

Pavement Asset Assessment For Secondary Roads

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ABSTRACT

The recordation of pavement distress has been used to identify pavement condition since the AASHO Road Test from 1959. System planning analysis has been used by many highway agencies since the 1970's and mandated by the FHWA for all states since 1987. However, many agencies have not undertaken pavement management evaluation of their secondary road system, partially due to the cost/benefit for this level of roadway and partially due to the size of the secondary road network.

The use of automated distress identification has been sought throughout these years as a way to expedite the data collection process, increase data repeatability, and enhance safety. Recent developments in computer technology have enabled the use of real time processing and storage of camera images with sufficient resolution to provide useful distress identification. This paper discusses the development of a simplified pavement management system for secondary roads, using automated imaging for the detection of pavement distress information.

Specific critical distress types are identified using digital images. For any given section of highway, the extent of these distresses is estimated by summing the results from sample images. Thus, good and poor pavement condition locations can be identified along the highway. Summaries are available for each individual county, district, or on a statewide basis. Using this information, together with a simplified treatment matrix, the condition of highways can be classified, and future funding needs identified for maintaining acceptable highway condition.

HISTORY OF PAVEMENT DISTRESS RATING

Interpretation of pavement distress as a means of identifying problems with pavement performance has been a standard practice for decades. It was the primary means of interpretation of pavement performance at the largest (of its time) pavement experiment ever conducted, the

AASHO Road Test from 1958-1960. It continues to be the primary means of interpreting today's pavement research, including the recently completed Westrack study of asphalt pavements, and the Long Term Pavement Performance (LTPP) study of in-service pavements. In each of these cases, distress interpretation has been recorded manually in the field.

During the past twenty years, efforts have been under way to develop automated means of collecting pavement distress data. In the case of LTPP test sections, distress data has also been recorded using high-speed 35 mm film to provide a permanent record of pavement condition at approximately two-year intervals. Several advantages of being able to automate distress data collection are evident. Of primary importance is the reduction in exposure of pavement raters to live traffic, and the ever increasing safety concerns associated with working on a highway. Second is the potential for increasing the speed with which the data can be collected, and stored in an accessible database for use in evaluating pavement needs.

Pavement needs are typically identified by highway agencies on a network level, as a means of estimating budgetary needs for future years. Pavement management activities have developed pavement performance trends, based on several years of distress data collection. These trend models can be used to predict budgetary needs several years in advance.

NEED FOR SECONDARY ROAD ASSESSMENT (NON-PMS)

Like other agencies, the Virginia Department of Transportation (VDOT) has undertaken pavement distress surveys for many years. Traditionally, these surveys have consisted of manually recorded distress conditions collected in the field. In recent years, efforts have been developed to collect the distress condition on the Pavement Management System (PMS) road network using video and digital imaging. This effort has evolved into the current activities being undertaken for the Inventory Condition and Assessment System (ICAS) project. For the

PMS routes – Interstate, Primary and select High-Volume Secondary roads, high-resolution downward images of the pavement surface are being collected. Distress data are being interpreted from these images at an offsite location, providing the needed pavement condition data for the pavement management system.

While the same techniques are possible for the secondary road system, the cost of this survey work lead to the need for a more economical technique of collecting pavement condition data for the 44,000 miles of secondary roads. Currently, this mileage is not managed as part of the state's pavement management system. Many of these routes are farm to market roads, local routes and subdivisions. However, VDOT management recognized the need to assess the condition of these routes. Thus, the Non-PMS road survey development project was undertaken as part of the ICAS project. This survey will provide automated condition data using computer imaging techniques, enabling VDOT to reasonably assess budgetary needs for coming years.

Since the 1980's VDOT has identified secondary road pavement evaluation and management as a major need. The major stumbling block has been data – what is needed, how to get it and what to do with it. In 1992, the Virginia Transportation Research Council issued report number VTRC 92-R4 – *A Pavement Management System for Pavement Secondary Roads*. While it was not adopted statewide, several VDOT residencies used this report as a model to develop and implement local pavement management and data collection procedures.

Pavement distress is the manifestation of deterioration of the pavement surface. For the Non-PMS system, ratings will be conducted on asphalt surfaced secondary highways. The interpretation of the pavement condition data will be used by VDOT to predict the needed maintenance and repairs for the secondary highway system, and on the basis of historical cost to provide these treatments, to estimate the fiscal needs for future years. This process will be

repeated at intervals adequate to maintain reasonable projections of annual highway preservation costs.

As an example of this process, alligator cracking in wheel paths is typically interpreted as an indication of full depth structural failure of a pavement. Thus, programming would indicate the need for budget to reconstruct that section of pavement.

APPROACH TO SYSTEM DEVELOPMENT

Software Tools

Imaging of sample pavement sections are already being collected as a part of the ICAS project for other applications, including the development of roadway centerlines, and inventory of highway features. Stereoscopic digital camera images are being used to develop the centerlines for highway mapping, using photogrammetric techniques. In addition, many highway assets are being inventoried by reviewing these images. These include the presence and condition of fourteen features including highway signing and pavement markings.

A semi-automated approach was adopted to develop a methodology for assessing secondary road pavement condition using these same digital images. VDOT provided guidelines regarding the types of pavement distress that they want to collect, as a means of measuring pavement condition.

Information is collected in accordance with ICAS Roadtracking Procedures Manual. The materials are provided in the form of digital images representing perspective views at about 50' intervals. The pavement rating is taken from these images.

It was found necessary to augment the software being used for other ICAS inventory needs. A specially enhanced version of STEPS (version 2.9.0) and a specific Vocarta package were developed to support the Non-PMS survey.

The following criteria are required for review and rating of the Non-PMS roads condition evaluation.

Computer Hardware: Pentium II Personal Computer with 21” High Resolution Monitor

- Software:
1. Vocarta voice entry , by Datria
 2. Augmented Transmap STEPS for NonPMS Rating
 3. Utilities for Plotting
 4. PMS-Microsoft Access
 5. Non-PMS Rating Routines for VDOT

Vocarta, developed by Datria, provides a specific voice entry routine merged with the Transmap STEPS for recording the distress viewed on the computer screen. This information is captured in a Microsoft Access database, for use in developing various query reports and graphic summaries.

Distress Identification

From the beginning, it was important that the distress data collected must fulfill VDOT’s business needs for Non-PMS routes – fund allocation, prioritization and budget development. To ensure the proper distresses were captured, VDOT formed a committee of central office and field personnel. This committee was tasked with assessing what distresses drove the business decisions made by districts and residencies. While ride quality is a major concern on higher volume and higher speed routes, it is not the predominant pavement characteristic on Non-PMS routes. Nor are functional distresses such as transverse cracking, block cracking, and raveling. The pavement characteristic that triggers maintenance on Non-PMS routes is structural failures. Based on this criteria, the following distresses were identified:

- | | |
|--------------------|---------------|
| Alligator cracking | Edge cracking |
| Localized failures | Bleeding |

Patches	Block cracking
Pavement cross-section distortion	No distress

These specific distresses have been selected as representing critical indicators of needed pavement repair. The VDOT Distress Rating Form shown in Figure 1 indicates the type of rating to be performed.

Definitions have been developed for these distresses based on VDOT image rating distress guidelines. Further reference is “A Guide to Evaluating Hard Surfaced Secondary Roads Through the Use of Digital Imagery”, Version 1.0 Draft dated July, 1999 by Virginia DOT. The identified distresses are defined below.

Localized Failures

Localized failures are isolated spots on the pavement surface which have developed into severely distressed areas which may include potholes, delaminations, failed patches or a combination of distresses such as alligator cracking and cross-section distortion. Alligator cracking which is depressed should be identified as a localized failure.

Localized failures may occur anywhere on the pavement surface. Typically they are indicative of weak spots in the pavement, resulting in a breakdown of the paving material.

Alligator Cracking

Cracking which occurs in the wheel paths of pavements. Typically it appears as a chicken wire or alligator skin pattern. This pattern is indicative of structural weakness in the pavement.

FIGURE 1 Example of the VDOT Distress Rating Form.

Route Name: _____ Sample Begin St./MP: _____
 Route Number: _____ Sample Length: 15 feet
 County Name: _____ Sample Width: 10 feet

Distress Name	Measurement
Localized Failures	Present
Alligator Cracking	Present
Edge Cracking	Present
Block Cracking	Present
Bleeding	Present
Patches	Present
Pavement Cross-Section/Distortions	Present
No Distress	Present
Image Unratable	Present

Comments:

Surveyor Initials: _____

Survey Date: _____

Edge Cracking

Cracking developed along the pavement as a result of lack of support from the shoulder. It typically develops as a longitudinal crack within one foot of the pavement edge, and progresses into a series of interconnected cracks resembling alligator cracking at the pavement edge. Pieces will eventually become loose and displaced.

Block Cracking

Block cracking is a series of interconnected longitudinal and transverse cracks forming a rectangular or square block pattern over a large area of the pavement surface. Blocks should not be greater than 6', but at least 1' on either side. Block cracking can form anywhere on the pavement surface and, therefore, block cracking must be distinguished from alligator cracking. If present in wheel paths, denote as alligator cracking.

Bleeding

The presence of excess liquid asphalt on the pavement surface. Bleeding is often seen in wheel paths, and may appear to have a reflective or shiny surface.

Patches

Areas of the pavement which have been repaired by the addition or replacement of new material on the surface. These may be full depth or surface depth patches. Patches are indicative of localized failures which have been repaired, or of other repaired areas, such as utility cuts. Cracking may exist within or around a patch. Patches generally should not exceed 10' in length. Any patch in poor condition should be identified as a localized failure.

Pavement Cross-Section Distortion

Non-uniformity of the pavement surface deviating from the originally constructed straight cross-slope of the pavement surface. Any distortion of the surface, such as ruts,

depressions, bumps, reverse super-elevation of curves, or excessive crown should be counted as cross-section distortion. Cross-section distortions may result in poor ride quality, and often cause a safety problem.

No Distress

It is important that this information be recorded for all images not exhibiting distress. As a quality control measure for the rating process, this will preclude the potential for overlooking unrated images, for which not data is reported.

For the secondary road network level evaluation, no distress severity levels are identified. Reported information includes only the presence or absence of the identified distress types. The application of this information will be discussed in a later section.

DISTRESS RATING PROCEDURES

Procedures have been developed for performing the rating of the forward pavement images provided for the ICAS features inventory. First, the STEPS image is enhanced by defining a rating window area within the right of way image. Since the images are generally captured every 0.01 miles, this image represents a 24% sample of the pavement. Any of the above noted distress types present within the rating area are recorded using the Vocarta software.

The rater scrolls along a section of highway using the STEPS software to view the sample pavement section. The software provides a zoom feature providing a close-up view of the pavement if needed to assist in satisfactorily identifying pavement distresses. Using the Vocarta program, the rater calls out the distress or lack of distress using the voice commands developed for the secondary road rating application.

Localized Failure

Bleeding

Image Unrateable

Patching

Edge Cracking

Alligator Cracking

Distortion

Block Cracking

No Distress

Either individual or multiple distresses can be recorded. To verify that lack of distress is not simply a rater error, the “No Distress” command was added. Also, the “Image Unrateable” command is used to indicate images which can not be viewed sufficiently clearly to determine a distress call. A sample image is provided as Figure 2.

FIGURE 2 Sample of a forward image.



The rater can select either the right or left forward camera images as the basis of rating. In addition, a rear left camera image is available, for further clarification of distress condition, however, the rating cannot be performed on the basis of the rear image alone.

SAMPLING PROCEDURES

The nature of the data collected provides one sampling every 50 feet of the roadway condition information. However, evaluation of information generated from the initial rating results has produced methods for conducting ratings using valid statistical sampling techniques.

Two sampling rates have been identified, depending upon the uniformity of pavement condition. In general a sampling rate of 20% of the images will be used for rating. However, in the case of little or no pavement distress, this can be reduced to 10%. The criteria for this change in rate is that if the rater identifies a pavement section with little or no distress, the 10% rate can be used. So long as no more than 20% (2 sections of the ten rated within each mile) do not exhibit distress, this sampling rate is acceptable. In all other cases, the 20% sampling rate is used.

An exercise has been conducted to verify that this sampling plan does not change the reported results. Initially 100% of the pavement images were rated, and the results compared with the sample rate identified above.

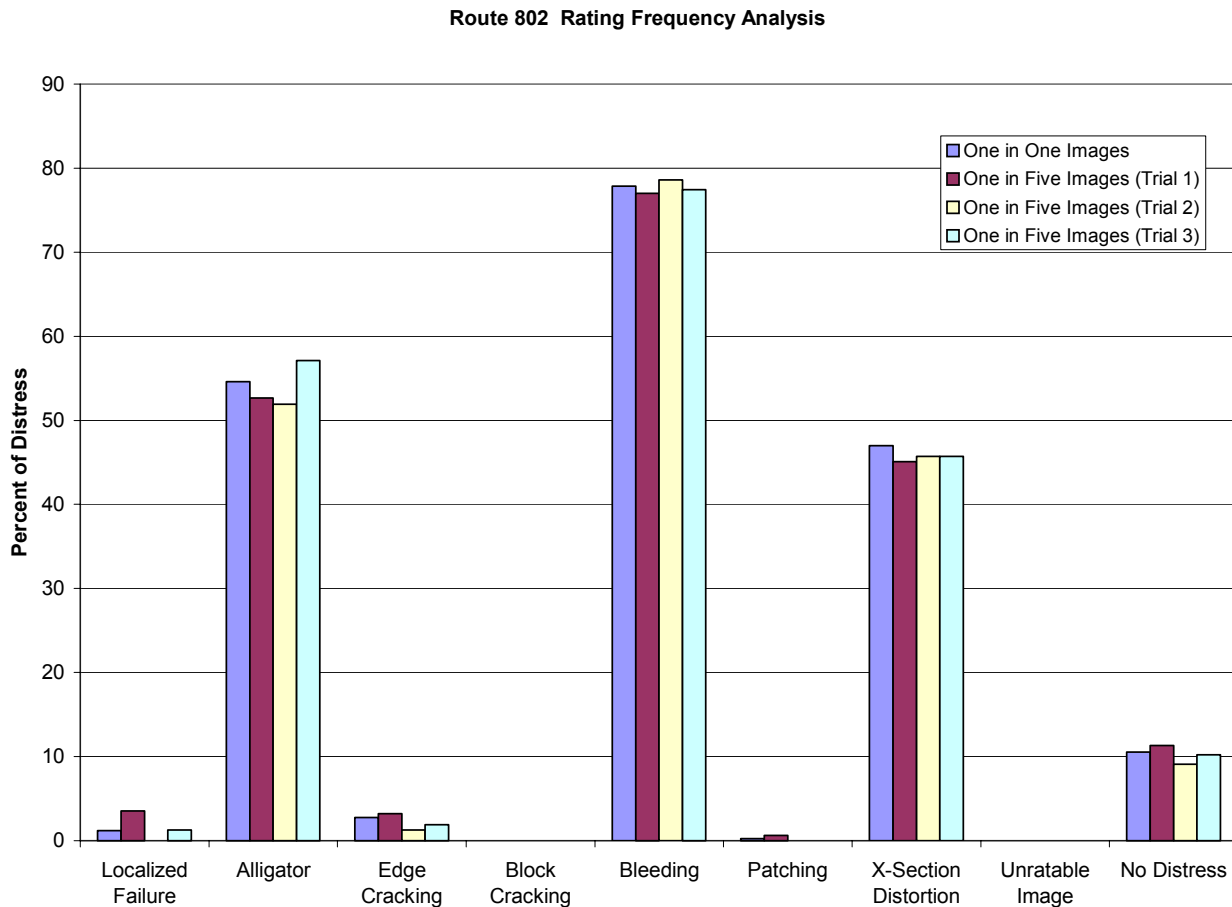
This information then served as the baseline for further reduced sample rate comparisons. To accomplish this, routes were randomly selected from Fauquier County, Virginia. Rating was performed on 200 miles of secondary roadways using the 100% sample rate.

A statistical assessment of sampling rates was conducted next. Representative data from the 200 miles was evaluated for this purpose. Sections were selected which contained variable levels of distress. Particularly, major VDOT distress types such as alligator cracking were assessed. A sampling rate of one image in five (20%) was determined to produce results only slightly different from the 100% sampling results. This was verified for several roadways, using different sets of sample images. These results are shown in Figure 3.

DISTRESS DATABASE

The Vocarta software stores the data in a Microsoft Access table for use in developing pavement condition reports. This format provides the ability to produce a variety of query reports, and summaries, as discussed in the next section.

FIGURE 3 Distress summaries for different sampling frequencies.



NON-PMS TREATMENT DECISION CRITERIA

A decision matrix for Non-PMS roads is provided for determining pavement treatment needs, and estimating budgets. The matrix serves as an appropriate treatment planning tool for individual highway sections. The matrix is provided as table 1.

Currently, this decision matrix remains in draft format, pending review of the Virginia DOT.

TABLE 1. NonPMS decision treatment matrix.

Distress Type	<10%	>10%<30%	>30%<50%	>50%
Localized Failures	4	5 or 6	7	7
Alligator Cracking	1 or 2	4 & 2,3, or 5	6 or 7	7
Edge Cracking	1	2	6 or 7	6 or 7
Block Cracking	1, 2, or 3	2 or 3	6	6
Bleeding	2 or 3	2 or 3	5 or 6	6
Patches	2 or 3	5	6 or 7	7
Pavement	4	2 or 3a, 5, or 6	5, 6, or 7	6 or 7
Cross-Section Distortions				

List of Treatments

1. Crack Seal
 2. Chip Seal
 3. Microsurfacing
 - 3a. Microsurfacing with rut filling
 4. Full Depth Patching*
 5. Asphalt Overlay
 6. Mill and resurface
 7. Major Rehabilitation
- *Evaluate the need for pavement drainage improvement

For sections with multiple distress present, the treatment should be based on the condition of the most severe distress, in accordance with the following hierarchy.

1. Alligator Cracking
2. Localized Failures
3. Patches
4. Edge Cracking
5. Pavement Cross-Section Distortion
6. Bleeding

7. Block Cracking

This method provides the criteria for addressing both structural and functional pavement problems.

DISTRESS RATING REPORTS

The distress ratings should be summarized for each mile of Non-PMS highway surveyed. The software will produce this summary. The results are then saved to a Microsoft Access database. A sample is provided as Figure 4.

FIGURE 4 Summarized distress information for Route 802.

County	Route	Mile	Percent of Images Containing:								
			Local Failure	Alligator	Edge Crack	Block Crack	Bleed	Patch	X-Section Distortion	Unratable Image	No Distress
Fauquier	SC 802 North	0	0.9	43.9	0.9	0	0	0	0.9	0	54.2
Fauquier	SC 802 North	1	1.8	49.5	8.1	0	63.1	0	82	0	9.9
Fauquier	SC 802 North	2	2.8	66	3.8	0	95.3	0.9	96.2	0	0
Fauquier	SC 802 North	3	0	58.3	0.9	0	98.1	0	81.5	0	0
Fauquier	SC 802 North	4	0.9	73.6	0.9	0	98.2	0	30.9	0	0
Fauquier	SC 802 North	5	0	47.7	2.8	0	100	0.9	37.4	0	0
Fauquier	SC 802 North	6	2	43.1	2	0	90.2	0	0	0	9.8

The summary will indicate the percentage of the roadway sections sampled which contain each specific distress. For example, if 40 of the 100 frames reviewed contain alligator cracking, and 10 frames contain patching, the summary will indicate:

Alligator cracking 40%

Patching 10%

This information will be used to develop planning estimates of the work needed on the highway section. The summary of all sections along a length of highway, will provide the information for that specific section of highway. This roadway information can be summarized by county, or even statewide as needed.

The summary information, from county to statewide can be shown as a series of data plots representing the percent of each distress present, or the presence of specific distresses present. Queries can be made by roadway section, length of highway from and to specified limits, and by county or on a statewide basis. Figure 5 provides an example of one such query for patching on a limited number of roadways.

QUALITY CONTROL REVIEW

A quality control process is important for rating work of this type to assure that the information collected is accurate. For each section of Non-PMS highway rated, a sample representing 1% of the total highway mileage rated is selected. A second rating is performed using the procedures provided above. A comparison of the results of the second rating with the first should result in the recorded summary being within 10% of the same. Comparisons can be made using the statistics included in summary plots, or from numerical output.

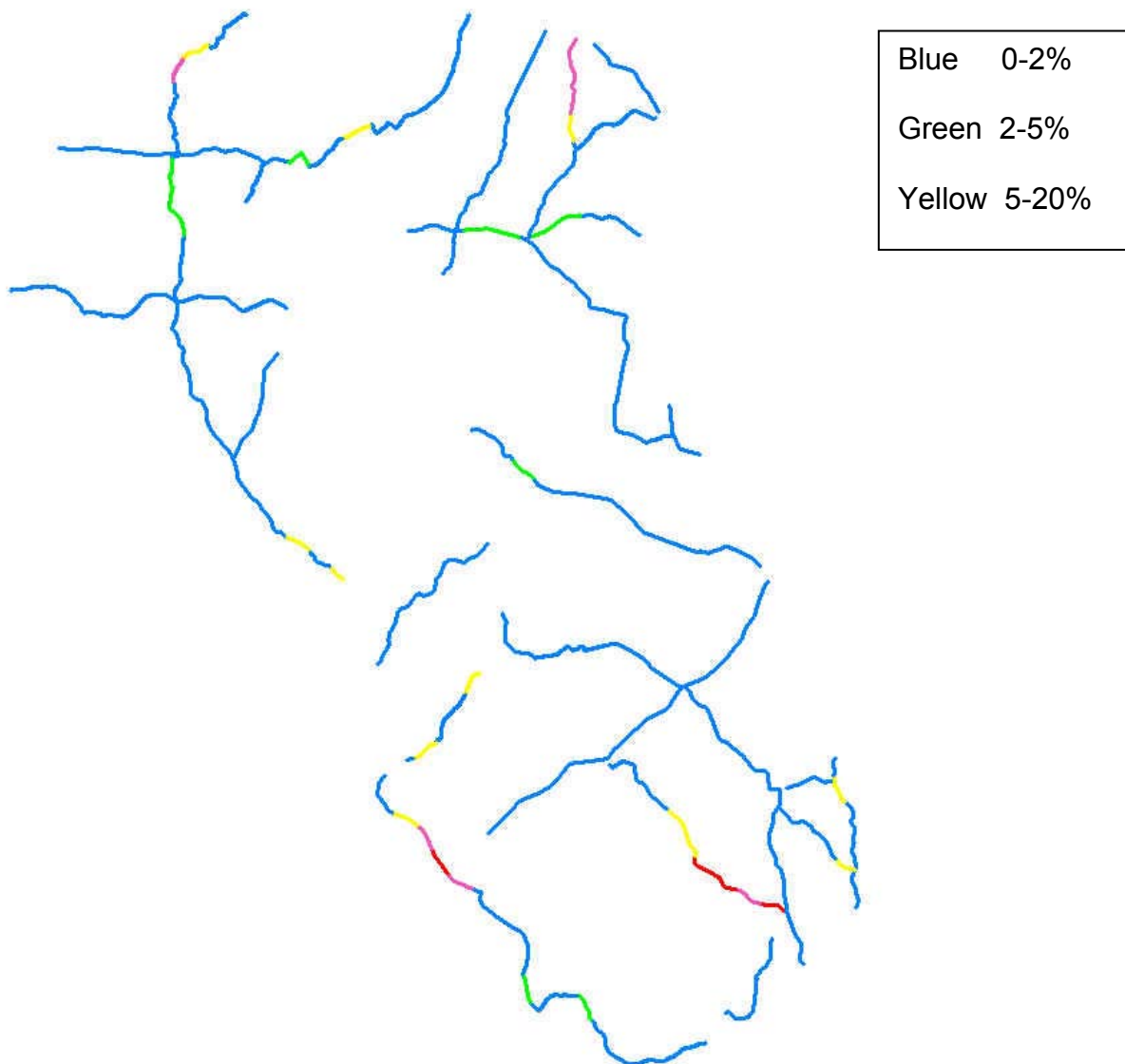
Should the comparison of the two ratings exceed a difference of 10%, it will be necessary to identify which distresses differ, and to determine the reason for the discrepancy. This will involve comparing the individual images reviewed, and the results of rating individual sample frames.

Once the discrepancies have been identified, it will be necessary to develop both a reconciliation, and a corrective action. The reconciliation will determine the appropriate rating for the sections in question. This may consist of a careful review of distress definitions and

rating instructions. The corrective action will consist of making whatever changes are necessary to prevent a reoccurrence of the problem.

The quality control reviewer completes a QC record for each review conducted that includes the reviewers name, date, section reviewed, results and both the reconciliation and the corrective actions taken.

FIGURE 5 Example of patching distress for a limited number of roadways in Fauquier County, Virginia.



SUMMARY

The rating process developed for the collection of pavement condition data for the secondary road system in Virginia has resulted in a practical method of using already existing roadway imagery to produce effective rating results. These rating results will provide the basis for network level needs assessment of the secondary road system which will be used for the first time in Virginia.

The system utilizes imaging collected by Transmap for use in developing roadway mapping centerlines and highway asset feature inventory. Specific identified pavement distress types are recorded using the voice activated Vocarta system to build a Microsoft Access database. This database will provide the information for later VDOT assessment of the secondary road system.

CONCLUSIONS

The use of pavement imaging techniques has been used successfully to identify pavement distresses sufficient to evaluate network level pavement maintenance and rehabilitation needs. While extensive detail of the pavement distress conditions is not possible using this system of information gathering, it is not necessary to successfully accomplish network level pavement need projections for secondary roadways.