

COUNTY OF RIVERSIDE TRANSPORTATION DEPARTMENT



PAVEMENT MANAGEMENT REPORT 2020

**Riverside County Transportation Dept
2020 Pavement Management Report**

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EXECUTIVE SUMMARY

The Riverside County Transportation Department strives to provide a safe, efficient, and sustainable transportation system to its users. The County has implemented a Pavement Management System (PMS) to assist with determining pavement needs and priorities. A PMS supplements decision-making by helping the County implement cost effective solutions to pavement problems and improve the overall condition of roads. A PMS allows the County to maximize the use of limited funding for pavement improvements by taking a comprehensive approach to managing the County’s pavements instead of a “worst-first” pavement plan. The PMS considers pavement life cycle costs in determining what work should be completed. This involves applying the right treatment to the right pavement at the right time to maximize a pavement’s service life at the lowest cost. An example would be to spend limited funding on applying preservation treatments to many miles of good road to keep them good instead of completing a costly reconstruction of one severely deteriorated but relatively low use section of road.

PAVEMENT CONDITION ASSESSMENT

The Pavement Condition Index (PCI) method was used in assessing the condition of the County’s pavements. The PCI method is an objective and repeatable method for assessing pavement conditions and is widely used in industry. Pavement conditions were categorized based on PCI values using the criteria shown in Figure ES.1.

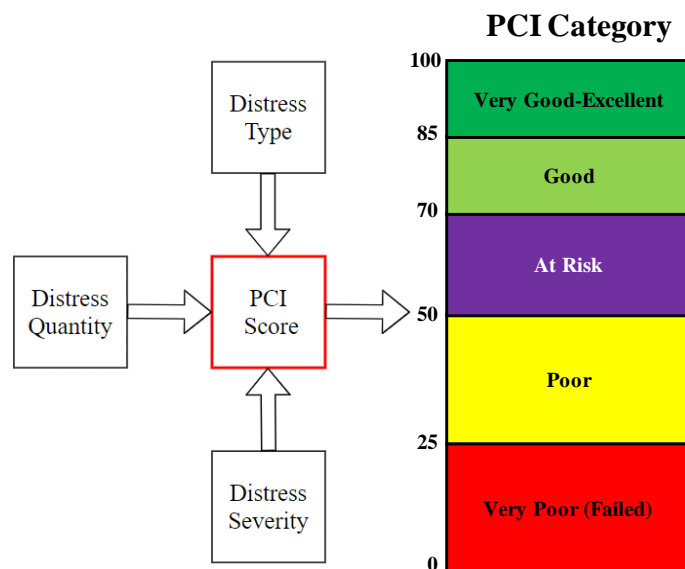


Figure ES.1 Pavement Condition Index Process and Categories

In 2020, the overall area weighted average PCI of the County’s roads was 74. About 30 percent of the total maintained miles throughout the County were found to be in need of resurfacing or replacement (considered to be AT RISK, POOR, or VERY POOR condition). The estimated cost to reduce this value from 30 percent to 25 percent is \$328 million; however, this is not a stagnant value. It grows as maintenance and repairs are delayed while roads continue to age and deteriorate. In fact, delayed maintenance accelerates pavement deterioration and the type of

maintenance or repair required changes from relatively low cost surface treatment to medium cost surface rehabilitation to high cost complete reconstruction.

From 2019 to 2020 the overall PCI score increased from 72 to 74. It should be noted that the PCI of 72 for 2019 was the “anticipated” PCI calculated in the StreetSaver program and the final PCI value of 74 was from the survey of all roads using a semi-automated laser inspection system that provided an accurate and consistent inspection rating for all County maintained roads.

SB1 FUNDING

The State legislature passed SB1 in April 2017. It established the Road Maintenance and Rehabilitation Program (RMRP) to fund road maintenance, rehabilitation, and critical safety improvements on both the state highway and local streets and roads. SB1 augments existing budgets for road maintenance and rehabilitation projects by infusing funds based on local needs and priorities. Since the passage of SB1 the County has received and invested approximately \$70 million into improving the safety and reliability of County roads and over 750 miles of road have been rehabilitated. It is expected that SB1 funding will provide approximately \$200 million over the next five years to fund road maintenance and rehabilitation improvements on local streets and roads. The purpose of the PMS is to use this funding as efficiently as possible to improve overall road conditions.

In order to provide a transportation system that is safe, cost-effective, sustainable, and efficient, environmental considerations and complete streets concepts will be incorporated into future SB1 projects. These considerations include:

- Using materials that reduce the life cycle cost and minimize greenhouse gas (GHG) through recycling, such as in-place Portland cement concrete pulverization, cold in-place asphalt recycling, and the use of crumb rubber from scrap tires in asphalt.
- Incorporating features resilient to climate change risks, such as flooding, by using Portland cement concrete (PCC) pavement in flood-prone areas.
- Incorporating complete streets elements to improve and increase mobility for pedestrians and bicyclists by installing curb ramps and sidewalks and widening the roadway, where feasible and practicable.

CURRENT TOTAL MAINTAINED MILES

The County of Riverside Transportation Department is responsible for the operation and maintenance of 2,243 centerline miles of road, as of the end of fiscal year 2020 (2,022 paved and 221 unpaved). The table below shows the breakdown of the roadway network grouped by functional classification with the average network Pavement Condition Index (PCI).

Table ES.1. Total Maintained Miles (Countywide)

FUNCTIONAL CLASSIFICATION ¹	CENTERLINE MILES ²	LANE MILES ³	PCI ⁵
Arterial	442	1000	73
Collector	637	1,294	72
Residential/Local	943	1,873	75
Gravel/Dirt ⁴	221	441	-
TOTAL	2,243	4,608	
Average PCI^{5,6} [FY 2020]	74		

- ¹) Functional classification is the grouping of roads based on traffic and degree of land access they provide.
- ²) Centerline mile represents the total length of a road from its starting point to its end point regardless of the pavement width or the number of lanes.
- ³) Lane miles represent the total length and the lane count of a road from its starting point to its endpoint. Lane miles take into account the number of lanes of a road maintained by the County.
- ⁴) PCI is not calculated for gravel and dirt roads.
- ⁵) The PCI shown is the area weighted PCI (i.e. larger areas impact the average PCI more than smaller areas)
- ⁶) The average PCI in 2020 was 74 whereas the desirable goal is 80 or higher. Roads with a PCI less than 70 are considered to be at risk of rapid deterioration.

CURRENT ROAD NETWORK CONDITION

Figure ES.2 through ES.4 show the County’s existing pavement condition categorized by functional classification and condition category. The total percentage of distressed roads, which includes the AT RISK, POOR, and VERY POOR road categories, is shown in Figure ES.2 at 28.5%. Over the last 5 years, the percentage of distressed roads have been declining gradually through the implementation of pavement preservation and effective pavement treatment solutions.

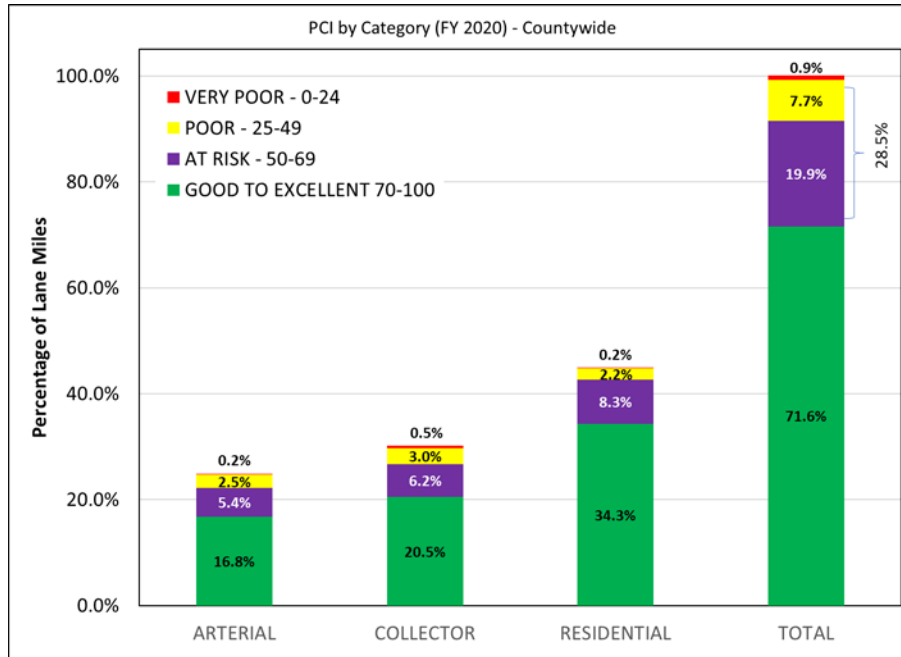


Figure ES.2. Pavement Condition by Category (FY 2020) – Countywide

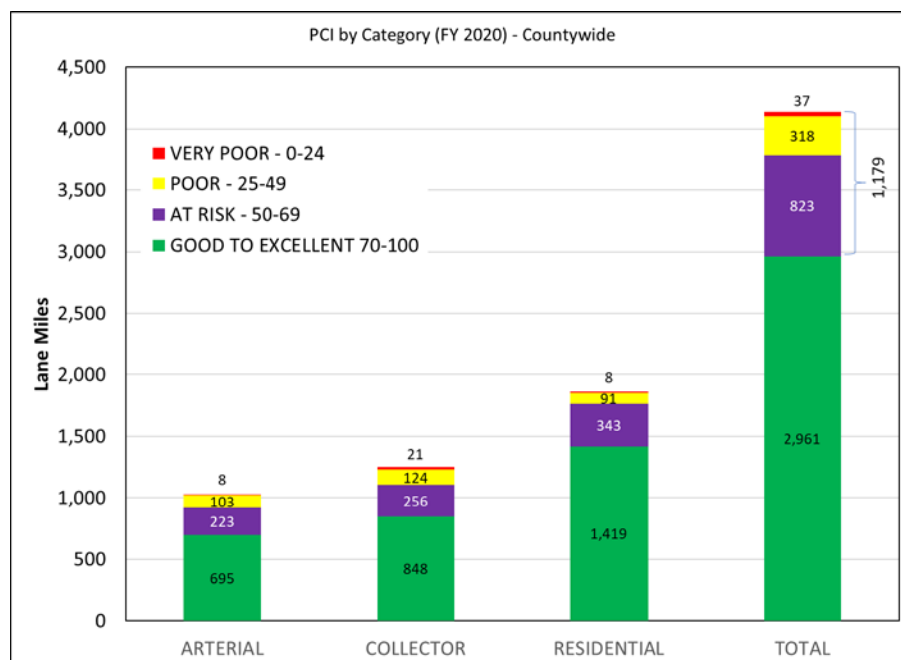


Figure ES.3. Pavement Condition by Category (FY 2020) – Countywide

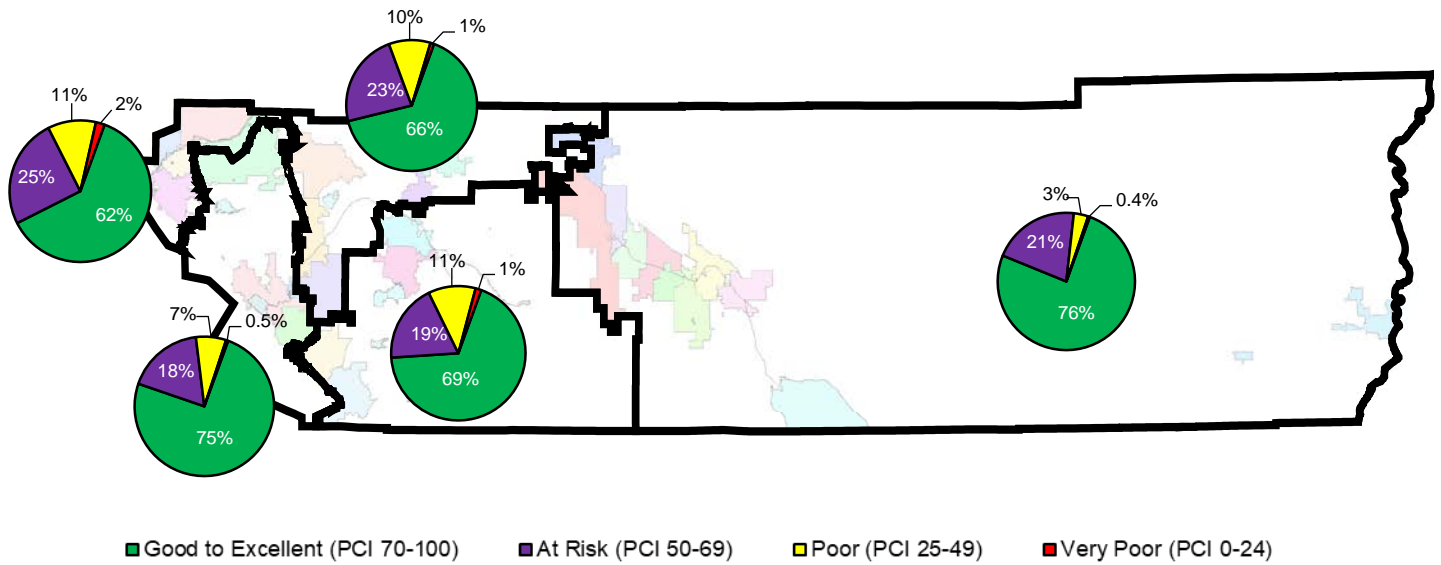


Figure ES.4 CURRENT ROAD CONDITION BY DISTRICT (FY 2020)

SUSTAINABLE PAVEMENT PRACTICES

As part of the County’s effort to reduce greenhouse gas emissions, from 2005 to 2020, the County has:

- Used approximately 190,000 tons of reclaimed asphalt, which translate to a reduction of 951,000 pounds of carbon emission.
- Used about 488,000 scrap/used tires for pavement overlays and rehabilitation, resulting in less tires at the landfill, greater longevity of pavement life, and reduced pavement/tire noise from vehicles.

CALIFORNIA STATEWIDE NEEDS ASSESSMENT

In 2008, the first California Statewide Needs Assessment report was published. This report provides a detailed analysis of California's local roads. It includes the current condition, cost to repair, and funding shortfall for local streets and roads. In April 2017, the Road Repair and Accountability Act (also known as SB1) passed with the goal to provide over \$5 billion annually for fixing roads, bridges, and improving safety across California.

It is anticipated that SB1 will distribute approximately \$1.5 billion in critical funding annually to help cities and counties maintain their local streets and roads and slow the deterioration that has occurred to local transportation infrastructure during the past decade or more. However, the 2018 "California Statewide Needs Assessment" report estimated that an additional \$6.8 billion is needed annually for the next 10 years "...to bring local street and road pavement into a state of good repair."

The average PCI in the State of California of all counties remained at 65 in the 2016 and 2018 assessment reports. The PCI ranges from a high of 79 in Orange County to a low of 37 in San Benito County; as of 2020, Riverside County has a PCI of 74.

The next statewide needs assessment update will be available in early 2021. The "California Statewide Local Streets and Roads Needs Assessment 2018" can be found at www.savecaliforniastreet.org.

PROJECT LISTS FOR FISCAL YEAR 2020-21

The Riverside County list of projects for rehabilitation and pavement preservation including slurry seal and chip seal for fiscal year 2020/21 are available on the County's website at:

<https://rctlma.org/trans/Project-Information/TIP/Transportation-Improvement-Document>

INTRODUCTION

PAVEMENT MANAGEMENT PROGRAM

A Pavement Management Program (PMP) is a tool that assists the County in making cost-effective decisions related to the maintenance and rehabilitation of roadway pavements. It provides an objective decision-making process or system for rating pavement condition, establishing a consistent maintenance and repair schedule, and evaluating the effectiveness of maintenance treatment strategies. A PMP is also an optimization tool that facilitates the prioritization of current and future needs to make the best use of available funds. The goal of a pavement management program is to strategize cost effective treatments to pavement sections that will deliver the best performance for the funds allocated. Simply put, a pavement management program saves public funds.

In the absence of a PMP, jurisdictions that lack the tools to strategize how to spend limited funds are likely to choose the “Worst First” approach to planning the repair of their roads, a reactive pavement management method. A “Worst First” approach would use limited funds for costly reconstruction where few roads can be repaired or waste limited preservation funds on severely deteriorated roads that will gain little if any additional life just to be seen as “doing something” for the road. Long-term use of this strategy will result in poor performance and the ultimate decline of the overall quality of the pavement network.

The PMP used by the County of Riverside Transportation Department is called “StreetSaver.” This program was developed by the Metropolitan Transportation Commission (MTC), which is the transportation planning, coordinating, and financing agency for the nine San Francisco Bay Area counties - Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma. Other users of the PMP from outside the bay region are cities, counties, universities, and consulting firms in Southern California.

PAVEMENT CONDITION INDEX

The MTC StreetSaver software combines the pavement condition assessment data from the visual inspection of the pavement frames to calculate the PCI. The PCI is based on the type, quantity, and severity of distresses from each segment of pavement. The PCI is a numerical index from 0 and 100. If properly designed and constructed, new pavements begin their service life with a PCI of 100. Due to the effects of loading and aging, the pavement deteriorates over time. For each combination of distress type, severity level, and quantity observed, points are deducted from 100, and the PCI decreases. Pavement management software, including StreetSaver, calculate the PCI scores for each pavement section based on a combination of distress types, severities, and quantities. Figure 1 shows the relationship between the PCI and pavement condition.

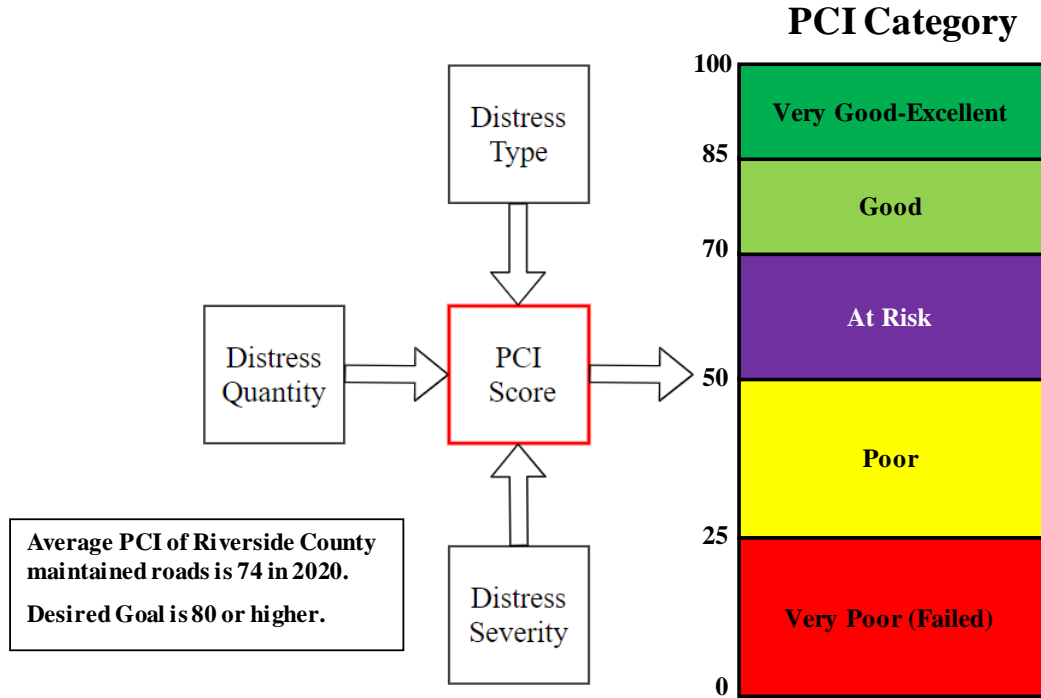


Figure 1. Relationship Between PCI and Pavement Condition

An example of StreetSaver output showing road data and a deterioration curve is shown in Figure 2 below.

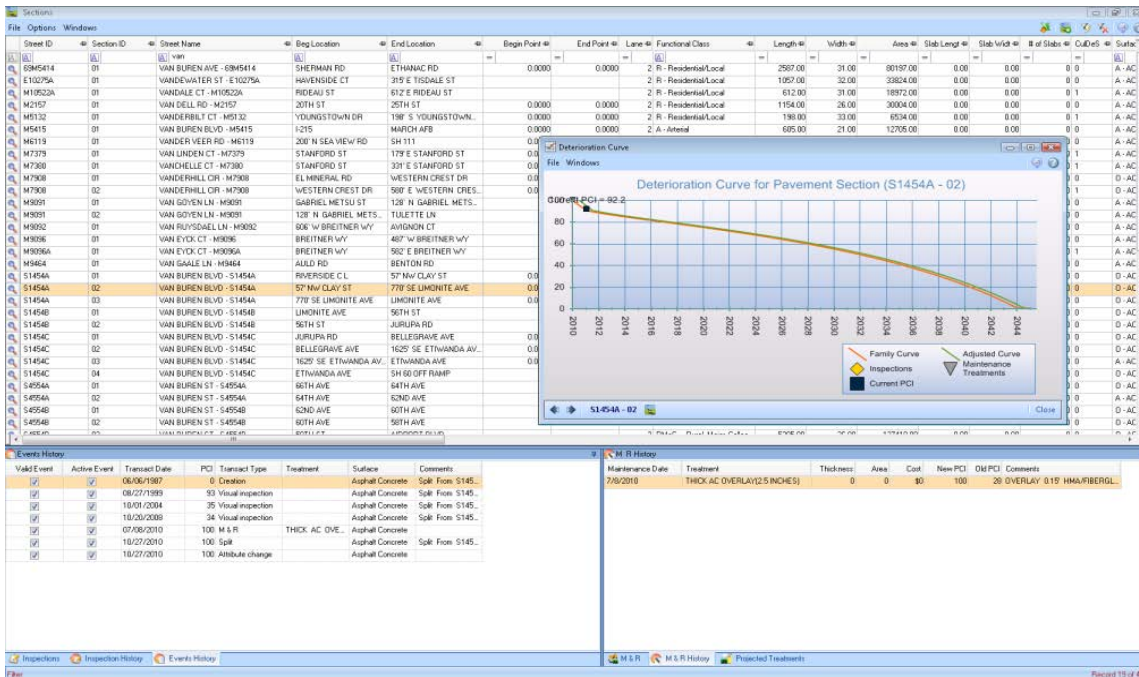


Figure 2. Pavement Management Program – StreetSaver

Additionally, the integration of the PMP with Geographic Information Systems (GIS) has provided the County with a snapshot of the roadway network to better organize the road segments, and data collected and improves the decision-making in selecting roads to be included for treatment/repair in the County’s annual Transportation Improvement Program. An example of the PMP/GIS integration is shown in Figure 3.

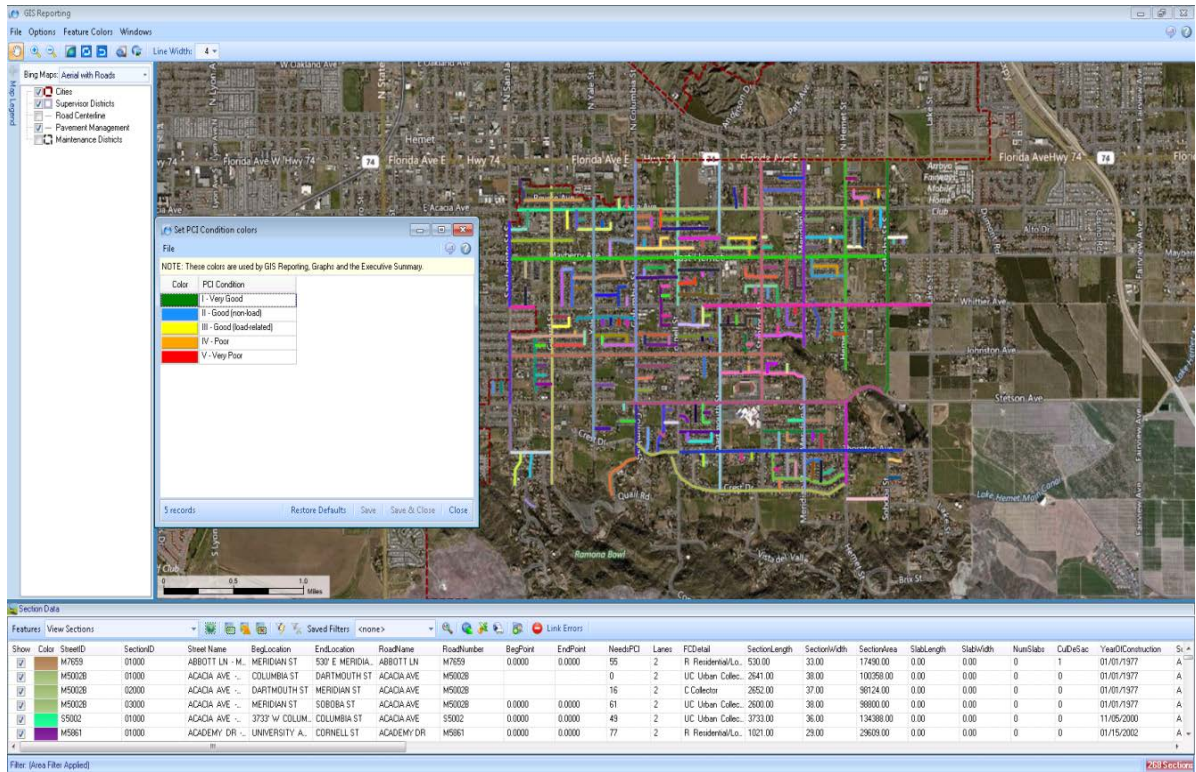


Figure 3. PMP PCI results on GIS map

PAVEMENT DISTRESS DATA COLLECTION

The survey method changed from manual surveying to a semi-automated survey in 2020. While the same distresses and severities are identified, there are differences between the two collection methods.

Manual Data Collection

Prior to 2020, the field inspection or visual inspection survey was conducted by pavement raters (two-man crew) who walked each individual road segment evaluating small samples of the pavement for signs of distress. The manual surveyors would enter the distresses on a tablet as shown in Figure 4.



Figure 4. Tablet device use in manual field inspection

Automated Data Collection

The County transitioned to the vehicle mounted automatic data collection system for 2020. The inspection involved collecting Right of Way (ROW) images and Downward Laser Crack Measurement System (LCMS) images. The images are rated by certified pavement inspectors on computers on a frame by frame basis and the distresses found in each frame are then imported into StreetSaver to calculate the PCI.

Table 1 examines the differences and the benefits of using the vehicle mounted system for the pavement inspection.

Table 1. Comparison of Manual and Semi-Automated Surveys

Manual Survey	Semi-Automated Survey
Visual survey is performed from the side of the road	Vehicle based laser downward images and Right of Way images
Manual survey exposes raters to traffic and environmental hazards	Vehicle travels at traffic speed, limiting hazards to inspectors
Areas and lengths of cracks are estimated	Measures crack lengths, widths, and depths
Small sample sizes, inspect complete road width but not complete length	All images collected are rated
Pavement roughness is not measured	Measures pavement roughness
Rutting is estimated	Includes accurate rutting measurements
2-4 images per sample	Laser Pavement and ROW images every 20ft
No road geometry measurements	Road geometrics possible
No additional asset condition evaluation possible	Additional asset condition evaluation possible, signs, guard rails, manholes, railroad crossings

Survey Equipment

The data collection equipment as shown in Figure 5 includes:

- LCMS Cameras: high-resolution laser scan, 13 ft wide pavement images
- High-Speed Laser Profiler for measuring road roughness
- High-definition Right of Way (ROW) cameras
- GPS coordinates location marker

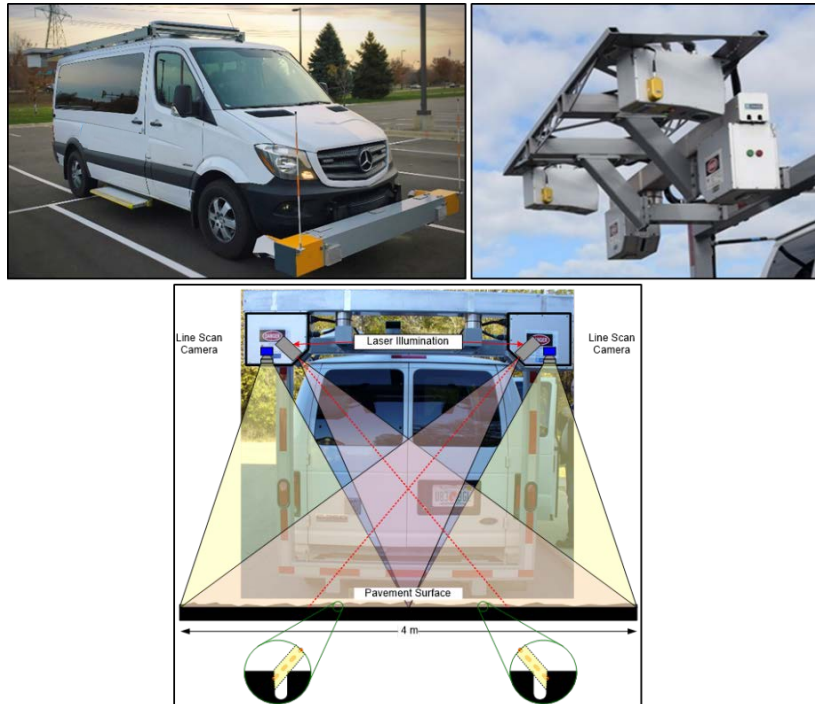


Figure 5. Vehicle mounted automated data collection equipment

Laser Crack Measurement System (LCMS)

The LCMS is composed of two lasers and high resolution cameras designed to take an image scan of the pavement surface. Image frames are created every 20 ft with GPS coordinates attached. Figure 6 shows a diagram of the laser data collection and a downward image of the pavement.

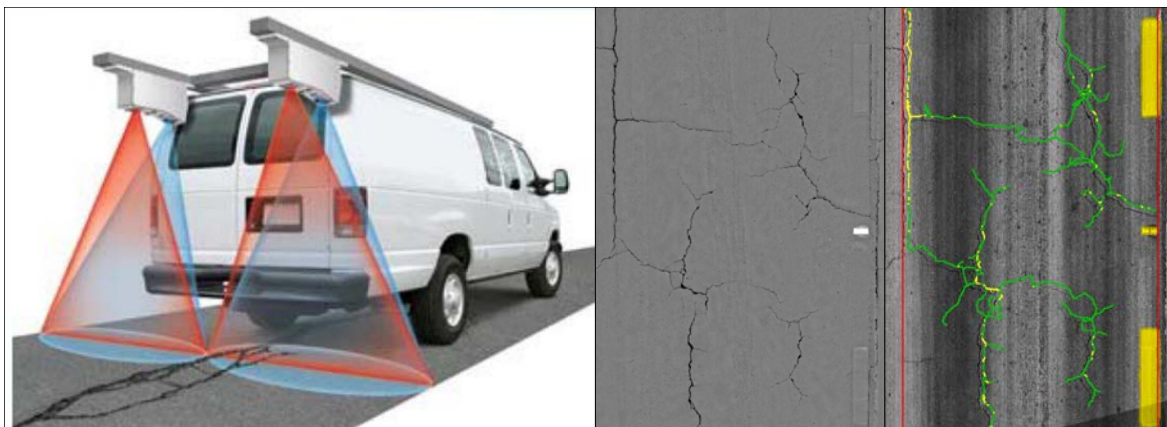


Figure 6. Schematic of LCMS Operation – Collection, 3D Range Image, and Crack Detection with Low and Medium Severity Cracks Identified

Right of Way (ROW) Images

Four high-definition digital cameras are used for acquiring ROW images. The images are collected every 20 ft. As with the downward images, the ROW images are collected with GPS coordinates attached. Sample ROW images are shown in Figure 7 below.



Figure 7. ROW Images

Computer Based Pavement Condition Rating

Pavement condition is rated using a distress rating software where the road is divided into 20-ft pavement frames and each downward image is rated. The rating data is imported into StreetSaver and the PCI values are calculated automatically. A sample diagram of the rating process can be seen in Figure 8.

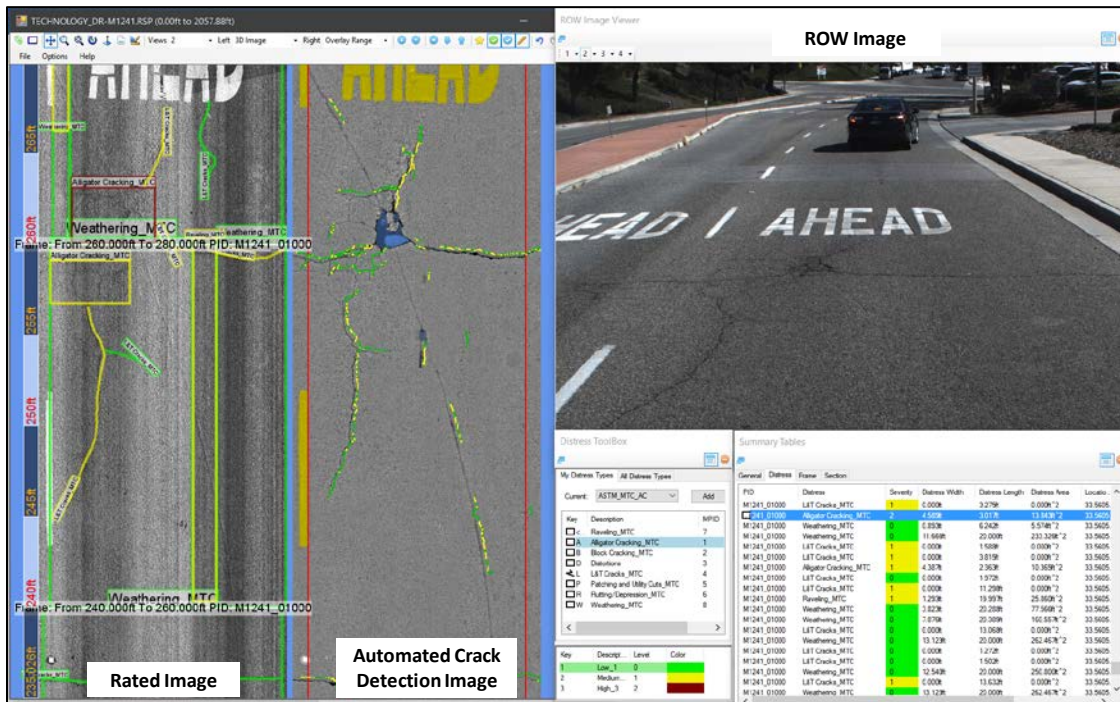


Figure 8. Distress Rating - PCI Distress Types and Pavement Frames

PAVEMENT STRUCTURAL DATA COLLECTION

The County invests millions of dollars each year in pavement maintenance activities. The Pavement Management Program (PMP) assists the County in determining the most cost-effective strategy for investing in pavement rehabilitation. In addition to the PMP tool, the County has invested in advanced structural data collection equipment including a Ground Penetrating Radar (GPR) and a Falling Weight Deflectometer (FWD). Figure 9 shows this advanced structural data collection equipment.



Figure 9. FWD and GPR Data Collection Equipment

The GPR is used to measure pavement layer thickness and detect groundwater and voids beneath the pavement. The FWD is used to measure and evaluate the physical properties of the pavement structure. The use of the StreetSaver PMP which has been populated with data from the PCI inspection and with data collected from this state of the art equipment, provides the County pavement Engineer with adequate information to make informed decisions to best utilize available funding.

PAVEMENT CONDITION BASED ON PCI

Figures 10A to 10H show different pavement sections with decreasing PCI values. The images are the Right of Way (ROW) image, the 3D downward laser image with identified cracks highlighted, and the 3D range image that smooths surface texture to highlight crack details.

Data was collected on the No.1 lane of 2 lane roads and 2 lanes for roads with 4 or more lanes. Each side of a divided road was treated independently, and data was collected for both directions on divided roads.

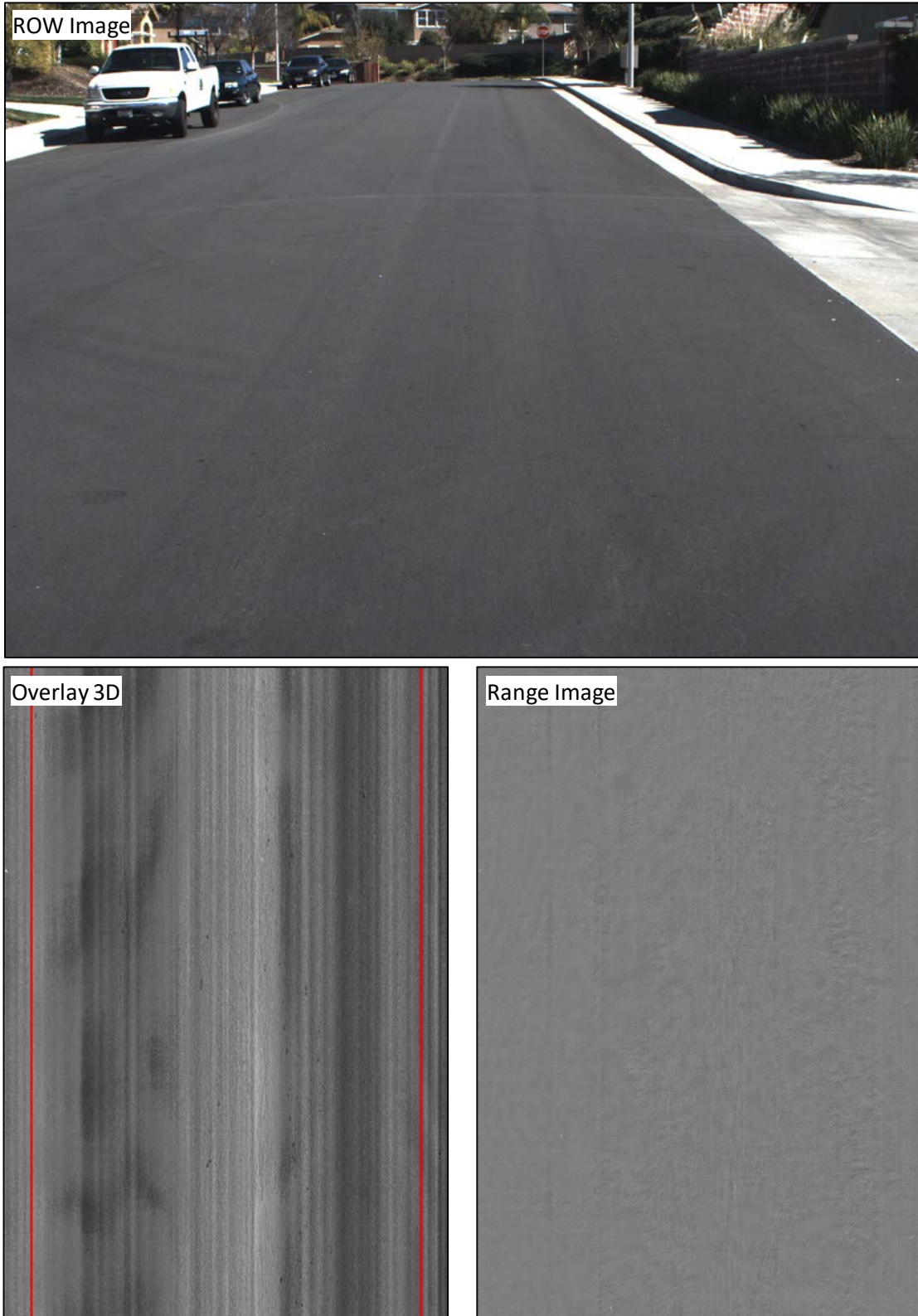


Figure 10A. PCI=99 (Excellent Condition)

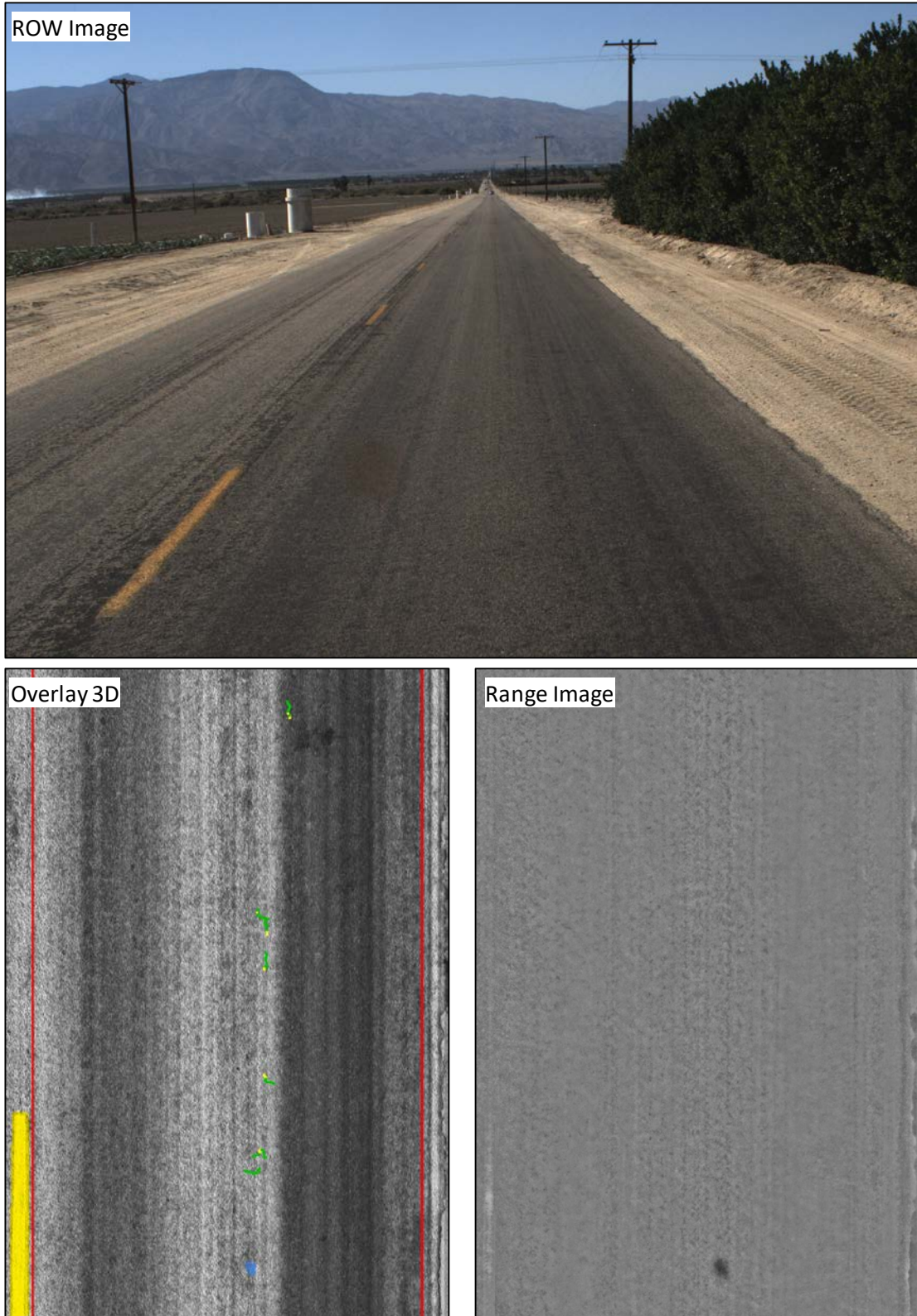


Figure 10B. PCI=85 (Very Good Condition)

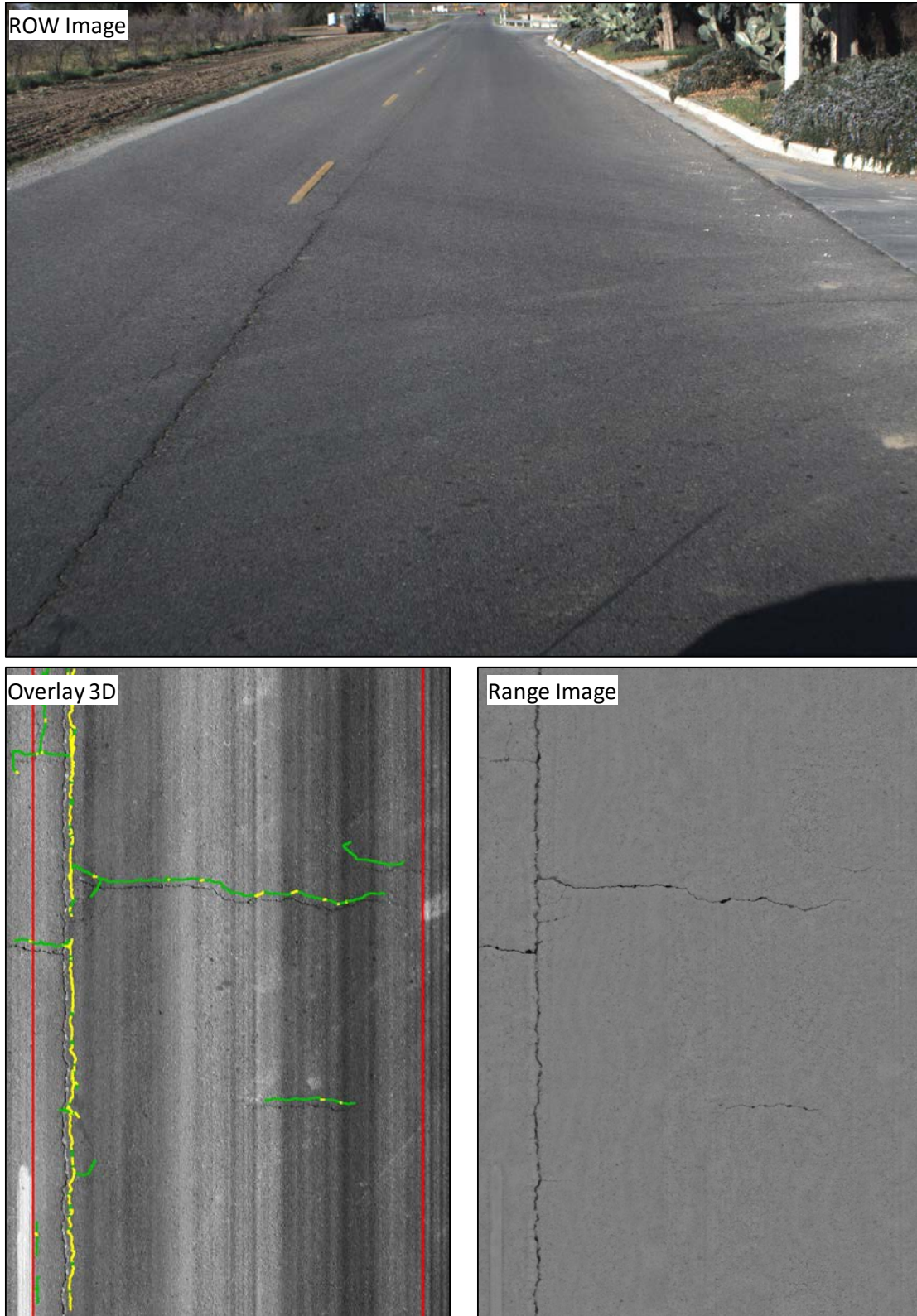


Figure 10C. PCI=73 (Good Condition)

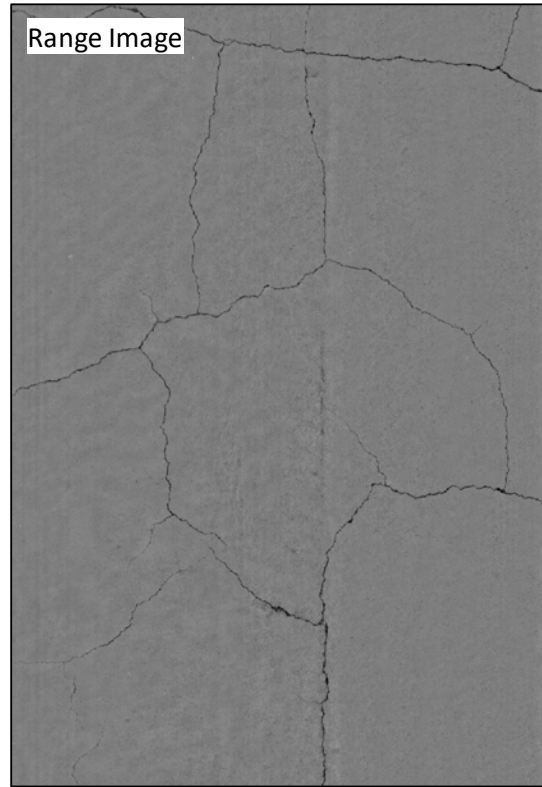
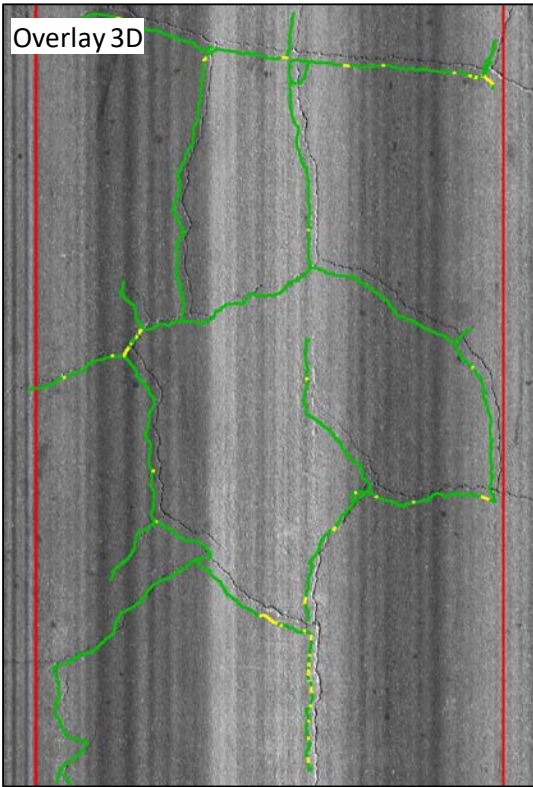


Figure 10D. PCI=68 (At Risk Condition)

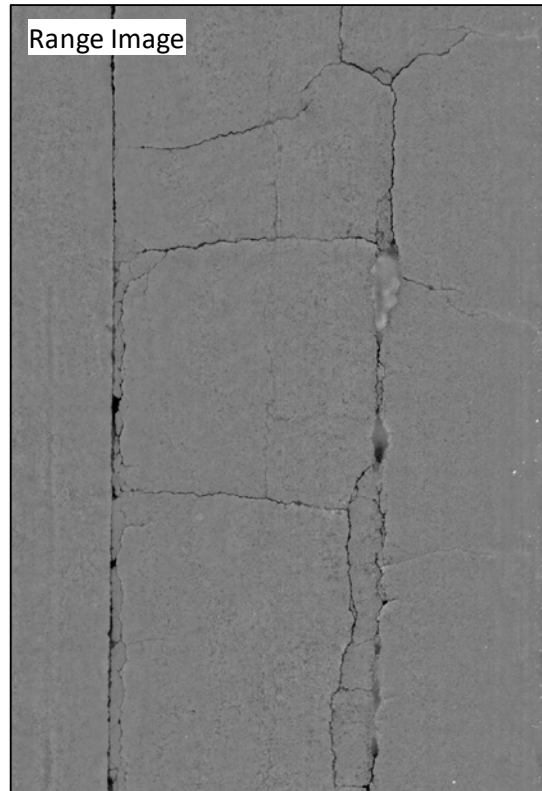
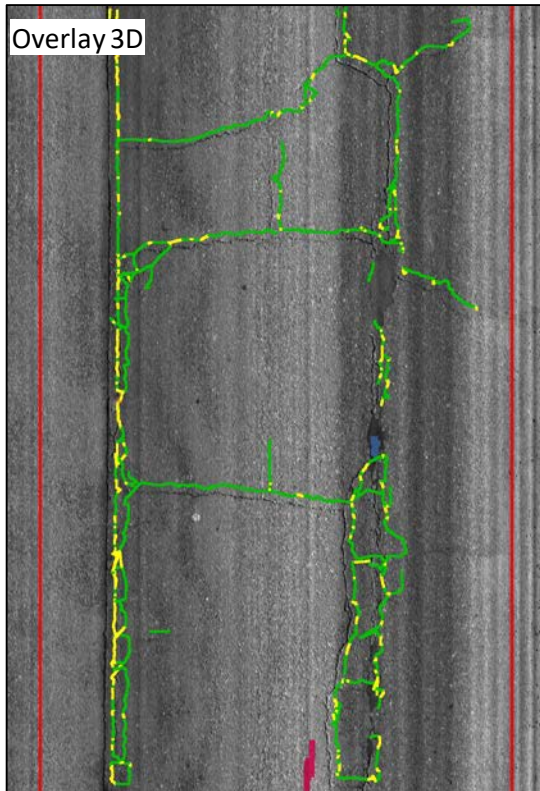


Figure 10E. PCI=54 (At Risk Condition)

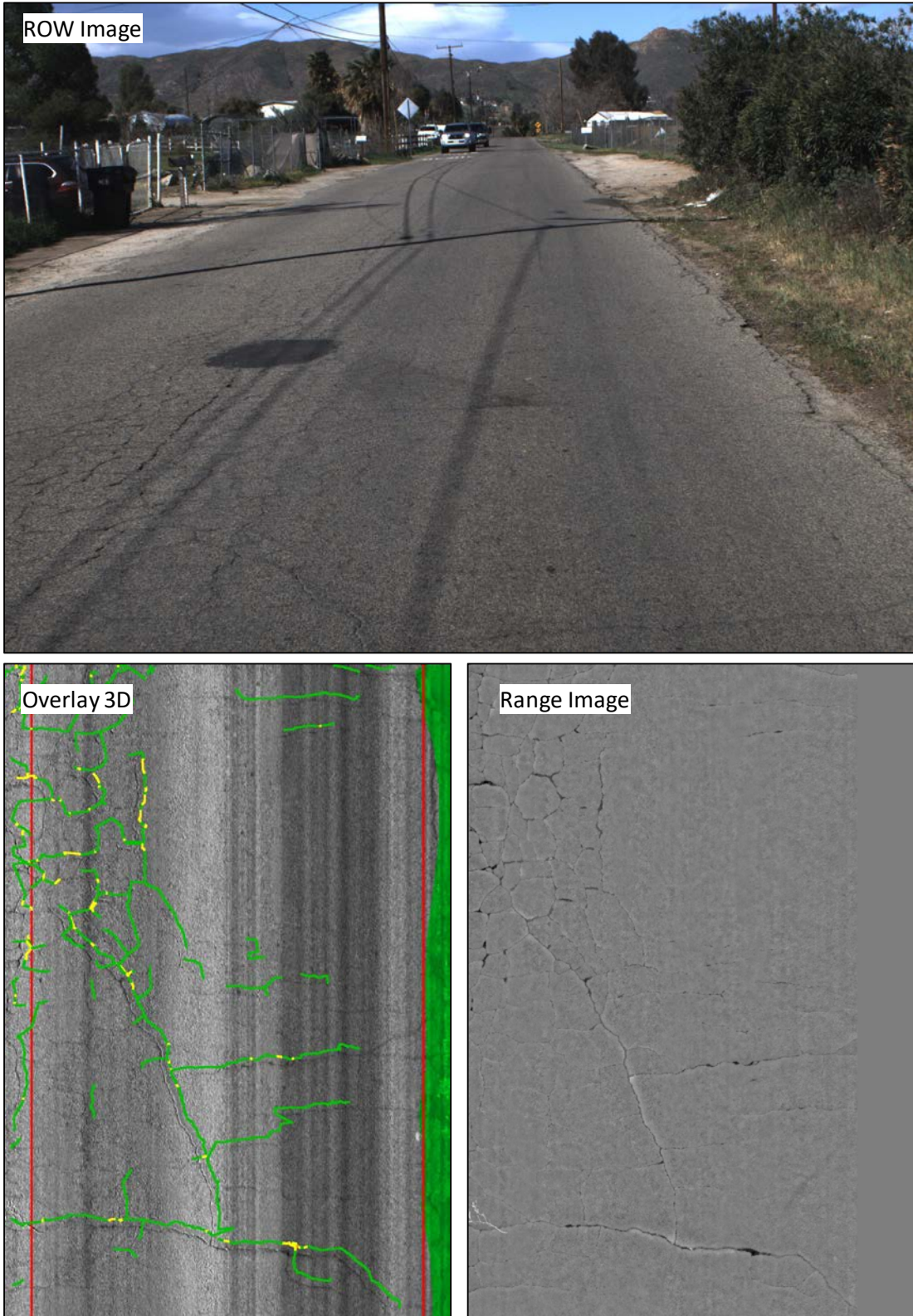


Figure 10F. PCI=38 (Poor Condition)

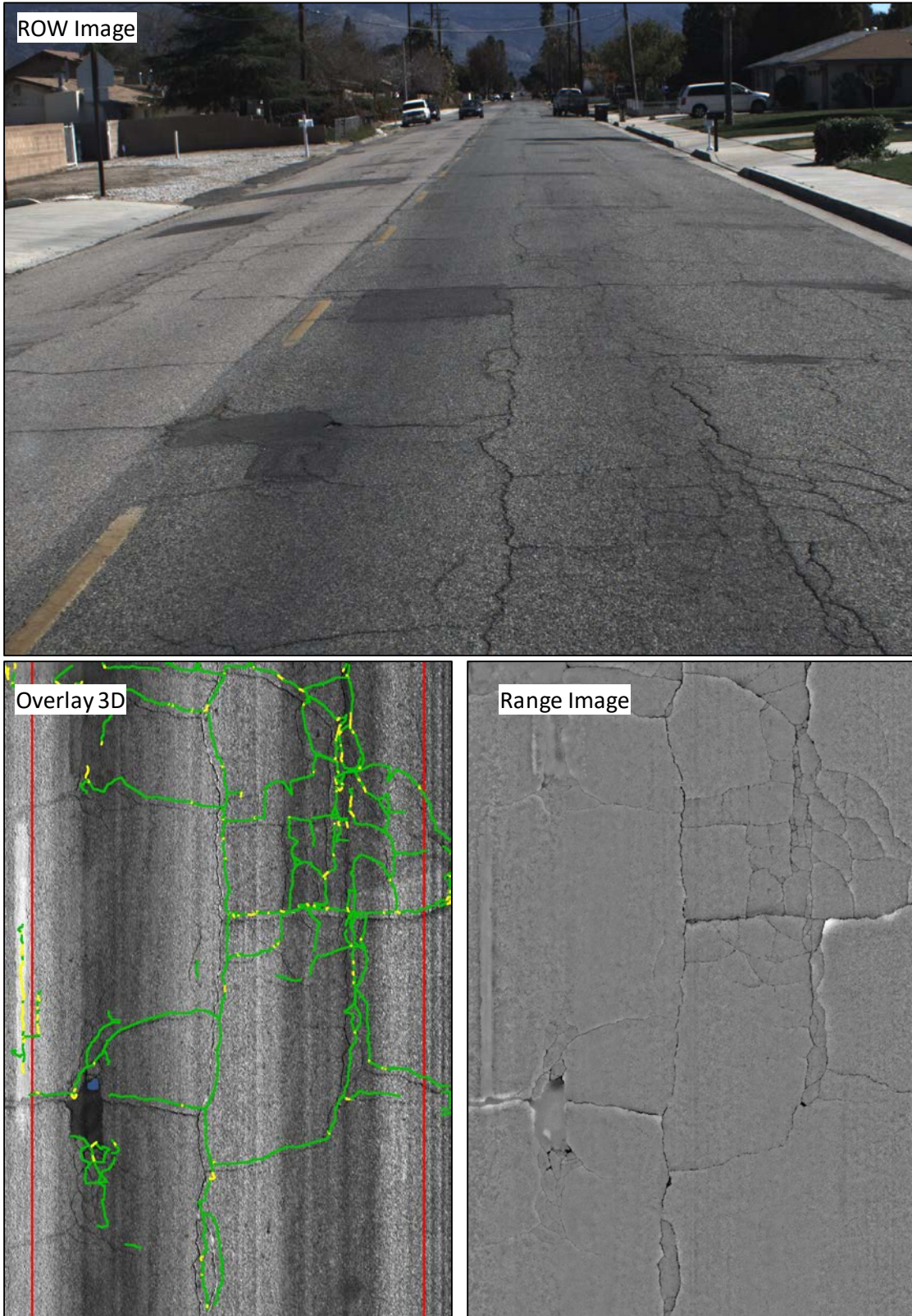


Figure 10G. PCI=26 (Poor Condition)

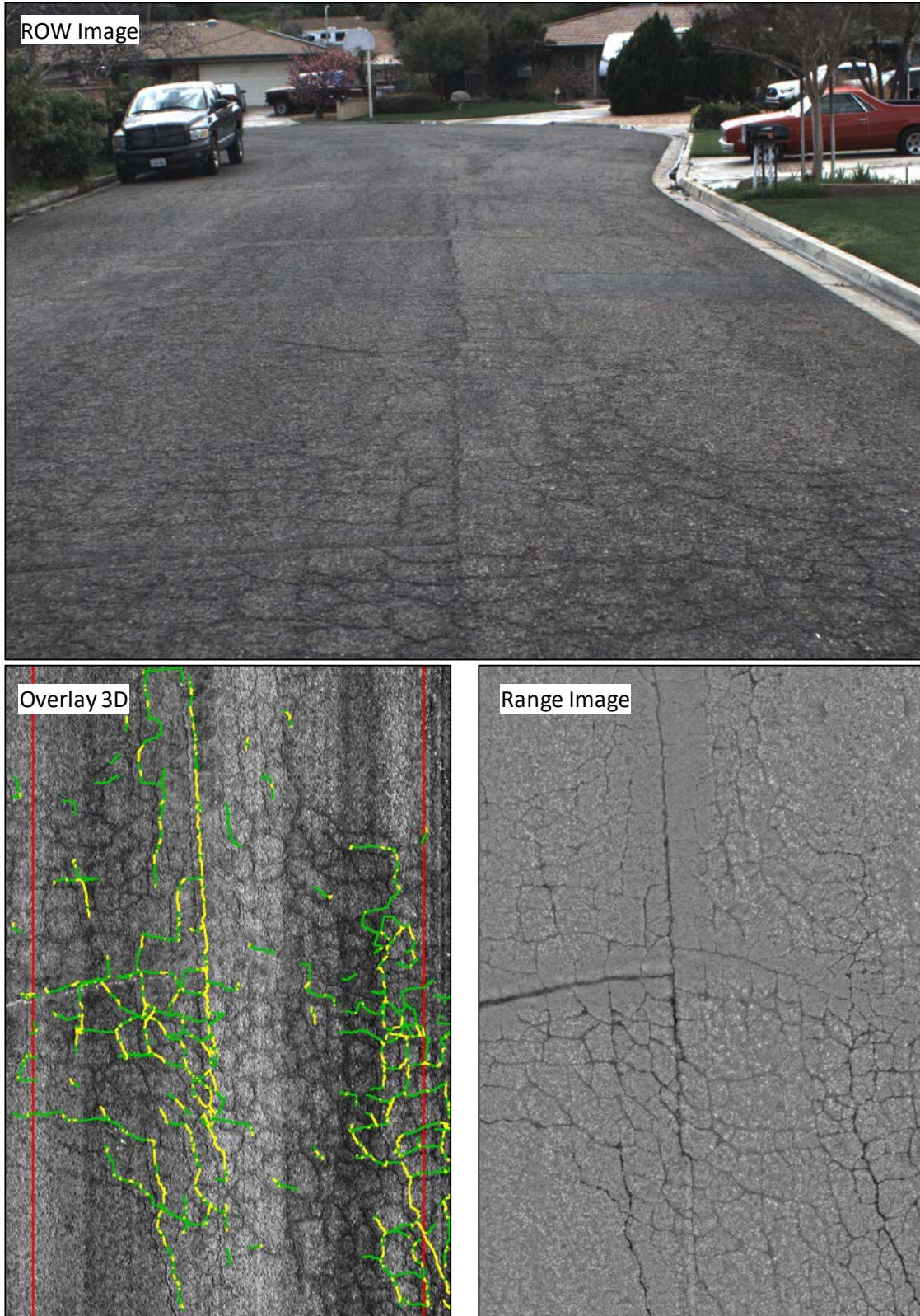


Figure 10H. PCI=8 (Very Poor Condition)

ROAD NETWORK

Road Condition

The percentage of mileage categorized by condition rating (good to excellent, at risk, poor, and very poor) over the last 5 years is summarized in Table 2. This table is also presented graphically showing the pavement condition trend in Figure 11 below.

Table 2. Condition Rating¹ (Countywide)

	GOOD TO EXCELLENT PCI 70-100	AT RISK PCI 50-69	POOR PCI 25-49	VERY POOR PCI 0-24	DISTRESSED ROADS ²
FY 2020	70%	21%	8%	1%	30%
FY 2019	66%	22%	9%	3%	34%
FY 2018	68%	21%	8%	4%	33%
FY 2017	63%	30%	6%	1%	37%
FY 2016	67%	21%	8%	4%	33%

¹) Gravel or dirt roads are not included in the condition rating above.

²) Distressed roads include roads from the AT RISK, POOR, and VERY POOR categories. Over the last 5 years, the percentage of distressed roads has been gradually declining from 33% to 30%.



Figure 11. Pavement Condition Trend (Countywide)

Funding History & Miles Treated by Treatment Type

Roadway rehabilitation funding varies from year to year. With the passage of SB1, the department will be able to plan for improvement projects into the future due to the relative certainty of gas tax revenue. Over the last 10 years, the transportation department has invested approximately \$282 million in pavement preservation and rehabilitation. Figure 12 and Figure 13 show the amount invested on preservation and rehabilitation and the associated total number of lane miles treated over the last 10 years.

In Figure 12, it is seen that the percentage of the budget spent on preservation versus rehabilitation increases. This is done to preserve as much pavement in the “good” condition as possible while deferring costly rehabilitation projects that will likely cost a similar amount to complete in future years as they would in the current year. The result of this practice is to stabilize and preserve the most roads possible to maintain the network wide PCI while allowing poor roads, where preservation would do little to slow deterioration, to continue to deteriorate. It should be noted that, regardless of planned work, safety hazards of severely deteriorated roads such as deep potholes, severe rutting (which could lead to ponding water and hydroplaning), or dangerous distortions are repaired as soon as they are discovered.

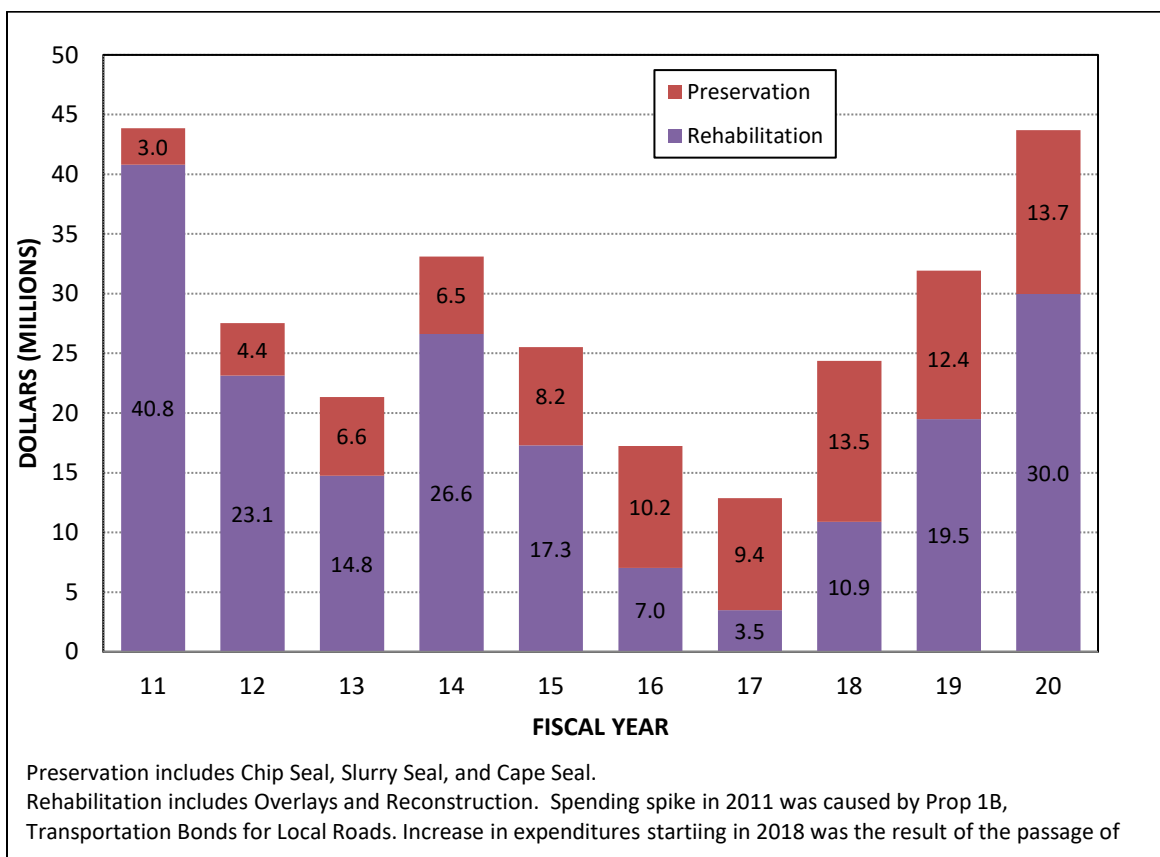


Figure 12. Funding History

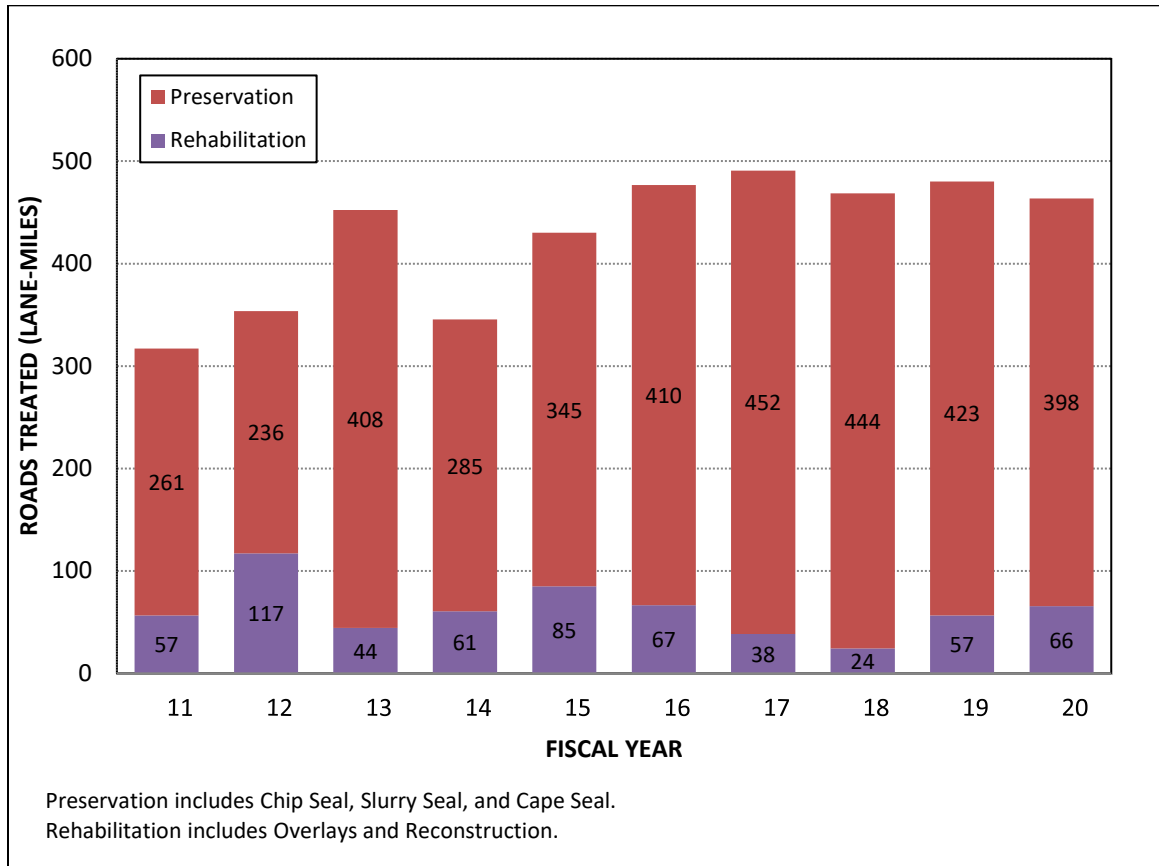


Figure 13. Road Miles Treated History

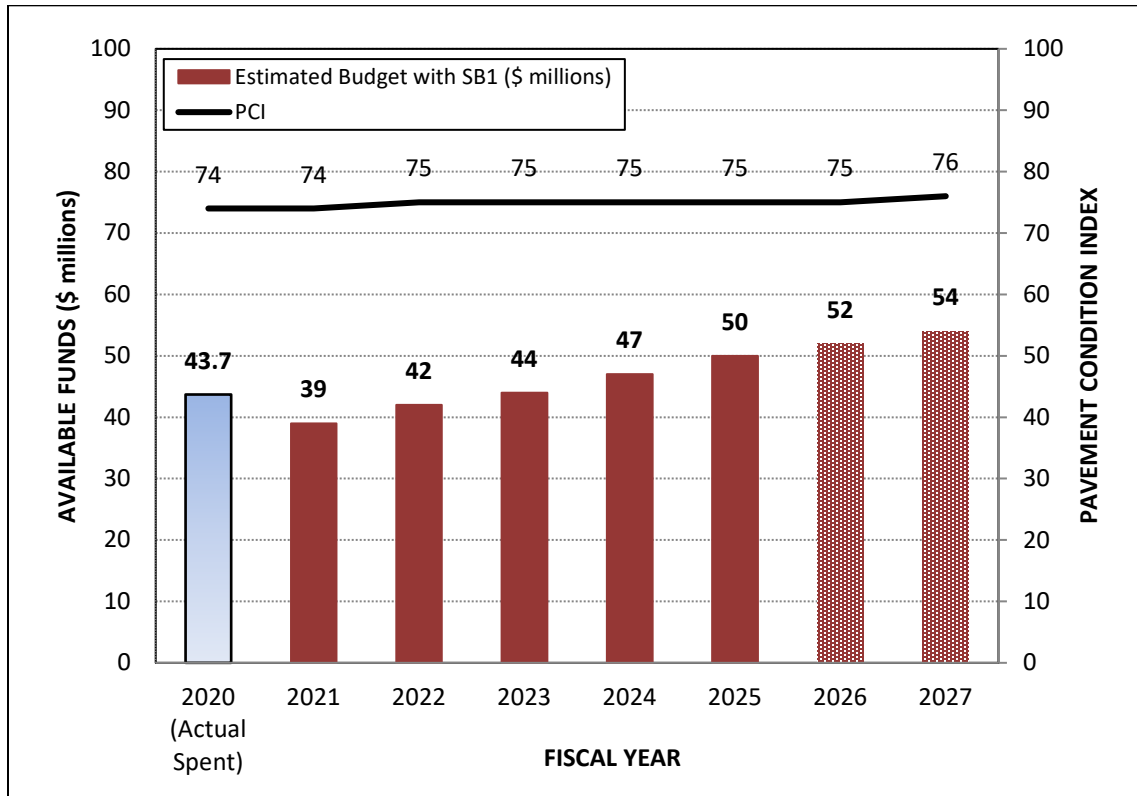
Needs Assessment

In determining the pavement needs to maintain the network condition at an acceptable level, a goal must first be defined. The goal for Riverside County unincorporated roads is as follows:

- attain a PCI of 80 or higher where Best Management Practices (BMPs) can be implemented. These BMPs maximize the use of the most cost-effective pavement preservation treatments.

For this goal to be effective, it should be attainable within a specific timeframe. Two funding scenarios were analyzed to determine the impact of various funding levels in terms of the overall change in PCI. These scenarios are:

1. Impact based on current funding projections (Figure 14)
2. Funding needed to maintain current PCI of 74 (Figure 15)

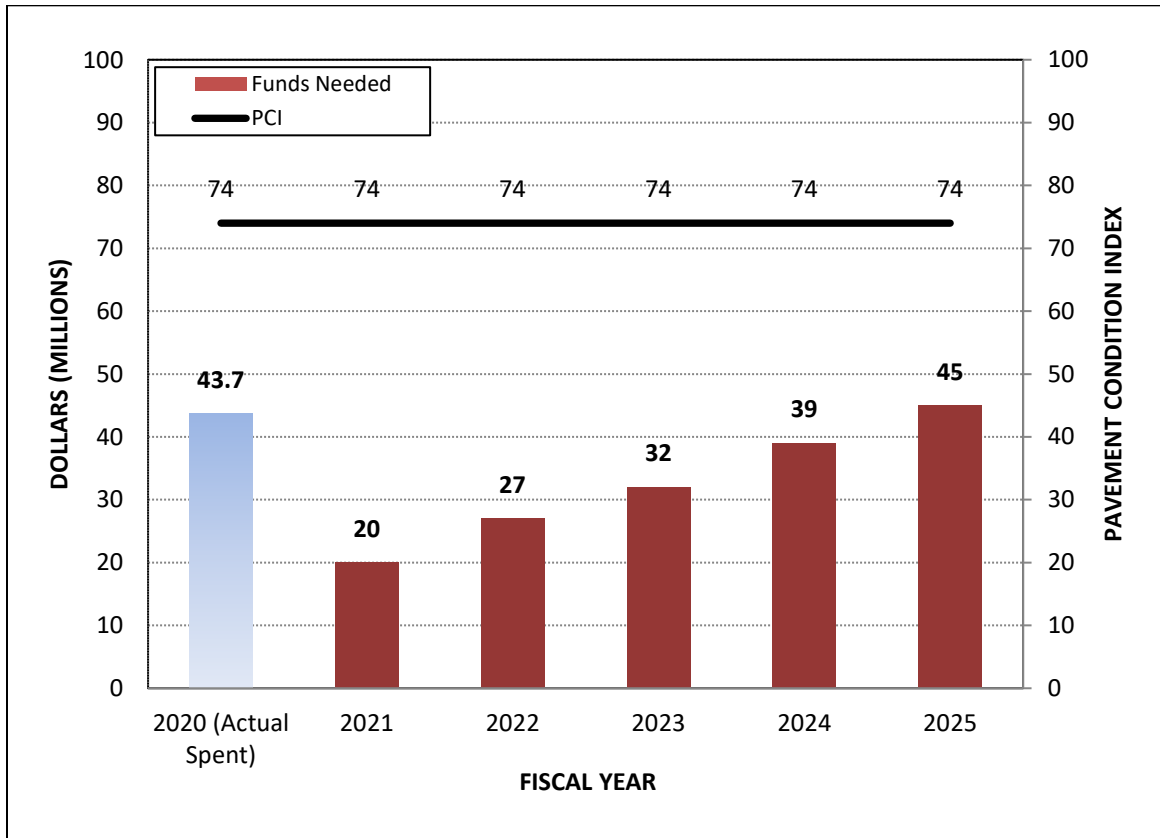


Note: The projected total budget in 2025 (5 years) and 2027 (7 years) is \$222 million and \$328 million, respectively.

Figure 14. PCI based on Current Funding Projections

With the passage of SB1 in April 2017, the overall condition of the road network is expected to improve. As can be seen in Figure 14, the PCI improves from 74 in 2020 to 75 in 2025. As was shown in Table 2, approximately 30 percent of the total maintained road miles throughout the County were identified to be in need of resurfacing or replacement in FY 2020. In order to reduce the percentage of AT RISK, POOR, and VERY POOR roads from 30 percent to 25 percent, it is estimated that it will cost at least \$328 million. Additionally, in Figure 14, two additional years were added to project the PCI to 76 based on the anticipated SB1 funds for the year 2026 and 2027. By attaining a PCI of 76 in 2027, the AT RISK, POOR, and VERY POOR roads will decline to less than 25% of roads.

Figure 15 shows the estimated funding required to maintain the average PCI for the County at 74. According to this analysis it will take \$163 million over 5 years to maintain the PCI, however, as can be seen in Figure 13, the amount required each year goes up. This indicates that, as much as preventative maintenance can be completed each year, the pavement continues to deteriorate resulting in a more expensive rehabilitation.



Note: The projected total funding needed through 2025 (5 years) is \$163 million to maintain current PCI

Figure 15. Funding Needed to Maintain Current PCI

Roadway Functional Classifications and Condition

Riverside County maintains approximately 2,022 centerline miles of paved road and 221 miles of unpaved road as of the end of fiscal year 2020. Table 3 shows the breakdown of the countywide road network grouped by functional classification with the average network Pavement Condition Index (PCI).

Table 3. Total Maintained Miles (Countywide)

FUNCTIONAL CLASSIFICATION ¹	CENTERLINE MILES ²	LANE MILES ³	PCI ⁵
Arterial	442	1000	73
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²) Centerline mile represents the total length of a road from its starting point to its end point regardless of the pavement width or the number of lanes.

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- 5) The PCI shown is the area weighted PCI (i.e. larger areas impact the average PCI more than smaller areas)
- 6) The average PCI in 2020 was 74 whereas the desirable goal is 80 or higher. Roads with a PCI less than 70 are considered to be at risk of rapid deterioration.

Figure 16 below shows the PCI trend for the County for the last 10 years.

Historical PCI

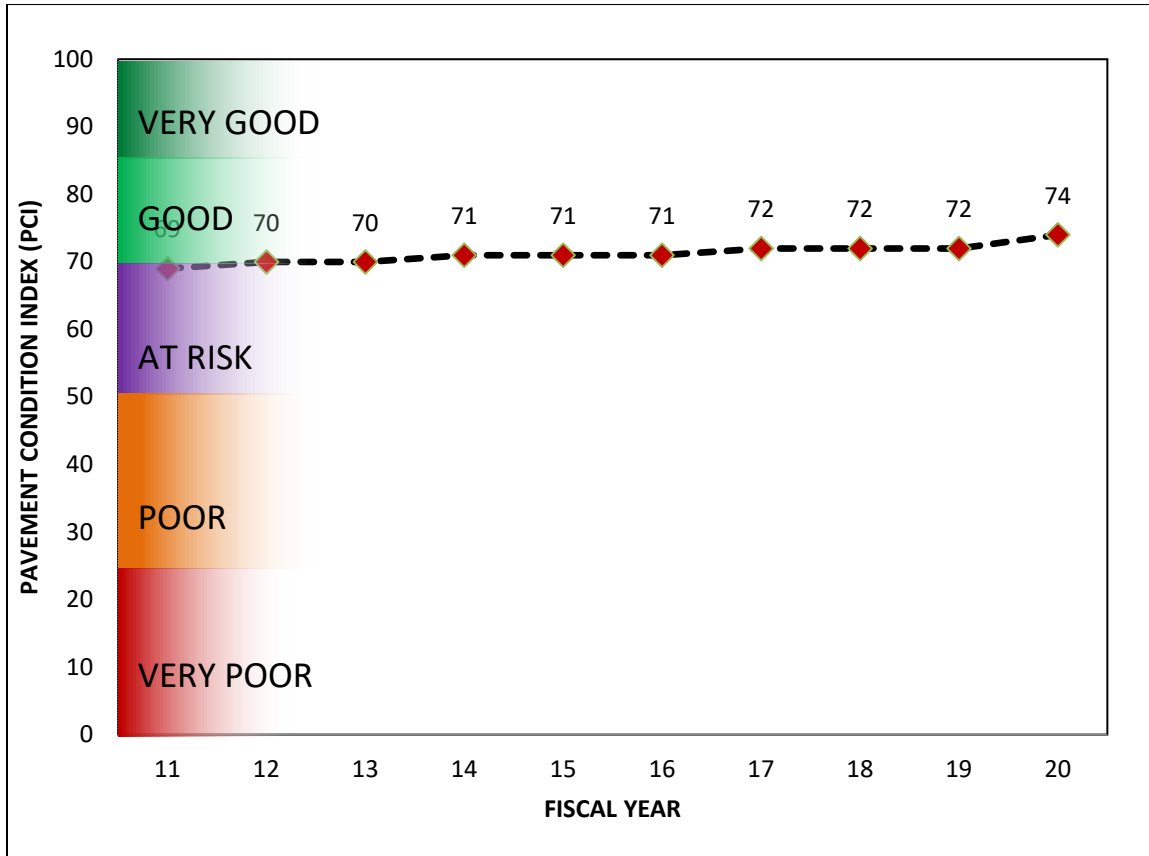


Figure 16. Pavement Condition Index Trend

Road Condition by Supervisorial District

Tables 4 and 5 depict the total number of centerline miles in each Supervisorial District by the functional classification of road and the associated area weighted average PCI.

Table 4. Supervisorial District Centerline Miles

FUNCTIONAL CLASSIFICATION	District Centerline Miles					Total
	1	2	3	4	5	
Arterial	111	8	115	136	68	442
Collector	91	15	157	305	67	637
Residential/Local	258	44	299	214	126	943
Gravel/Dirt	9	5	43	138	22	221
TOTAL	469	72	614	793	283	2243

Table 5. Supervisorial District PCI

FUNCTIONAL CLASSIFICATION	District PCI ¹					Overall
	1	2	3	4	5	
Arterial	73	58	71	75	73	73
Collector	71	74	70	75	65	72
Residential/Local	80	73	72	76	73	75
Gravel/Dirt	-	-	-	-	-	
Average PCI	76	71	71	75	71	74

¹)Area weighted average PCI

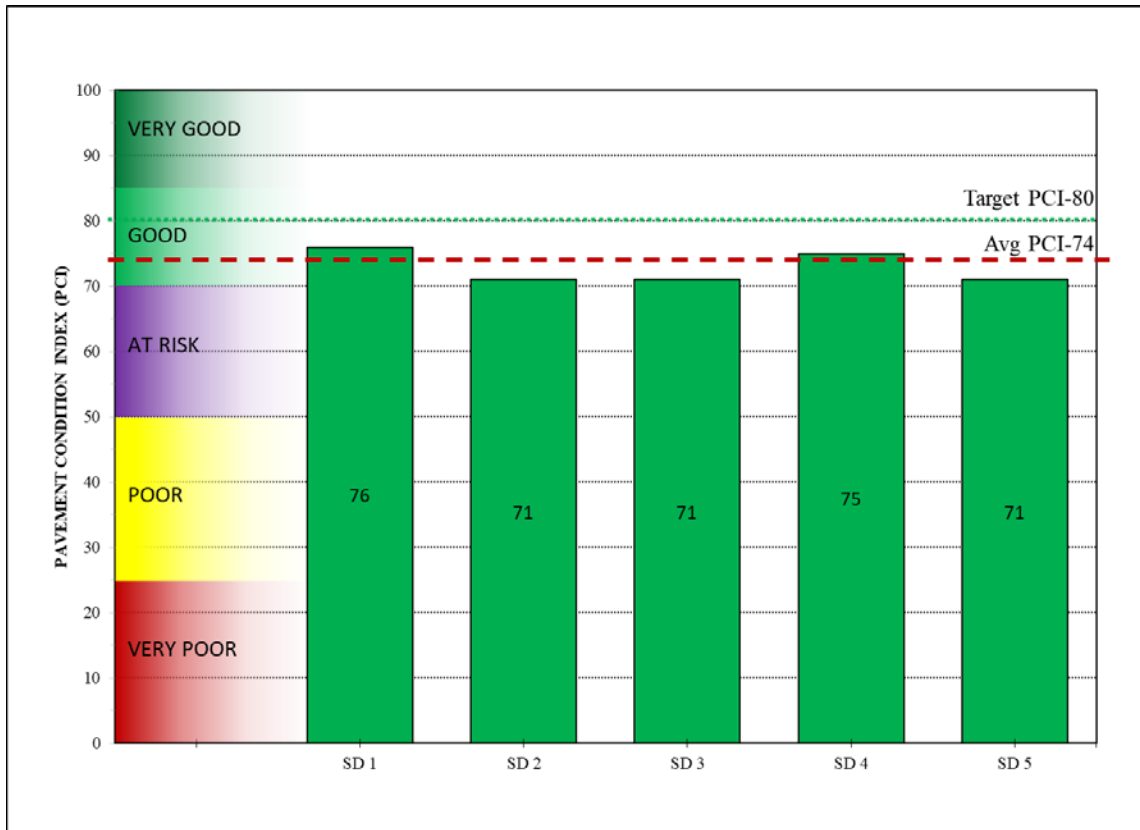


Figure 17. Pavement Condition Index by Supervisorial District

The Target PCI of 80 or higher, as shown in Figure 17, is based on a set goal that all pavements throughout the County road network system be in a condition where Best Management Practices (BMP) can occur. This means that the service life of roads can be extended by cost-effective pavement preservation treatments, such as, chip seal, slurry seal, cape seal, and thin overlay. Reaching and maintaining the target PCI of 80 offers other benefits to the public (other than cost):

- Fewer and shorter construction delays
- Reduced environmental impacts - less noise, dust, energy use, and greenhouse gas emissions
- Smoother roads (reducing accidents, fuel use, and vehicle maintenance and repair costs)

The average PCI of County roads is 74. A PCI of 74 is approaching the “At Risk” category and deterioration of a pavement can increase rapidly once the PCI falls below 70 (also called the “critical PCI”). If repairs are delayed by just a few years, the PCI drops quickly and the cost of repair could be up to ten times more than the pavement preservation treatment.

PAVEMENT PRESERVATION

The desired goal of the County is to extend pavement life with the most effective treatment solution at the minimal life cycle cost. Over the useful life of a road, it is less expensive to “preserve” the pavement surface than to do nothing and have to reconstruct it.

Pavement Life Cycle

A pavement’s life cycle is the relationship between its condition (PCI) and age. A newly constructed pavement is considered in perfect condition (PCI=100), but as it gets older, factors such as use, applied load, and climate cause its PCI to decrease. A properly designed pavement will usually have a slow deterioration rate during the first part of its life and at some PCI value and age combination, the pavement’s deterioration rate will increase rapidly. The PCI value at this point in a pavement’s life is called the “critical PCI”. Figure 18 demonstrates this concept, at 75 percent of pavement design life (15yrs), the PCI drops by 40 percent (a rate of loss of ~2.7 PCI points/yr). If left untreated, it only takes another 15 percent of pavement life (3yrs) for the PCI to decline another 40 percent (a rate of loss of ~13.3 PCI points/yr). So, for this example, the “critical PCI” would be 70, at 15 years of in service life. The work required to improve the road back to an acceptable PCI will cost 4 to 5 times as much at the 18-year point than if a preservation treatment had been applied at or before the 15 year point.

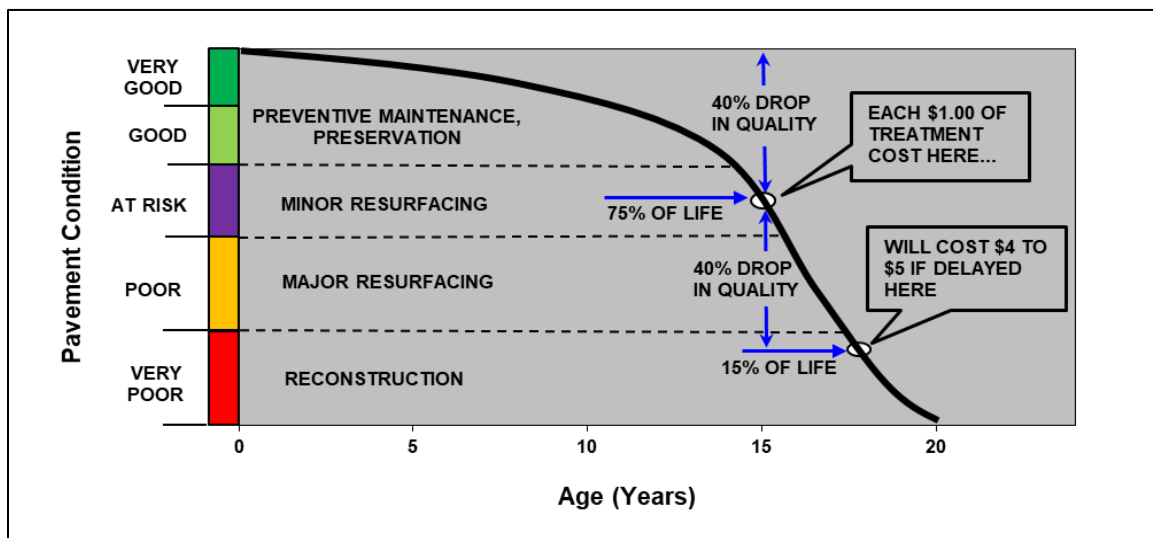


Figure 18. Pavement Life Cycle with No Maintenance and Repair

Life Cycle Cost Concept

A key concept in life cycle costing for pavement management is the timing of pavement preservation work; the work needs to be completed before the pavement reaches the critical PCI, this is a “proactive” approach to pavement management.

In “reactive” pavement management, projects are developed and funded in response to impending or critical failure and/or customer complaints. Reactive pavement management is both inconvenient and costly because large portions of a budget are consumed by small but expensive reconstruction projects or surface treatments are applied to deteriorated pavements which are doomed to premature failure requiring additional costly work and road closures. The

overall poor condition of pavements from a reactive approach ultimately has a negative effect on both the local economy and the quality of life for users.

“Proactive” management determines what maintenance should be planned, when it should be budgeted, and what the consequences will be if the maintenance is not completed. A proactive approach uses a long-term, life-cycle cost perspective and takes advantage of sound, engineering-based procedures through the use of a network level pavement management program.

Pavement treatments include surface treatments such as slurry seals and cape seals, minor and major resurfacing, and reconstruction. The best treatment for a road is determined by pavement condition, location, and functional classification of the road. Proactive treatments are designed to bring the pavement up to an acceptable condition and extend the service life of the pavement.

Proactive pavement treatment actions can be effectively planned by monitoring the condition of the pavement network and conducting maintenance or repair on roads before the critical PCI is reached. This will increase the life of the pavement and reduce the “life cycle cost.” Additionally, if a pavement PCI is too low, a choice may be made to forego a “preservation” treatment that would likely not extend the useful life of the pavement so that the funding can be used to preserve a road above the critical PCI point.

Figure 19 shows an example of life cycle costs for the life of an asphalt pavement for 60 years if proactive preservation is not applied to the pavement. The construction costs to keep the 2 lane road operational is estimated at \$950k/mile of road and the road will be out of service for 70 days for each mile of road.

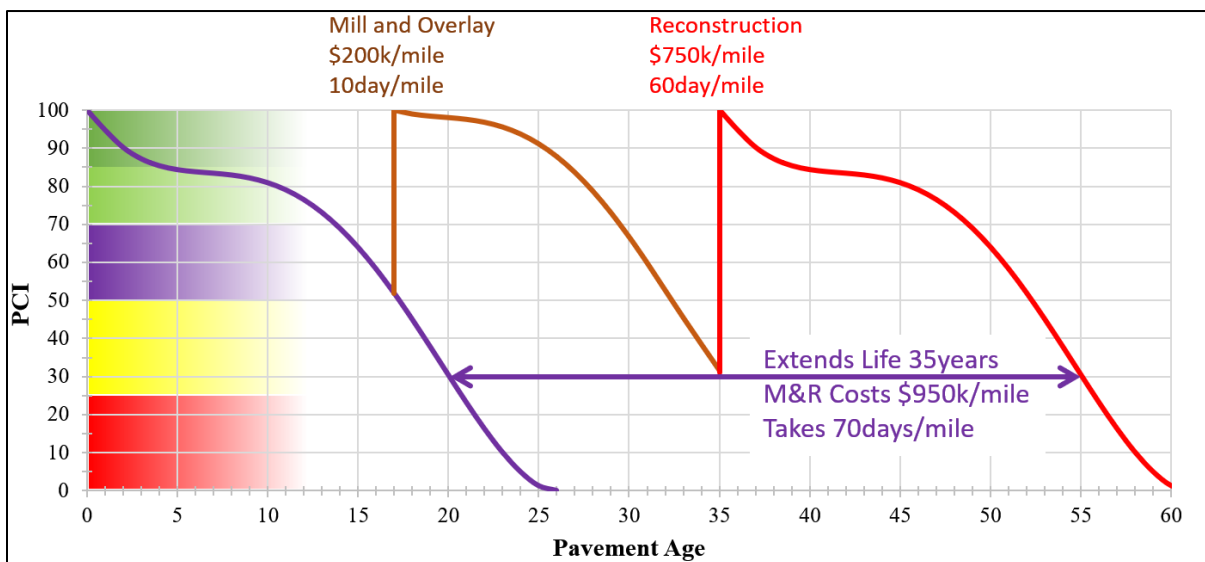


Figure 19. Life Cycle Cost Estimate with No Pavement Preservation

Using the wrong treatment on a road at the wrong time will increase the life cycle costs for that road. An effective pavement management program will extend the life of pavements through preventive maintenance and preservation. By applying a cost-effective treatment at the right time, the pavement is restored almost to its original condition. Figure 20 illustrates the concept of pavement preservation as it relates to enhancing pavement performance, extending

pavement life, and ensuring taxpayer dollars are utilized wisely while providing improved safety and mobility to the public. Figure 20 also shows the cumulative effect of systematic, successive M&R treatments which result in the postponement of costly resurfacing and reconstruction. The life cycle cost to “maintain” the pavement for 60 years in this figure is \$233k/mile for the construction costs, 4 times cheaper than not using pavement preservation and causes 57.5 days less traffic disruption.

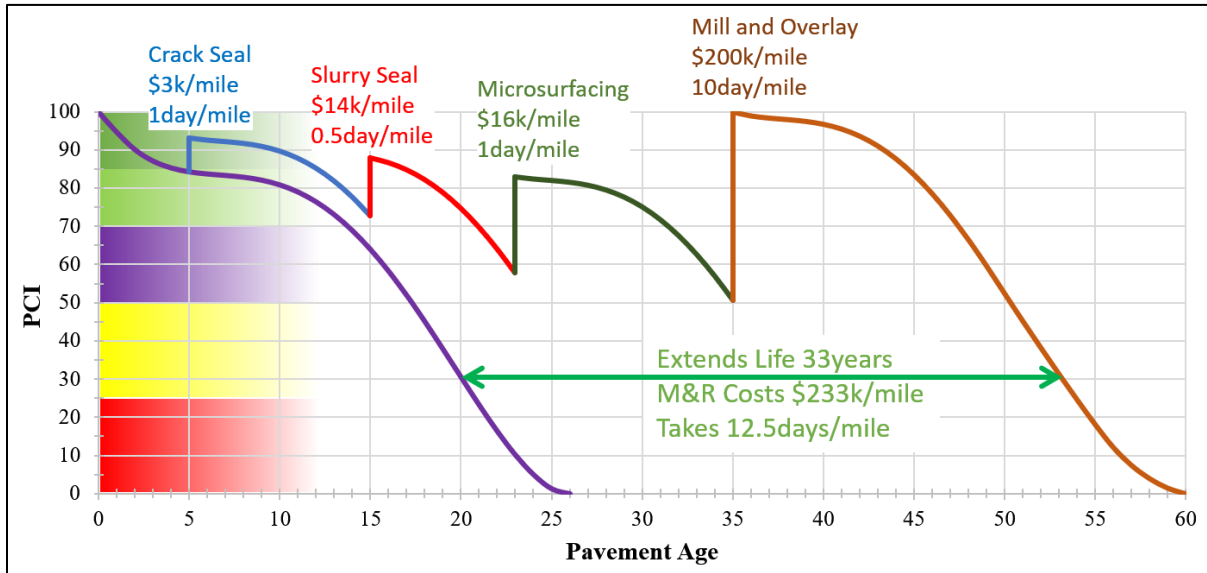


Figure 20. Treatment Zone Alternatives as a Function of Pavement Condition

IMPLEMENTATION OF PAVEMENT PRESERVATION USING BEST MANAGEMENT PRACTICES

Riverside County implements pavement preservation treatments to preserve roads in good condition. In order to keep the good roads from deteriorating further, treatment strategies that can extend the life of roads at minimal costs are used. These treatment strategies include various surface treatments such as chip seals, scrub seals, slurry seals, and cape seals.

Pavement surface treatments are non-structural preventive maintenance applications that are classified as pavement preservation techniques. While these surface treatments do not increase the load carrying capacity of the road, if applied at the right time on the right pavement they do extend pavement life by keeping water out of the pavement layers and improve safety by decreasing road roughness and increasing surface friction.

Seal Coat (Preventive) Treatment

A seal coat treatment is “preventive maintenance” designed to preserve a pavement in good condition and prolong its service life. Seal coats “prevent” further deterioration by sealing and rejuvenating the pavement surface. Sealing the pavement keeps water and debris from entering cracks and causing the pavement system to lose the capacity to carry loads without causing additional cracking. Sealing also prevents additional “weathering” or aging of the pavement surface. Weathering leads to a more brittle pavement surface which will crack due to temperature changes or load. Some seal coat treatments are as described below in more detail.

Chip / Scrub Seal

A chip seal is a surface treatment applied to pavement with minimal surface distress to provide a new wearing surface, extend pavement life, and delay major rehabilitation or reconstruction. It is a process in which an asphalt emulsion is sprayed on the pavement then immediately covered by small crushed aggregate particles, also known as “chips.” Figure 21 illustrates the spreading of aggregate over the sprayed emulsion. When the asphalt emulsion is applied to the road surface in conjunction with a mechanized scrub broom (that forces the emulsion into the cracks), this process is called “scrub seal” (shown in Figure 22).



Figure 21. Chip Seal (slurry emulsion applied on right, chips applied on left)



Figure 22. Scrub Seal (brooms on left, in use on right)

Slurry Seal / Micro-surfacing

A slurry seal is a maintenance treatment applied to pavement to improve the functional characteristics of the pavement surface. It is a mixture of asphalt emulsion, aggregates, and mineral fillers. It is mixed and placed in a continuous basis using a truck mixer. A micro-surfacing is a maintenance treatment similar to slurry seal except it uses polymer modified and fast setting asphalt emulsion allowing thicker layers to be placed. The thick layer application allows the microsurfacing slurry to fill in ruts commonly found on roads with light to moderate truck traffic. Prior to application, any surface distresses, such as cracks, are filled and sealed. After thoroughly mixing the emulsion, aggregates, and mineral fillers in the slurry truck's built-in pug mill, the slurry mixture is poured into a spreader box. As the truck moves forward, the slurry is extruded from the backside of the spreader box, see Figure 23. The box is capable of spreading the slurry over the width of a traffic lane in a single pass resulting in a uniform application. The slurry cures as the water evaporates and turns the freshly placed brown slurry into black slurry. Traffic can be returned once the slurry has cured, which is usually two to four hours.



Figure 23. Spreading of Microsurface Slurry

Cape Seal

Cape seal treatment consists of a bottom course of a chip seal covered with a wearing course of slurry seal to lock the aggregate chips in place (Figure 24). Preventing the aggregate from the chip seal application from being dislodged is particularly useful for roads with curb and gutter where loose chips can fill the gutter. In addition, chip seals are also not popular with the public because of the rough ride and the loose chips that are picked up by vehicles.



Figure 24. Cape Seal

RECYCLING AND ENVIRONMENTAL CONSIDERATIONS OF PAVEMENT CONSTRUCTION AND PRESERVATION

The County maximizes the recycling and reuse of materials in construction projects whenever feasible. These materials include reuse of existing pavements as well as other recycled materials such as scrap tires. Consideration is given whenever such materials meet the minimum engineering standards and are economically feasible. It should be noted that the use of recycled materials is made on a case-by-case basis based on material properties, past performance of the recycled material, benefit/cost analysis, and engineering judgment.

With high-volumes of industrial by-products, construction and demolition debris, and scrap tires being generated each year, hundreds of millions of waste materials are added to landfills and have a potential of being a threat to both the environment and public health and safety. Such materials can have beneficial uses, particularly in roadway construction. Pavement made with these materials can be stronger, more durable and less costly. Recycling and reusing these materials saves energy, conserves natural resources, and reduces greenhouse gas emissions (carbon footprint).

Over the last few years, the highway construction industry has developed more options and better techniques on building “green.” This has provided public agencies with tools to protect

the environment and reduce greenhouse gas emissions. The use of Reclaimed Asphalt Pavement (RAP) in hot mix asphalt, base stabilization and subgrade treatment using the Full Depth Reclamation (FDR) process, warm mix asphalt, and rehabilitation/maintenance of existing roadways using Cold-in-place Recycling (CIR) method, are some of the recycling technologies being practiced in the County.

Reclaimed Asphalt Pavement

Reclaimed Asphalt Pavement (RAP) – removed/reprocessed asphalt concrete pavement – is a commonly recycled material incorporated in the production of new Hot-Mixed Asphalt (HMA). RAP can be generated from a number of different sources including cold milling, full-depth removal, and pulverize-in-place operations of existing pavements. The use of RAP in HMA is the most efficient use of this material as it provides a reduction in virgin asphalt binder and aggregate demand, thus conserving natural resources. RAP is also used as recycled aggregate base and helps reduce the pavement structural section due to its increased strength in comparison to conventional aggregate base.

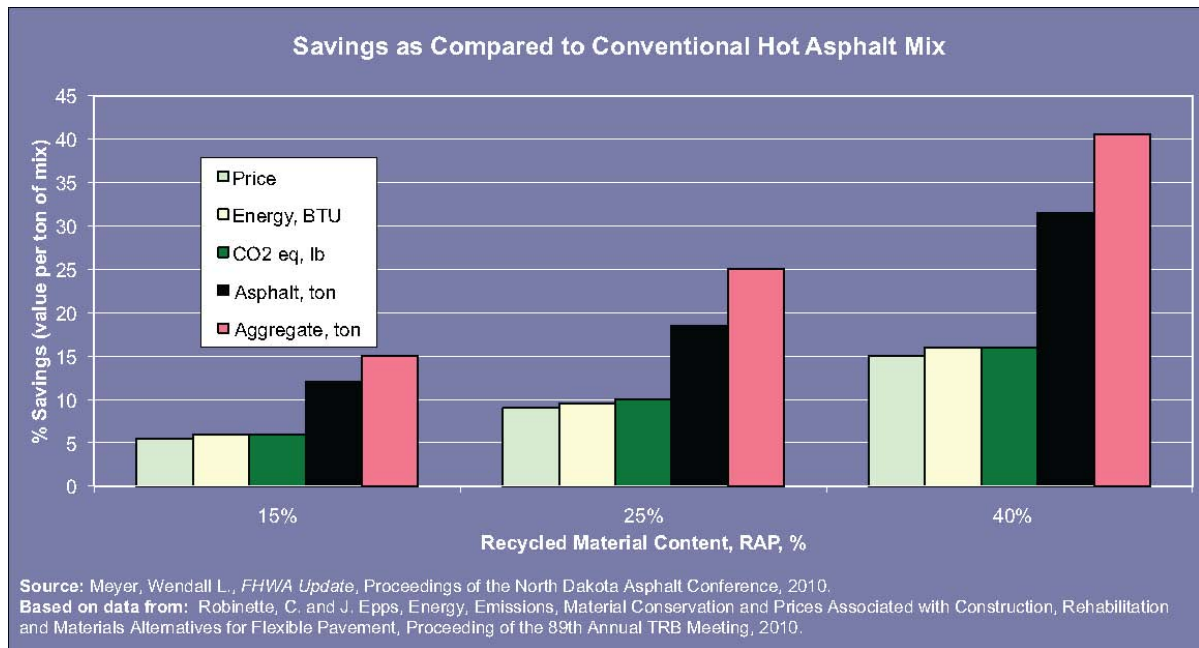
In California, the Caltrans goal is 40 percent RAP in HMA. In the recent report published by Caltrans in the “Specifications for the Use of Reclaimed Asphalt Pavement: A Status Report,” dated 18 July 2016, up to 40 percent is allowed for the subsurface course in the asphalt pavement and up to 25 percent for the surface course. In the same report, concerns have been raised regarding premature cracking in relatively new asphalt pavements as a result of using high content of RAP. Caltrans is currently working with the asphalt industry to address the issue of premature cracking in asphalt pavements containing up to 40% of RAP. The status report on the reclaimed asphalt pavement can be found at the following address:

<https://dot.ca.gov/SearchResults?q=reclaimed+asphalt+pavement>

Recycling asphalt is simple in concept but complex in execution because the asphalt surface that is recycled will have variability in the asphalt chemistry, aggregate qualities, and contaminants in the mix. Developing an HMA mix design capable of accounting for this variability is extremely difficult and costly. The use of more than 15% RAP may potentially cause long-term durability and premature cracking issues with the asphalt because of stability, swell, and moisture vapor susceptibility of the RAP in the asphalt mix. Because of this, in Riverside County, the goal is 15% of RAP in HMA. The County will continue to allow up to 15% RAP until Caltrans and the asphalt industry come up with solutions to address durability and cracking.

From the chart illustrated in Figure 25, some environmental benefits and cost savings of using at least 15 percent RAP in conventional HMA will yield a reduction in asphalt by about 12%, a decrease of virgin aggregate by about 15%, and a reduction of greenhouse gas emissions at a rate of 5 pounds per ton of RAP used in the hot mix asphalt.

Figure 25. Benefits and Cost Savings of using RAP



Price corresponds to materials, construction, rehabilitation, and maintenance costs based on Life Cycle Cost Analysis (LCCA) with environmental impact assessment. Energy (BTU) represents the requirements for construction materials processing and construction material production. CO₂ eq (lb) is a measure of greenhouse emissions and it includes the production of raw materials, transportation, production, and laydown of materials. Asphalt and Aggregate in tons are considered the natural resources [Sources: Transportation Research Board and Federal Highway Administration (FHWA)].

Since 2005, the County has used over 175,500 tons of RAP in its pavement rehabilitation and reconstruction projects. This translates to approximately 154 lane miles of recycled county maintained roads and a reduction of 878,000 pounds of carbon emissions or the equivalent of about 78 passenger cars removed from the County roads.

Full-Depth Reclamation (FDR)

Full-Depth Reclamation (FDR) involves the pulverization of the asphalt layers of the pavement and a portion of the underlying materials in-place four to ten inches deep, removing any excess material, and then stabilizing the materials with cement, foam asphalt, or asphalt emulsion (Figure 26). The new material is shaped and compacted in preparation for a new wearing surface such as hot mix asphalt. The wearing surface is placed within one to three days of completing the FDR material.



Figure 26. Full Depth Reclamation (FDR)

Cold In-Place Recycling (CIR)

Another method that involves the reuse of pavement material is Cold In-Place Recycling (CIR). Pavement is removed by cold planing or milling 3 to 4 inches of material, leaving a small amount of pavement to support the equipment during the construction process (Figure 27). The material is crushed, sized, and mixed with an asphalt emulsion and other additives. Then the material is immediately placed and compacted. Within two to five days of placing the CIR material, a layer of hot mix asphalt is placed. Typically, a 3-piece “train” is used consisting of a cold planing machine, a screening/crushing/mixing unit, and conventional laydown and rolling equipment. This “train” occupies only one lane, thus maximizing traffic flow.



Figure 27. Cold In-Place Recycling (CIR)

Warm Mix Asphalt (WMA)

Warm Mix Asphalt (WMA) is the generic term for a variety of technologies that allow producers of Hot Mix Asphalt (HMA) pavement material to lower temperatures at which the material is mixed and placed on the road. WMA production methods use mix temperatures 30 to 120 degrees Fahrenheit lower than traditional hot-mix asphalt. Because less energy is needed to heat the asphalt mix, less fuel is needed to produce WMA. Fuel consumption during WMA manufacturing is typically reduced by 20 percent.

In paving projects, the greater the temperature difference between the asphalt mix and the outside temperature, the faster the mix cools. Since faster cooling effects durability, cold ambient temperatures adversely affect hot-mix asphalt. Relative to HMA, WMA cools more slowly allowing WMA to be successfully placed in lower temperatures. As a result, WMA extends the paving season. It also makes night paving more feasible.

Additionally, WMA saves time in production as well as in surfacing roads. Because WMA makes compaction easier, cost savings are achieved by reducing time and labor spent compacting the mix. Lower temperatures also permit larger haul volumes per vehicle, reducing transportation costs.

WMA technologies work by reducing the viscosity (thickness) of the asphalt binder so that asphalt aggregates can be coated at lower temperatures. The key is the addition of additives (water-based, organic, chemical, or hybrids) to the asphalt mix. The additives allow the asphalt binders and asphalt aggregates to be mixed at the lower temperatures. Reducing the viscosity also makes the mixture easier to manipulate and compact at the lower temperature saving time and money on compaction.

Because of the lower temperatures involved, warm mix also lowers emissions during placement, creating a better environment for workers and the public.

Rubberized Asphalt Concrete (RAC)

Rubberized asphalt concrete (RAC) is a road paving material made by blending and heating ground tire rubber with asphalt to produce a binder, which is then mixed with conventional aggregate materials (Figure 28). This mix is then placed and compacted into a road surface.



Figure 28. Rubberized Asphalt Concrete using Crumb Rubber

Benefits of using RAC are as follows:

Cost-effective

In most applications, RAC can be used at a reduced thickness compared to conventional asphalt overlays--in some cases at half the thickness of conventional material--which can result in significant material reduction and cost savings.

Durable, Safe and Quiet

RAC is long lasting. It resists cracking, which can reduce maintenance costs, it provides better skid resistance, it retains its darker color longer so that road markings are more clearly visible, and RAC can also reduce road noise.

Environmentally Friendly

California produces more than 40 million waste tires annually, of which approximately 75 percent are diverted from landfill disposal. Over the past few years, California has used more than 10 million waste tires in RAC paving projects, diverting them from landfills or illegal disposal.

Asphalt-Rubber Aggregate Membrane (ARAM)

ARAM is a 3/8 to 1/2 inch rubberized membrane comprised of both California scrap tire rubber and tires with a high natural rubber content that can provide maintenance-free street surfaces for 10 to 15 (or more) years. ARAM recycles the equivalent of over 600 scrap tires in every lane mile. ARAM can be applied to both residential and arterial streets.

ARAM can be used as a final wearing surface, which is common practice for Caltrans on open, often rural, highways. ARAM can also be used as part of a composite layering system (ARAM Interlayers). In this instance, ARAM is "sandwiched" between layers, which may include a leveling course, slurry seal or final hot mix asphalt overlay (Figure 29). Arterial streets, highways and streets that are potentially targeted for reconstruction are usually the best candidates for these types of systems.

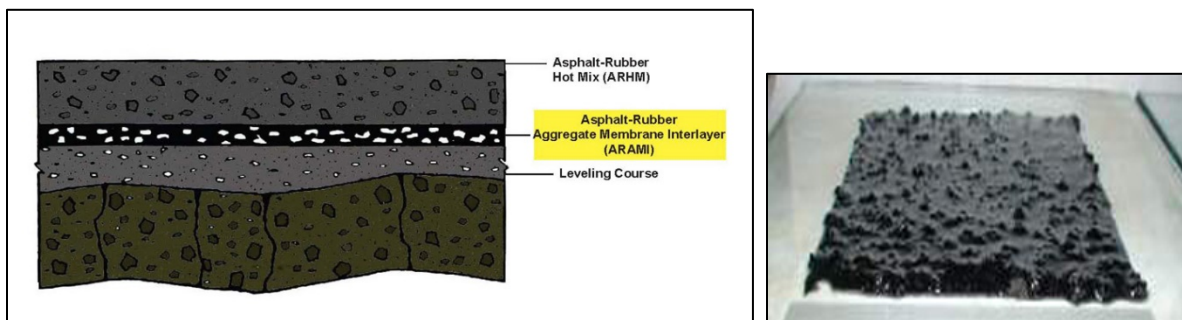


Figure 29. Asphalt Rubber Aggregate Membrane (ARAM)

Asphalt-Rubber Aggregate Membrane (ARAM) applications are different in comparison to other "rubberized" chip seals and products because it is the only product whose binder reacts with the rubber particles to form a hot, thick, viscous jellied composition for a significantly thicker binder application resulting in better crack mitigation and longer pavement life. (In contrast, other "rubberized" products digest or "dissolve" the rubber.) At less than 1/2 inch thick, the ARAM membrane is thin and flexible, expanding and contracting with the various weather cycles to mitigate reflective cracking and maintain the integrity of the subgrade and final wearing surface. It also acts as a barrier to water intrusion.

Use of RAC in Riverside County

The County of Riverside has been using RAC since 1995. The county typically uses a 2-inch thick overlay on all RAC resurfacing projects. A 2-inch thick RAC overlay uses over 1,200 scrap tires per lane mile. This means that for a one-mile section of a four-lane highway, over 4,800 scrap tires can be used in creating a safer, quieter, longer-lasting road. Since 2005, the County has used over 488,000 scrap tires in its pavement rehabilitation projects. This translates to at least 400 lane miles of rubber treated county maintained roadway.

Recycled Materials Usage Summary

A summary of the environmental benefits of recycling and reusing of roadway materials in road paving is as follows (as implemented by Riverside County) and as shown in Figure 30:

- 190,000 tons of RAP used in HMA which translate to a reduction of 880,000 pounds of carbon emissions.
- 488,000 scrap tires diverted from the landfill by substituting RAC in HMA.

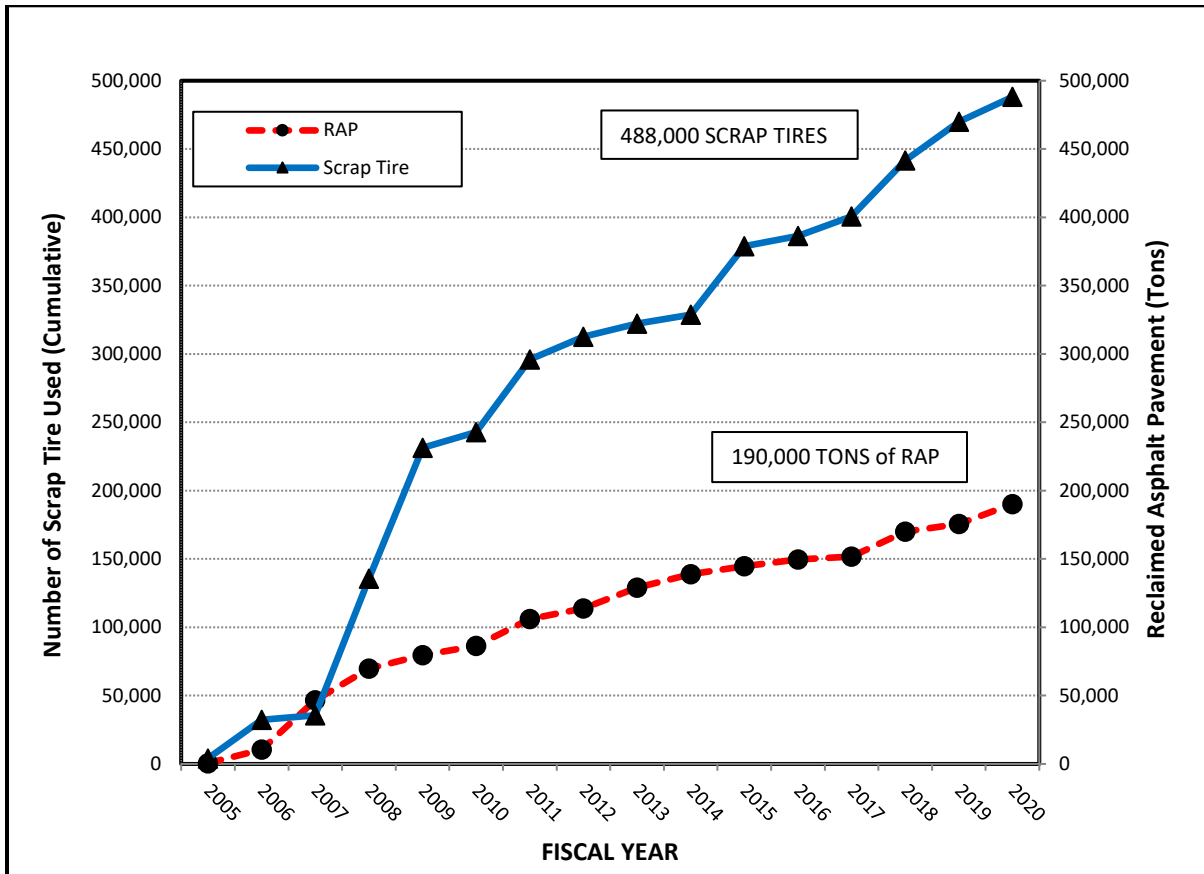


Figure 30. Benefits and Cost Savings of using RAP.

SUMMARY

The objectives of this Pavement Management Report are to (1) describe the results of the 2020 network-level semi-automated pavement condition survey in the County, (2) to describe the County's StreetSaver pavement management program to use best pavement management practices, (3) to discuss the pavement management analysis used to estimate the future maintenance and rehabilitation (M&R) funding requirements of the County's pavements, and (4) to describe how the County is using recycling to reduce landfill waste and greenhouse gas emissions while improving the County's roads.

The data collection scope of the 2020 PCI inspection included the County's approximately 2,022 centerline miles of paved roadways.

The County's StreetSaver database includes a total of 6,504 pavement section of which 6,347 are paved. At the time of the 2020 inspection, approximately 70% of the County's paved roads were found to be in good condition (i.e., PCI scores higher than 70), with an overall network area weighted average PCI of 74. The Arterial roads were found to have an area weighted average PCI of 73, the Collector roads had an average PCI of 72, and the residential roads had an area weighted average PCI of 75.

StreetSaver was used to analyze the impact of different funding scenarios on the condition of the County's pavement network. It was determined that because of the input of SB1 and Measure A funding the County's current and anticipated budgets will be able to maintain and provide a slight improvement to the County's PCI values. It is expected that if funding levels remain as expected, the County's PCI value will increase to 76 by 2027. This will also reduce the number of AT RISK, POOR, and VERY POOR roads from 30% to 25%.