

STATE OF THE PAVEMENT 2016

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Comments should be directed to

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EXECUTIVE SUMMARY

The Virginia Department of Transportation (VDOT) is responsible for about 128,000 lane miles of roadway. Virginia’s current highway network is the result of more than 100 years of investment in infrastructure that provides safe, easy movement of people and goods and enhances the economy of 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 2016. It also provides trend analysis over the last five 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 sufficiency 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 conditions during the early months of 2016. The data displayed highlights the pavement condition and ride quality summary. These results are broken down into further detail in the main body of this report. Throughout this report the abbreviations in Table I are used to denote the construction 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 | 528 | 3,005 | 12,307 | 113 | 15,953 |
| Salem | 493 | 2,664 | 14,750 | 106 | 18,013 |
| Lynchburg | 0 | 2,873 | 12,392 | 43 | 15,308 |
| Richmond | 1,323 | 3,462 | 13,996 | 75 | 18,856 |
| Hampton Roads | 879 | 1,774 | 7,138 | 87 | 9,878 |
| Fredericksburg | 281 | 2,191 | 9,334 | 24 | 11,830 |
| Culpeper | 279 | 1,830 | 8,295 | 52 | 10,456 |
| Staunton | 940 | 2,498 | 10,524 | 76 | 14,038 |
| Nova | 727 | 1,736 | 11,046 | 76 | 13,585 |
| Statewide | 5,450 | 22,033 | 99,782 | 652 | 127,917 |

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 as well as forward images for the collection of right of way images for assets and shoulder condition data. Roughness and rutting data are simultaneously captured with sensors mounted on the van. Downward images collected during the survey are processed with specialized automated crack detection software for the identification of cracks. Further analysis of the digital images is necessary for the identification of other distresses, such as patching, bleeding or delamination.

This year data was collected by the above-mentioned method on the entire Interstate, Primary, and Secondary systems of highway network. The distresses are interpreted according to the methodology detailed in the VDOT Distress Identification Manual⁽¹⁾, processed, and summarized in a pre-defined format. Quality Control (QC) is conducted by the contractor and Quality Assurance (QA) and Independent Validation and Verification (IV&V) is performed by a third party consultant - Quality Engineering Solutions (QES). This consultant independently rates and verifies approximately 5% of all the data collected by the data collection contractor. For the Interstate and Primary systems the ratings on pavement sections are also compared with the previous year's ratings on the same sections and any major differences in ratings are further investigated. The data are processed, verified and delivered in batches. VDOT then accepts the data based on predefined acceptance criteria mentioned in the quality review document.

Individual distress data are aggregated into two Pavement Condition Indices, the Load-related Distress Rating (LDR) and Non-load-related Distress Rating (NDR). The LDR incorporates pavement distresses that are related to vehicle load related damages (e.g. fatigue cracking, patching, rutting, etc.) to pavement. The 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 material 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⁽²⁾ 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. For jointed concrete pavements the Slab Distress Rating (SDR) is used while the 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⁽³⁾.

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. Pavement sections with a CCI value of at least 60 (fair or better) are considered ‘sufficient’.

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 is generally defined as an expression of the aggregation of irregularities in the pavement surface, per linear mile, that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle delay costs, fuel consumption and maintenance costs. 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 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⁽⁴⁾ and incorporated consensus opinions from VDOT pavement experts regarding what thresholds were considered appropriate to represent acceptable roughness levels on Virginia highways. 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 the 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.

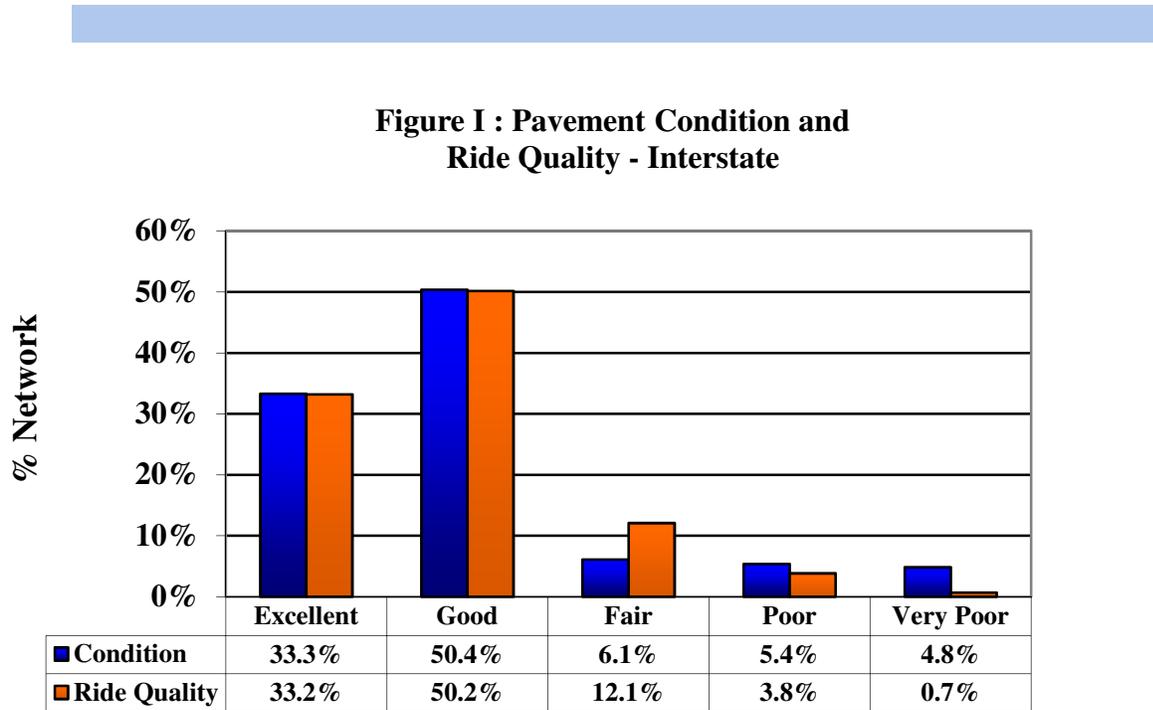


Figure II : Pavement Condition and Ride Quality - Primary

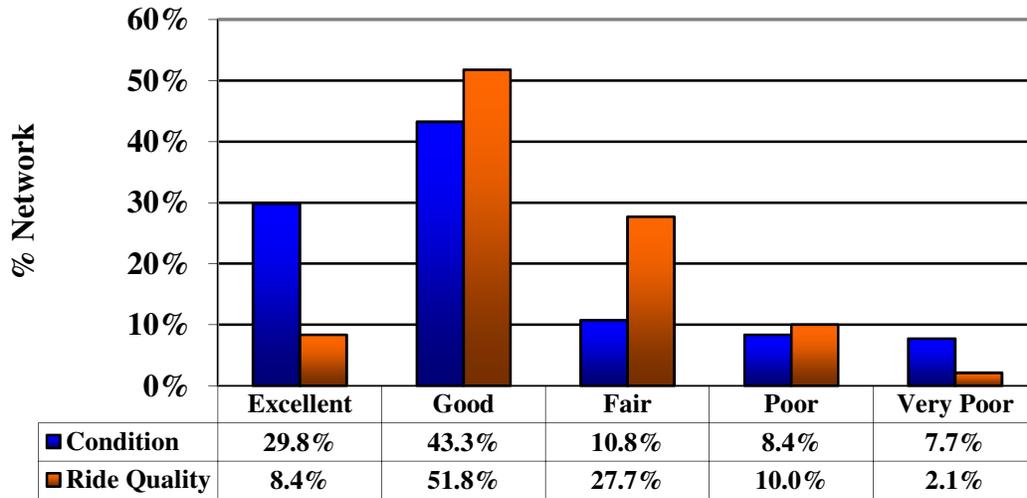
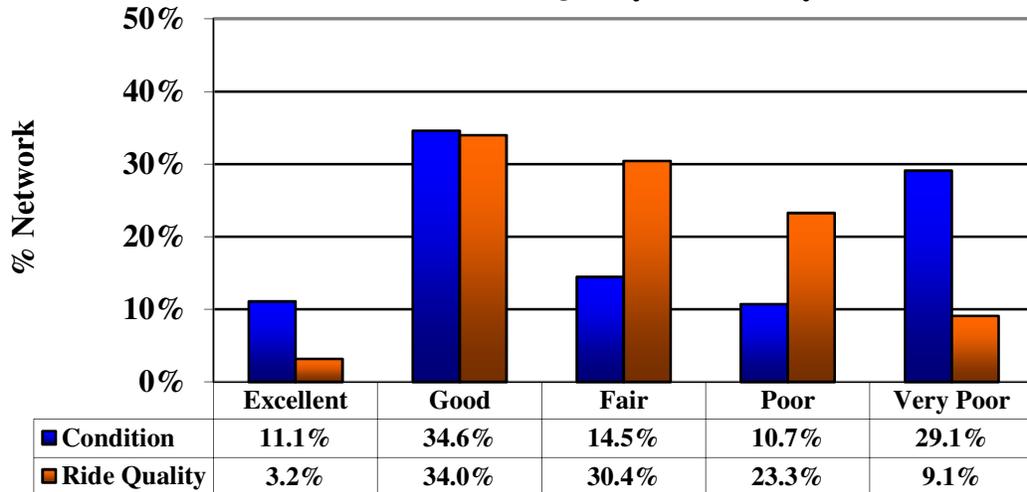


Figure III : Pavement Condition and Ride Quality - Secondary



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 sufficient, i.e., in fair condition or better, is 82% or more. Similarly, the performance target for statewide sufficient ride quality on the Interstate systems is 85% or better. Figure IV shows the percent sufficient on the Interstate system by district based on pavement condition and ride quality. Almost 90% of the Interstate network has been rated to be in ‘sufficient’ condition and more than 95% has sufficient 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 lane miles in each district on the Interstate system.

The number of miles maintained by each district varies considerably, therefore, one district may have a larger percentage of miles in sufficient condition but fewer lane miles sufficient than another. The percent of lane miles rated sufficient varies from as high as 100% in Fredericksburg District to as low as 79.4% in Richmond 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 sufficiency varies from as high as 99.4% in Fredericksburg District to as low as 90.5% in Richmond District.

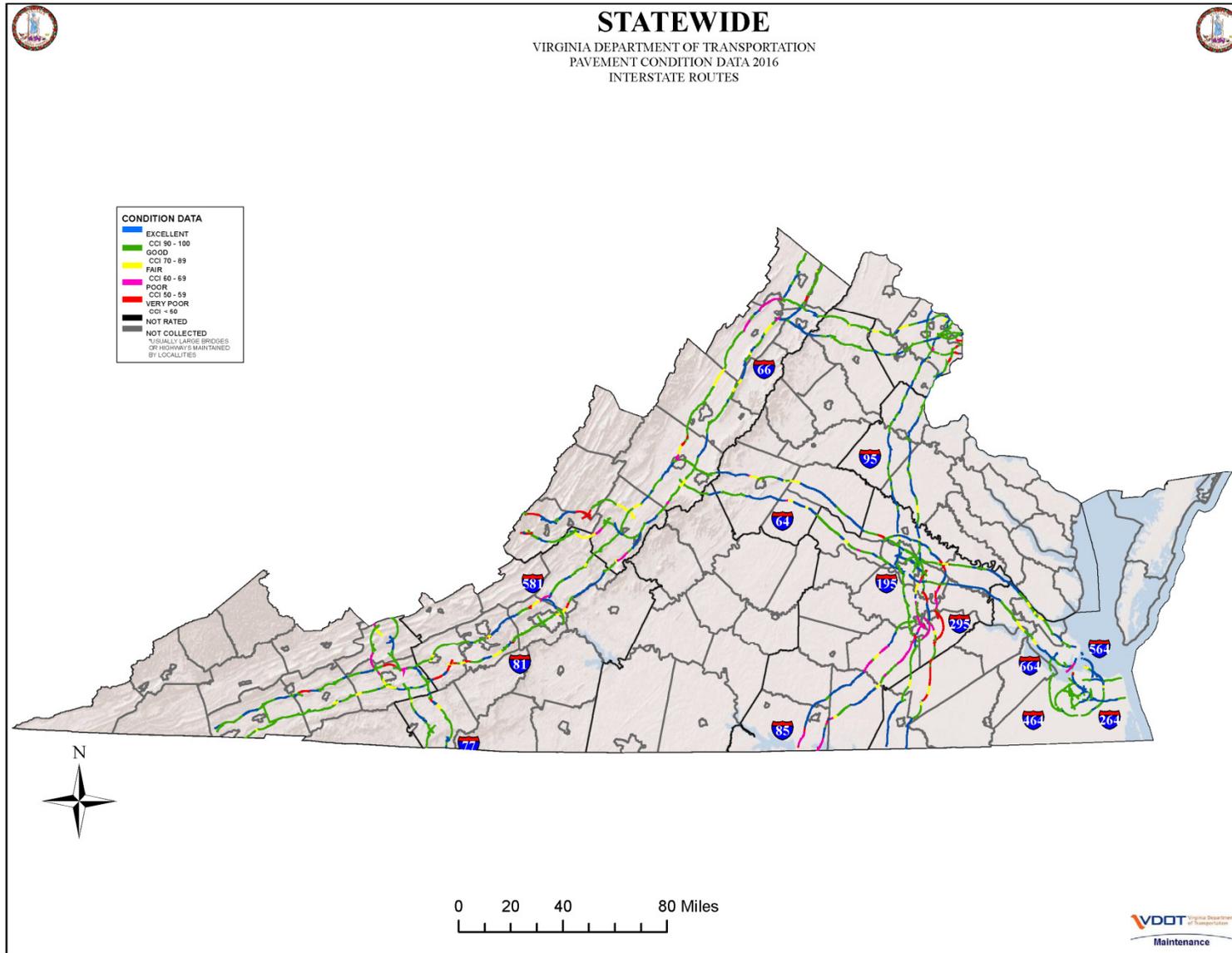


Figure IV: Percent Sufficient by District - Interstate

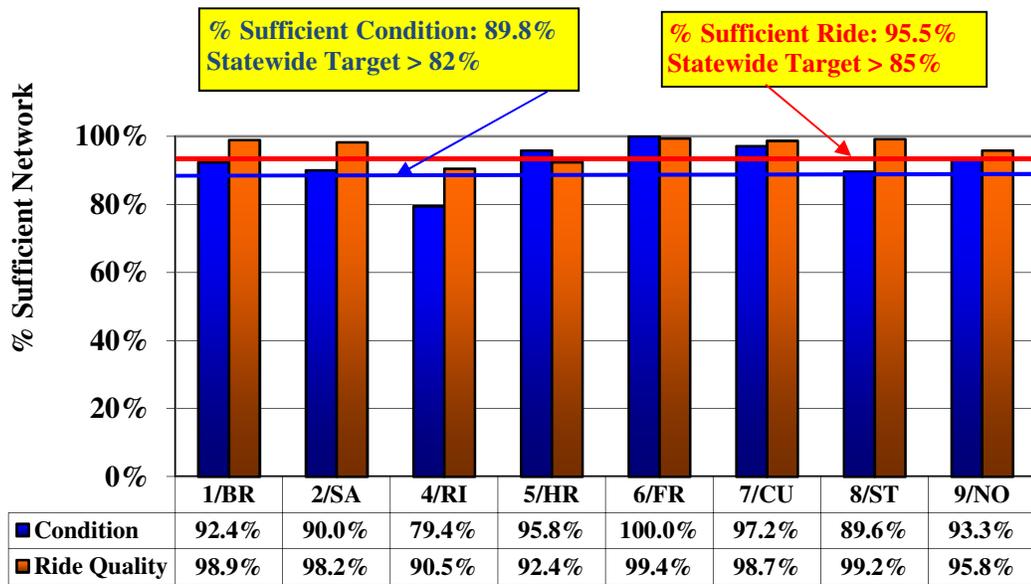
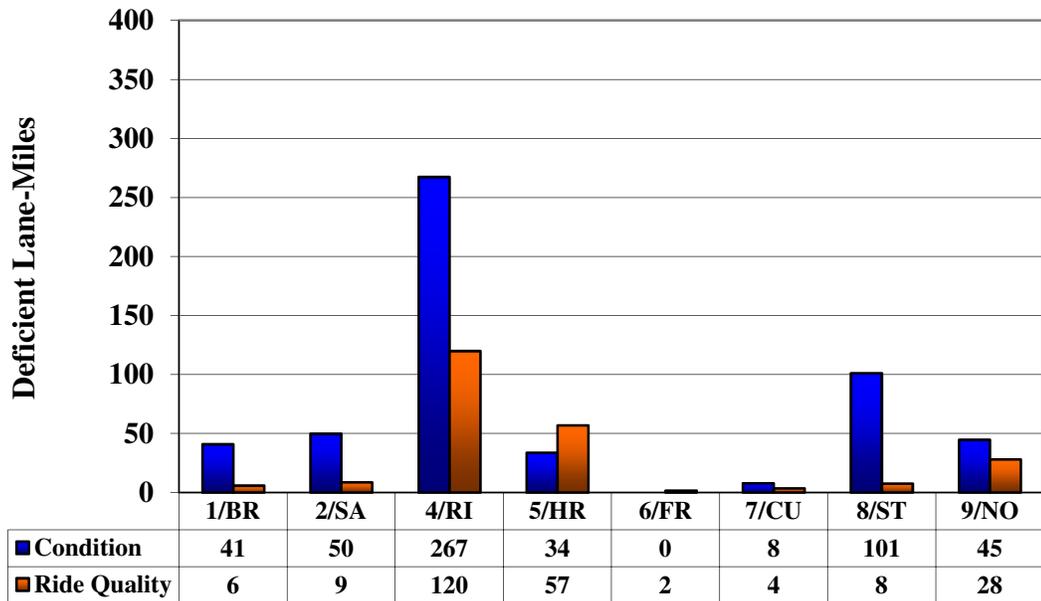


Figure V: Deficient Lane Miles by District - Interstate



Primary Pavement Condition and Ride Quality by District

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

Figures VI and VII show pavement condition and ride quality summaries for the Primary pavement network. Figure VI shows the percent of sufficient network 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 for 82 percent or more of pavements to be in sufficient condition and for 85 percent or more to have a sufficient ride quality. Based on the data, approximately 83.9% of the Primary network has been rated to be in sufficient condition and 87.9% has sufficient ride quality.

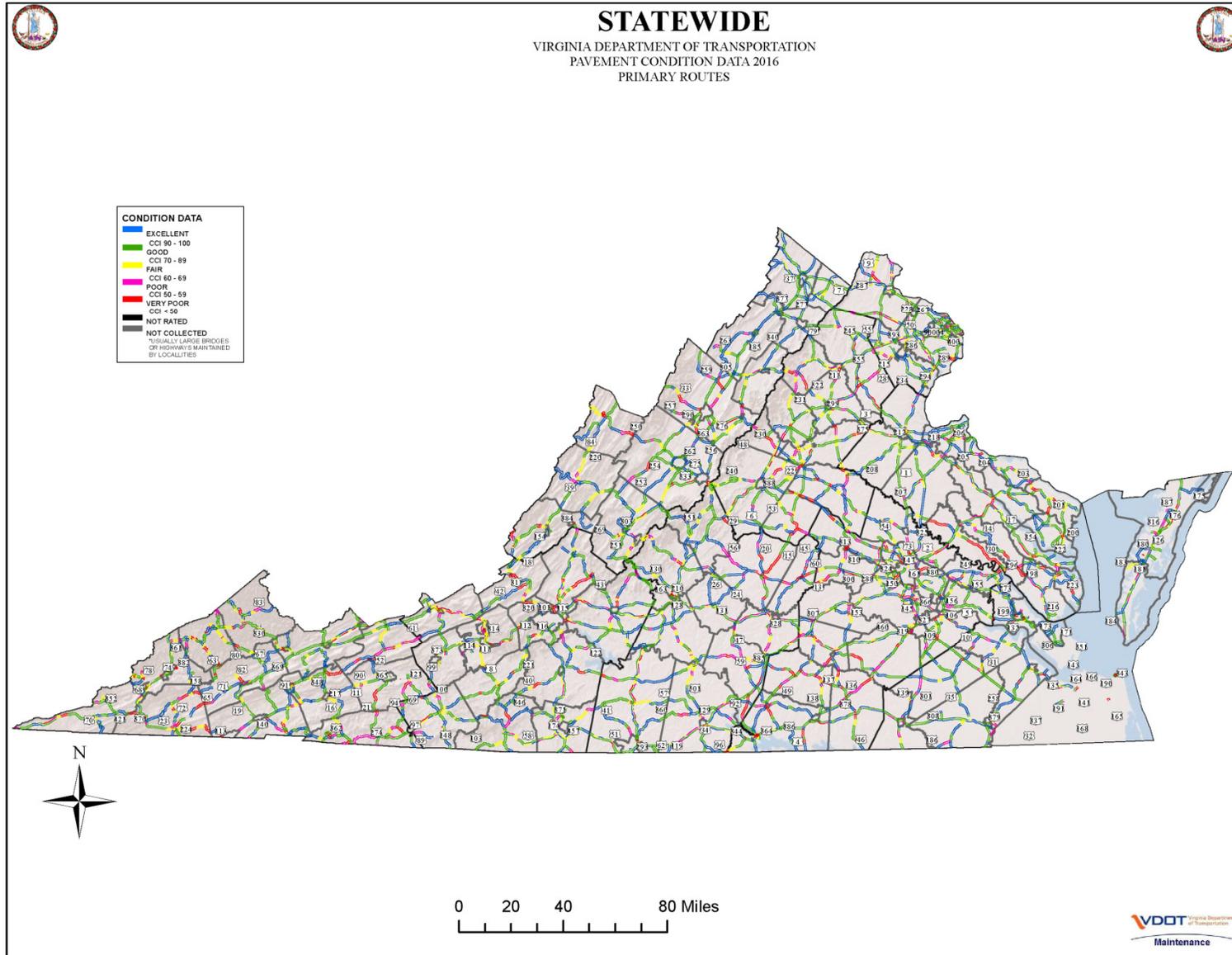


Figure VI: Percent Sufficient by District - Primary

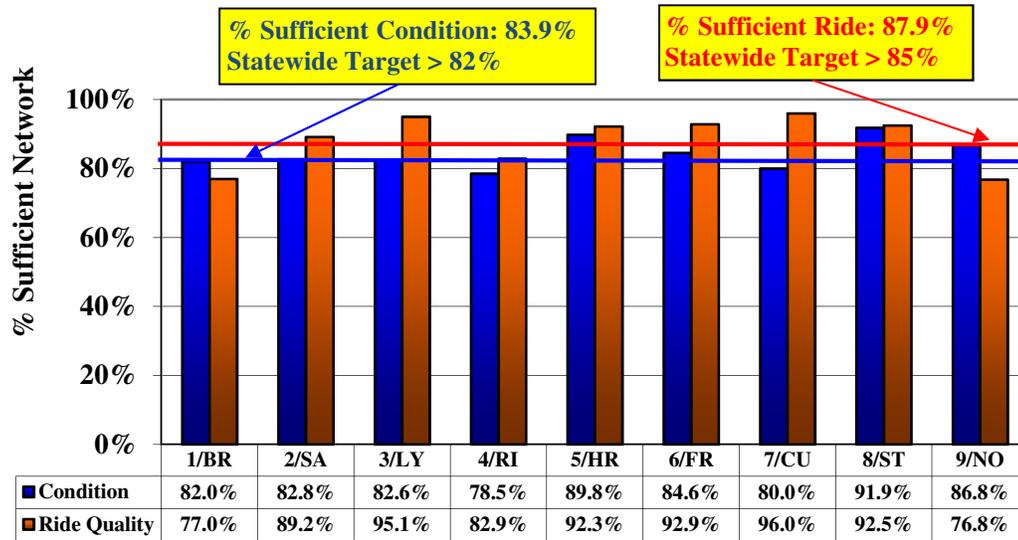
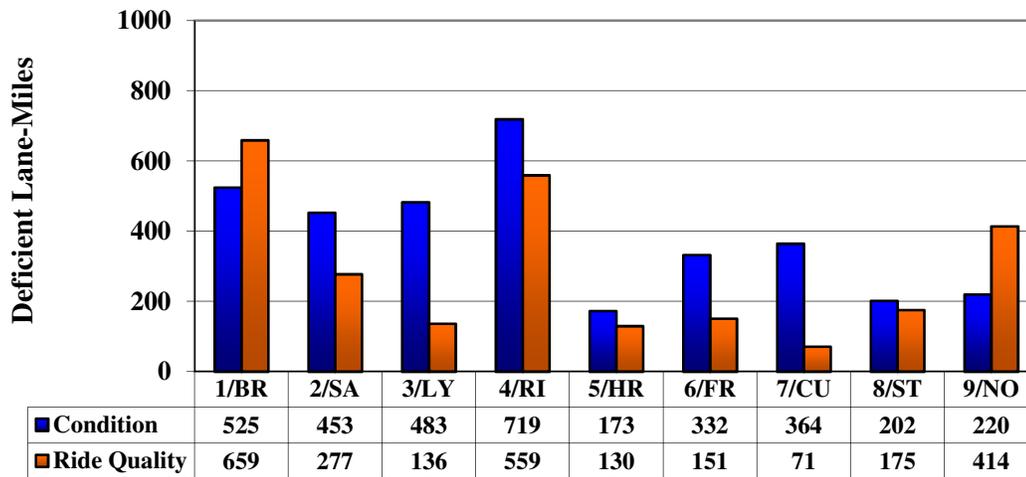


Figure VII: Deficient Lane Miles by District - Primary



Secondary Pavement Condition and Ride Quality by District

In 2016, data in each county was collected and processed for a total of 83,609 lane miles of the VDOT maintained, hard-surfaced Secondary network.

Figure VIII shows the percent sufficient network 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 lowest percentage of its Secondary rated as sufficient (36.4%), followed by Bristol and Richmond Districts. Hampton Roads District has the highest percent of sufficient Secondary pavements. Statewide, 60.2% of the sampled Secondary system was found to have pavement condition rated sufficient.

Based on ride quality, the sufficient ratings range from a low of 59.3% sufficient in Salem District to a high of 75.6% in Culpeper District. Statewide 67.6% of the rated samples on the Secondary system were found to have sufficient ride quality.

Figure VIII: Percent Sufficient by District - Secondary

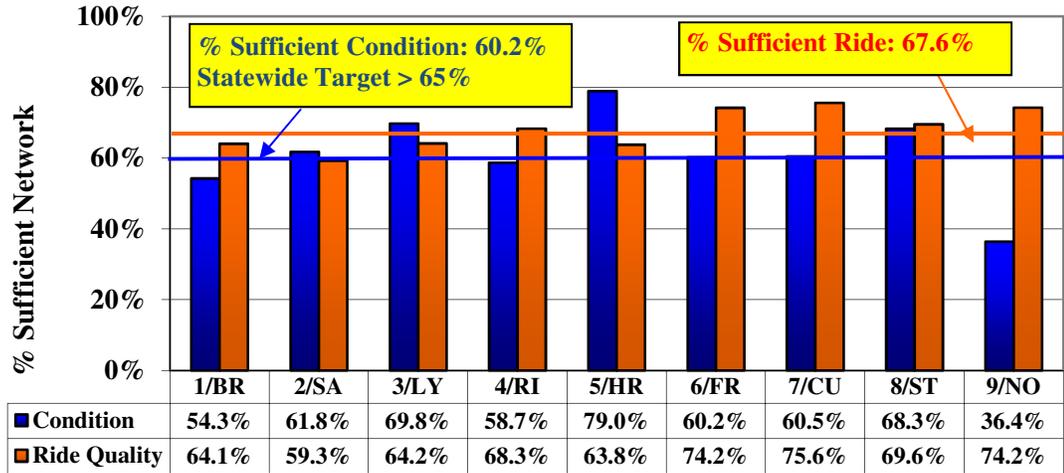
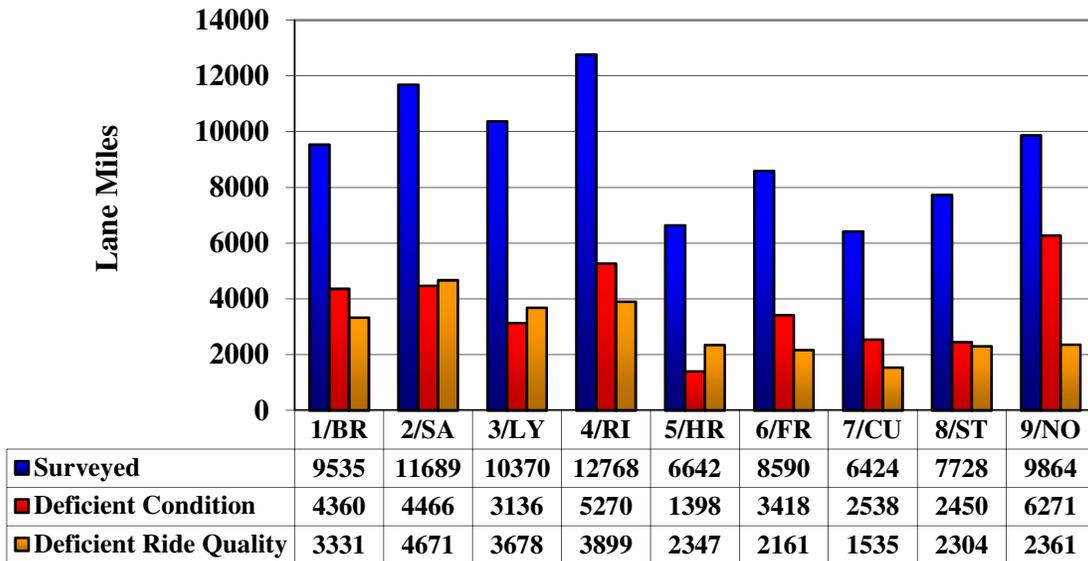


Figure IX: Surveyed, Deficient Condition and Deficient Ride Quality Lane Miles by District - Secondary



Statewide Pavement Deficiency Trends

The trends over recent years in Interstate and Primary percent sufficient network are shown in Figure X; trends for the Secondary pavements are shown in Figure XI. The higher the percentage of sufficient pavements, the better is the pavement network condition in general. In Figure X, the statewide performance targets of 82% sufficient are shown for interstate and primary pavements.

Figure X: Trend in Percent Sufficient - Interstate and Primary

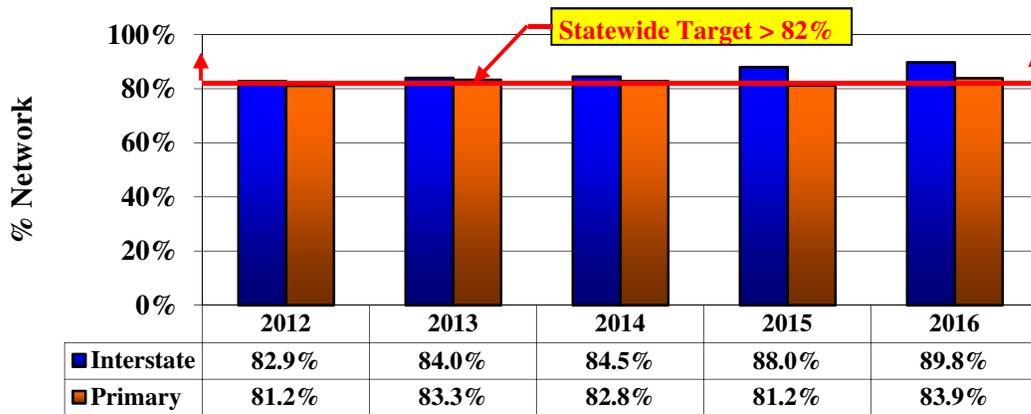
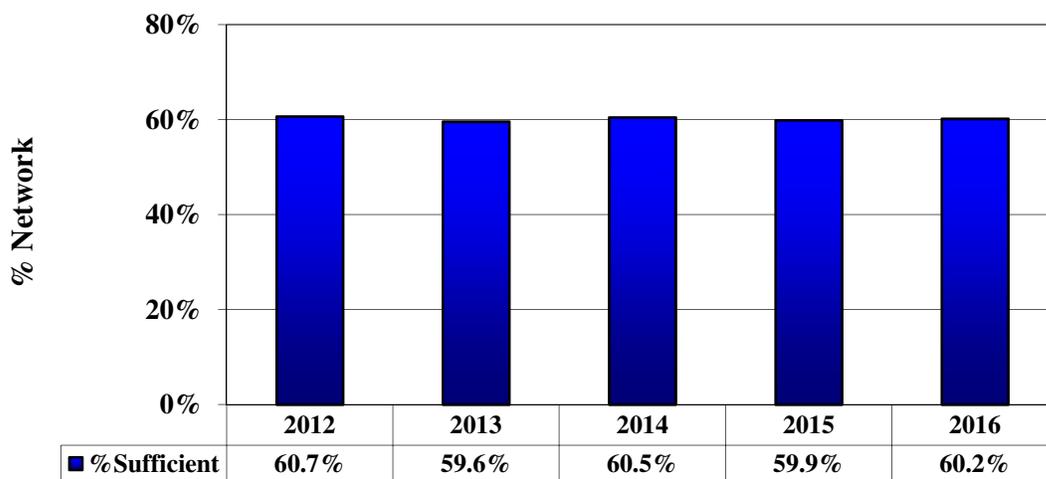


Figure XI: Trend in Percent Sufficient - Secondary



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 data are also used to feed the maintenance decision trees to determine the unconstrained maintenance needs for the pavement assets. Unconstrained needs analysis establishes the maintenance and rehabilitation needs to appropriately correct the existing pavement conditions where available funding for work would not be considered a constraint. It provides an idea of the amount and type of work needed on the whole network. For this needs determination, each section's distress quantities and severities, and CCI are input from the condition survey data into the unconstrained decision trees⁽⁵⁾. Traffic level, structural condition, and maintenance history are also used as additional inputs to the selection of maintenance treatments wherever the data are available. In many cases the unconstrained needs are used as the first indicator of the scope of necessary maintenance which is further refined by field inspections, detailed project level analysis, and overall needs of the network.

2. Planning for Preventive Maintenance and Resurfacing. The surface distress condition data are 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 schedules. Automated data that provide high consistency and efficiency are 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 annual asset condition report required by Section 33.2-232 of the Code of Virginia. The second report, required by Section 33.2-352 each year, concerns asset management practices in the operation and maintenance of the systems of state highways.

The data are also used for tracking performance measures on the dashboard and are 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 as a bar chart. 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, as established by the Commonwealth Transportation Board's policy, is to have a minimum of 82% of Interstate and Primary pavement; and 65% of Secondary pavement in Excellent, Good, or Fair condition.

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

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⁽⁶⁾. HPMS data specifications have expanded 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 customers both internal and external to VDOT to meet research, analysis and planning needs. The data are also used for other purposes including determination of performance of various types

of paving materials/mix designs as well as in initial screening to identify locations for detailed project level analysis when planning maintenance and rehabilitation activities.

Accumulation of consistent and quality pavement condition data over time will also allow VDOT to 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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STATE OF THE PAVEMENT - 2016

BACKGROUND

The Virginia Department of Transportation (VDOT) maintains the third largest public road network in this country, covering a total of about 58,675 miles consisting of about 1,118 miles of Interstate highways, 8,064 miles of Primary highways and 49,167 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 was known in VDOT as the Highway Traffic Records Information/Inventory System (HTRIS). While, as the name implies, HTRIS was heavily oriented toward traffic engineering needs, it also was the first repository for pavement construction and rehabilitation records or pavement inventory. The Roadway Network System (RNS) created a replacement system for the aging HTRIS mainframe system. The new system now incorporates a relational database that provides universal enterprise data access, links geo-spatial data and business attributes to the roadway centerlines, and provides web accessibility to users currently unable to retrieve critical roadway data. From 2016 Roadway Inventory Management System (RIMS) is the new system of record for VDOT's road data inventory. As this initiative evolves, new business processes will be established that will streamline data editing and maintenance and will clarify and clean data and allow efficient data sharing across applications.

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⁽⁷⁾. 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 ⁽⁸⁾, the 2002-2004 reports ⁽⁹⁾⁻⁽¹¹⁾, the 2006 report ⁽¹²⁾, and the 2008-2015 condition reports ⁽¹³⁾⁻⁽²⁰⁾ 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 all of the Interstate, Primary, and the hard-surfaced Secondary pavement network.

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 simultaneously captured with the sensors mounted on the van. The data are collected at highway speeds as the vans are driven along the pavement. Downward images collected

during the survey are processed with specialized automated crack detection software for the identification of cracks. Further analysis of digital images is necessary for the identification of other distresses; such as patching, bleeding or delamination. The following sections describe the major data items that are collected, and the results of the 2016 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 A 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 similar in format to the “windshield” data obtained while data were collected by windshield surveys before automated data collection method was adopted. 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 can be found in Appendix B.

QUALITY ASSURANCE

An independent QA process is an important consideration for quality data. For the 2016 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 17 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⁽²¹⁾ 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. Five 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 5% 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.

PAVEMENT INVENTORY EVALUATED

The 2016 automated condition surveys began in August, 2015 and were completed, including the QA evaluations, by late July of 2016. 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 5,347 lane miles on Interstate and 21,487 lanes miles on Primary (26,107 lanes miles of ACP pavements and 727 lanes miles of JCP and CRCP pavements) are accounted for in 2016 surveys.

Approximately 83,609 lane miles of Secondary pavements were surveyed in 2016 (45,647 lane miles of plant mix and 37,962 lane miles of non-plant mix).

PAVEMENT CONDITION - 2016

The 2016 automated condition surveys began in August, 2015 and were completed, including the QA evaluations, by late July of 2016. 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 2016 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 for JCP pavements and the Concrete Punchout Rating (CPR) and the Concrete Distress Rating (CDR) are collected 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⁽³⁾. 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 82 percent of the Interstate pavements are in fair or better condition on statewide basis. The distribution of Interstate condition states on a district basis is presented in Figure 2. Here all of the condition states are represented as percentages in the chart along with numerical values.

Figure 3 is a bar chart that presents the Interstate deficient lane miles in each district. This chart also presents the deficient lane miles by pavement type: 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. The percentage of deficient pavements equals one hundred minus the percentage of sufficient pavements.

Figure 1 : Pavement Condition - Interstate

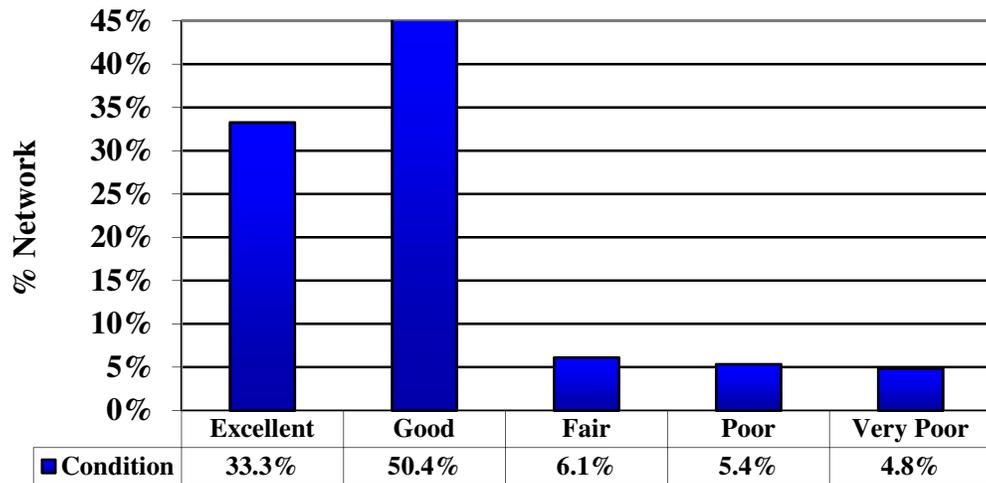


Figure 2 : Pavement Condition by District - Interstate

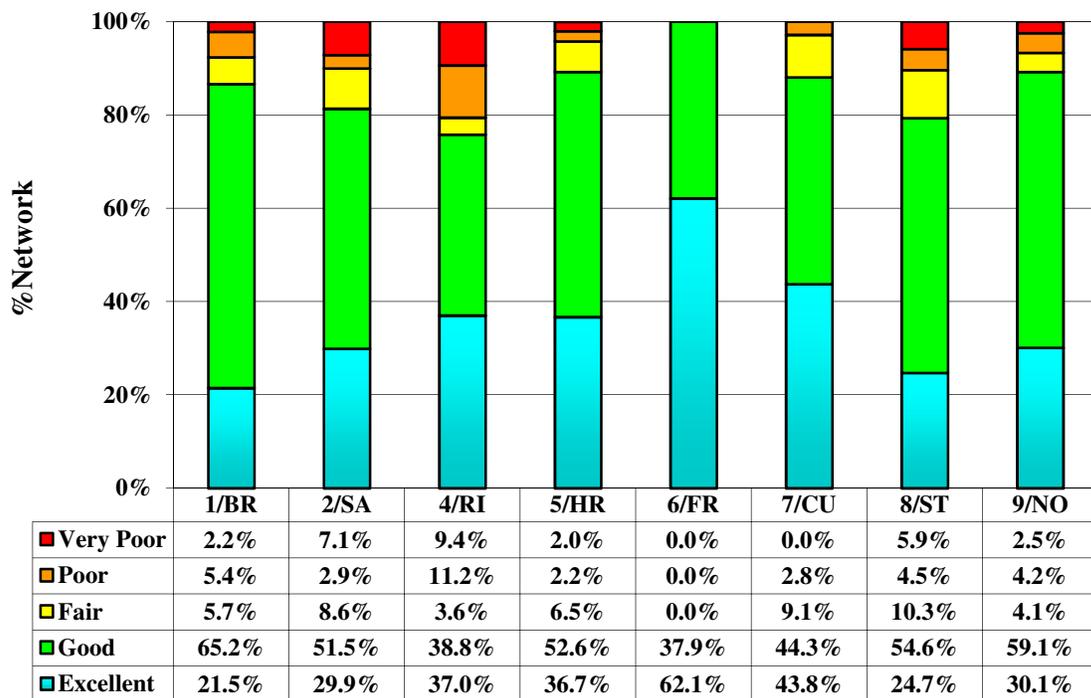


Figure 3: Deficient Lane Miles by District - Interstate

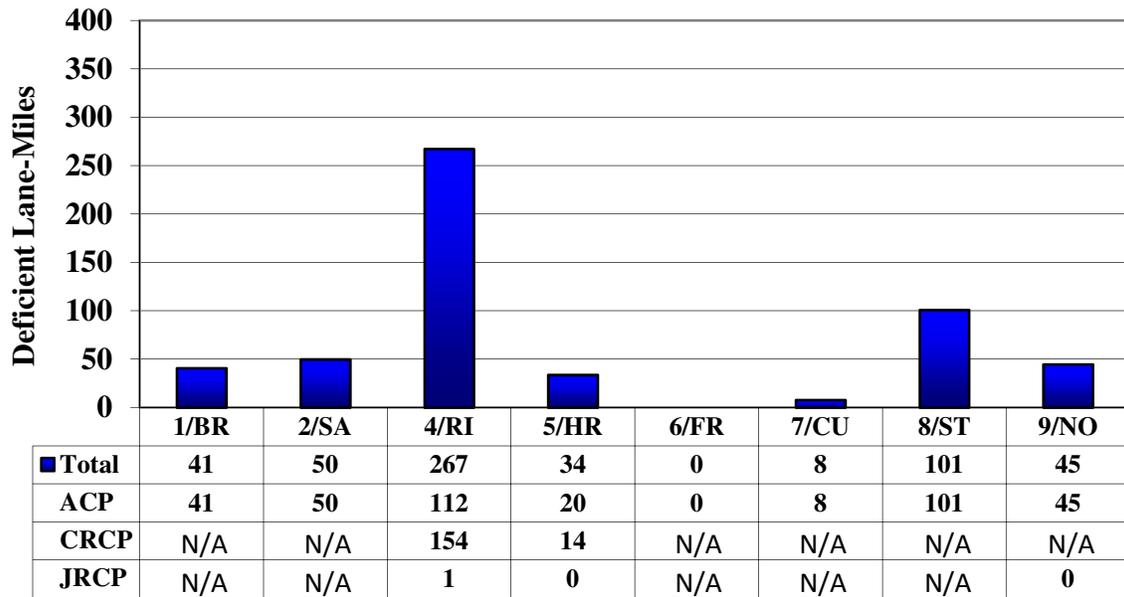
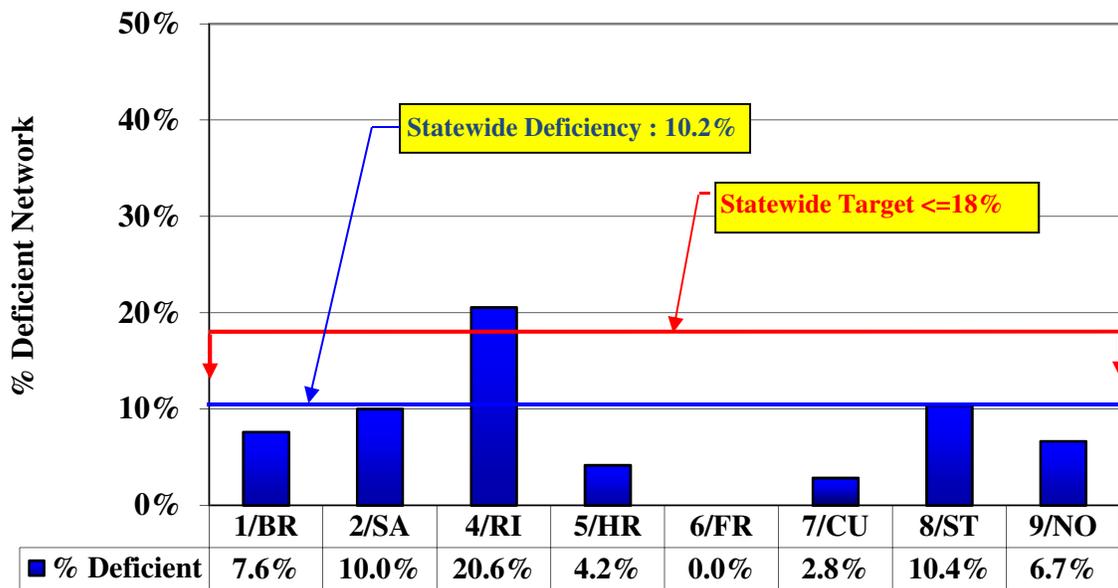


Figure 4: Percent Deficiency by District - Interstate



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 10.2% for Interstate pavements is represented by another line. It can be seen that eight districts are below performance target of maximum 18% deficiency. District 6 shows the lowest percentage deficient, at 0%, whereas the highest percentage, 20.6%, is found in District 4.

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 0.1% in Fredericksburg District to a high of 2% in Staunton district. Also, it can be seen that, by district, the variation of average rutting values is relatively small from a lowest value of 0.13 inch to a highest value of 0.18 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) | 1.7% | 1.3% | 1.4% | 1.0% | 0.1% | 1.1% | 2.0% | 1.7% |
| Patching (% total area) | 0.6% | 2.6% | 0.6% | 1.4% | 0.1% | 0.3% | 1.6% | 0.7% |
| Rutting (inches) | 0.15 | 0.17 | 0.17 | 0.16 | 0.18 | 0.15 | 0.16 | 0.13 |
| Transverse Cracking (ft/lane mile) | 262 | 353 | 774 | 368 | 244 | 229 | 497 | 550 |
| Longitudinal Cracking (ft/lane mile) | 2786 | 2262 | 1495 | 989 | 276 | 1335 | 3046 | 1430 |

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

For CRC pavements the percentage of asphalt patching, punchout area, PCC patching, and transverse cracking are presented in Table 3. A 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 until a more permanent concrete patch can be applied. Punchouts, asphalt patching, and concrete patching are presented in terms of percent area of pavement. In the 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 cluster cracking occur 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) | | 0.8% | 1.3% |
| Punchout (% total area) | | 0.1% | 0.1% |
| PCC Patching (% total area) | | 21.0% | 8.6% |
| Transverse Cracking | ft/lane mile | 6,886 | 6,029 |
| | Spacing (ft) | 7.8 | 10.0 |

JOINTED REINFORCED CONCRETE PAVEMENT

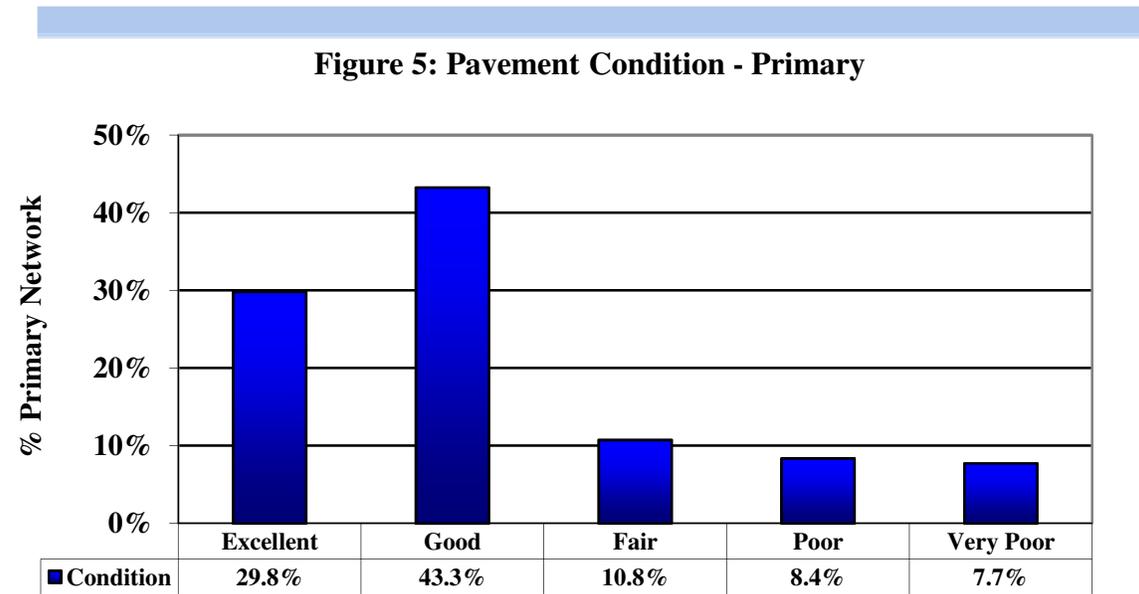
The percent of slabs of jointed concrete pavements with transverse cracks, corner breaks, PCC patching, and asphalt patching are presented in Table 4. On the Interstate system, JRC pavements are present only in Richmond, Hampton Roads, and Northern Virginia districts. Corner breaks and transverse cracks 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) | 6.1% | 6.1% | 0.4% |
| Corner Breaks (% slabs) | 1.0% | 0.6% | 2.4% |
| PCC Patching (% slabs) | 3.6% | 2.7% | 1.0% |
| Asphalt Patching (% slabs) | 9.1% | 3.1% | 9.8% |

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 83.9%.



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 Staunton district with the worst conditions observed in Richmond.

Figure 6 : Pavement Condition by District - Primary

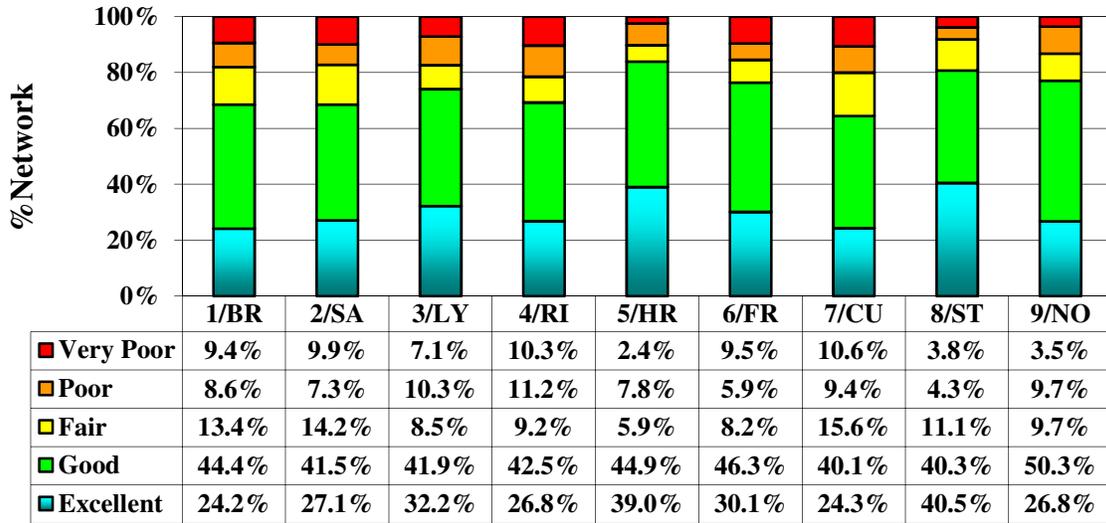


Figure 7: Deficient Lane Miles by District - Primary

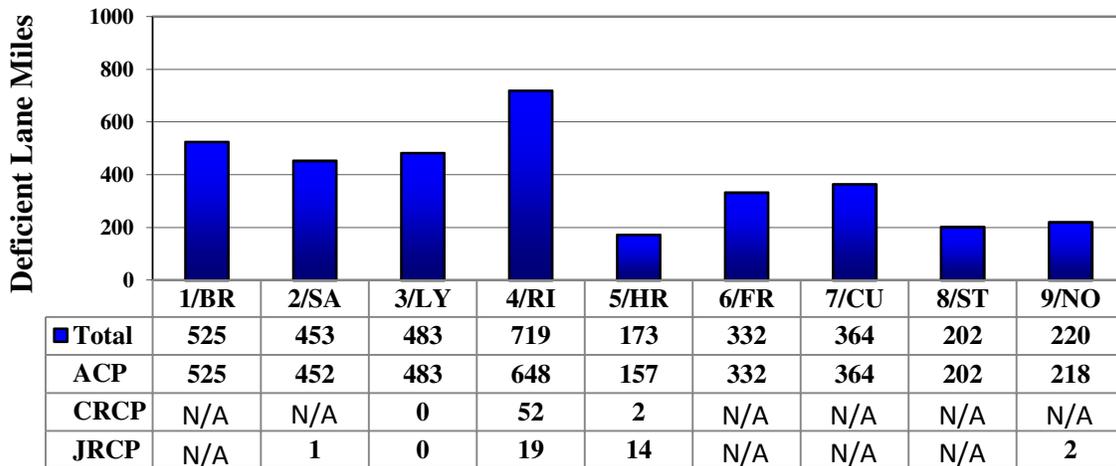
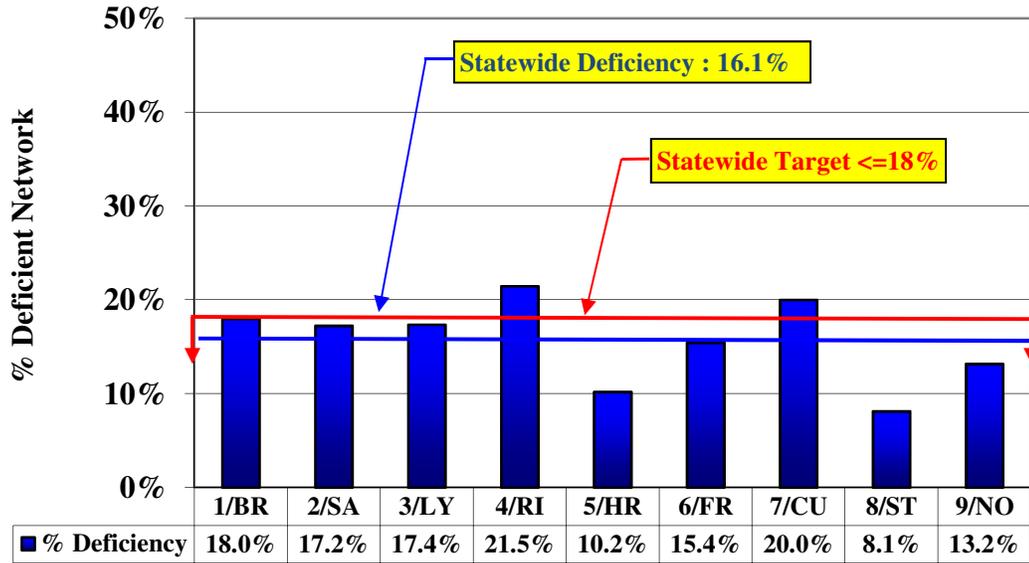


Figure 7 presents the deficient lane miles in each district, with numerical values by pavement type. Again, each district maintains a different size network, so the total deficient lane miles vary from district to district based on both the relative size and condition of each network. For Primary pavements, Hampton Roads District has the least number of deficient lane-miles (173) while Richmond District has the highest (719).

Figure 8: Percent Deficiency by District - Primary



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 16.1% are also shown in the figure. Districts 4 and 7 are above the target and the rest of the districts are below the target. The percentage of deficient pavements varies from a low of 8.1% in District 8 to a maximum of 21.5% in District 4.

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) | 4.0% | 3.6% | 4.3% | 3.8% | 2.8% | 4.0% | 5.1% | 3.1% | 3.6% |
| Patching (% total area) | 2.4% | 1.9% | 1.4% | 1.5% | 0.5% | 0.7% | 1.3% | 2.3% | 1.5% |
| Rutting (inches) | 0.14 | 0.15 | 0.13 | 0.14 | 0.13 | 0.13 | 0.13 | 0.12 | 0.13 |
| Transverse Cracking (ft/lane mile) | 647 | 1359 | 2107 | 2023 | 1520 | 1714 | 1870 | 873 | 1381 |
| Longitudinal Cracking (ft/lane mile) | 1320 | 1265 | 734 | 927 | 694 | 967 | 770 | 629 | 1245 |

CONTINUOUSLY REINFORCED CONCRETE PAVEMENT

Some of the key distresses in CRC pavements include: asphalt patching, punchouts, PCC patching, and transverse cracking and 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% | 2.1% | 0.0% |
| Punchout (% total area) | | 0.0% | 0.2% | 0.0% |
| PCC Patching (% total area) | | 0.0% | 9.3% | 0.4% |
| Transverse Cracking | ft/lane mile | 11,998 | 6,830 | 7,902 |
| | Spacing (ft) | 5.1 | 7.4 | 7.2 |

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 five districts have JRC pavements on the Primary system.

Table 7: Major Distresses on Primary JRC Pavement

| Key Distresses | D2 SA | D3 LY | D4 RI | D5 HR | D9 NO |
|-------------------------------------|----------|----------|----------|----------|----------|
| Transverse Cracking (% slabs) | 34.5% | 25.2% | 10.4% | 7.2% | 8.1% |
| Corner Breaks (% slabs) | 3.4% | 0.6% | 1.3% | 1.3% | 5.0% |
| PCC Patching (% slabs) | 62.1% | 0.1% | 3.6% | 12.0% | 29.3% |
| Asphalt Patchings (% slabs) | 44.8% | 0.0% | 13.5% | 3.4% | 27.7% |

CONDITION OF SECONDARY PAVEMENT

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

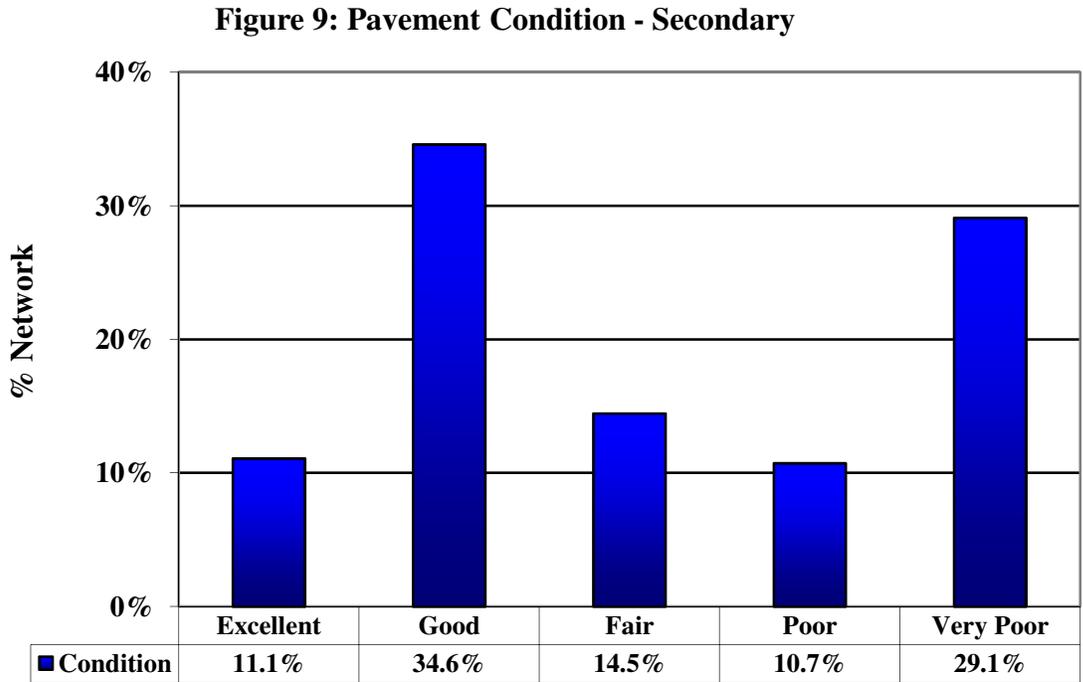


Figure 10 : Pavement Condition by District - Secondary

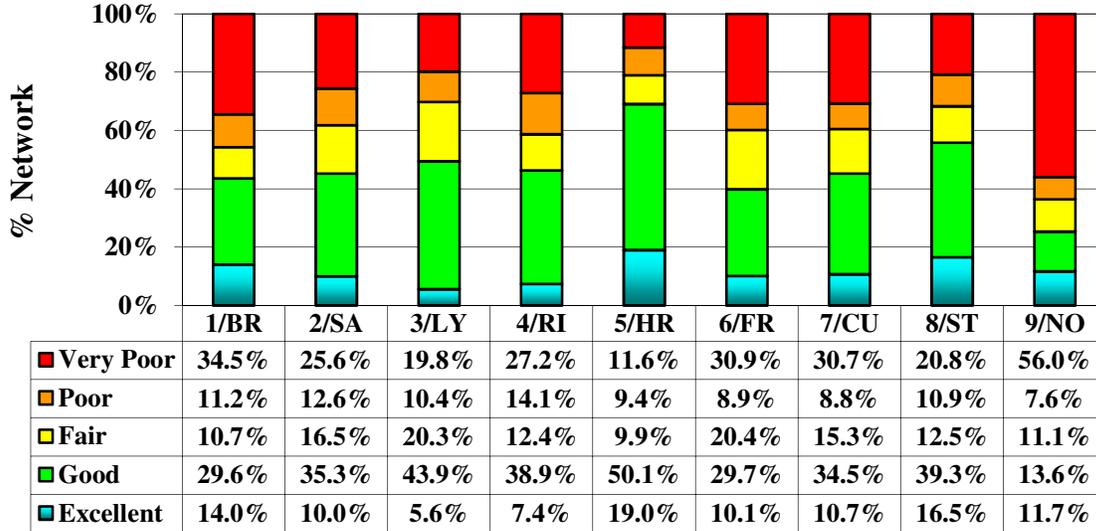


Figure 11 shows the number of lane-miles surveyed in each district as well as the number of lane-miles rated as ‘deficient’. Figure 12 represents the percent deficient in terms of lane miles surveyed. Based on these figures, Northern Virginia District has the highest percentage of its Secondary network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

Within the Secondary network, the rated lane miles of plant mix surfaces and non-plant mix surfaces are shown in Figure 13. Some districts have more plant mix lanes miles while non-plant mix lane miles are more in other districts.

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

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

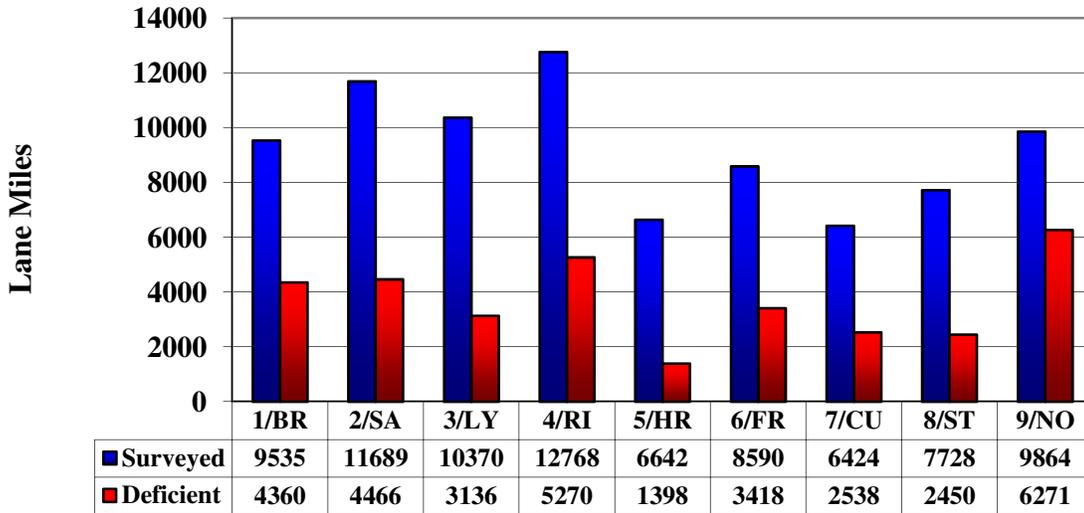


Figure 12: Percent Deficiency by District - Secondary

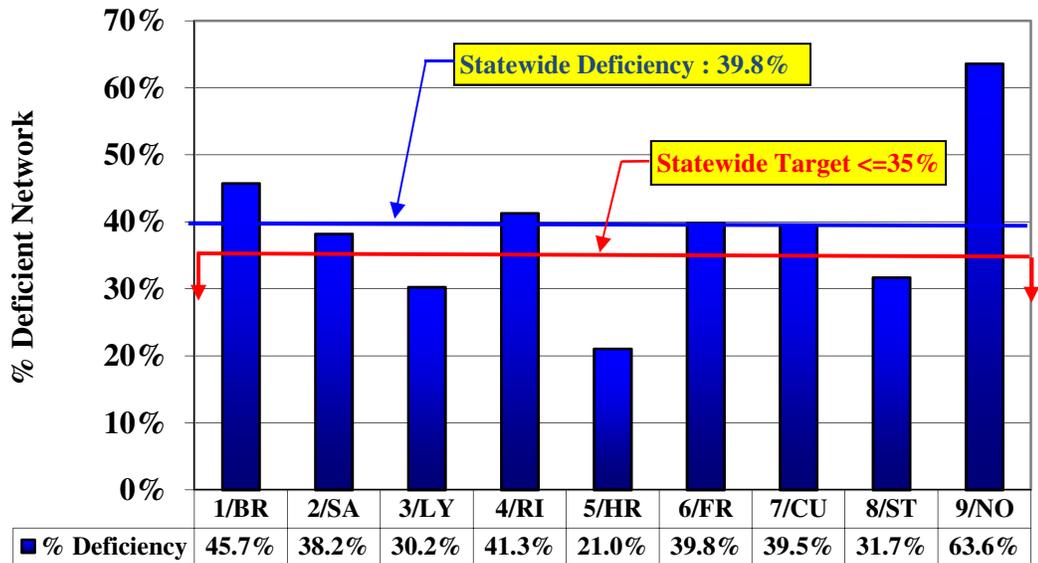


Figure 13: Surveyed Lane Miles - Secondary with Plant Mix (PM) & Non-Plant Mix (NPM) Surface

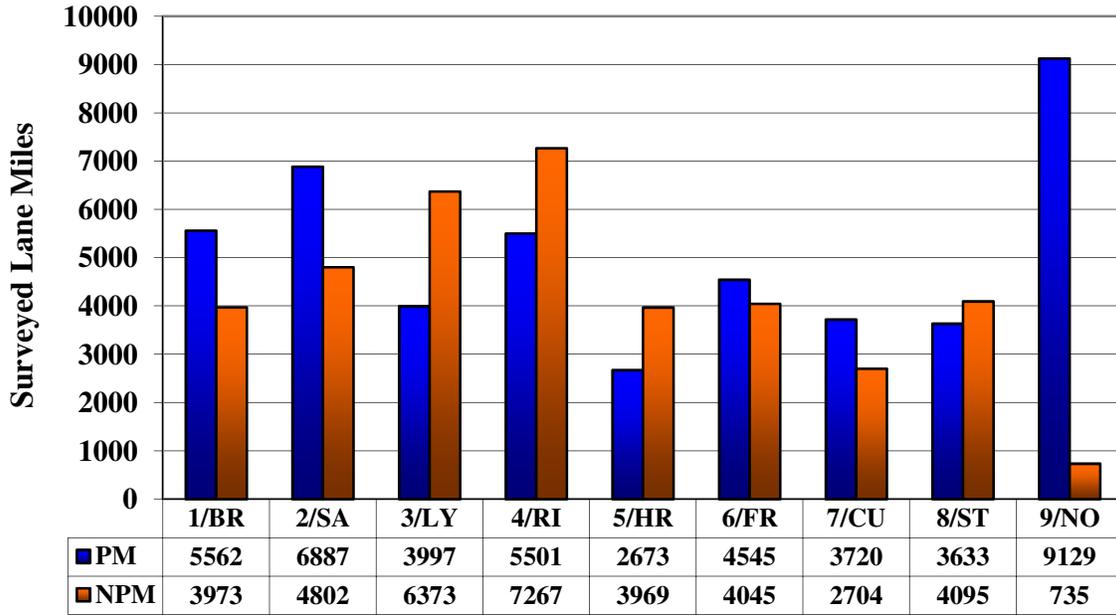
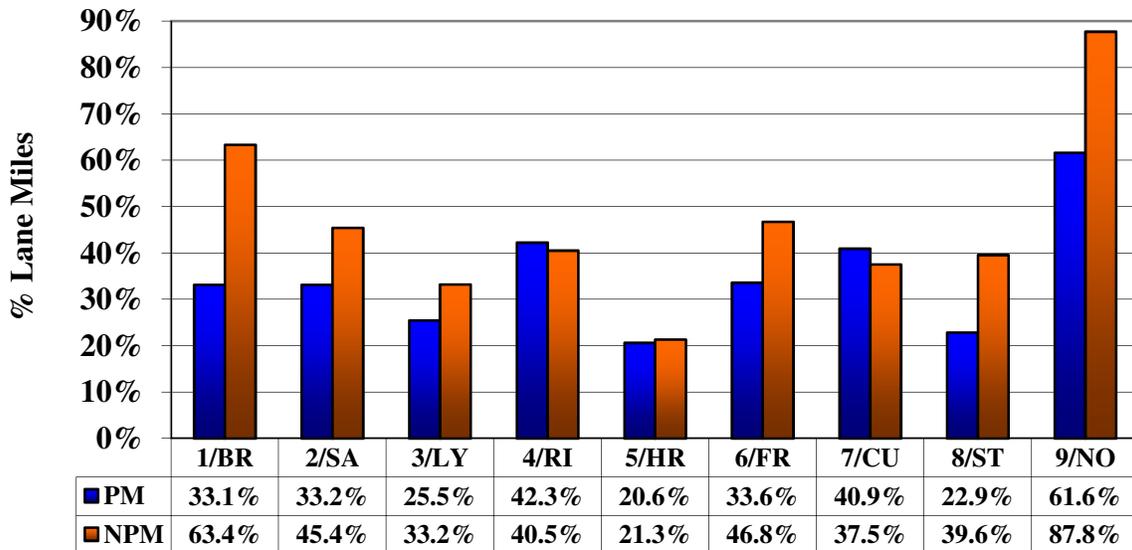


Figure 14: Percent Deficiency by District and Pavement Type - Secondary



PLANT MIX SECONDARY PAVEMENT

Some of the key distress types are shown in Table 8 for plant mix surfaced pavements on the Secondary network.

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) | 3.8% | 3.0% | 3.6% | 5.0% | 3.1% | 4.9% | 5.3% | 2.7% | 6.6% |
| Patching (% total area) | 4.6% | 4.2% | 3.1% | 3.4% | 0.7% | 2.1% | 2.8% | 3.9% | 2.8% |
| Rutting (inches) | 0.16 | 0.19 | 0.19 | 0.16 | 0.15 | 0.14 | 0.15 | 0.17 | 0.13 |
| Transverse Cracking (ft/lane mile) | 842 | 1165 | 1371 | 2109 | 1454 | 1995 | 2131 | 770 | 3311 |
| Longitudinal Cracking (ft/lane mile) | 1421 | 776 | 778 | 1335 | 832 | 1315 | 1262 | 666 | 2494 |

NON-PLANT MIX SECONDARY PAVEMENT

Some of the key distress types are shown in Table 9 for non-plant mix surfaced Secondary 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) | 4.5% | 2.7% | 2.8% | 3.3% | 2.6% | 5.1% | 4.1% | 2.5% | 9.4% |
| Patching (% total area) | 8.8% | 6.2% | 5.5% | 6.0% | 1.2% | 3.6% | 3.7% | 8.2% | 4.4% |
| Rutting (inches) | 0.26 | 0.25 | 0.25 | 0.21 | 0.21 | 0.24 | 0.23 | 0.23 | 0.18 |
| Transverse Cracking (ft/lane mile) | 843 | 879 | 714 | 1010 | 756 | 1744 | 1041 | 507 | 3715 |
| Longitudinal Cracking (ft/lane mile) | 1632 | 899 | 718 | 755 | 587 | 1075 | 999 | 557 | 3048 |

PAVEMENT RIDE QUALITY - 2016

RIDE QUALITY EVALUATION CRITERIA

Pavement roughness is generally defined as an expression of the aggregation of irregularities in the pavement surface per linear mile that adversely affect the ride quality of a vehicle (and thus the user). Roughness is an important pavement characteristic because it affects not only ride quality but also vehicle delay costs, fuel consumption and maintenance costs; also, 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.

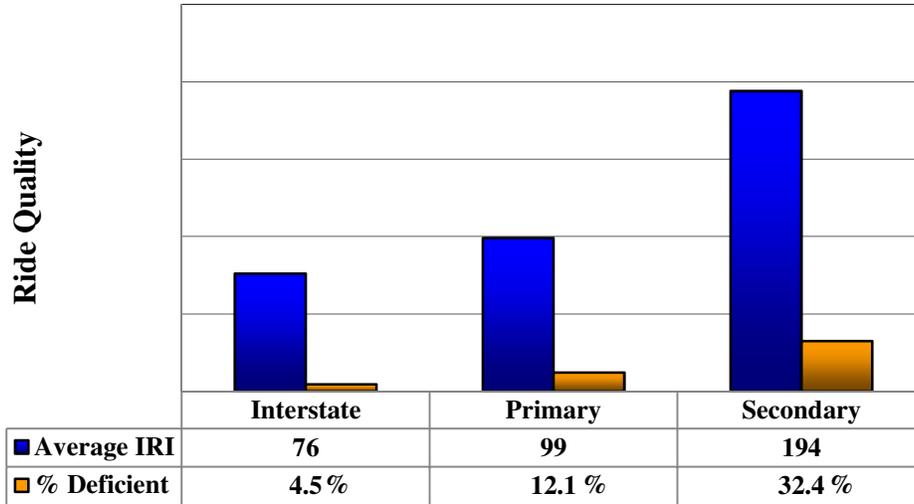
Table 10 contains two IRI scales used for evaluation of the 2016 pavement ride quality survey: one set for Interstate and Primary highways, and the other for Secondary roads. It needs to be pointed out that ranges of IRI values corresponding to qualitative descriptors of ride quality were built upon similar categories promulgated by FHWA ⁽⁴⁾ and incorporated consensus 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, Primary, and Secondary pavements the data are collected on the entire network.

**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 for AC pavements are the lower than for CRC and 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

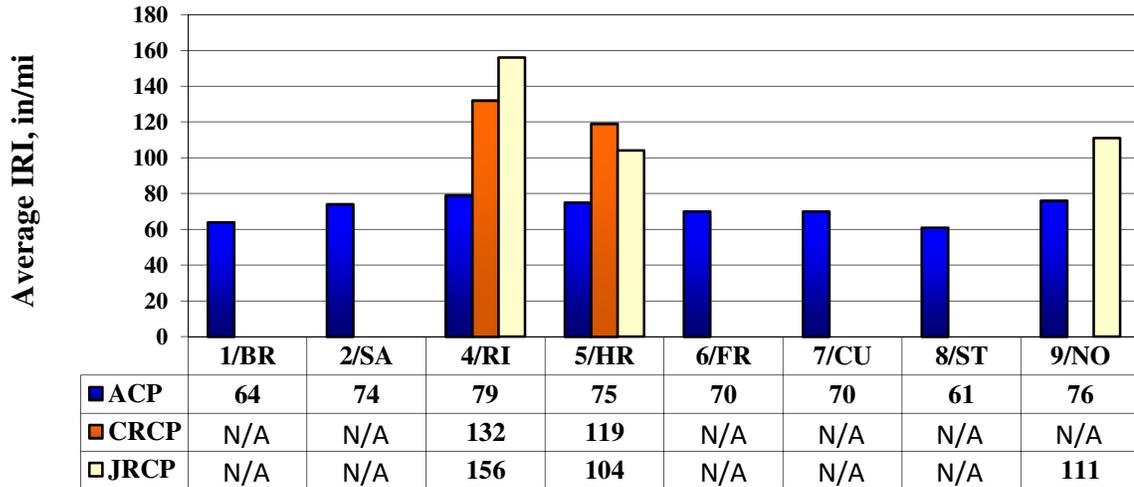
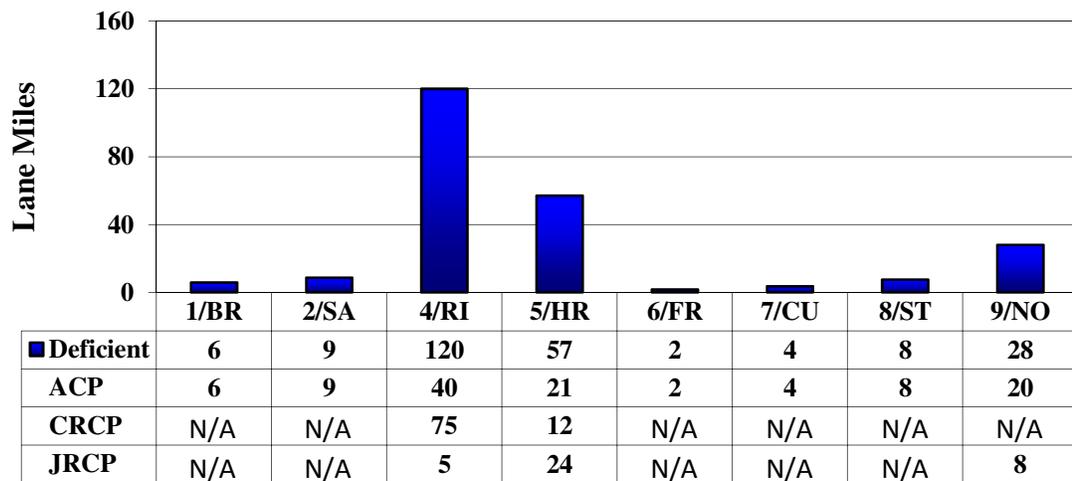


Figure 17: No. of Deficient Lane Miles Due to Ride Quality by Pavement Type - Interstate



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 IRI values lower than CRC or JRC pavements.

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

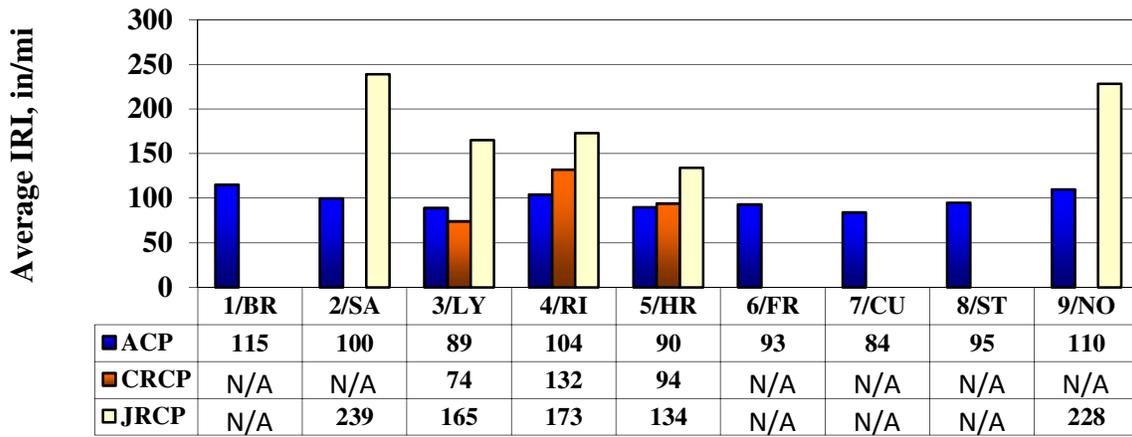
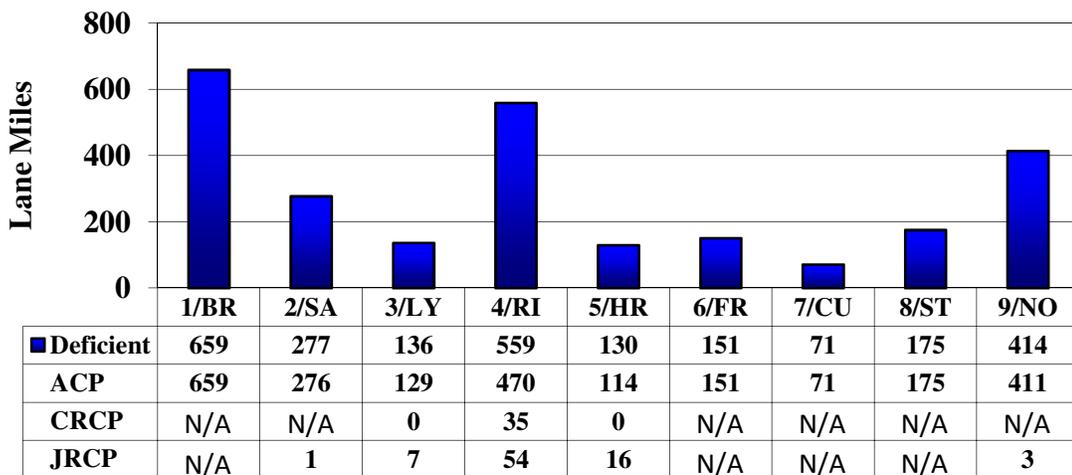


Figure 19: No. of Deficient Lane Miles Due to Ride Quality by Pavement Type - Primary



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

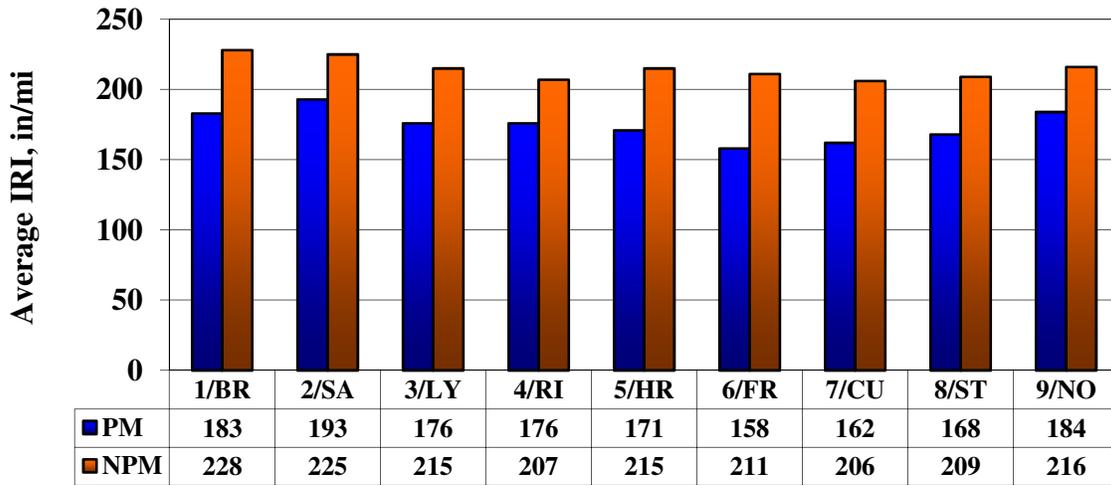
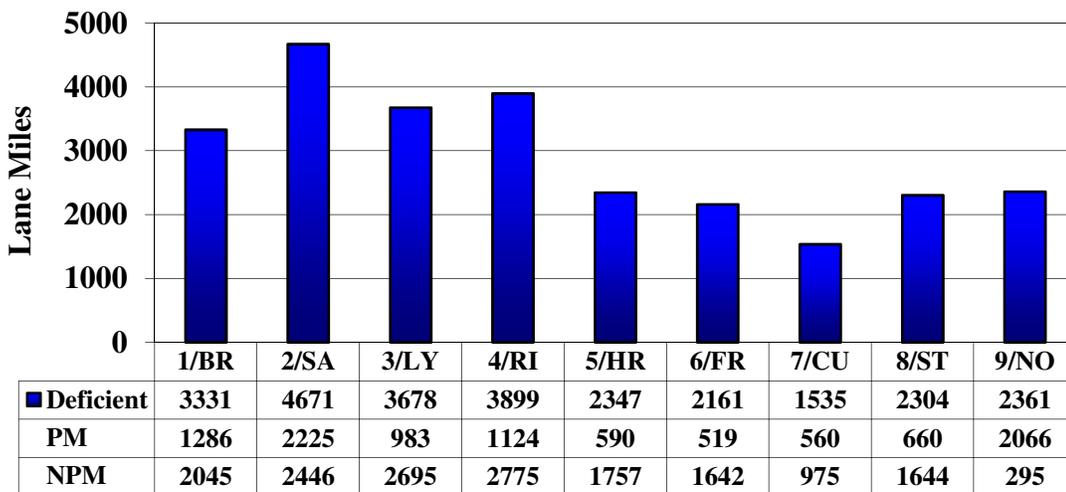


Figure 21 : No. of Deficient Lane Miles Due to Ride Quality by Pavement Type - Secondary



USES & LIMITATIONS OF 2016 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 data are also used to feed the maintenance decision trees to determine the unconstrained maintenance needs for the pavement assets. 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⁽⁵⁾. Also, traffic level, structural condition, and maintenance history are provided as additional inputs wherever these are available for the selection of treatment. 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.

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 annual infrastructure condition report required by Section 33.2-232 of the Code of Virginia. The second biennial report required by Section 33.2-352 of the Code of Virginia, concerns asset management practices.

The data are also used for tracking performance measures on the dashboard and are 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 as a bar chart. 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 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.

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.

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⁽⁶⁾.

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.

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 VDOT's 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) might indicate the need for a more detailed investigation or testing. For example, excessive early fatigue cracking suggests structural inadequacy, but does not indicate where the inadequacy lies (foundation, base, surface, etc.) warranting the need for detailed investigation.

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<http://www.fhwa.dot.gov/policy/2002cpr/ch3b.cfm>
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10. *State of the Pavement – 2003, Interstate and Primary Highways*, Virginia Department of Transportation, Asset Management Division, Pavement Management Program, 2003.
11. *State of the Pavement – 2004, Interstate and Primary Highways*, Virginia Department of Transportation, Asset Management Division, Pavement Management Program, 2004.
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13. *State of the Pavement – 2008*, Virginia Department of Transportation, Asset Management Division, Pavement Management Program, 2008.

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15. *State of the Pavement – 2010*, Virginia Department of Transportation, Maintenance Division, Pavement Management Program, 2010.
16. *State of the Pavement – 2011*, Virginia Department of Transportation, Maintenance Division, Pavement Management Program, 2011.
17. *State of the Pavement – 2012*, Virginia Department of Transportation, Maintenance Division, Pavement Management Program, 2012.
18. *State of the Pavement – 2013*, Virginia Department of Transportation, Maintenance Division, Pavement Management Program, 2013.
19. *State of the Pavement – 2014*, Virginia Department of Transportation, Maintenance Division, Pavement Management Program, 2014.
20. *State of the Pavement – 2015*, Virginia Department of Transportation, Maintenance Division, Pavement Management Program, 2015.
21. ASTM E 177 – 13, *Standard Practice for Use of the Terms Precision and Bias in ASTM Test Methods*.

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 ¾ 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 ¾ 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

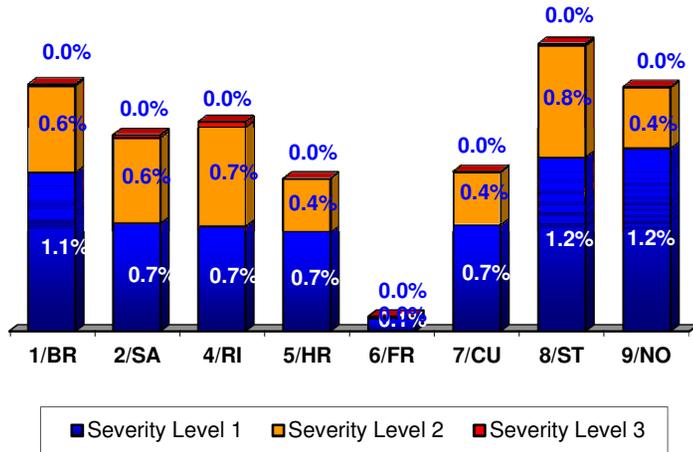
| Description | Field Name | Pavement Type | Units | Format | Comments |
|--|--------------|---------------|-------------|--------|---|
| IRI Left WP | NIRI_L | JRCP | inches/mile | 999 | Save profile data - RoadRuf, Maximum IRI is 500 inches per mile |
| IRI Right WP | NIRI_R | JRCP | inches/mile | 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") | NJFLT0_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

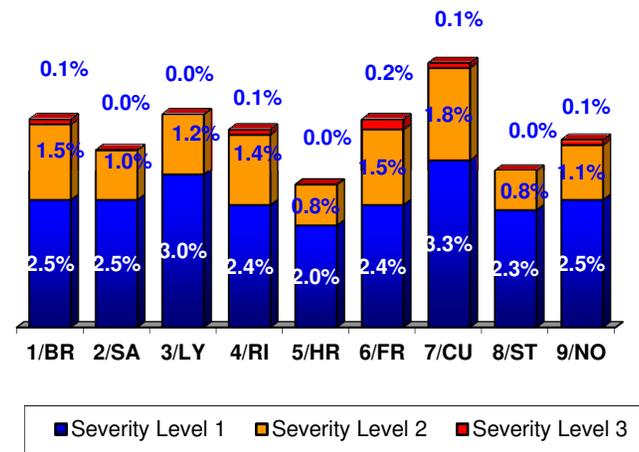
| Description | Field Name | Format | Comments | Calculations |
|---|------------------|---------|--|---|
| Frequency of Alligator/Fatigue cracking. This is a numeric field with values of 0, 1, 2 or 3. | la_cr_freq | 9 | 0 is none, 1 is rare, 2 is occasional and 3 is frequent. | rare = (wheel path + non wheel path alligator cracking area in SF) / (7*length), if this quantity is > 0 to 10% : Occasional 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 999999. | 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 to 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**

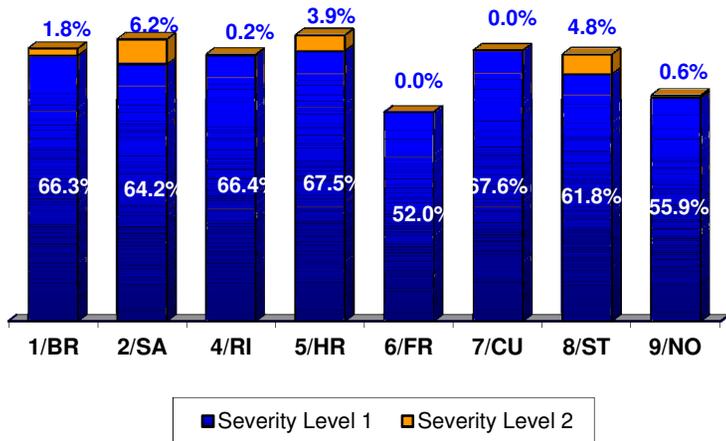
Interstate Asphalt Pavement - Alligator Cracking
(% of total area)



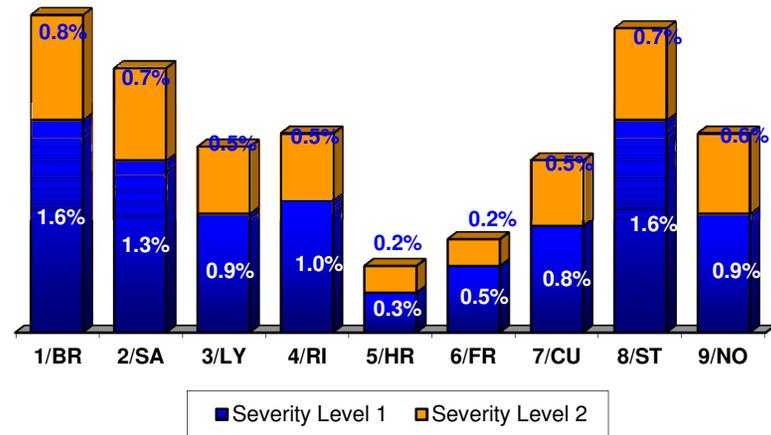
Primary Asphalt Pavement - Alligator Cracking
(% of total area)



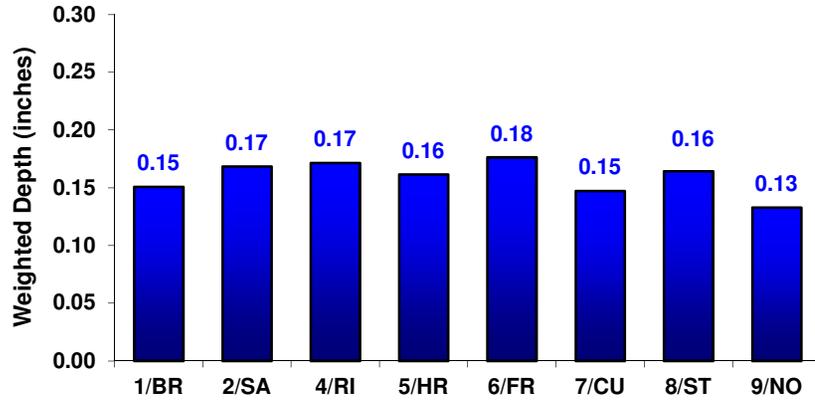
Interstate Asphalt Pavement - Patching
(% of pavement with patching, weighted by area)



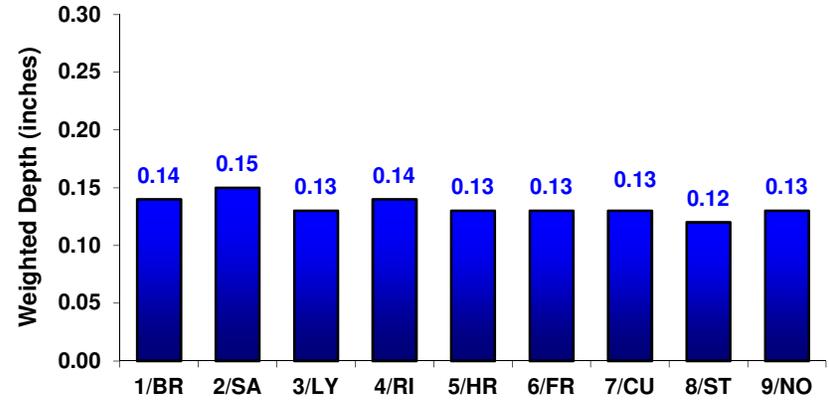
Primary Asphalt Pavement - Patching
(% of pavement with patching, weighted by area)



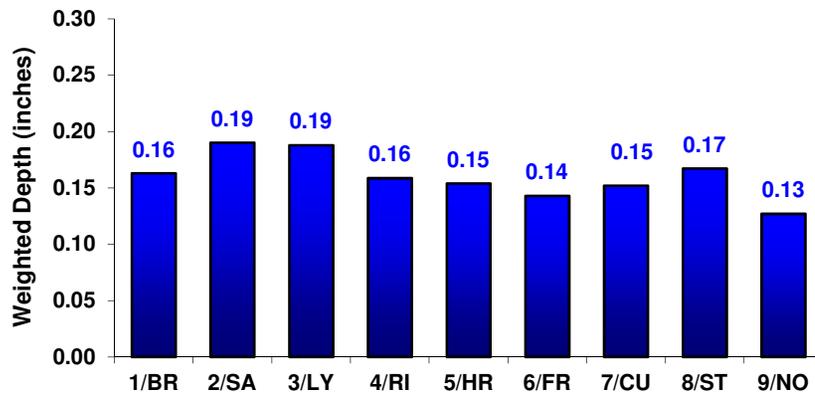
**Interstate Asphalt Pavement - Rut Depth
(inches)**



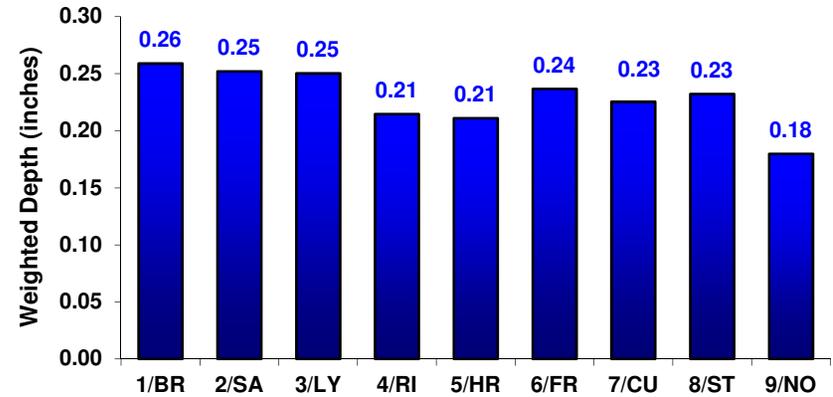
**Primary Asphalt Pavement - Rut Depth
(inches)**



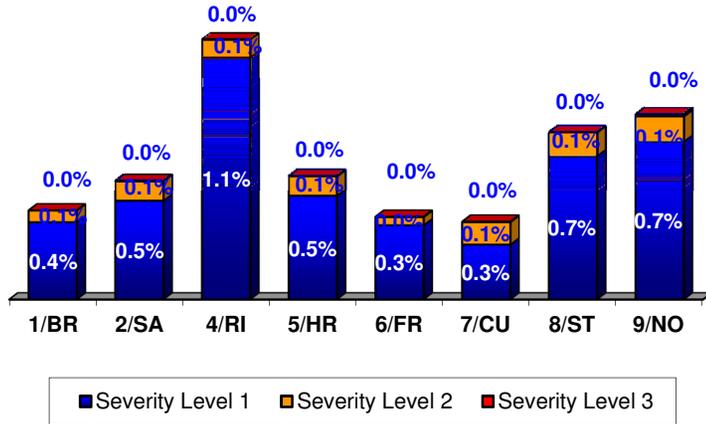
**Secondary Plant Mix Pavement - Rut Depth
(inches)**



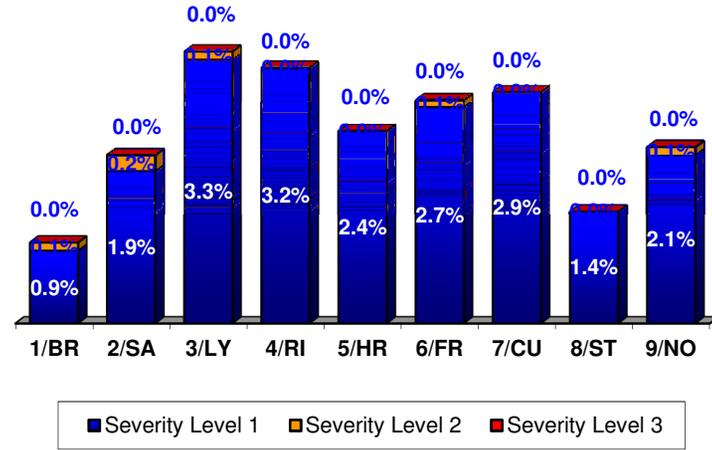
**Secondary Non-Plant Mix Pavement - Rut Depth
(inches)**



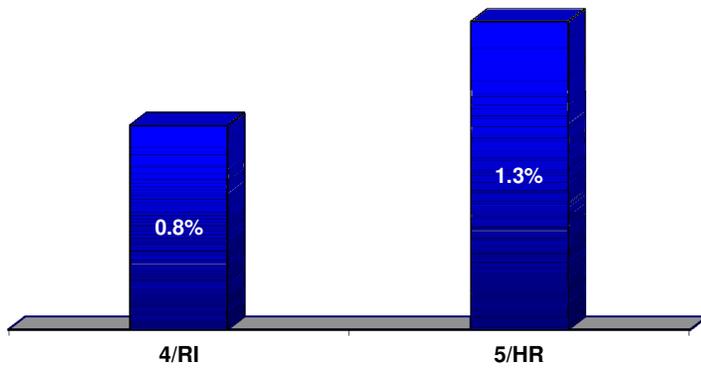
Interstate Asphalt Pavement - Transverse Cracking
(% of total area)



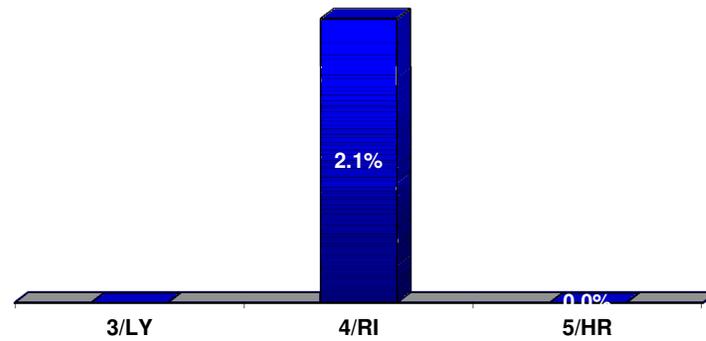
Primary Asphalt Pavement - Transverse Cracking
(% of total area)



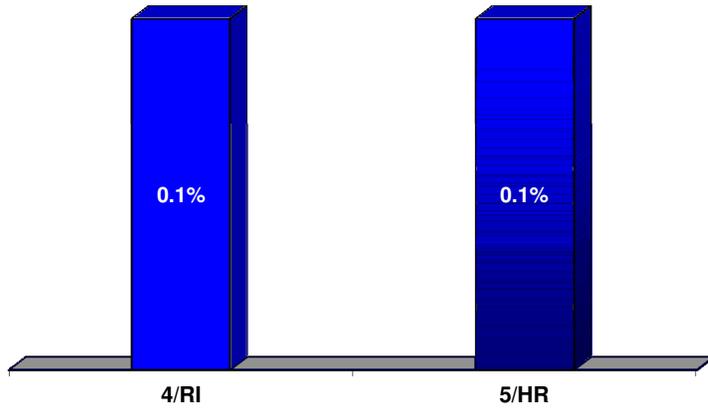
Interstate CRC Pavement - Asphalt Patching
(% of total area)



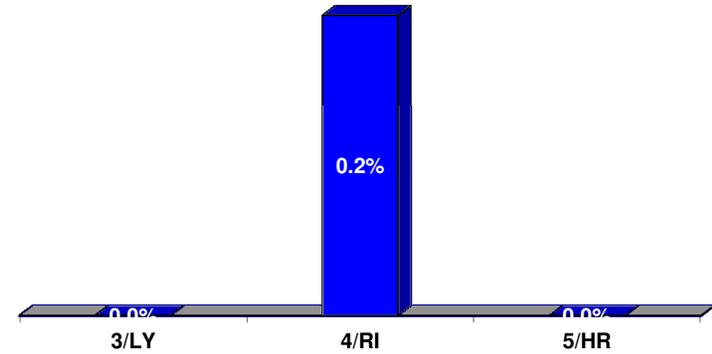
Primary CRC Pavement - Asphalt Patching
(% of total area)



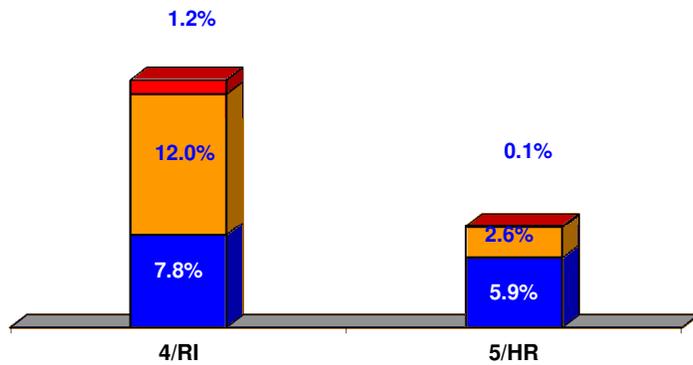
**Interstate CRC Pavement - Punchout
(% of total area)**



**Primary CRC Pavement - Punchout
(% of total area)**

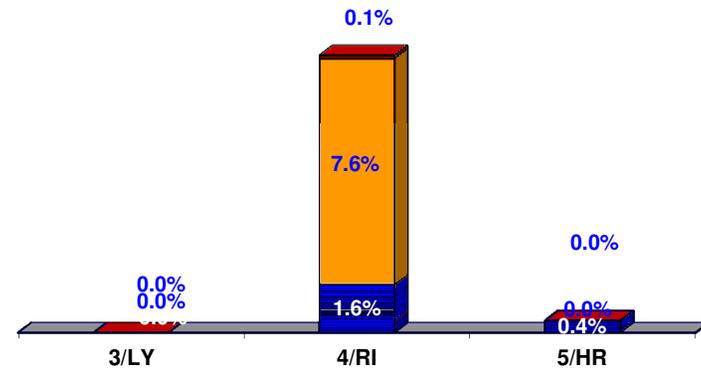


**Interstate CRC Pavement - PCC Patching
(% of total area)**



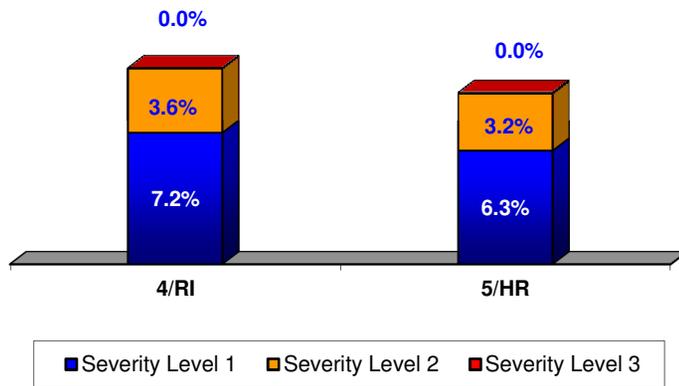
■ Severity Level 1 ■ Severity Level 2 ■ Severity Level 3

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

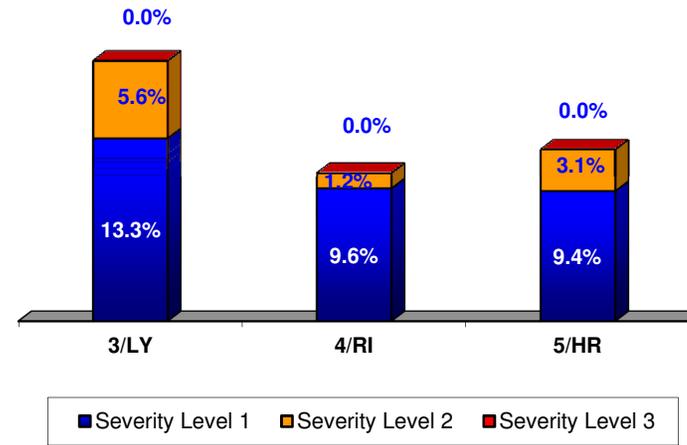


■ Severity Level 1 ■ Severity Level 2 ■ Severity Level 3

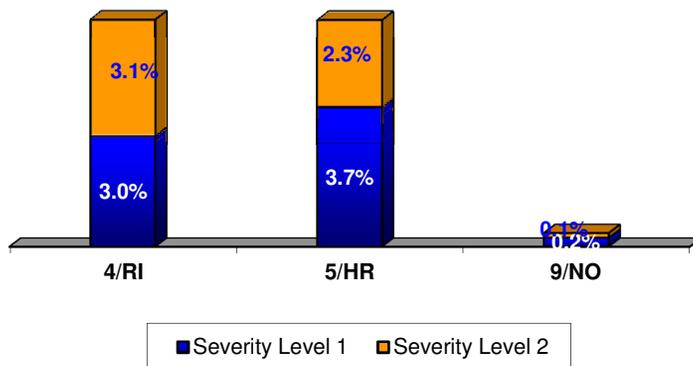
Interstate CRC Pavement-Transverse Cracking
(% of total area)



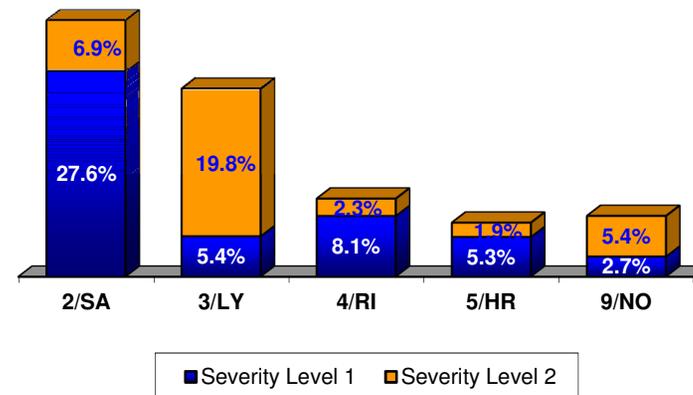
Primary CRC Pavement - Transverse Cracking
(% of total area)



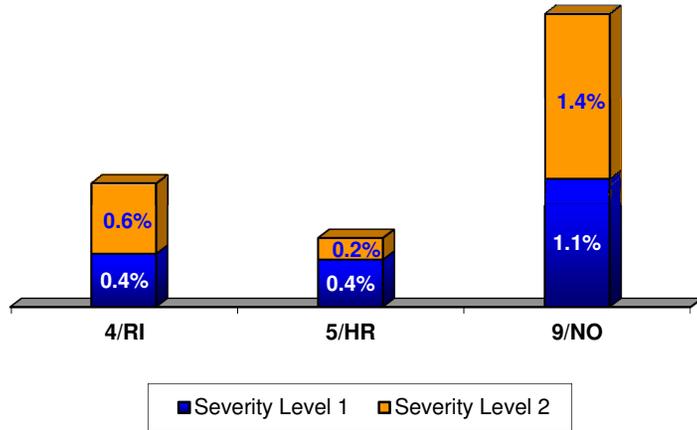
Interstate JRC Pavement - Transverse Cracking
(% of total slabs)



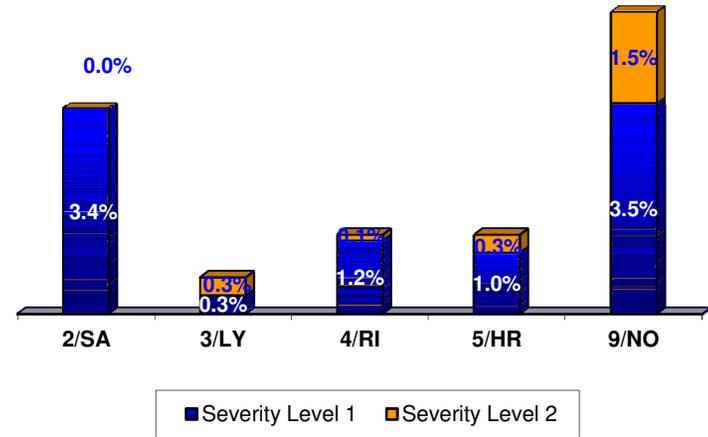
Primary JRC Pavement - Transverse Cracking
(% of total slabs)



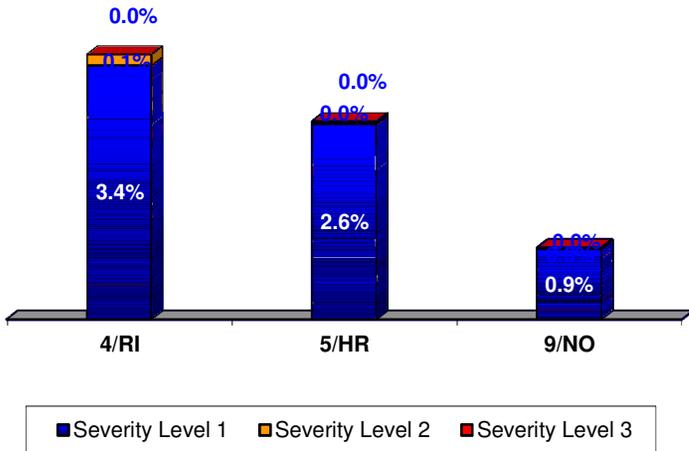
Interstate JRC Pavement - Corner Breaks
(% of total slabs)



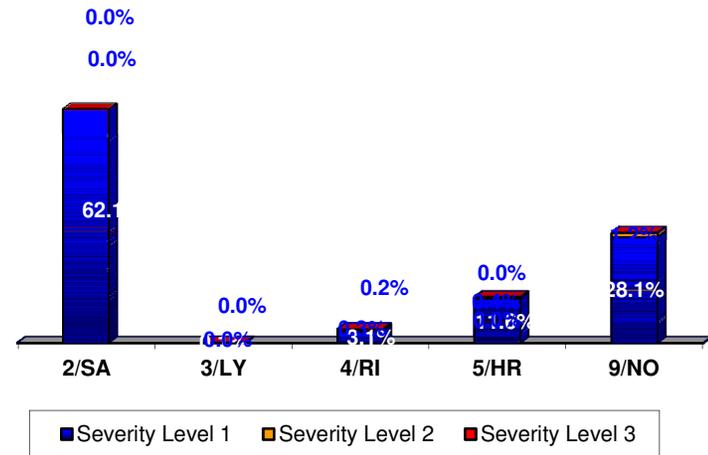
Primary JRC Pavement - Corner Breaks
(% of total slabs)



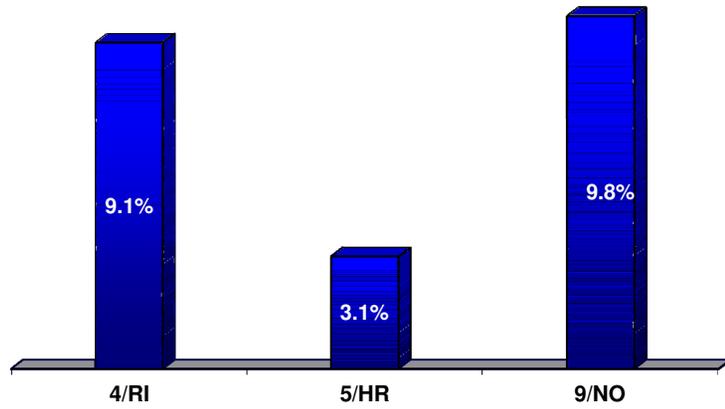
Interstate JRC Pavement - PCC Patching
(% of total slabs)



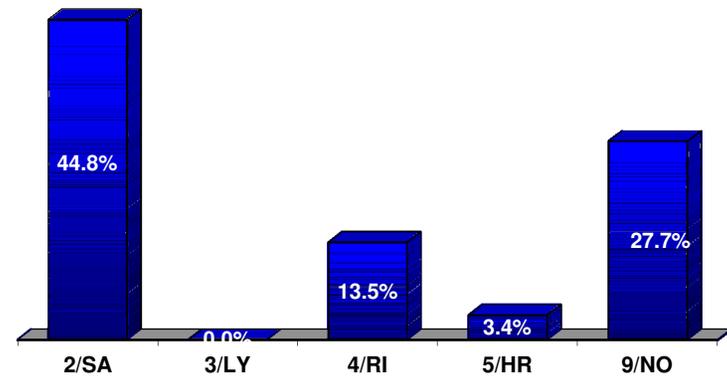
Primary JRC Pavement - PCC Patching
(% of total slabs)



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



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



**APPENDIX C: PAVEMENT CONDITION BY DISTRICT AND COUNTY -
2016**

Table C1. Pavement Condition by District and County for Interstate System – 2016

| District | County No. | County Name | Lane Miles Rated, Interstate | Deficient Lane Miles | % Deficient |
|--------------------|------------|---------------|------------------------------|----------------------|-------------|
| Bristol (1) | 10 | Bland | 86.76 | 8.34 | 9.61% |
| | 86 | Smythe | 93.18 | 8.48 | 9.10% |
| | 95 | Washington | 164.66 | 2.70 | 1.64% |
| | 98 | Wythe | 192.10 | 21.48 | 11.18% |
| District 1 Total | | | 536.70 | 41.00 | 7.64% |
| Salem (2) | 11 | Botetourt | 107.20 | 4.16 | 3.88% |
| | 17 | Carroll | 103.69 | 7.84 | 7.56% |
| | 60 | Montgomery | 109.81 | 9.60 | 8.74% |
| | 77 | Pulaski | 70.36 | 17.20 | 24.45% |
| | 80 | Roanoke | 106.99 | 11.30 | 10.56% |
| District 2 Total | | | 498.05 | 50.10 | 10.06% |
| Richmond (4) | 12 | Brunswick | 82.68 | 2.46 | 2.98% |
| | 20 | Chesterfield | 136.80 | 7.29 | 5.33% |
| | 26 | Dinwiddie | 120.18 | 46.10 | 38.36% |
| | 37 | Goochland | 111.66 | 6.52 | 5.84% |
| | 42 | Hanover | 168.22 | 6.18 | 3.67% |
| | 43 | Henrico | 394.66 | 77.94 | 19.75% |
| | 58 | Mecklenburg | 78.08 | 38.98 | 49.92% |
| | 63 | New Kent | 80.48 | 0.72 | 0.89% |
| | 74 | Prince George | 127.99 | 81.56 | 63.72% |
| District 4 Total | | | 1300.75 | 267.75 | 20.58% |
| Hampton Roads (5) | 40 | Greensville | 68.56 | 0.00 | 0.00% |
| | 47 | James City | 34.76 | 0.00 | 0.00% |
| | 61 | Nansemond | 13.60 | 0.00 | 0.00% |
| | 64 | Norfolk | 302.80 | 8.23 | 2.72% |
| | 75 | Princess Anne | 91.42 | 0.00 | 0.00% |
| | 91 | Sussex | 70.34 | 16.14 | 22.95% |
| | 99 | York | 228.51 | 9.42 | 4.12% |
| District 5 Total | | | 809.99 | 33.79 | 4.17% |
| Fredericksburg (6) | 16 | Caroline | 93.69 | 0.00 | 0.00% |
| | 88 | Spotsylvania | 92.55 | 0.00 | 0.00% |
| | 89 | Stafford | 91.77 | 0.00 | 0.00% |
| District 6 Total | | | 278.01 | 0.00 | 0.00% |
| Culpeper (7) | 2 | Albemarle | 124.82 | 4.94 | 3.96% |
| | 30 | Fauquier | 87.80 | 0.00 | 0.00% |
| | 54 | Louisa | 66.62 | 3.02 | 4.53% |
| District 7 Total | | | 279.24 | 7.96 | 2.85% |
| Staunton (8) | 3 | Alleghany | 163.98 | 46.80 | 28.54% |
| | 7 | Augusta | 191.91 | 20.00 | 10.42% |
| | 34 | Frederick | 102.22 | 4.18 | 4.09% |
| | 81 | Rockbridge | 210.11 | 9.06 | 4.31% |

| District | County No. | County Name | Lane Miles Rated, Interstate | Deficient Lane Miles | % Deficient |
|-----------------------|------------|----------------|------------------------------|----------------------|---------------|
| Staunton (8) | 82 | Rockingham | 108.36 | 0.00 | 0.00% |
| | 85 | Shenandoah | 138.72 | 21.06 | 15.18% |
| | 93 | Warren | 58.98 | 0.00 | 0.00% |
| District 8 Total | | | 974.28 | 101.10 | 10.38% |
| Northern Virginia (9) | 0 | Arlington | 70.70 | 11.16 | 15.79% |
| | 29 | Fairfax | 440.70 | 33.55 | 7.61% |
| | 76 | Prince William | 158.80 | 0.00 | 0.00% |
| District 9 Total | | | 670.20 | 44.71 | 6.67% |
| Statewide | | | 5347.22 | 546.41 | 10.22% |

Table C2. Pavement Condition by District and County for Primary System – 2016

| District | County No. | County Name | Lane Miles Rated, Primary | Deficient Lane Miles | % Deficient |
|------------------|---------------|--------------|---------------------------|----------------------|-------------|
| Bristol (1) | 10 | Bland | 155.57 | 48.58 | 31.23% |
| | 13 | Buchanan | 186.95 | 33.81 | 18.08% |
| | 25 | Dickenson | 163.15 | 31.05 | 19.03% |
| | 38 | Grayson | 237.07 | 69.18 | 29.18% |
| | 52 | Lee | 329.64 | 57.71 | 17.51% |
| | 83 | Russell | 295.81 | 29.63 | 10.02% |
| | 84 | Scott | 275.94 | 73.27 | 26.55% |
| | 86 | Smythe | 176.81 | 22.52 | 12.74% |
| | 92 | Tazewell | 355.58 | 28.59 | 8.04% |
| | 95 | Washington | 256.26 | 34.21 | 13.35% |
| | 97 | Wise | 344.52 | 62.44 | 18.12% |
| 98 | Wythe | 142.88 | 33.71 | 23.59% | |
| District 1 Total | | | 2920.18 | 524.70 | 17.97% |
| Salem (2) | 9 | Bedford | 373.06 | 63.92 | 17.13% |
| | 11 | Botetourt | 264.98 | 65.10 | 24.57% |
| | 17 | Carroll | 208.01 | 31.66 | 15.22% |
| | 22 | Craig | 119.32 | 20.78 | 17.42% |
| | 31 | Floyd | 109.59 | 7.62 | 6.96% |
| | 33 | Franklin | 242.35 | 36.46 | 15.04% |
| | 35 | Giles | 231.72 | 58.23 | 25.13% |
| | 44 | Henry | 343.74 | 49.12 | 14.29% |
| | 60 | Montgomery | 191.91 | 37.95 | 19.77% |
| | 70 | Patrick | 221.72 | 27.84 | 12.56% |
| | 77 | Pulaski | 106.68 | 4.36 | 4.09% |
| 80 | Roanoke | 212.13 | 49.79 | 23.48% | |
| District 2 Total | | | 2625.21 | 452.83 | 17.25% |
| Lynchburg (3) | 5 | Amherst | 298.85 | 38.99 | 13.05% |
| | 6 | Appomattox | 150.79 | 11.54 | 7.65% |
| | 14 | Buckingham | 192.33 | 70.40 | 36.61% |
| | 15 | Campbell | 317.88 | 22.11 | 6.95% |
| | 19 | Charlotte | 274.99 | 80.02 | 29.10% |
| | 24 | Cumberland | 106.52 | 25.55 | 23.99% |
| | 41 | Halifax | 428.28 | 73.50 | 17.16% |
| | 62 | Nelson | 259.50 | 27.60 | 10.63% |
| | 71 | Pittsylvania | 536.59 | 79.09 | 14.74% |
| 73 | Prince Edward | 212.46 | 53.86 | 25.35% | |
| District 3 Total | | | 2778.19 | 482.66 | 17.37% |
| Richmond (4) | 4 | Amelia | 113.50 | 19.94 | 17.56% |
| | 12 | Brunswick | 249.68 | 67.24 | 26.93% |
| | 18 | Charles City | 88.13 | 8.84 | 10.03% |
| | 20 | Chesterfield | 536.09 | 116.56 | 21.74% |

| District | County No. | County Name | Lane Miles Rated, Primary | Deficient Lane Miles | % Deficient |
|--------------------|---------------|----------------|---------------------------|----------------------|-------------|
| Richmond (4) | 26 | Dinwiddie | 252.41 | 46.88 | 18.57% |
| | 37 | Goochland | 191.01 | 40.02 | 20.95% |
| | 42 | Hanover | 235.35 | 48.19 | 20.48% |
| | 43 | Henrico | 410.61 | 97.56 | 23.76% |
| | 55 | Lunenburg | 127.61 | 45.66 | 35.78% |
| | 58 | Mecklenburg | 425.54 | 61.24 | 14.39% |
| | 63 | New Kent | 186.99 | 37.44 | 20.02% |
| | 67 | Nottoway | 216.68 | 54.00 | 24.92% |
| | 72 | Powhatan | 126.62 | 39.24 | 30.99% |
| 74 | Prince George | 188.81 | 36.11 | 19.13% | |
| District 4 Total | | | 3349.03 | 718.92 | 21.47% |
| Hampton Roads (5) | 1 | Accomack | 274.03 | 31.02 | 11.32% |
| | 40 | Greensville | 83.45 | 17.94 | 21.49% |
| | 46 | Isle of Wight | 206.00 | 16.00 | 7.77% |
| | 47 | James City | 179.65 | 10.98 | 6.11% |
| | 61 | Nansemond | 4.48 | 2.94 | 65.65% |
| | 64 | Norfolk | 41.70 | 6.33 | 15.18% |
| | 65 | Northampton | 159.13 | 27.40 | 17.22% |
| | 87 | Southampton | 278.21 | 24.41 | 8.77% |
| | 90 | Surry | 96.08 | 11.49 | 11.96% |
| | 91 | Sussex | 220.66 | 17.24 | 7.81% |
| 99 | York | 149.32 | 6.82 | 4.57% | |
| District 5 Total | | | 1692.71 | 172.57 | 10.19% |
| Fredericksburg (6) | 16 | Caroline | 290.37 | 22.55 | 7.77% |
| | 28 | Essex | 169.31 | 38.33 | 22.64% |
| | 36 | Gloucester | 185.55 | 28.00 | 15.09% |
| | 48 | King George | 208.35 | 33.77 | 16.21% |
| | 49 | King & Queen | 133.78 | 47.11 | 35.21% |
| | 50 | King William | 109.90 | 50.59 | 46.03% |
| | 51 | Lancaster | 126.61 | 5.65 | 4.46% |
| | 57 | Mathews | 66.62 | 15.56 | 23.36% |
| | 59 | Middlesex | 131.71 | 28.73 | 21.81% |
| | 66 | Northumberland | 112.06 | 17.70 | 15.80% |
| | 79 | Richmond | 106.41 | 5.14 | 4.83% |
| | 88 | Spotsylvania | 207.52 | 10.54 | 5.08% |
| | 89 | Stafford | 162.10 | 8.45 | 5.21% |
| 96 | Westmoreland | 141.17 | 20.21 | 14.32% | |
| District 6 Total | | | 2151.46 | 332.33 | 15.45% |
| Culpeper (7) | 2 | Albemarle | 353.32 | 55.21 | 15.62% |
| | 23 | Culpeper | 212.55 | 26.72 | 12.57% |
| | 30 | Fauquier | 319.05 | 57.94 | 18.16% |
| | 32 | Fluvanna | 102.33 | 30.31 | 29.62% |
| | 39 | Greene | 87.70 | 44.29 | 50.50% |
| 54 | Louisa | 239.62 | 46.49 | 19.40% | |

| District | County No. | County Name | Lane Miles Rated, Primary | Deficient Lane Miles | % Deficient |
|-----------------------------|------------|----------------|---------------------------|----------------------|---------------|
| Culpe per (7) | 56 | Madison | 158.57 | 20.81 | 13.12% |
| | 68 | Orange | 187.75 | 35.93 | 19.14% |
| | 78 | Rappahannock | 160.08 | 46.69 | 29.17% |
| District 7 Total | | | 1820.97 | 364.39 | 20.01% |
| Staunton (8) | 3 | Alleghany | 157.24 | 16.57 | 10.54% |
| | 7 | Augusta | 408.22 | 30.67 | 7.51% |
| | 8 | Bath | 149.58 | 11.07 | 7.40% |
| | 21 | Clarke | 148.55 | 1.26 | 0.85% |
| | 34 | Frederick | 345.85 | 1.86 | 0.54% |
| | 45 | Highland | 141.90 | 24.14 | 17.01% |
| | 69 | Page | 149.05 | 12.08 | 8.11% |
| | 81 | Rockbridge | 268.65 | 15.92 | 5.93% |
| | 82 | Rockingham | 407.54 | 79.20 | 19.43% |
| | 85 | Shenandoah | 214.82 | 8.96 | 4.17% |
| 93 | Warren | 88.87 | 0.00 | 0.00% | |
| District 8 Total | | | 2480.27 | 201.73 | 8.13% |
| Northern Virginia (9) | 0 | Arlington | 154.12 | 29.57 | 19.19% |
| | 29 | Fairfax | 757.71 | 100.66 | 13.28% |
| | 53 | Loudoun | 375.01 | 61.30 | 16.35% |
| | 76 | Prince William | 381.76 | 28.35 | 7.43% |
| District 9 Total | | | 1668.60 | 219.88 | 13.18% |
| Statewide | | | 21486.62 | 3470.01 | 16.15% |

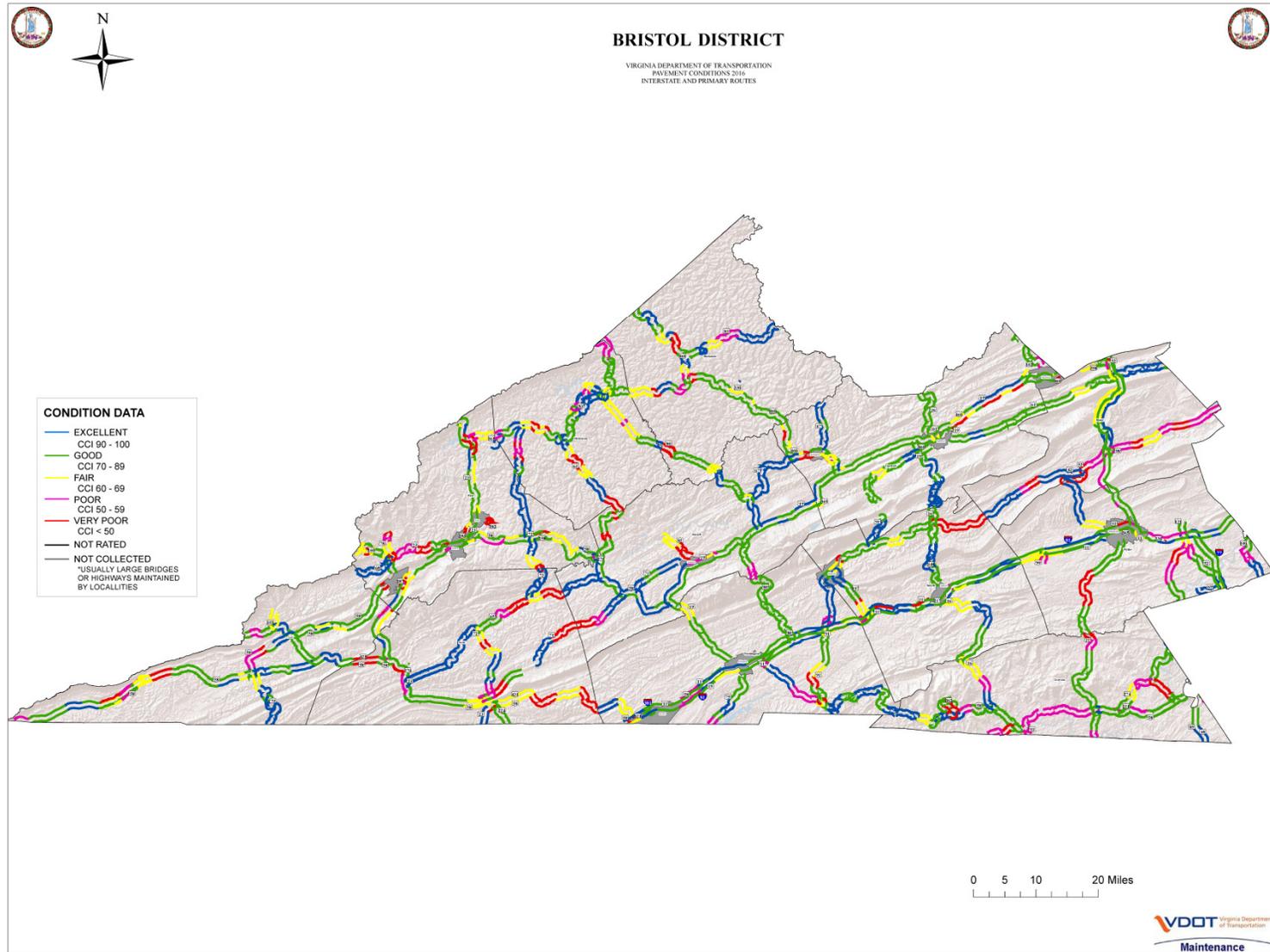
**Table C3. Pavement Condition by District and County for
Secondary System – 2016**

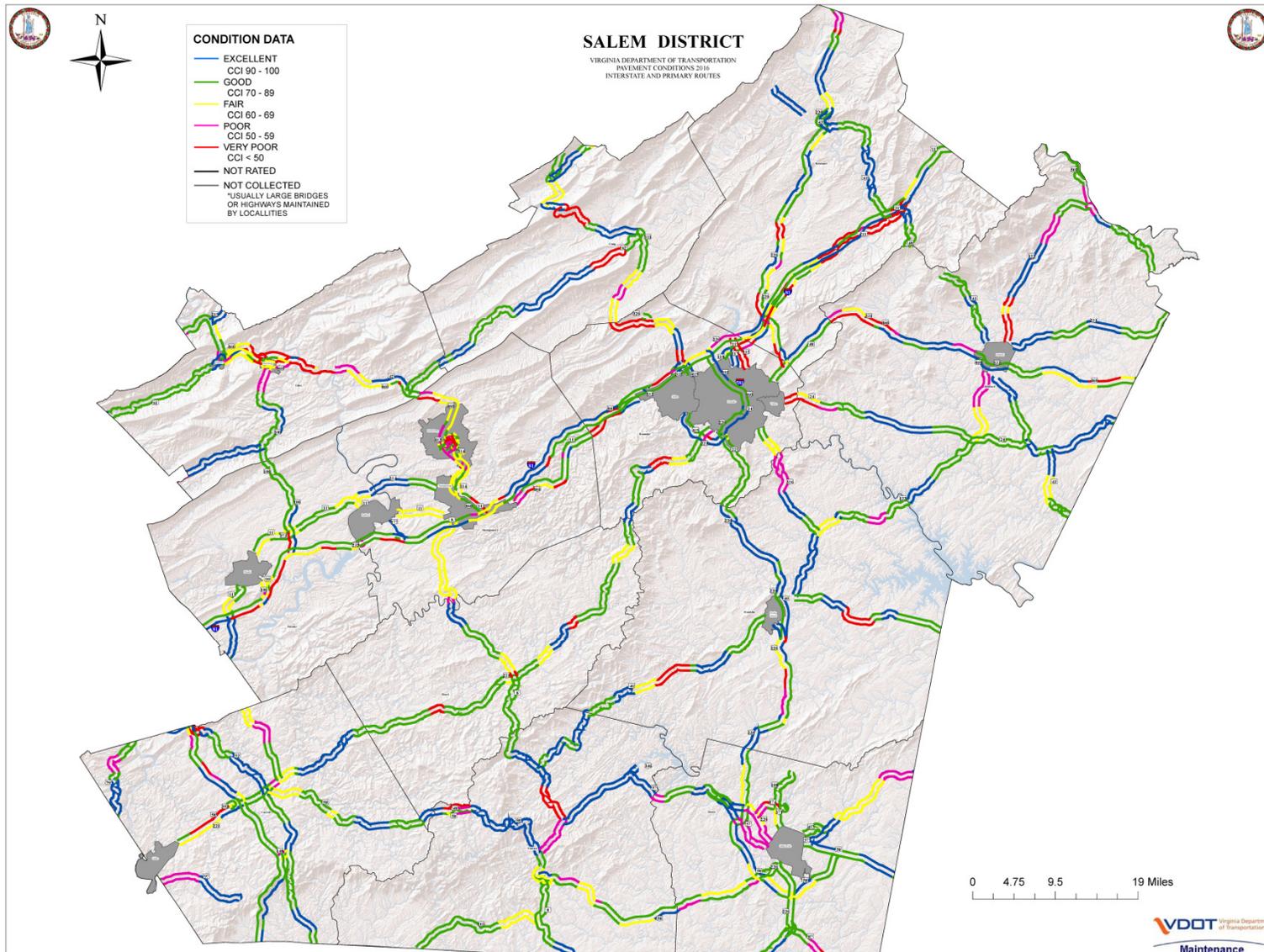
| District | County No. | County Name | Lane Miles Rated, Secondary | Deficient Lane Miles | % Deficient |
|------------------|---------------|--------------|-----------------------------|----------------------|-------------|
| Bristol (1) | 10 | Bland | 340.55 | 165.34 | 48.55% |
| | 13 | Buchanan | 843.62 | 375.02 | 44.45% |
| | 25 | Dickenson | 749.10 | 318.97 | 42.58% |
| | 38 | Grayson | 708.47 | 412.39 | 58.21% |
| | 52 | Lee | 836.08 | 196.14 | 23.46% |
| | 83 | Russell | 946.96 | 539.23 | 56.94% |
| | 84 | Scott | 832.55 | 310.76 | 37.33% |
| | 86 | Smythe | 786.08 | 376.42 | 47.89% |
| | 92 | Tazewell | 797.02 | 287.44 | 36.06% |
| | 95 | Washington | 1,295.52 | 758.40 | 58.54% |
| | 97 | Wise | 775.79 | 283.07 | 36.49% |
| 98 | Wythe | 623.14 | 336.84 | 54.06% | |
| District 1 Total | | | 9534.88 | 4360.02 | 45.73% |
| Salem (2) | 9 | Bedford | 1,570.68 | 428.88 | 27.31% |
| | 11 | Botetourt | 809.21 | 317.16 | 39.19% |
| | 17 | Carroll | 1,128.71 | 604.15 | 53.53% |
| | 22 | Craig | 282.98 | 91.82 | 32.45% |
| | 31 | Floyd | 634.45 | 327.91 | 51.68% |
| | 33 | Franklin | 1,959.01 | 768.83 | 39.25% |
| | 35 | Giles | 438.41 | 127.72 | 29.13% |
| | 44 | Henry | 1,367.90 | 544.70 | 39.82% |
| | 60 | Montgomery | 713.48 | 222.91 | 31.24% |
| | 70 | Patrick | 1,033.26 | 325.11 | 31.46% |
| | 77 | Pulaski | 626.38 | 187.30 | 29.90% |
| 80 | Roanoke | 1,124.03 | 519.57 | 46.22% | |
| District 2 Total | | | 11688.50 | 4466.06 | 38.21% |
| Lynchburg (3) | 5 | Amherst | 849.65 | 463.54 | 54.56% |
| | 6 | Appomattox | 790.28 | 246.16 | 31.15% |
| | 14 | Buckingham | 841.43 | 321.04 | 38.15% |
| | 15 | Campbell | 1,351.71 | 311.65 | 23.06% |
| | 19 | Charlotte | 812.23 | 203.09 | 25.00% |
| | 24 | Cumberland | 427.71 | 170.85 | 39.94% |
| | 41 | Halifax | 1,575.92 | 356.52 | 22.62% |
| | 62 | Nelson | 586.46 | 317.14 | 54.08% |
| | 71 | Pittsylvania | 2,478.12 | 590.32 | 23.82% |
| 73 | Prince Edward | 656.95 | 155.88 | 23.73% | |
| District 3 Total | | | 10370.46 | 3136.19 | 30.24% |
| Richmond (4) | 4 | Amelia | 646.25 | 287.87 | 44.54% |
| | 12 | Brunswick | 1,016.42 | 291.79 | 28.71% |
| | 18 | Charles City | 266.12 | 84.31 | 31.68% |
| | 20 | Chesterfield | 3,465.11 | 1,680.92 | 48.51% |

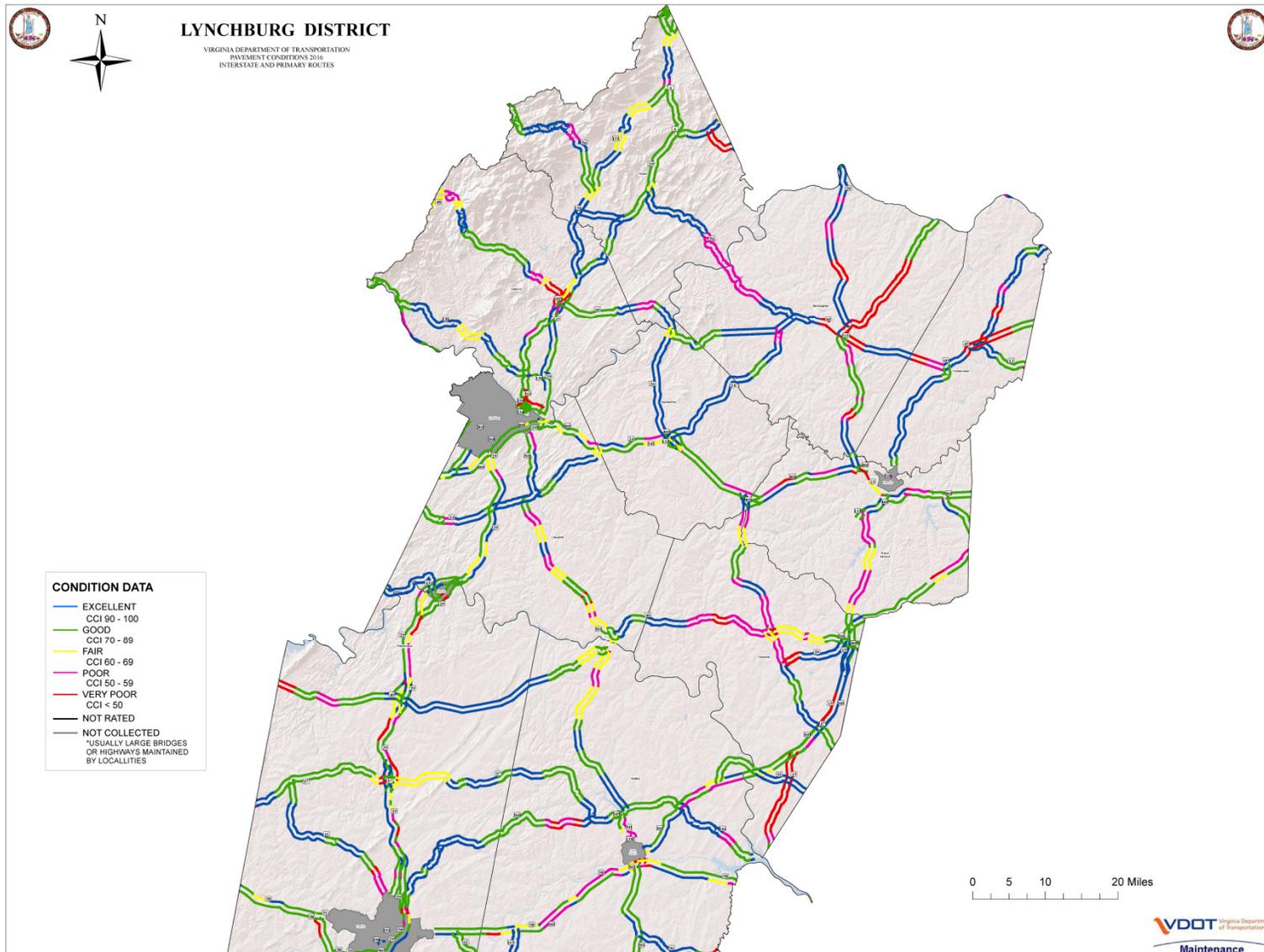
| District | County No. | County Name | Lane Miles Rated, Secondary | Deficient Lane Miles | % Deficient |
|--------------------|------------|----------------|-----------------------------|----------------------|-------------|
| Richmond (4) | 26 | Dinwiddie | 1,007.76 | 344.27 | 34.16% |
| | 37 | Goochland | 662.64 | 300.04 | 45.28% |
| | 42 | Hanover | 1,680.37 | 757.76 | 45.10% |
| | 55 | Lunenburg | 687.01 | 279.64 | 40.70% |
| | 58 | Mecklenburg | 1,160.33 | 284.91 | 24.55% |
| | 63 | New Kent | 418.38 | 154.09 | 36.83% |
| | 67 | Nottoway | 546.18 | 237.48 | 43.48% |
| | 72 | Powhatan | 621.67 | 357.85 | 57.56% |
| | 74 | Prince George | 589.46 | 209.55 | 35.55% |
| District 4 Total | | | 12767.70 | 5270.48 | 41.28% |
| Hampton Roads (5) | 1 | Accomack | 1,103.10 | 505.75 | 45.85% |
| | 40 | Greensville | 547.06 | 52.51 | 9.60% |
| | 46 | Isle of Wight | 826.15 | 118.13 | 14.30% |
| | 47 | James City | 635.58 | 147.23 | 23.16% |
| | 61 | Nansemond | 0.14 | 0.0 | 0.00% |
| | 65 | Northampton | 485.96 | 196.18 | 40.37% |
| | 87 | Southampton | 1,160.35 | 94.96 | 8.18% |
| | 90 | Surry | 495.40 | 57.54 | 11.62% |
| | 91 | Sussex | 783.24 | 64.17 | 8.19% |
| | 99 | York | 604.67 | 161.37 | 26.69% |
| District 5 Total | | | 6641.65 | 1397.84 | 21.05% |
| Fredericksburg (6) | 16 | Caroline | 896.09 | 271.88 | 30.34% |
| | 28 | Essex | 461.56 | 227.27 | 49.24% |
| | 36 | Gloucester | 596.33 | 267.99 | 44.94% |
| | 48 | King George | 332.27 | 96.65 | 29.09% |
| | 49 | King & Queen | 451.86 | 129.42 | 28.64% |
| | 50 | King William | 491.70 | 137.50 | 27.96% |
| | 51 | Lancaster | 418.44 | 138.21 | 33.03% |
| | 57 | Mathews | 268.25 | 105.82 | 39.45% |
| | 59 | Middlesex | 335.12 | 39.88 | 11.90% |
| | 66 | Northumberland | 661.55 | 414.10 | 62.60% |
| | 79 | Richmond | 398.31 | 193.42 | 48.56% |
| | 88 | Spotsylvania | 1,443.95 | 527.89 | 36.56% |
| | 89 | Stafford | 1,237.31 | 521.37 | 42.14% |
| | 96 | Westmoreland | 597.03 | 347.01 | 58.12% |
| District 6 Total | | | 8589.77 | 3418.41 | 39.80% |
| Culpeper (7) | 2 | Albemarle | 1,362.78 | 486.80 | 35.72% |
| | 23 | Culpeper | 704.30 | 361.20 | 51.29% |
| | 30 | Fauquier | 1,258.90 | 752.91 | 59.81% |
| | 32 | Fluvanna | 549.54 | 64.66 | 11.77% |
| | 39 | Greene | 292.27 | 102.51 | 35.07% |
| | 54 | Louisa | 1,002.00 | 260.94 | 26.04% |
| | 56 | Madison | 428.90 | 164.56 | 38.37% |
| | | 68 | Orange | 566.47 | 201.34 |

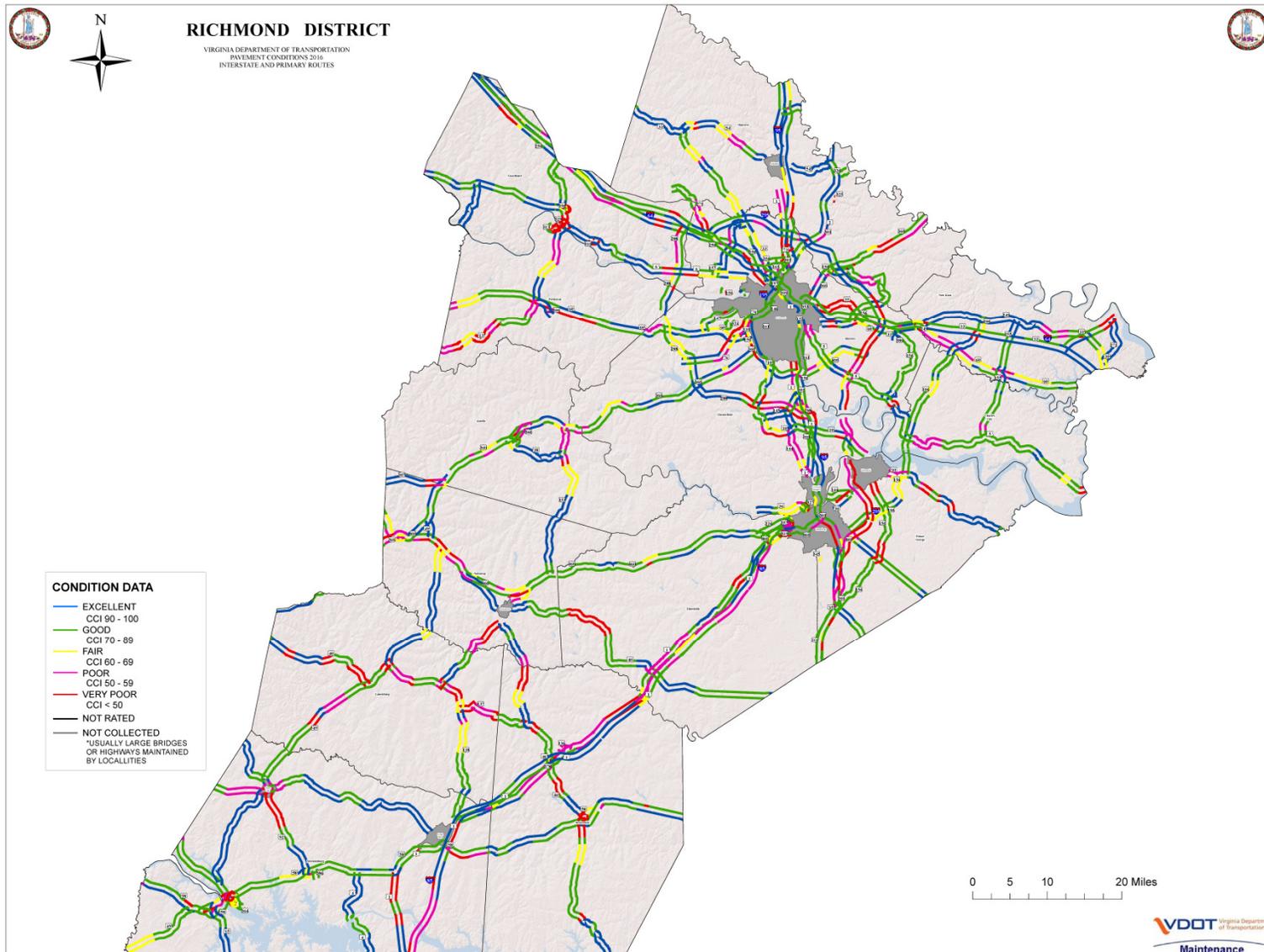
| District | County No. | County Name | Lane Miles Rated, Secondary (Samples) | Deficient Lane Miles | % Deficient |
|-----------------------|------------|----------------|---------------------------------------|----------------------|---------------|
| | 78 | Rappahannock | 259.15 | 143.35 | 55.32% |
| District 7 Total | | | 6424.31 | 2538.27 | 39.51% |
| Staunton (8) | 3 | Alleghany | 430.95 | 174.78 | 40.56% |
| | 7 | Augusta | 1,472.02 | 524.06 | 35.60% |
| | 8 | Bath | 478.20 | 208.51 | 43.60% |
| | 21 | Clarke | 338.44 | 62.30 | 18.41% |
| | 34 | Frederick | 1,036.06 | 237.48 | 22.92% |
| | 45 | Highland | 209.98 | 94.40 | 44.96% |
| | 69 | Page | 488.04 | 51.19 | 10.49% |
| | 81 | Rockbridge | 859.90 | 445.79 | 51.84% |
| | 82 | Rockingham | 1,252.30 | 294.84 | 23.54% |
| | 85 | Shenandoah | 847.99 | 286.13 | 33.74% |
| | 93 | Warren | 314.14 | 70.52 | 22.45% |
| District 8 Total | | | 7728.02 | 2450.00 | 31.70% |
| Northern Virginia (9) | 29 | Fairfax | 5,597.35 | 3,550.42 | 63.43% |
| | 53 | Loudoun | 1,987.94 | 1,246.02 | 62.68% |
| | 76 | Prince William | 2,278.33 | 1,475.01 | 64.74% |
| District 9 Total | | | 9863.62 | 6271.45 | 63.58% |
| Statewide | | | 83,608.91 | 33,308.72 | 39.84% |

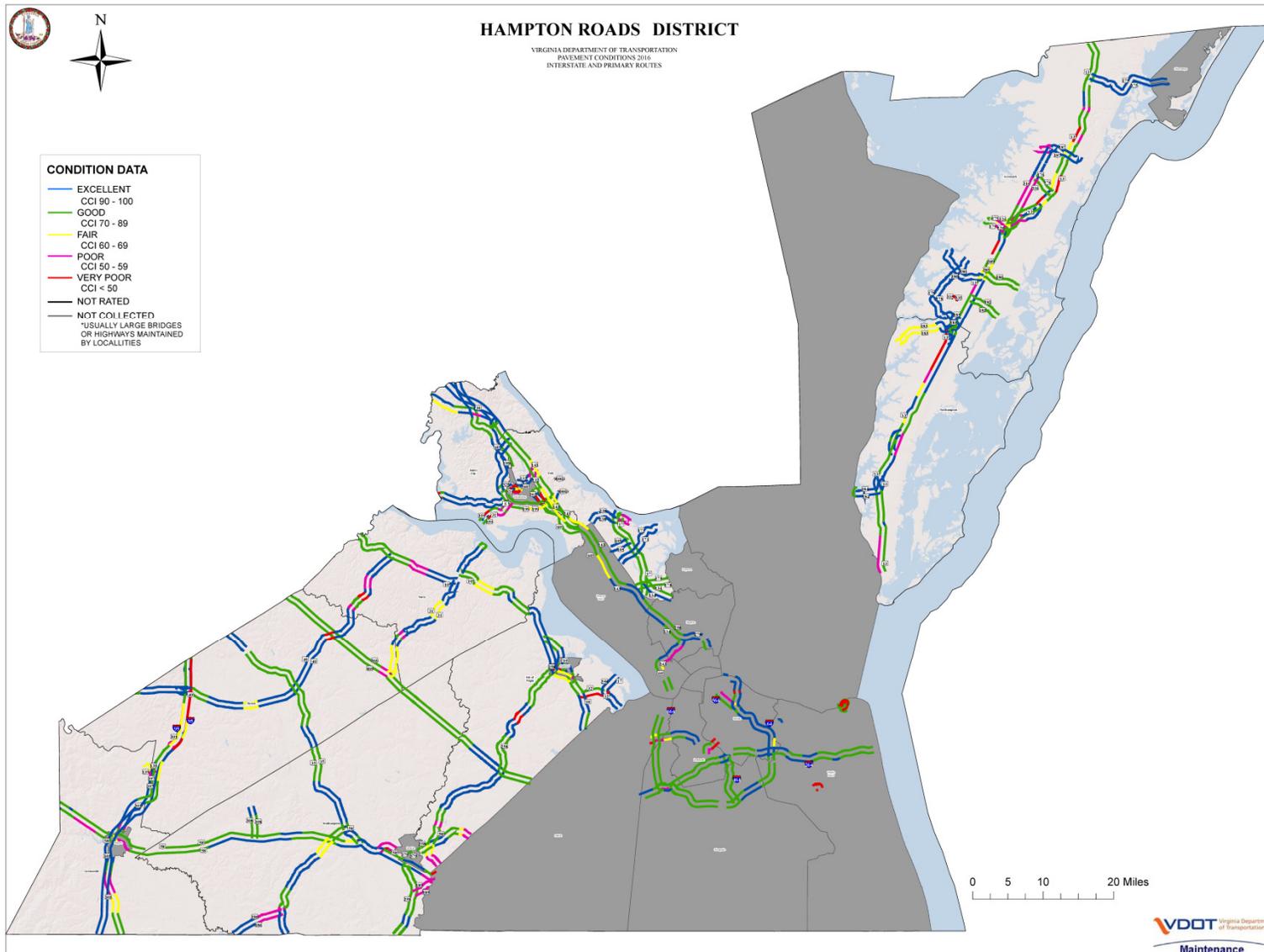
**APPENDIX D: PAVEMENT CONDITION MAPS FOR INTERSTATE AND
PRIMARY SYSTEMS - 2016**

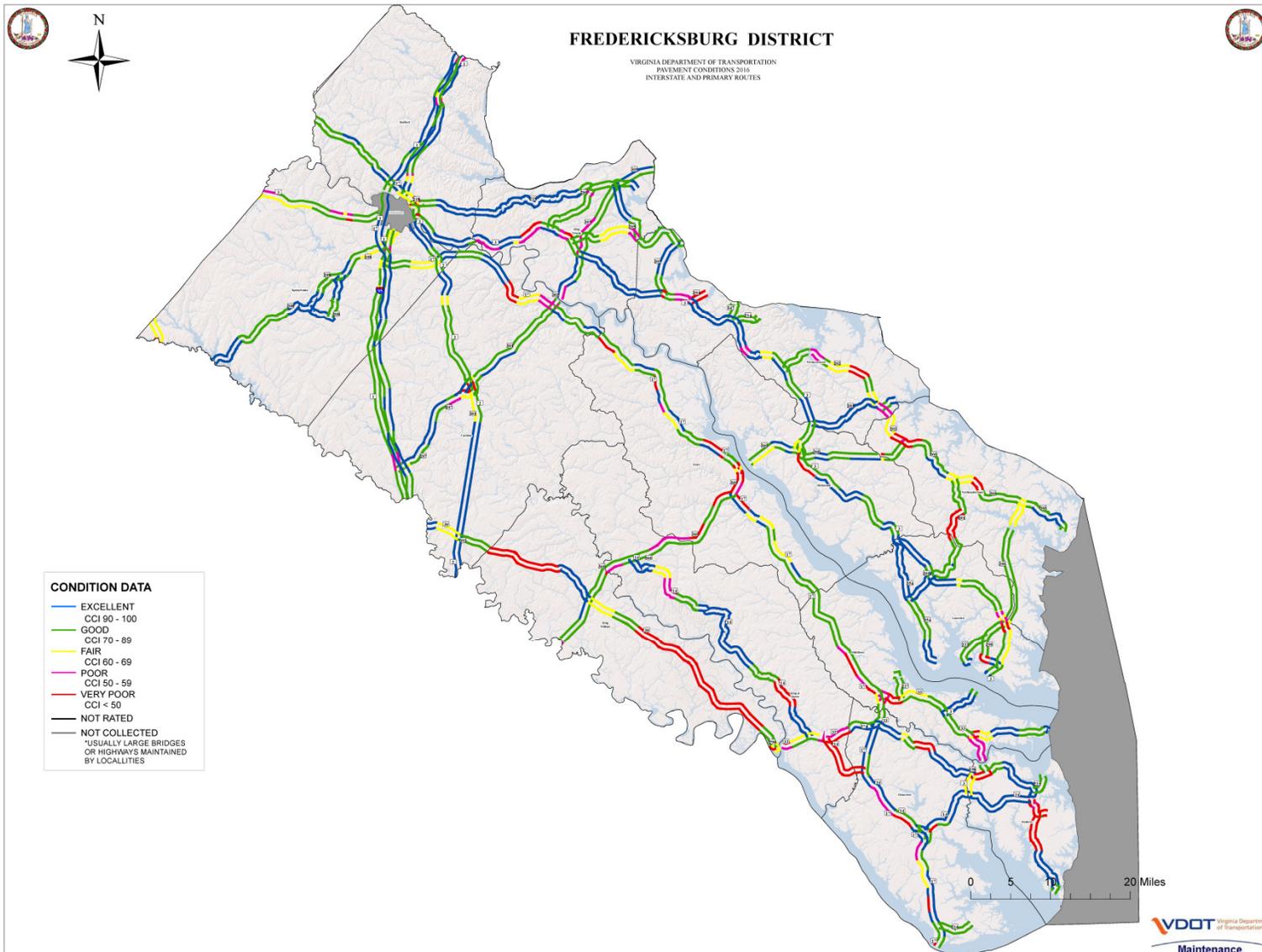


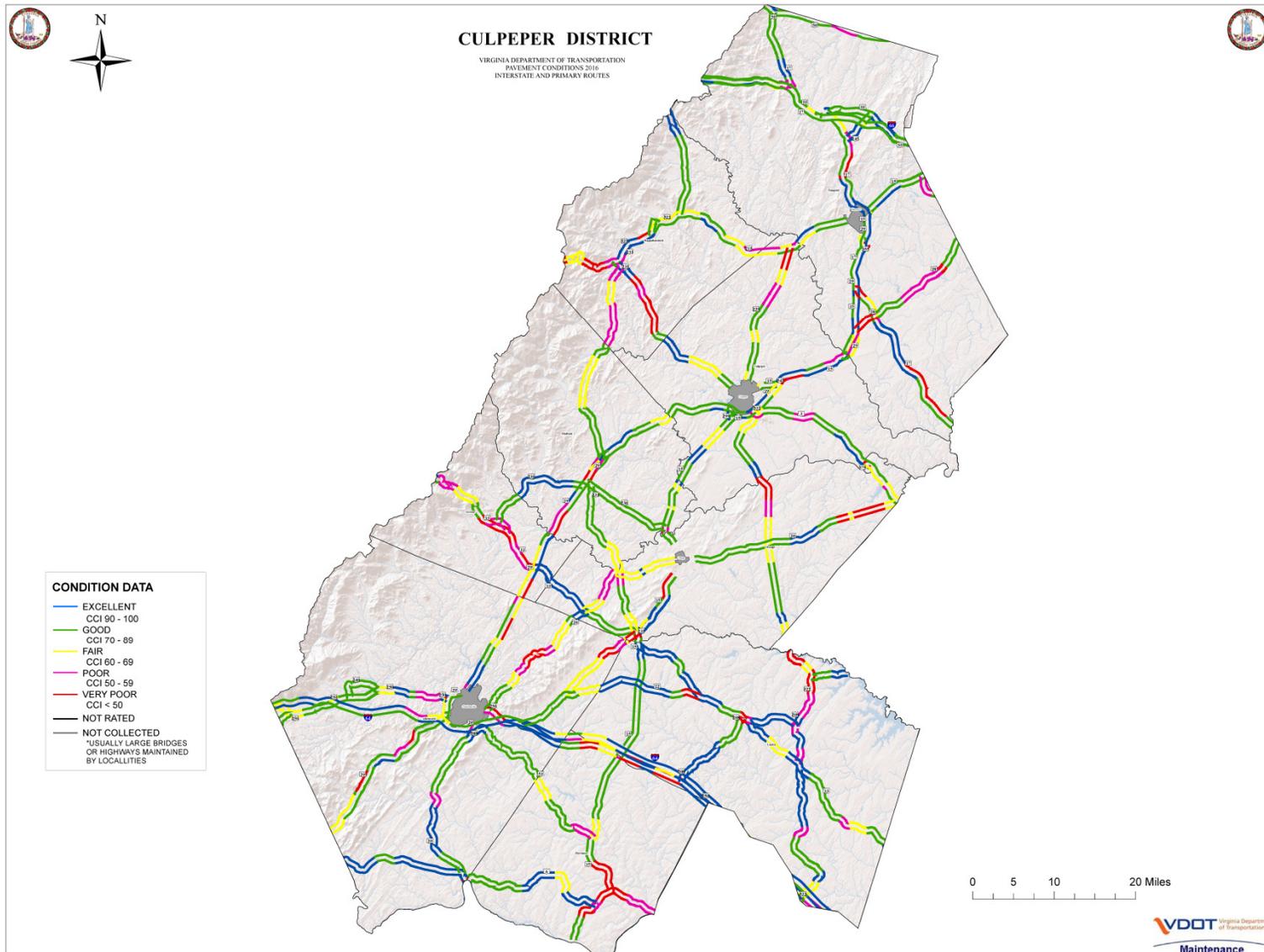


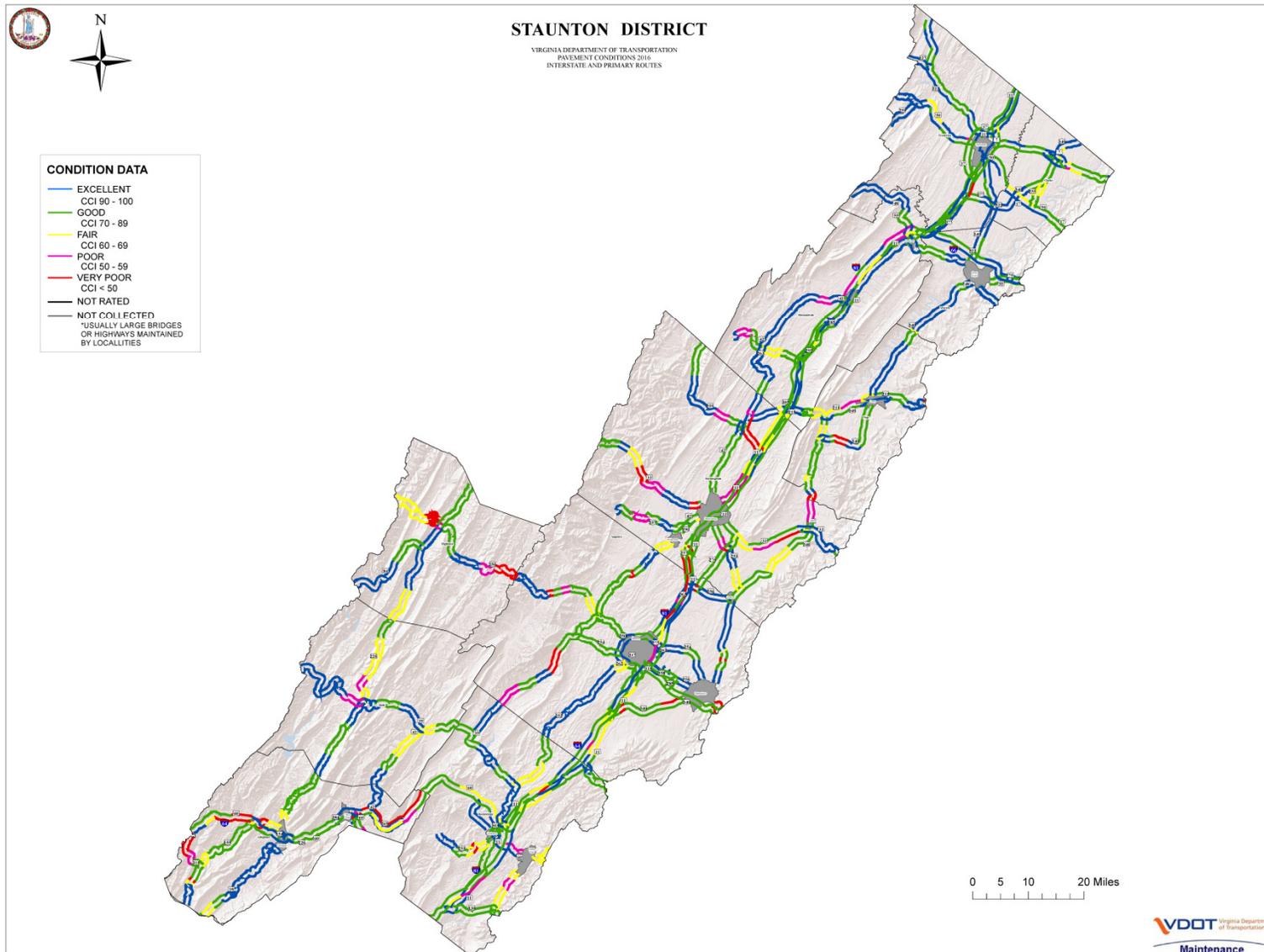


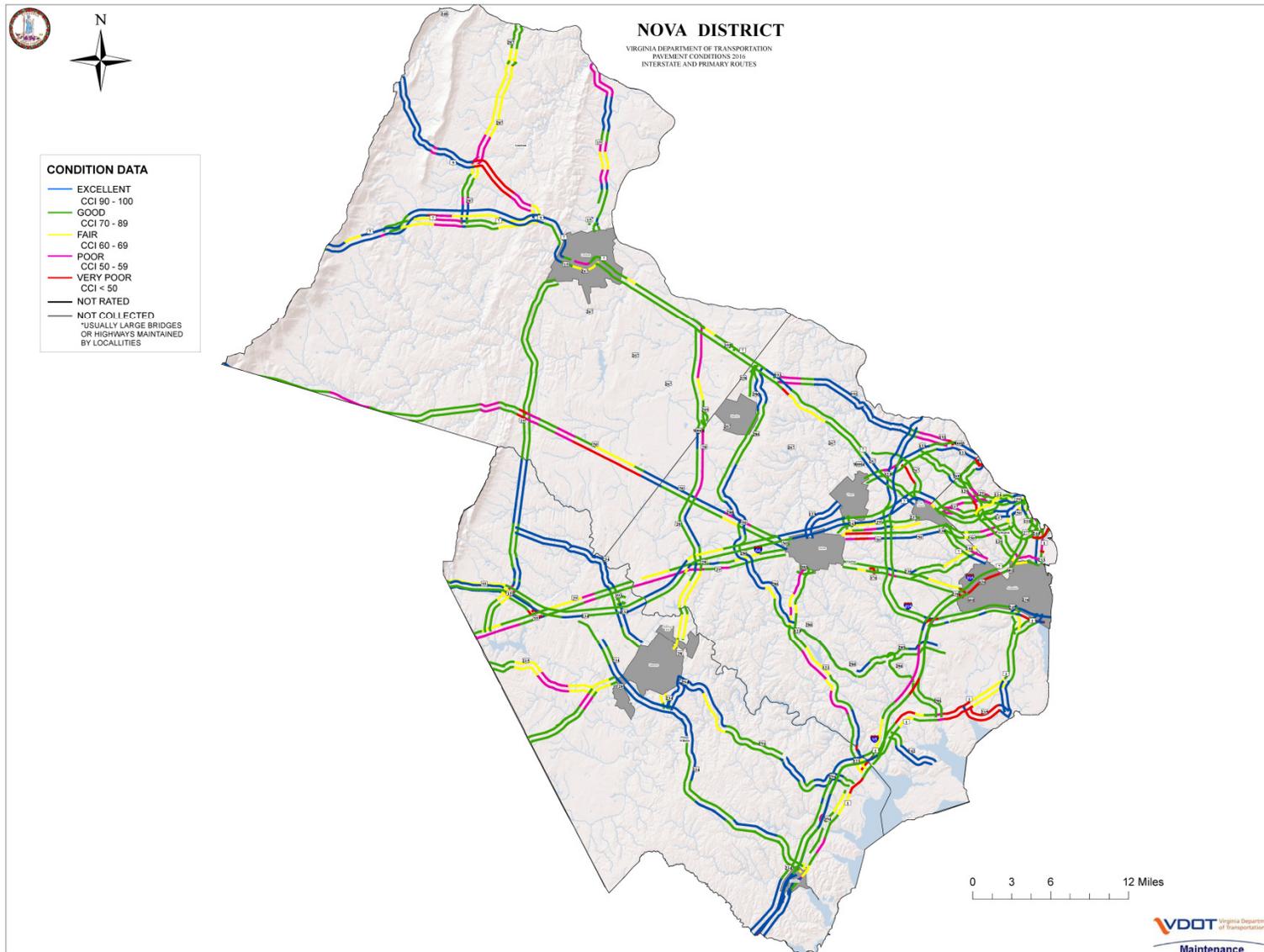












APPENDIX E: PAVEMENT RIDE QUALITY BY DISTRICT AND COUNTY – 2016

Table E1. Pavement Ride Quality by District and County for Interstate System – 2016

| District | County No. | County Name | Lane Miles (LM) Rated, Interstate | Deficient Ride Quality, LM | % Deficient Ride Quality |
|--------------------|------------|---------------|-----------------------------------|----------------------------|--------------------------|
| Bristol (1) | 10 | Bland | 85.33 | 1.66 | 1.94% |
| | 86 | Smythe | 90.72 | 0.35 | 0.39% |
| | 95 | Washington | 156.56 | 0.90 | 0.58% |
| | 98 | Wythe | 186.41 | 2.95 | 1.58% |
| District 1 Total | | | 519.02 | 5.86 | 1.13% |
| Salem (2) | 11 | Botetourt | 105.08 | 3.61 | 3.44% |
| | 17 | Carroll | 102.32 | 0.96 | 0.93% |
| | 60 | Montgomery | 113.20 | 0.91 | 0.81% |
| | 77 | Pulaski | 68.74 | 1.08 | 1.57% |
| | 80 | Roanoke | 101.44 | 2.14 | 2.11% |
| District 2 Total | | | 490.78 | 8.70 | 1.77% |
| Richmond (4) | 12 | Brunswick | 81.10 | 3.60 | 4.43% |
| | 20 | Chesterfield | 134.14 | 7.00 | 5.22% |
| | 26 | Dinwiddie | 117.33 | 32.88 | 28.02% |
| | 37 | Goochland | 112.81 | 3.31 | 2.94% |
| | 42 | Hanover | 167.21 | 5.52 | 3.30% |
| | 43 | Henrico | 366.74 | 38.66 | 10.54% |
| | 58 | Mecklenburg | 77.02 | 1.00 | 1.30% |
| | 63 | New Kent | 79.46 | 1.05 | 1.32% |
| | 74 | Prince George | 123.87 | 27.03 | 21.82% |
| District 4 Total | | | 1259.68 | 120.05 | 9.53% |
| Hampton Roads (5) | 40 | Greensville | 67.04 | 0.62 | 0.92% |
| | 47 | James City | 34.62 | 0.20 | 0.59% |
| | 61 | Nansemond | 13.24 | 0.35 | 2.66% |
| | 64 | Norfolk | 269.21 | 25.43 | 9.45% |
| | 75 | Princess Anne | 86.36 | 2.62 | 3.03% |
| | 91 | Sussex | 69.21 | 2.72 | 3.92% |
| | 99 | York | 211.87 | 25.07 | 11.84% |
| District 5 Total | | | 751.55 | 57.01 | 7.59% |
| Fredericksburg (6) | 16 | Caroline | 77.36 | 1.16 | 1.50% |
| | 88 | Spotsylvania | 91.97 | 0.22 | 0.23% |
| | 89 | Stafford | 91.62 | 0.33 | 0.36% |
| District 6 Total | | | 260.95 | 1.71 | 0.65% |
| Culpeper (7) | 2 | Albemarle | 120.38 | 2.96 | 2.46% |
| | 30 | Fauquier | 85.17 | 0.36 | 0.42% |
| | 54 | Louisa | 65.75 | 0.32 | 0.49% |
| District 7 Total | | | 271.30 | 3.64 | 1.34% |
| Staunton (8) | 3 | Alleghany | 158.16 | 3.25 | 2.05% |
| | 7 | Augusta | 173.52 | 0.34 | 0.20% |
| | 34 | Frederick | 101.20 | 0.54 | 0.53% |
| | 81 | Rockbridge | 193.13 | 2.00 | 1.04% |
| | 82 | Rockingham | 107.73 | 0.55 | 0.51% |

| District | County No. | County Name | Lane Miles (LM) Rated, Interstate | Deficient Ride Quality, LM | % Deficient Ride Quality |
|-----------------------------|------------|----------------|-----------------------------------|----------------------------|--------------------------|
| | 85 | Shenandoah | 136.18 | 0.60 | 0.44% |
| | 93 | Warren | 55.41 | 0.28 | 0.50% |
| District 8 Total | | | 925.33 | 7.56 | 0.82% |
| North in Virginia (9) | 0 | Arlington | 64.10 | 4.67 | 7.28% |
| | 29 | Fairfax | 433.32 | 21.97 | 5.07% |
| | 76 | Prince William | 176.23 | 1.37 | 0.78% |
| District 9 Total | | | 673.65 | 28.01 | 4.16% |
| Statewide | | | 5152.26 | 232.54 | 4.51% |

Table E2. Pavement Ride Quality by District and County for Primary System – 2016

| District | County No. | County Name | Lane Miles (LM) Rated, Primary | Deficient Ride Quality, LM | % Deficient Ride Quality |
|------------------|------------|---------------|--------------------------------|----------------------------|--------------------------|
| Bristol (1) | 10 | Bland | 154.36 | 25.03 | 16.21% |
| | 13 | Buchanan | 183.66 | 76.07 | 41.42% |
| | 25 | Dickenson | 161.40 | 79.52 | 49.27% |
| | 38 | Grayson | 233.34 | 52.75 | 22.61% |
| | 52 | Lee | 324.92 | 32.99 | 10.15% |
| | 83 | Russell | 293.29 | 45.49 | 15.51% |
| | 84 | Scott | 272.02 | 69.12 | 25.41% |
| | 86 | Smythe | 174.89 | 46.32 | 26.48% |
| | 92 | Tazewell | 349.61 | 75.39 | 21.56% |
| | 95 | Washington | 249.78 | 61.12 | 24.47% |
| | 97 | Wise | 330.63 | 79.11 | 23.93% |
| | 98 | Wythe | 140.40 | 16.09 | 11.46% |
| District 1 Total | | | 2868.30 | 659.00 | 22.98% |
| Salem (2) | 9 | Bedford | 370.07 | 47.91 | 12.95% |
| | 11 | Botetourt | 260.13 | 36.03 | 13.85% |
| | 17 | Carroll | 202.53 | 17.79 | 8.78% |
| | 22 | Craig | 118.91 | 22.71 | 19.10% |
| | 31 | Floyd | 108.96 | 5.00 | 4.59% |
| | 33 | Franklin | 240.80 | 25.52 | 10.60% |
| | 35 | Giles | 225.05 | 21.22 | 9.43% |
| | 44 | Henry | 332.57 | 22.65 | 6.81% |
| | 60 | Montgomery | 186.40 | 20.22 | 10.85% |
| | 70 | Patrick | 215.54 | 28.13 | 13.05% |
| | 77 | Pulaski | 105.74 | 8.39 | 7.94% |
| | 80 | Roanoke | 199.44 | 21.83 | 10.94% |
| District 2 Total | | | 2566.14 | 277.40 | 10.81% |
| Lynchburg (3) | 5 | Amherst | 301.02 | 23.57 | 7.83% |
| | 6 | Appomattox | 148.48 | 12.08 | 8.14% |
| | 14 | Buckingham | 191.27 | 4.86 | 2.54% |
| | 15 | Campbell | 319.14 | 17.75 | 5.56% |
| | 19 | Charlotte | 273.03 | 12.25 | 4.49% |
| | 24 | Cumberland | 106.16 | 2.82 | 2.66% |
| | 41 | Halifax | 425.29 | 19.81 | 4.66% |
| | 62 | Nelson | 257.20 | 22.74 | 8.84% |
| | 71 | Pittsylvania | 525.47 | 16.40 | 3.12% |
| | 73 | Prince Edward | 209.49 | 3.97 | 1.89% |
| District 3 Total | | | 2756.55 | 136.25 | 4.94% |
| Richmond (4) | 4 | Amelia | 112.65 | 4.84 | 4.29% |
| | 12 | Brunswick | 232.05 | 27.52 | 11.86% |
| | 18 | Charles City | 88.73 | 5.58 | 6.29% |
| | 20 | Chesterfield | 562.74 | 137.01 | 24.35% |
| | 26 | Dinwiddie | 228.57 | 30.43 | 13.31% |

| District | County No. | County Name | Lane Miles (LM) Rated, Primary | Deficient Ride Quality, LM | % Deficient Ride Quality |
|--------------------|--------------|----------------|--------------------------------|----------------------------|--------------------------|
| Richmond (4) | 37 | Goochland | 191.04 | 25.41 | 13.30% |
| | 42 | Hanover | 226.54 | 31.66 | 13.98% |
| | 43 | Henrico | 382.35 | 121.38 | 31.75% |
| | 55 | Lunenburg | 126.65 | 9.29 | 7.33% |
| | 58 | Mecklenburg | 400.84 | 40.73 | 10.16% |
| | 63 | New Kent | 184.17 | 63.84 | 34.66% |
| | 67 | Nottoway | 213.11 | 10.67 | 5.00% |
| | 72 | Powhatan | 128.88 | 17.50 | 13.58% |
| | 74 | Prince George | 186.78 | 33.59 | 18.00% |
| District 4 Total | | | 3265.10 | 559.45 | 17.13% |
| Hampton Roads (5) | 1 | Accomack | 266.06 | 24.14 | 9.07% |
| | 40 | Greensville | 81.32 | 3.51 | 4.31% |
| | 46 | Isle of Wight | 201.87 | 18.16 | 8.99% |
| | 47 | James City | 176.97 | 20.79 | 11.75% |
| | 61 | Nansemond | 4.37 | 0.70 | 15.93% |
| | 64 | Norfolk | 49.11 | 9.80 | 19.96% |
| | 65 | Northampton | 157.57 | 5.04 | 3.20% |
| | 87 | Southampton | 274.30 | 14.25 | 5.20% |
| | 90 | Surry | 95.19 | 2.29 | 2.41% |
| | 91 | Sussex | 219.32 | 12.80 | 5.84% |
| 99 | York | 147.69 | 18.26 | 12.36% | |
| District 5 Total | | | 1673.77 | 129.74 | 7.75% |
| Fredericksburg (6) | 16 | Caroline | 289.03 | 14.20 | 4.91% |
| | 28 | Essex | 167.87 | 4.48 | 2.67% |
| | 36 | Gloucester | 185.48 | 9.69 | 5.22% |
| | 48 | King George | 192.69 | 7.67 | 3.98% |
| | 49 | King & Queen | 133.63 | 9.25 | 6.92% |
| | 50 | King William | 100.99 | 6.44 | 6.37% |
| | 51 | Lancaster | 125.39 | 16.95 | 13.52% |
| | 57 | Mathews | 66.08 | 8.95 | 13.55% |
| | 59 | Middlesex | 130.80 | 5.91 | 4.51% |
| | 66 | Northumberland | 110.94 | 8.76 | 7.90% |
| | 79 | Richmond | 105.44 | 4.93 | 4.67% |
| | 88 | Spotsylvania | 209.24 | 11.77 | 5.63% |
| | 89 | Stafford | 161.06 | 25.48 | 15.82% |
| 96 | Westmoreland | 139.75 | 16.48 | 11.80% | |
| District 6 Total | | | 2118.39 | 150.96 | 7.13% |
| Culpeper (7) | 2 | Albemarle | 348.24 | 30.22 | 8.68% |
| | 23 | Culpeper | 208.80 | 4.46 | 2.13% |
| | 30 | Fauquier | 320.55 | 5.76 | 1.80% |
| | 32 | Fluvanna | 101.70 | 5.94 | 5.84% |
| | 39 | Greene | 86.97 | 3.11 | 3.57% |
| | 54 | Louisa | 238.79 | 10.51 | 4.40% |
| | 56 | Madison | 157.86 | 3.49 | 2.21% |
| | 68 | Orange | 186.74 | 7.21 | 3.86% |

| District | County No. | County Name | Lane Miles (LM) Rated, Primary | Deficient Ride Quality, LM | % Deficient Ride Quality |
|-----------------------|------------|----------------|--------------------------------|----------------------------|--------------------------|
| | 78 | Rappahannock | 156.36 | 0.75 | 0.49% |
| District 7 Total | | | 1806.01 | 71.45 | 3.96% |
| Staunton (8) | 3 | Alleghany | 148.62 | 23.65 | 15.91% |
| | 7 | Augusta | 383.82 | 20.46 | 5.33% |
| | 8 | Bath | 148.76 | 16.82 | 11.31% |
| | 21 | Clarke | 145.20 | 6.26 | 4.31% |
| | 34 | Frederick | 316.59 | 13.82 | 4.36% |
| | 45 | Highland | 141.51 | 12.24 | 8.65% |
| | 69 | Page | 136.75 | 6.77 | 4.95% |
| | 81 | Rockbridge | 255.44 | 31.86 | 12.47% |
| | 82 | Rockingham | 392.95 | 23.62 | 6.01% |
| | 85 | Shenandoah | 194.00 | 17.39 | 8.96% |
| | 93 | Warren | 88.01 | 2.56 | 2.92% |
| District 8 Total | | | 2351.65 | 175.45 | 7.46% |
| Northern Virginia (9) | 0 | Arlington | 136.89 | 104.78 | 76.54% |
| | 29 | Fairfax | 829.54 | 205.49 | 24.77% |
| | 53 | Loudoun | 446.23 | 25.73 | 5.77% |
| | 76 | Prince William | 371.90 | 78.12 | 21.01% |
| District 9 Total | | | 1784.56 | 414.12 | 23.21% |
| Statewide | | | 21190.47 | 2573.82 | 12.15% |

Table E3. Pavement Ride Quality by District and County for Secondary System – 2016

| District | County No. | County Name | Lane Miles (LM) Rated, Secondary | Deficient Ride Quality, LM | % Deficient Ride Quality |
|------------------|---------------|--------------|----------------------------------|----------------------------|--------------------------|
| Bristol (1) | 10 | Bland | 331.40 | 79.42 | 23.97% |
| | 13 | Buchanan | 822.04 | 232.43 | 28.27% |
| | 25 | Dickenson | 729.05 | 323.32 | 44.35% |
| | 38 | Grayson | 682.58 | 288.65 | 42.29% |
| | 52 | Lee | 812.01 | 301.52 | 37.13% |
| | 83 | Russell | 917.71 | 448.38 | 48.86% |
| | 84 | Scott | 805.46 | 354.67 | 44.03% |
| | 86 | Smythe | 767.69 | 224.05 | 29.18% |
| | 92 | Tazewell | 781.39 | 247.04 | 31.62% |
| | 95 | Washington | 1,267.00 | 444.22 | 35.06% |
| | 97 | Wise | 752.28 | 207.18 | 27.54% |
| 98 | Wythe | 601.67 | 180.02 | 29.92% | |
| District 1 Total | | | 9,270.28 | 3,330.90 | 35.93% |
| Salem (2) | 9 | Bedford | 1,546.00 | 743.23 | 48.07% |
| | 11 | Botetourt | 786.51 | 422.02 | 53.66% |
| | 17 | Carroll | 1,115.74 | 354.57 | 31.78% |
| | 22 | Craig | 279.80 | 164.32 | 58.73% |
| | 31 | Floyd | 630.34 | 259.41 | 41.15% |
| | 33 | Franklin | 1,930.76 | 670.28 | 34.72% |
| | 35 | Giles | 424.74 | 117.01 | 27.55% |
| | 44 | Henry | 1,342.65 | 619.88 | 46.17% |
| | 60 | Montgomery | 699.33 | 182.51 | 26.10% |
| | 70 | Patrick | 1,024.05 | 423.42 | 41.35% |
| | 77 | Pulaski | 612.72 | 205.26 | 33.50% |
| 80 | Roanoke | 1,073.82 | 509.52 | 47.45% | |
| District 2 Total | | | 11,466.46 | 4,671.43 | 40.74% |
| Lynchburg (3) | 5 | Amherst | 829.44 | 462.13 | 55.72% |
| | 6 | Appomattox | 784.27 | 348.63 | 44.45% |
| | 14 | Buckingham | 835.32 | 212.98 | 25.50% |
| | 15 | Campbell | 1,329.36 | 633.65 | 47.67% |
| | 19 | Charlotte | 805.65 | 235.64 | 29.25% |
| | 24 | Cumberland | 426.16 | 149.21 | 35.01% |
| | 41 | Halifax | 1,565.96 | 255.39 | 16.31% |
| | 62 | Nelson | 576.39 | 335.32 | 58.18% |
| | 71 | Pittsylvania | 2,456.39 | 823.32 | 33.52% |
| 73 | Prince Edward | 652.08 | 222.00 | 34.05% | |
| District 3 Total | | | 10,261.02 | 3,678.27 | 35.85% |
| Richmond (4) | 4 | Amelia | 642.11 | 141.57 | 22.05% |
| | 12 | Brunswick | 1,007.82 | 392.31 | 38.93% |
| | 18 | Charles City | 263.53 | 163.82 | 62.16% |
| | 20 | Chesterfield | 3,178.36 | 863.74 | 27.18% |
| | 26 | Dinwiddie | 992.56 | 428.71 | 43.19% |

| District | County No. | County Name | Lane Miles (LM) Rated, Secondary | Deficient Ride Quality, LM | % Deficient Ride Quality |
|--------------------|--------------|----------------|----------------------------------|----------------------------|--------------------------|
| Richmond (4) | 37 | Goochland | 650.92 | 271.61 | 41.73% |
| | 42 | Hanover | 1,618.62 | 586.88 | 36.26% |
| | 55 | Lunenburg | 677.04 | 154.49 | 22.82% |
| | 58 | Mecklenburg | 1,145.94 | 283.35 | 24.73% |
| | 63 | New Kent | 404.24 | 148.04 | 36.62% |
| | 67 | Nottoway | 537.45 | 160.31 | 29.83% |
| | 72 | Powhatan | 612.35 | 117.54 | 19.19% |
| | 74 | Prince George | 579.16 | 186.59 | 32.22% |
| District 4 Total | | | 12,310.10 | 3,898.96 | 31.67% |
| Hampton Roads (5) | 1 | Accomack | 1,080.67 | 665.07 | 61.54% |
| | 40 | Greensville | 542.14 | 187.21 | 34.53% |
| | 46 | Isle of Wight | 806.83 | 137.72 | 17.07% |
| | 47 | James City | 601.10 | 108.87 | 18.11% |
| | 65 | Northampton | 471.58 | 293.75 | 62.29% |
| | 87 | Southampton | 1,149.71 | 408.42 | 35.52% |
| | 90 | Surry | 490.82 | 190.18 | 38.75% |
| | 91 | Sussex | 775.97 | 270.34 | 34.84% |
| | 99 | York | 562.94 | 85.56 | 15.20% |
| District 5 Total | | | 6,481.76 | 2,347.12 | 36.21% |
| Fredericksburg (6) | 16 | Caroline | 885.90 | 179.21 | 20.23% |
| | 28 | Essex | 455.61 | 123.52 | 27.11% |
| | 36 | Gloucester | 581.09 | 174.96 | 30.11% |
| | 48 | King George | 325.86 | 61.62 | 18.91% |
| | 49 | King & Queen | 447.61 | 95.90 | 21.42% |
| | 50 | King William | 481.77 | 80.07 | 16.62% |
| | 51 | Lancaster | 411.10 | 164.28 | 39.96% |
| | 57 | Mathews | 263.61 | 110.05 | 41.75% |
| | 59 | Middlesex | 328.98 | 84.33 | 25.63% |
| | 66 | Northumberland | 649.85 | 348.71 | 53.66% |
| | 79 | Richmond | 394.29 | 181.59 | 46.06% |
| | 88 | Spotsylvania | 1,386.46 | 113.04 | 8.15% |
| | 89 | Stafford | 1,184.48 | 171.27 | 14.46% |
| 96 | Westmoreland | 587.86 | 272.74 | 46.40% | |
| District 6 Total | | | 8,384.47 | 2,161.29 | 25.78% |
| Culpeper (7) | 2 | Albemarle | 1,314.58 | 459.67 | 34.97% |
| | 23 | Culpeper | 693.58 | 190.14 | 27.41% |
| | 30 | Fauquier | 1,234.85 | 295.49 | 23.93% |
| | 32 | Fluvanna | 544.13 | 48.54 | 8.92% |
| | 39 | Greene | 286.48 | 71.09 | 24.81% |
| | 54 | Louisa | 989.56 | 192.80 | 19.48% |
| | 56 | Madison | 423.43 | 85.49 | 20.19% |
| | 68 | Orange | 559.65 | 125.72 | 22.46% |
| | 78 | Rappahannock | 255.41 | 66.05 | 25.86% |
| District 7 Total | | | 6,301.67 | 1,534.99 | 24.36% |
| | 3 | Alleghany | 419.18 | 253.70 | 60.52% |

| District | County No. | County Name | Lane Miles (LM) Rated, Secondary | Deficient Ride Quality, LM | % Deficient Ride Quality |
|-------------------------|------------|----------------|----------------------------------|----------------------------|--------------------------|
| Staunton (8) | 7 | Augusta | 1,436.09 | 471.29 | 32.82% |
| | 8 | Bath | 469.76 | 288.23 | 61.36% |
| | 21 | Clarke | 336.06 | 78.76 | 23.44% |
| | 34 | Frederick | 1,005.89 | 168.91 | 16.79% |
| | 45 | Highland | 208.04 | 85.74 | 41.21% |
| | 69 | Page | 481.09 | 55.72 | 11.58% |
| | 81 | Rockbridge | 845.44 | 472.76 | 55.92% |
| | 82 | Rockingham | 1,227.47 | 133.20 | 10.85% |
| | 85 | Shenandoah | 830.51 | 259.45 | 31.24% |
| | 93 | Warren | 308.88 | 35.75 | 11.57% |
| District 8 Total | | | 7,568.41 | 2,303.51 | 30.44% |
| Northern Virginia (9) | 29 | Fairfax | 5,124.52 | 1,610.79 | 31.43% |
| | 53 | Loudoun | 1,889.66 | 295.98 | 15.66% |
| | 76 | Prince William | 2,150.66 | 453.92 | 21.11% |
| District 9 Total | | | 9,164.84 | 2,360.69 | 25.76% |
| Statewide | | | 81,209.01 | 26,287.16 | 32.37% |