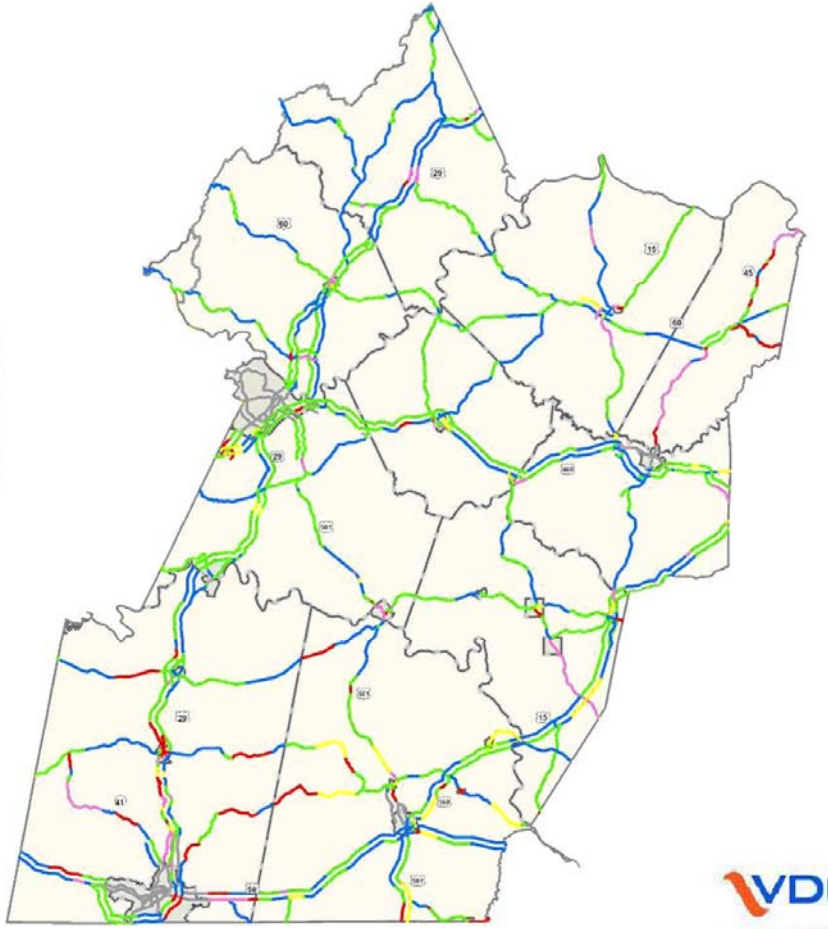
APPENDIX D: PAVEMENT CONDITION MAPS FOR INTERSTATE AND PRIMARY SYSTEMS - 2009


INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION
CCI RATING
COLOR SCHEME
EXCELLENT
90 - 100
GOOD
70 - 89
FAIR
60 - 69
POOR
50 - 59
VERY POOR
0 - 49
0 3.5 7 14 21 28
Miles
BRISTOL DISTRICT
VDOT
Virginia Department of Transportation
Maintenance


INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 3 6 12 18 24 Miles
Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated
Note: Data was collected between November 2008 and July 2009
SALEM DISTRICT

INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009

PAVEMENT CONDITION	CCI RATING	COLOR SCHEME
EXCELLENT	90 - 100	
GOOD	70 - 89	
FAIR	60 - 69	
POOR	50 - 59	
VERY POOR	0 - 49	



0 3.5 7 14 21 28 Miles

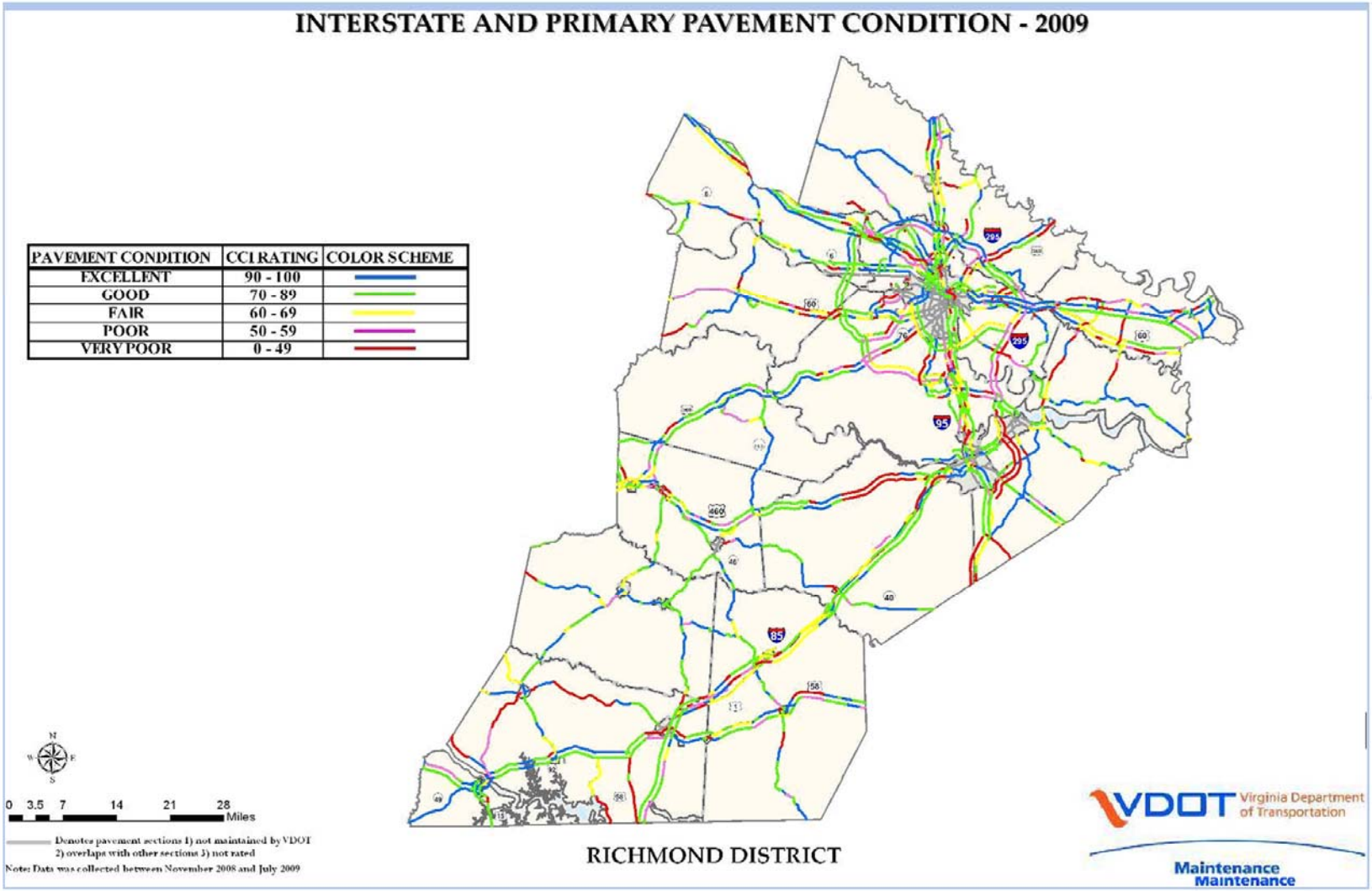
Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated

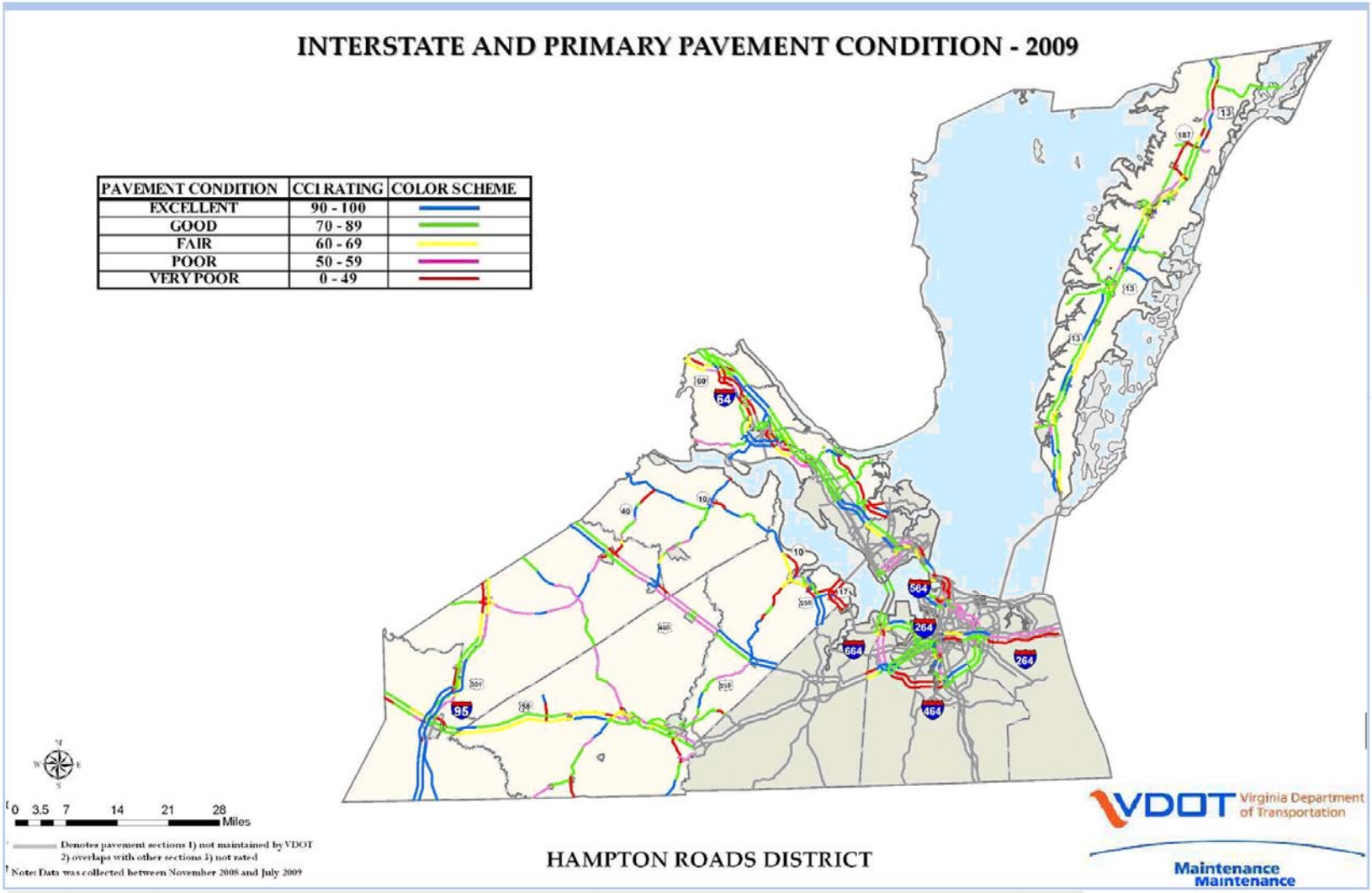
Note: Data was collected between November 2008 and July 2009

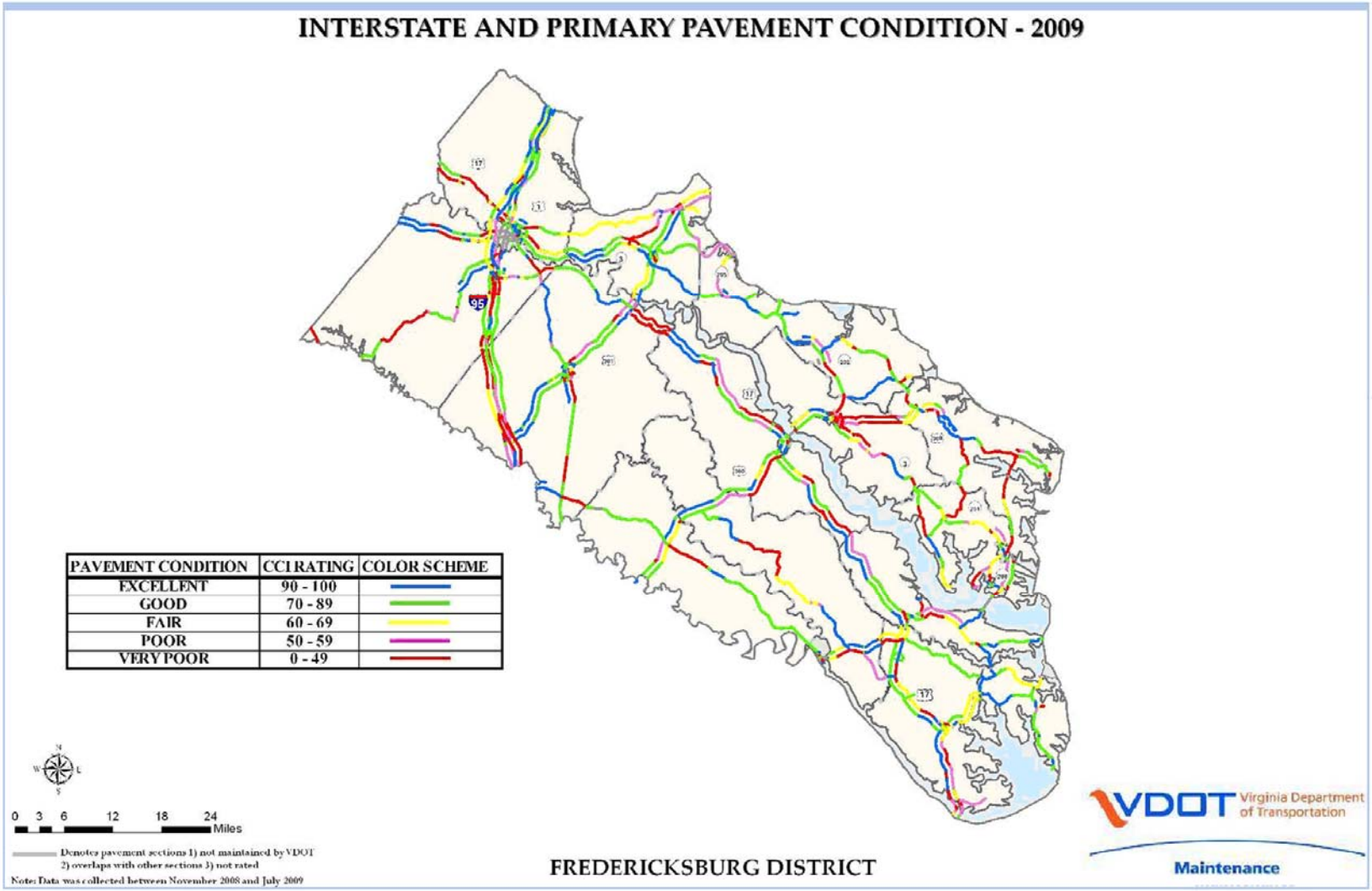
LYNCHBURG DISTRICT

VDOT Virginia Department of Transportation

Maintenance

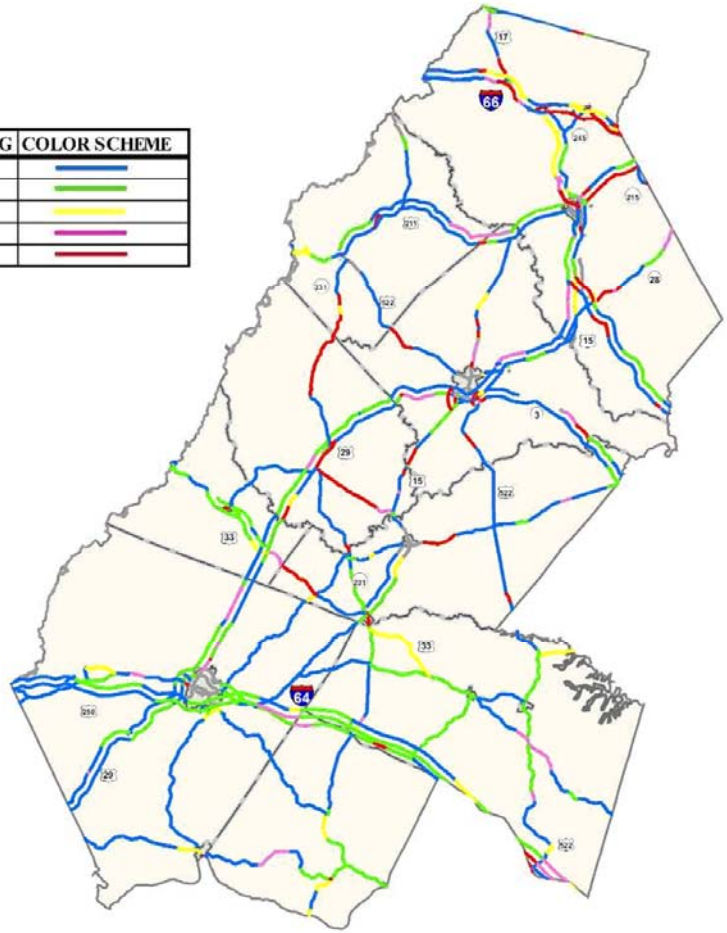

INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 3.5 7 14 21 28 Miles
Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated
Note: Data was collected between November 2008 and July 2009
RICHMOND DISTRICT
VDOT Virginia Department of Transportation
Maintenance
Maintenance


INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 3.5 7 14 21 28 Miles
Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated
Note: Data was collected between November 2008 and July 2009
HAMPTON ROADS DISTRICT
VDOT Virginia Department of Transportation
Maintenance Maintenance


INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 3 6 12 18 24 Miles
Denotes pavement sections 1) not maintained by VDOT
2) overlaps with other sections 3) not rated
Note: Data was collected between November 2008 and July 2009
FREDERICKSBURG DISTRICT
VDOT Virginia Department of Transportation
Maintenance

INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009

PAVEMENT CONDITION	CCI RATING	COLOR SCHEME
EXCELLENT	90 - 100	
GOOD	70 - 89	
FAIR	60 - 69	
POOR	50 - 59	
VERY POOR	0 - 49	

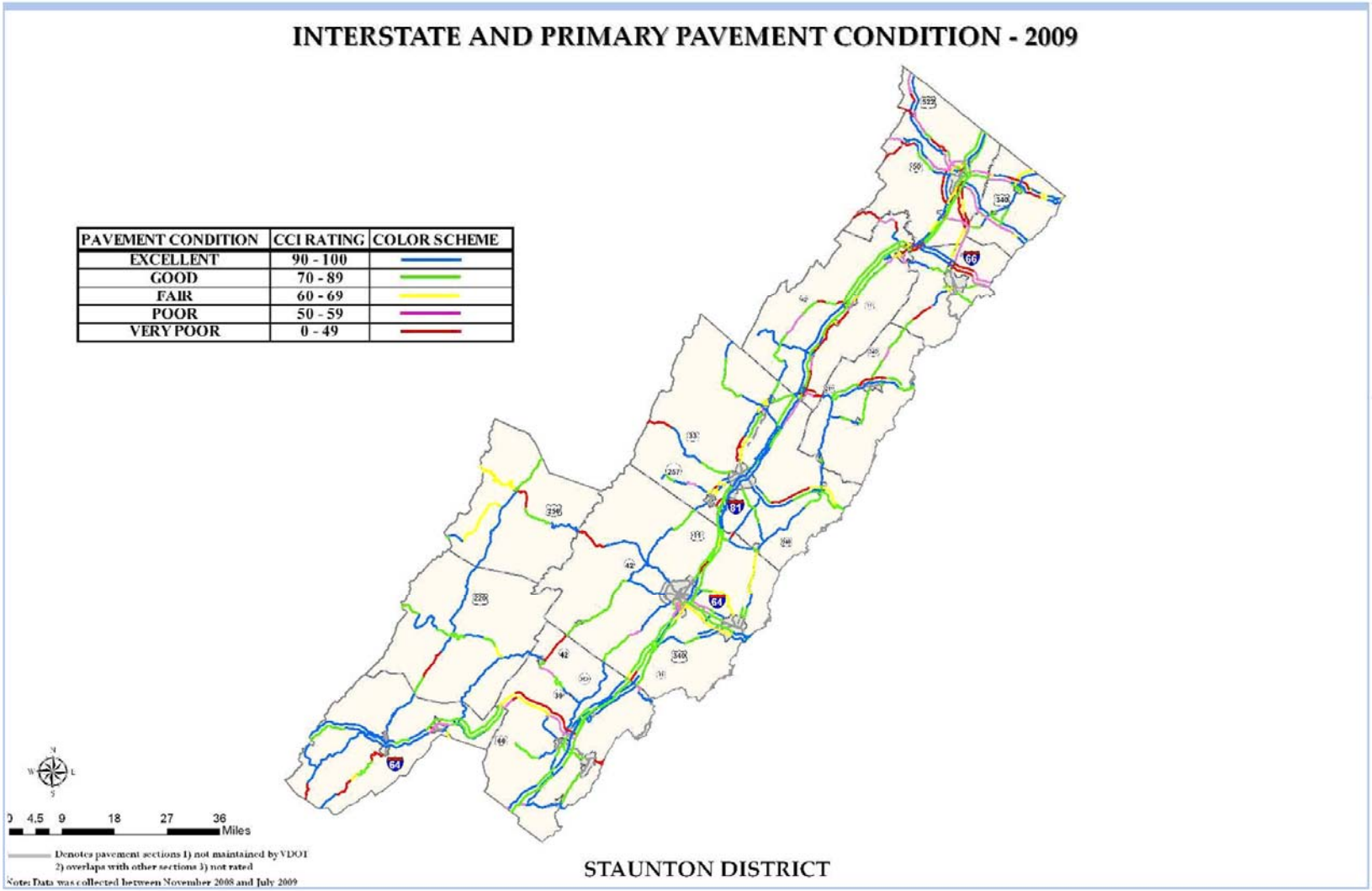


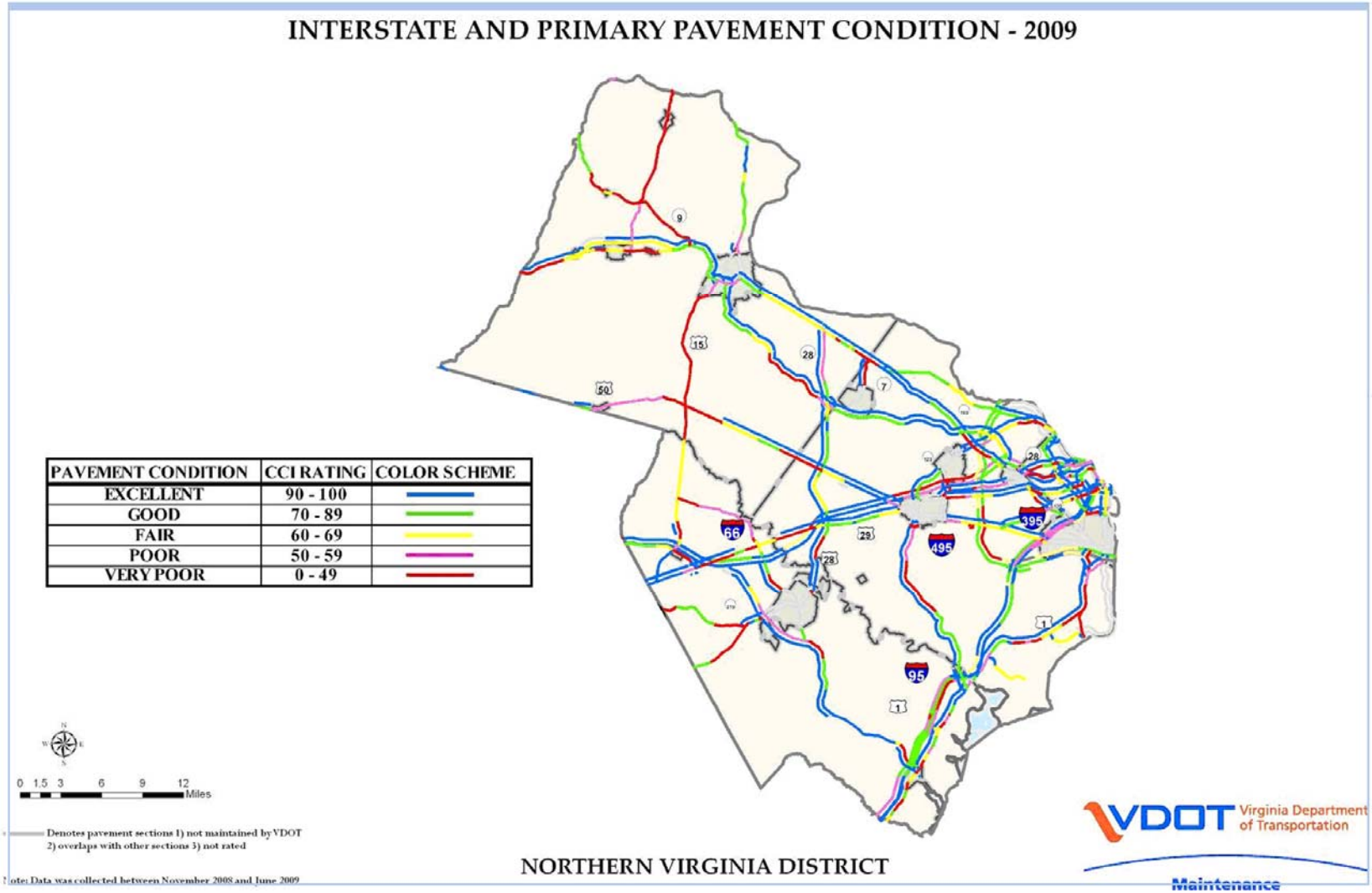
0 3 6 12 18 24 Miles

Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated

Note: Data was collected between November 2008 and July 2009

CULPEPER DISTRICT


INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 4.5 9 18 27 36 Miles
Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated
Note: Data was collected between November 2008 and July 2009
STAUNTON DISTRICT


INTERSTATE AND PRIMARY PAVEMENT CONDITION - 2009
PAVEMENT CONDITION | CCI RATING | COLOR SCHEME
EXCELLENT | 90 - 100
GOOD | 70 - 89
FAIR | 60 - 69
POOR | 50 - 59
VERY POOR | 0 - 49
0 1.5 3 6 9 12 Miles
Denotes pavement sections 1) not maintained by VDOT 2) overlaps with other sections 3) not rated
Note: Data was collected between November 2008 and June 2009
NORTHERN VIRGINIA DISTRICT
VDOT Virginia Department of Transportation
Maintenance

APPENDIX E: PAVEMENT RIDE QUALITY BY DISTRICT AND COUNTY FOR INTERSTATE AND PRIMARY SYSTEMS - 2009

District	County No.	County Name	Lane Miles Rated	Deficient Lane Miles	% Deficient
1	10	Bland	240.32	18.15	7.55%
	13	Buchanan	185.84	72.58	39.06%
	25	Dickenson	161.81	72.21	44.62%
	38	Grayson	232.24	32.03	13.79%
	52	Lee	312.63	30.29	9.69%
	83	Russell	291.30	48.80	16.75%
	84	Scott	280.54	68.19	24.31%
	86	Smythe	267.75	38.02	14.20%
	92	Tazewell	348.49	78.32	22.47%
	95	Washington	404.69	55.68	13.76%
	97	Wise	330.79	69.73	21.08%
	98	Wythe	329.81	13.09	3.97%
District 1 Total			3386.21	597.09	17.63%
2	9	Bedford	376.67	59.98	15.92%
	11	Botetourt	357.35	45.75	12.80%
	17	Carroll	290.73	13.37	4.60%
	22	Craig	118.89	13.22	11.12%
	31	Floyd	109.01	2.90	2.66%
	33	Franklin	241.13	20.15	8.36%
	35	Giles	224.54	15.47	6.89%
	44	Henry	337.73	12.77	3.78%
	60	Montgomery	282.53	6.63	2.34%
	70	Patrick	230.73	24.61	10.67%
	77	Pulaski	177.03	9.16	5.17%
	80	Roanoke	305.58	18.28	5.98%
District 2 Total			3051.92	242.29	7.94%
3	5	Amherst	280.78	18.43	6.56%
	6	Appomattox	145.93	9.75	6.68%
	14	Buckingham	197.81	5.50	2.78%
	15	Campbell	317.71	13.82	4.35%
	19	Charlotte	272.22	8.32	3.06%
	24	Cumberland	105.59	9.60	9.09%
	41	Halifax	430.01	19.82	4.61%
	62	Nelson	257.87	23.61	9.15%
	71	Pittsylvania	532.90	16.34	3.07%
	73	Prince Edward	217.75	4.20	1.93%
District 3 Total			2758.57	129.38	4.69%

4	4	Amelia	114.22	4.17	3.65%
	12	Brunswick	313.69	40.62	12.95%
	18	Charles City	89.16	5.66	6.35%
	20	Chesterfield	696.87	117.00	16.79%
	26	Dinwiddie	338.75	36.58	10.80%
	37	Goochland	300.81	12.89	4.29%
	42	Hanover	395.34	48.42	12.25%
	43	Henrico	737.04	163.81	22.23%
	55	Lunenburg	126.01	4.13	3.27%
	58	Mecklenburg	471.40	42.61	9.04%
	63	New Kent	264.32	64.56	24.42%
	67	Nottoway	218.10	8.07	3.70%
	72	Powhatan	130.62	15.79	12.09%
	74	Prince George	308.33	29.90	9.70%
District 4 Total			4504.66	594.23	13.19%
5	1	Accomack	281.83	41.39	14.69%
	40	Greensville	149.89	6.15	4.10%
	46	Isle of Wight	197.48	11.15	5.65%
	47	James City	215.05	24.41	11.35%
	61	Nansemond	19.35	1.23	6.35%
	64	Norfolk	305.37	97.12	31.80%
	65	Northampton	158.55	7.46	4.70%
	75	Princess Anne	88.19	39.06	44.29%
	87	Southampton	279.26	37.65	13.48%
	90	Surry	96.98	7.82	8.07%
	91	Sussex	290.93	12.59	4.33%
	99	York	358.21	33.78	9.43%
District 5 Total			2441.08	319.80	13.10%

6	16	Caroline	385.74	35.85	9.29%
	28	Essex	170.82	9.94	5.82%
	36	Gloucester	184.20	8.54	4.64%
	48	King George	207.08	24.65	11.90%
	49	King & Queen	135.31	12.12	8.96%
	50	King William	108.63	5.23	4.81%
	51	Lancaster	125.31	28.61	22.83%
	57	Mathews	66.31	6.54	9.86%
	59	Middlesex	131.04	3.99	3.05%
	66	Northumberland	111.73	18.40	16.47%
	79	Richmond	106.14	12.52	11.79%
	88	Spotsylvania	298.86	28.21	9.44%
	89	Stafford	257.87	36.27	14.06%
	96	Westmoreland	139.40	19.00	13.63%
District 6 Total			2428.45	249.86	10.29%
7	2	Albemarle	481.75	21.49	4.46%
	23	Culpeper	208.19	2.24	1.07%
	30	Fauquier	408.68	9.07	2.22%
	32	Fluvanna	101.93	2.77	2.71%
	39	Greene	87.14	1.52	1.75%
	54	Louisa	304.79	7.63	2.50%
	56	Madison	157.75	4.39	2.78%
	68	Orange	186.67	5.33	2.85%
	78	Rappahannock	156.40	1.93	1.23%
District 7 Total			2093.30	56.36	2.69%
8	3	Alleghany	310.31	29.77	9.59%
	7	Augusta	535.06	34.24	6.40%
	8	Bath	148.70	15.35	10.32%
	21	Clarke	146.55	10.51	7.17%
	34	Frederick	419.36	30.62	7.30%
	45	Highland	140.81	46.49	33.01%
	69	Page	138.32	10.90	7.88%
	81	Rockbridge	455.24	32.63	7.17%
	82	Rockingham	516.29	24.49	4.74%
	85	Shenandoah	333.19	35.05	10.52%
	93	Warren	146.87	8.72	5.94%
District 8 Total			3290.70	278.77	8.47%

9	0	Arlington	226.94	120.77	53.22%
	29	Fairfax	1078.40	323.79	30.03%
	53	Loudoun	449.59	68.12	15.15%
	76	Prince William	452.07	92.87	20.54%
District 9 Total			2207.00	605.56	27.44%
Statewide			**26161.89**	**3073.34**	**11.75%**