COUNTY OF RIVERSIDE
TRANSPORTATION DEPARTMENT

2016

PAVEMENT MANAGEMENT REPORT

PAVEMENT MANAGEMENT REPORT 2016

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PAVEMENT MANAGEMENT REPORT 2016

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EXECUTIVE SUMMARY

Riverside County needs a reliable and well-maintained road system. Unfortunately, funding continues to be unreliable and demand through increased traffic volume is putting the County's roadway at risk. Having a pavement management system (PMS) is one of the crucial steps the County has implemented to support in determining pavement needs and priorities. PMS further supplements in the decision-making on certain critical key points as far as understanding pavement life cycle and its ranking approach in implementing cost-effective strategies such as the use of pavement preservation through preventive maintenance on roads in good condition.

Providing reliable and well-maintained roads continues to be a challenge due to increased demand and decreased funding. In 2016, about 35 percent of the total maintained road miles throughout the County were identified to be in need of resurfaced or replaced. It will cost $338 million to bring the road network to the most cost effective condition (or Best Management Practices) in 5 years.

♦ CURRENT TOTAL MAINTAINED MILES

Riverside County maintained 2,204 centerline miles of paved road as of the end of fiscal year 2016. The table below shows the breakdown of the road network grouped by functional classification with the average network Pavement Condition Index (PCI).

Total Maintained Miles (Countywide)

FUNCTIONAL CLASSIFICATION[1]	CENTERLINE MILES[2]	LANE MILES[3]	PCI
Arterial	448	959	70
Collector	564	1,130	71
Residential/Local	943	1,872	71
Gravel/Dirt	248	489	-
TOTAL	2,204	4,452	
Average PCI[4] [FY 2016]	**71**		

[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 mile represents the total length and the lane count of a road from its starting point to its endpoint. Lane mile takes into account the number of lanes of a road maintained by the County.
[4] The average PCI in 2016 was 71 whereas the desirable goal is 75 or higher. Roads with a PCI less than 70 are considered to be at risk of failing.

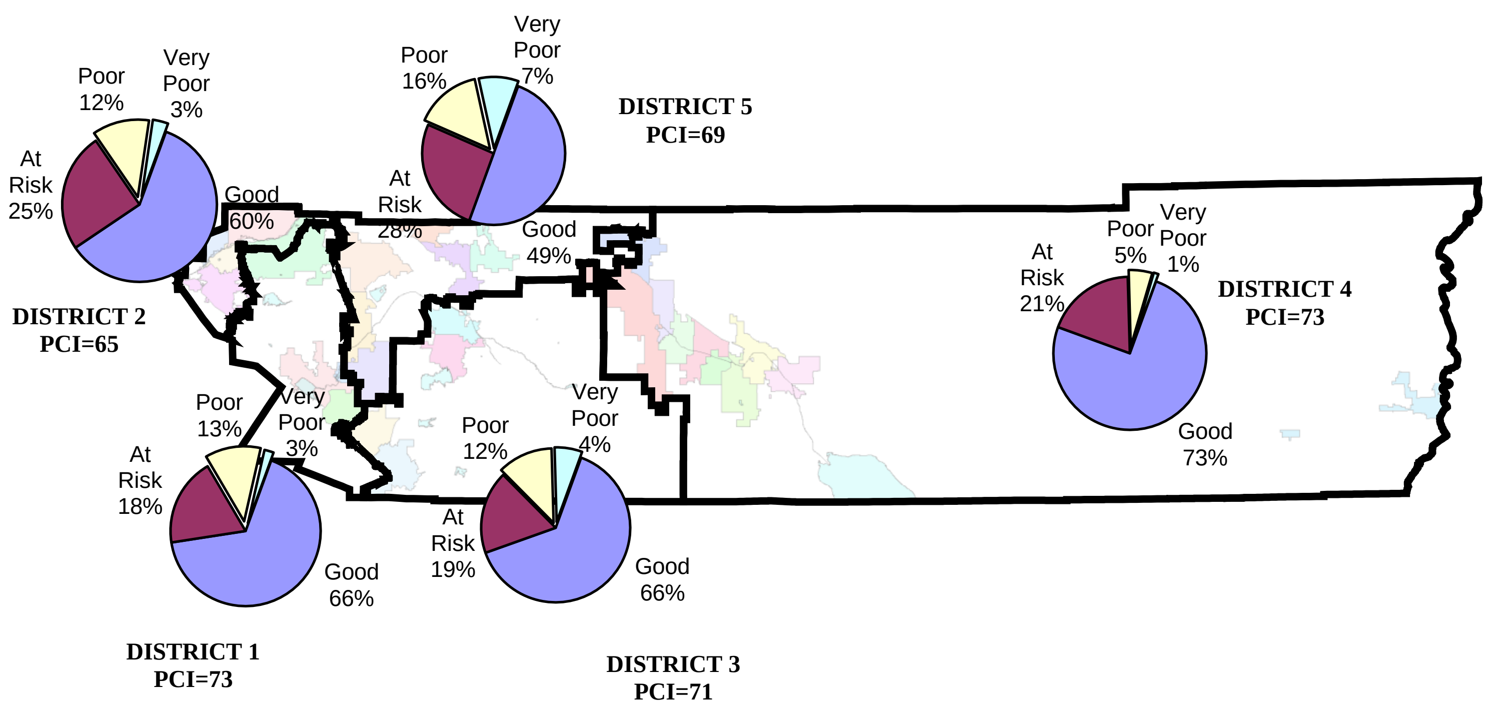
♦ CURRENT ROAD NETWORK CONDITION

The table below shows the current pavement condition categorized by condition category and functional classification throughout the county. It illustrates the total percentage of distressed roads, which covers roads from the AT RISK, POOR, and VERY POOR categories.

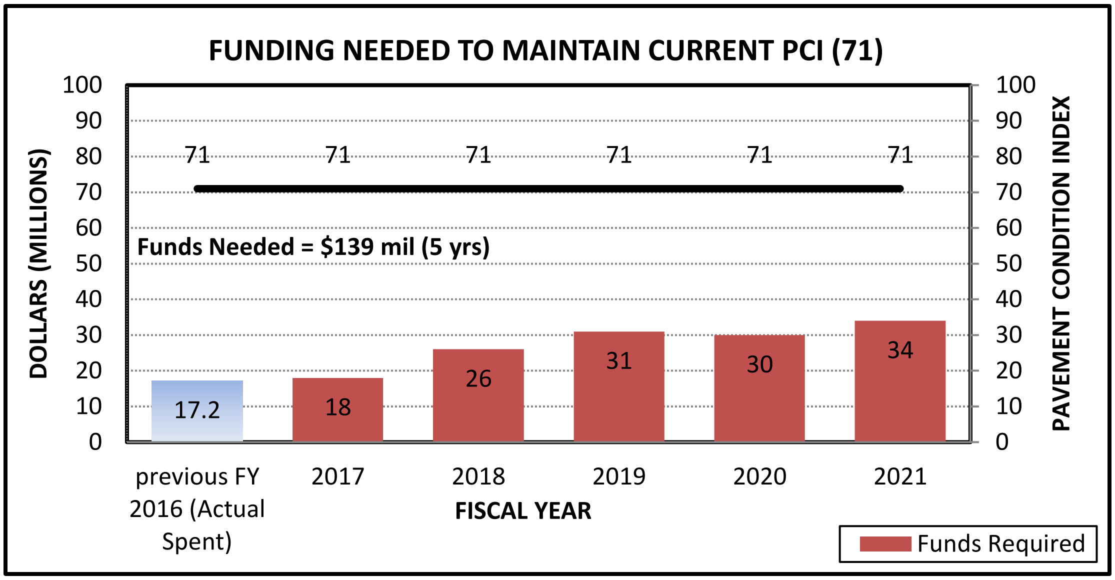
Pavement Condition by Category (FY 2016) - Countywide

CLASSIFICATION	GOOD TO EXCELLENT PCI 70-100	AT RISK PCI 50-69	POOR PCI 25-49	VERY POOR PCI 0-24	TOTAL
ARTERIAL	14%	5%	4%	2%	25%
COLLECTOR	19%	5%	2%	2%	28%
RESIDENTIAL	32%	10%	4%	1%	47%
TOTAL	65%	20%	10%	5%	100%
DISTRESSED ROADS		35%			

♦ CURRENT ROAD CONDITION BY DISTRICT (FY 2016)



♦ FUNDING SHORTFALL



Funding shortfall is $64 million over the next 5 years to maintain existing condition (PCI 71) based on a constant yearly budget of $15 million for the next 5 years.

♦ SUSTAINABLE PAVEMENT PRACTICES

As part of the County's effort to reduce greenhouse gas emissions, the County has been able to:

- Use approximately 149,000 tons of reclaimed asphalt, which translate to a reduction of 745,000 pounds of carbon emission or the equivalent of 66 passenger cars removed from the County roads;
- Use about 381,000 scrap/used tires for pavement overlays and rehabilitation, which translates to at least 318 lane miles of rubber treated County maintained roads.

♦ 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 street and road system, its current condition, cost to repair, and funding shortfall. The 2014 "California Statewide Needs Assessment" report estimated that an additional $5.6 billion is needed annually for the next 10 years "….to bring local streets and road pavement into a state of good repair." The average PCI in the State of California of all counties remain at 66 in 2014 (similar to the 2012 assessment report). The PCI ranges from a high of 77 in Orange County to a low of 33 in Amador County; Riverside County has a PCI of 71. The report evaluated all 58 counties and 482 cities in the State and found the funding shortfall over the next 10 years to be $56 billion for pavements. The annual "California Local Streets and Roads Needs Assessment 2014 Update" can be found at www.savecaliforniastreets.org.

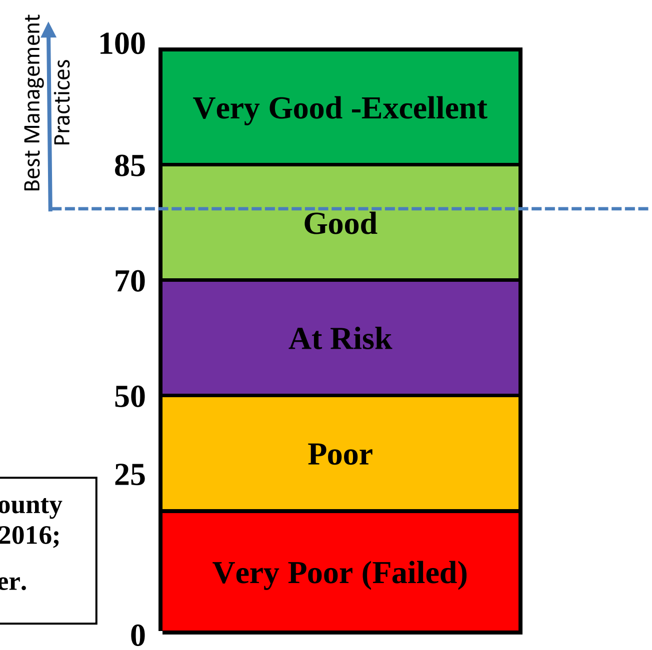
INTRODUCTION

A Pavement Management Program (PMP) is a decision-making tool that assists the County in making cost-effective decisions related to the maintenance and rehabilitation of roadway pavements. It provides a process or system for rating pavement condition, establishing a consistent maintenance and repair schedule, and evaluating the effectiveness of maintenance treatment strategies. 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-county San Francisco Bay Area - 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

In the MTC StreetSaver software, the pavement condition assessment is based on collecting data to determine the type, amount, and severity of surface distress for each segment of pavement being managed. The distress data is used to calculate a Pavement Condition Index (PCI), which is based on a visual survey of the pavement and a numerical index between 0 and 100, with 0 being defined as failed roadway and 100 representing an excellent pavement (newly paved). Figure 1 shows the relationship between the PCI and pavement condition. Photos showing examples of pavement in excellent through very poor condition are shown in Figure 2A through 2F.

Figure 1. Relationship Between PCI and Condition



Average PCI of Riverside County maintained roads was 71 in 2016;

Desirable Goal is 75 or higher.

Figure 2A. PCI=98 (Excellent Condition)

Figure 2B. PCI=85 (Very Good Condition)

Figure 2C. PCI=78 (Good Condition)

Figure 2D. PCI=56 (At Risk Condition)

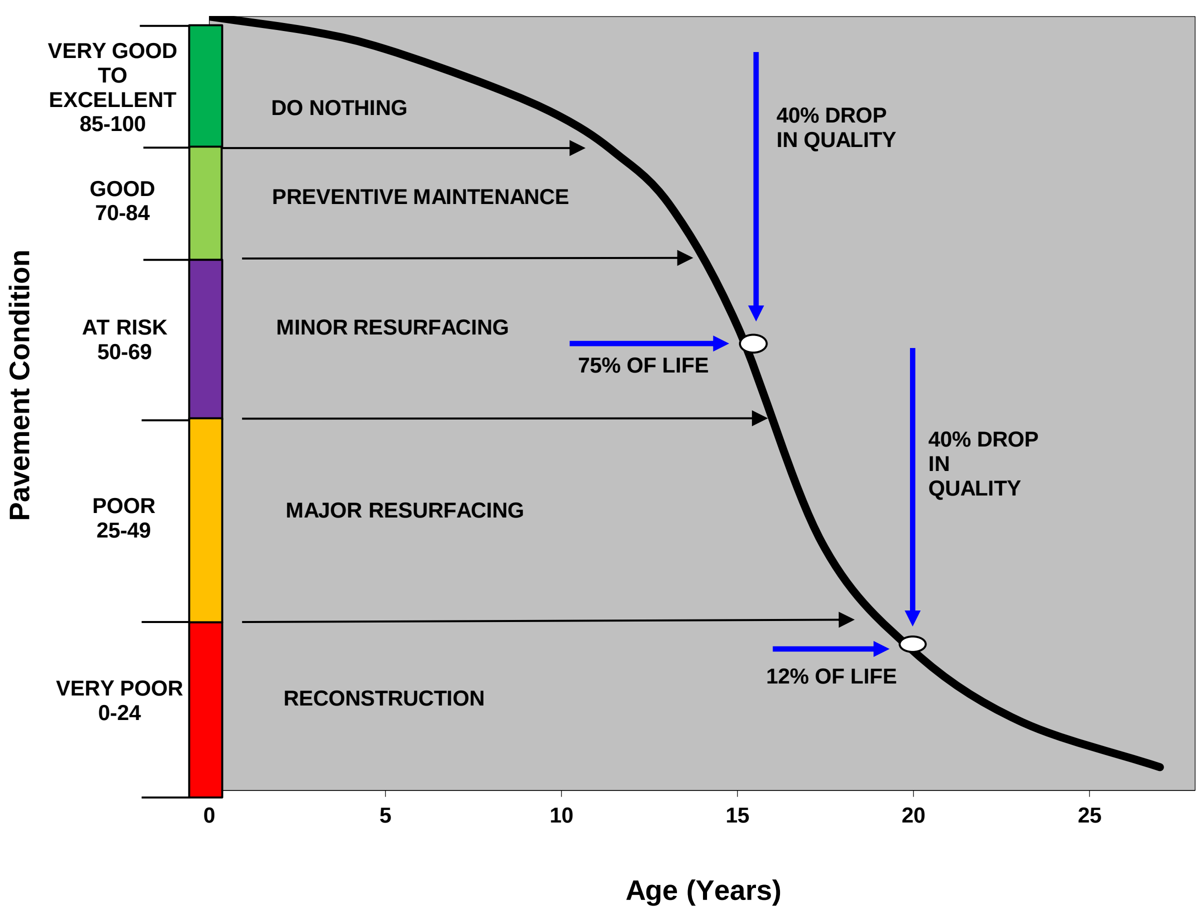
Figure 2E. PCI=30 (Poor Condition)

Figure 2F. PCI<10 (Very Poor Condition)

► Pavement Life Cycle

A critical concept in overall pavement life is the timing of maintenance and rehabilitation (resurfacing or reconstruction) actions being undertaken before the pavement falls beyond the optimum rehabilitation point. Figure 3 demonstrates this concept. Notice that for the first 75 percent of pavement life, the pavement condition drops by about 40 percent. However, if left untreated, it only takes another 12 percent of pavement life for the pavement condition to drop another 40 percent. Additionally, in order to restore pavement condition to a predetermined or an acceptable minimum level (i.e., PCI of 70 or higher), it will cost 4 to 5 times as much if the pavement is allowed to deteriorate for 2 to 3 years beyond the optimum rehabilitation point (PCI of 50), as illustrated in Figure 3.

Figure 3. Pavement Deterioration Curve



ROAD NETWORK

► Road Condition Trendline

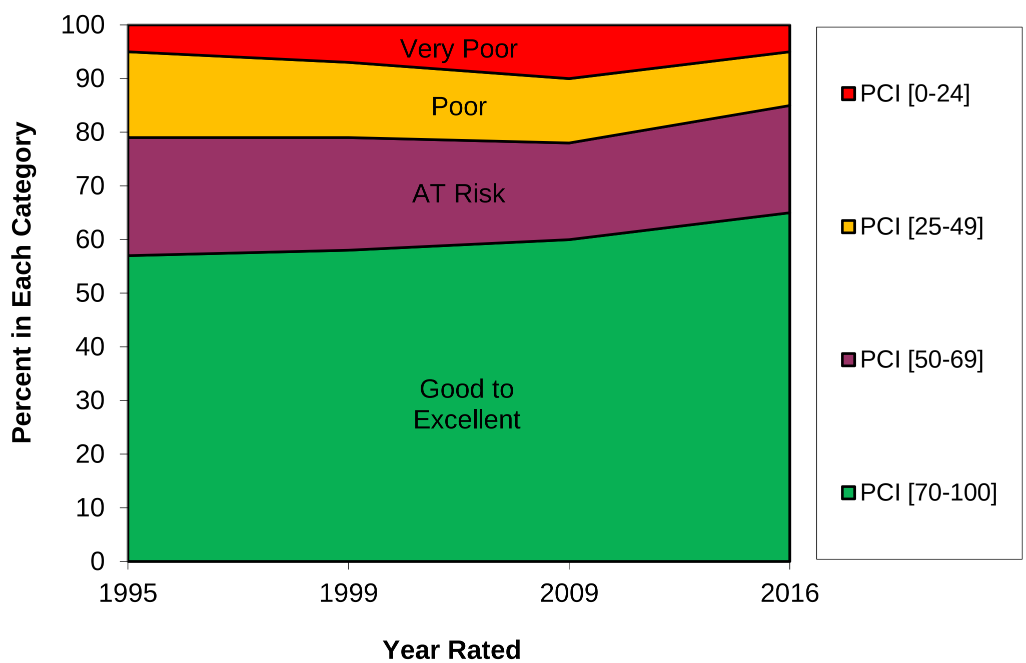
The percentage of mileage categorized by condition rating (good to excellent, at risk, poor, and very poor) over the last 20 years is summarized in Table 1. This table is also presented graphically showing the pavement condition trend in Figure 4 below.

Table 1. Condition Rating (Countywide)

	GOOD TO EXCELLENT PCI 70-100	AT RISK PCI 50-69	POOR PCI 25-49	VERY POOR PCI 0-24	DISTRESSED ROADS[1]
FY 2016	65%	20%	10%	5%	35%
FY 2009	60%	18%	12%	10%	40%
FY 1999	58%	21%	14%	7%	42%
FY 1995	57%	22%	16%	5%	43%

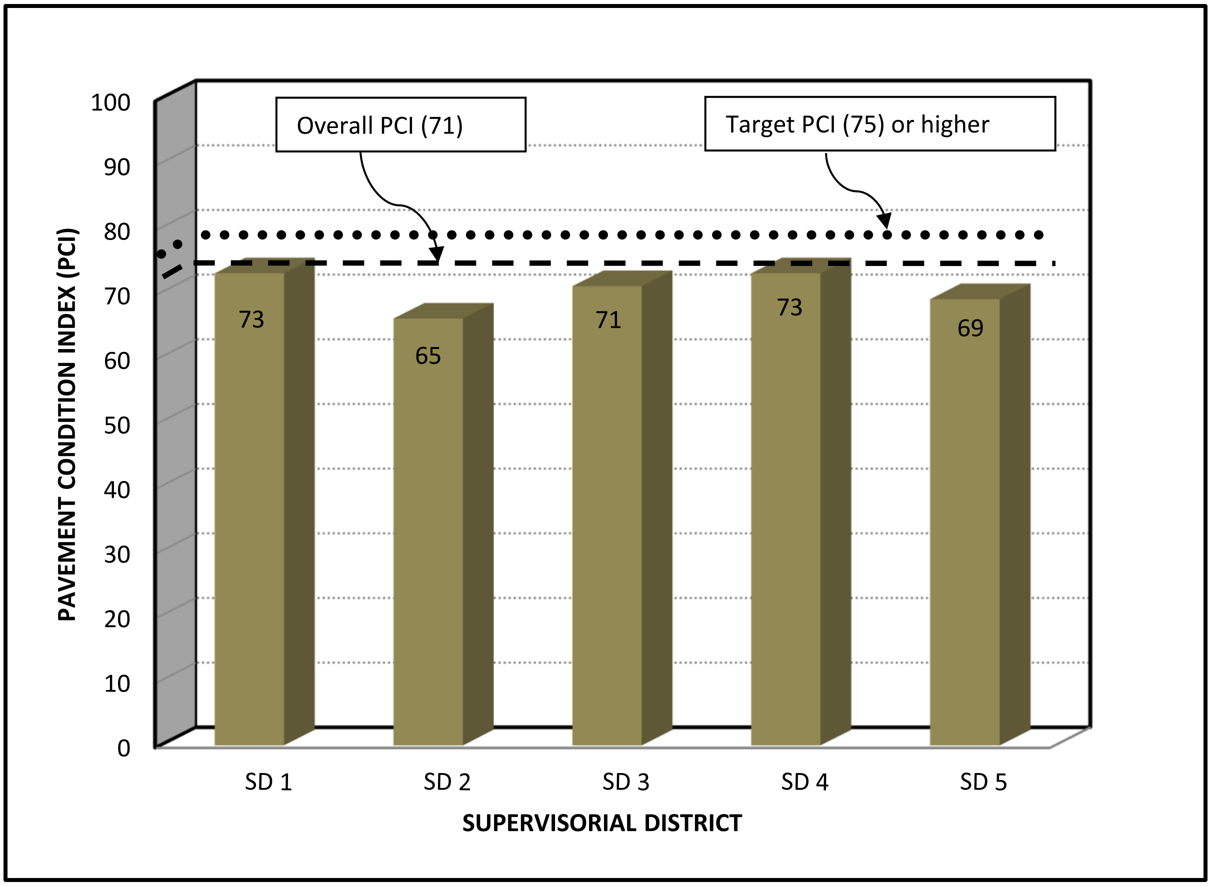
[1)] Distressed roads include roads from the AT RISK, POOR, and VERY POOR categories. Over the last 21 years, the percentage of distressed roads has been gradually declining from 43% to 35%.

Figure 4. Pavement Condition Trendline (Countywide)



► Road Condition by District

Figure 5. Pavement Condition Index by Supervisorial District



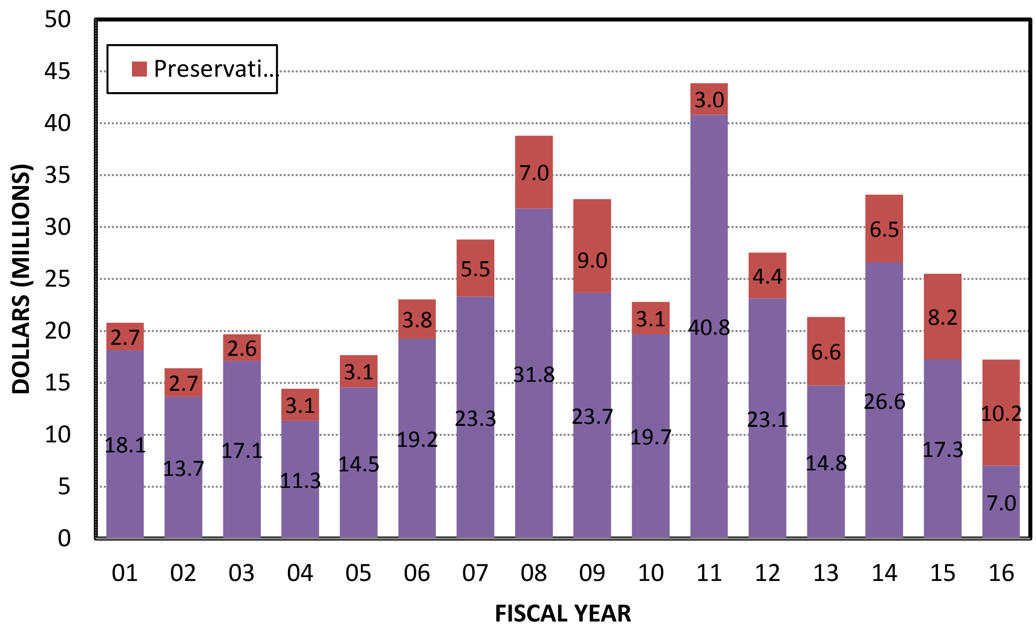
The Target PCI of 75 or higher, as shown in Figure 5, is based on a set goal that all pavements throughout the County road network system need to reach a condition where Best Management Practices (BMP) can occur. This means that generally the most cost-effective pavement preservation treatments are needed, such as, chip seal, slurry seal, cape seal, and thin overlay. Reaching and maintaining the target PCI offers other benefits (other than cost) such as reduced impact to the public in terms of:

- Construction delays
- Environment (noise, dust, energy usage – less greenhouse gas emissions)

As noted on the chart in Figure 5, the overall PCI of 71 is considered “Good” or near “At Risk” by definition of PCI shown in Figure 1 (page 1), “Relationship between PCI and Condition,” of this report. From the generalized pavement deterioration curve shown in Figure 3 (page 5), “Pavement Deterioration Curve,” of this report, a PCI below 70 signifies a pavement at risk. The roadway network’s life and deterioration accelerates rather rapidly at a PCI between 50 and 69 and if repairs are delayed by just a few years, preventative maintenance could increase the cost of the treatment significantly, as much as ten times.

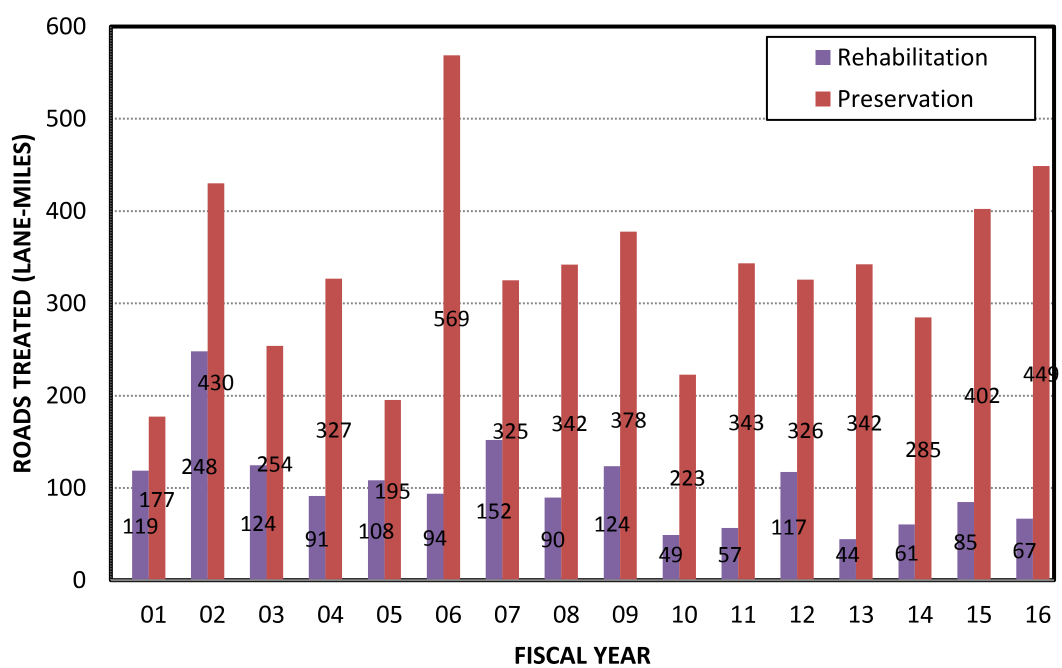
► Funding History & Miles Treated by Treatment Type

Figure 6. FUNDING vs PCI TREND



Preservation includes Chip Seal, Slurry Seal, and Cape Seal.
Rehabilitation includes Overlays and Reconstruction. Spending spikes in 2008, 2009 & 2011 were caused by Prop 1B, Transportation Bonds for Local Roads.

Figure 7. ROAD MILES TREATED vs PCI TREND



Preservation includes Chip Seal, Slurry Seal, and Cape Seal.
Rehabilitation includes Overlays and Reconstruction.

► Needs Assessment Goal

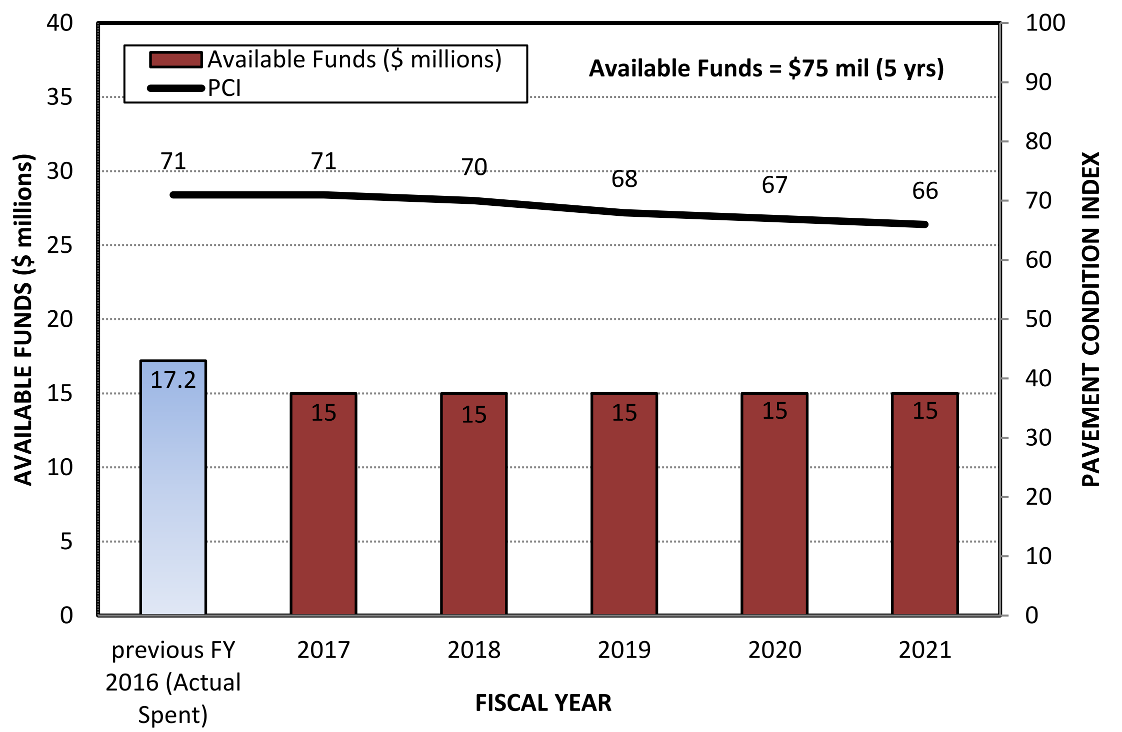
In determining the pavement needs to maintain the network condition at an acceptable level, a needs assessment goal must first be defined. The goal is as follows:

- attain a PCI of 75 or higher where Best Management Practices (BMPs) can be implemented. These BMPs encompass 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 of current funding on PCI
2. Funding required to achieve BMP in 5 years

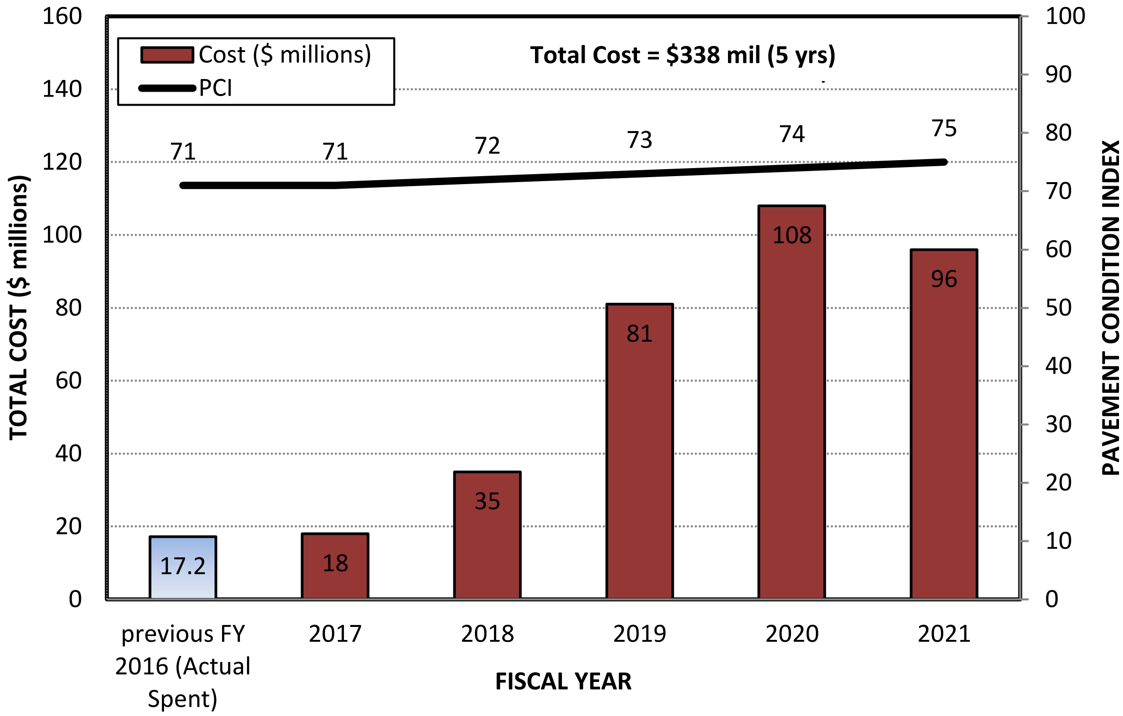
Figure 8. PCI AT CURRENT FUNDING (CONSTANT FOR 5 YRS)



From previous reports, the reported available funds have been reduced to $15 million per year. The current/projected funding for this year's report stays at $15 million per year. The reduction of funding is primarily attributable to the decrease in Gas Tax being released by the State to Counties and Cities because of less Gas Tax being collected at the pump due to low gasoline prices. While other fund sources are holding steady, the State Gas Tax is being substantially reduced.

As illustrated by the funding scenario in Figure 8, maintaining the current funding of $15 million annually for the next 5 years will have an impact on the PCI of the road network. Initially for the first year, the PCI will be 71 starting in 2017 then gradually declining to 66 over a 5-year period. The previous fiscal year (2016) is shown for the actual money spent in maintaining the PCI of 71.

Figure 9. FUNDING NEEDED TO ACHIEVE TARGET PCI (75)



► Funding Shortfall (PCI 75)

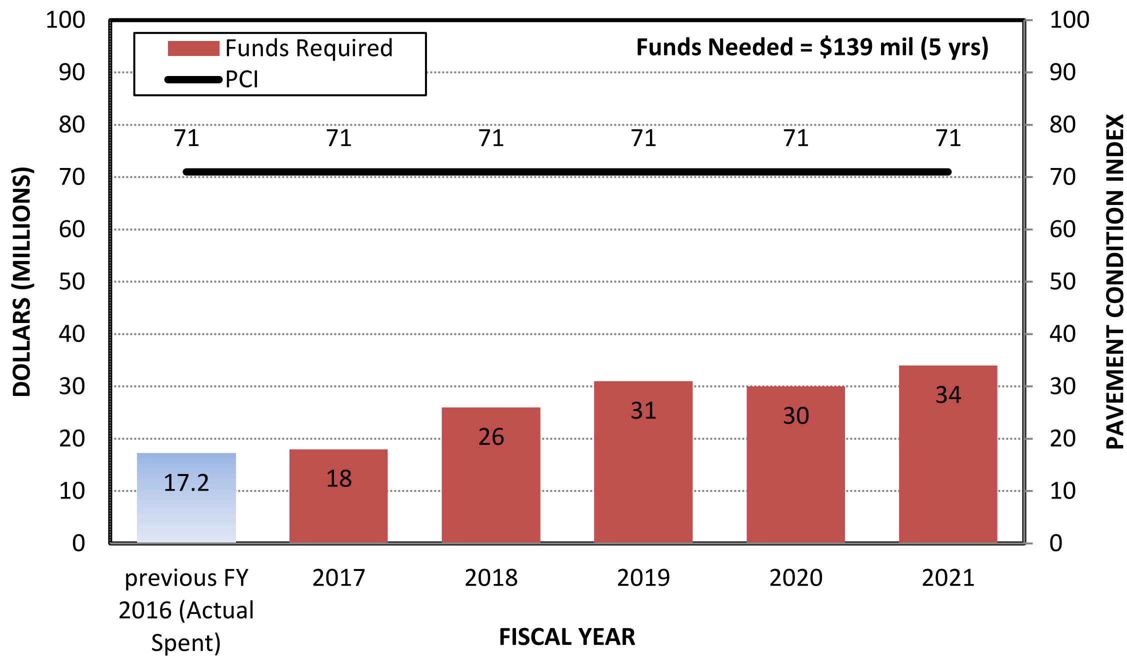
Given the two funding scenarios illustrated in Figure 8 and Figure 9 for the needs and available cash, the funding shortfall can be calculated. For each scenario, the total cost or available cash is simply the sum of each cost or available cash per year for 5 years. As depicted in Table 2, the shortfall is $263 million. Clearly, the available funding is inadequate in meeting the BMP goal within the period analyzed. Based on the results of this analysis, approximately $263 million of additional funding is needed to bring the pavement condition of the county roads to an overall PCI of 75.

Table 2. Funding Shortfall (based on Target PCI of 75)

Goal	5-Year Needs ($ millions)	Available Funds ($ millions)	Funding Shortfall ($ millions)
Achieve BMP (PCI=75) in 5 years	$ 338	$ 75	**$ (263)**

► Funding Needed to Maintain Current PCI

Figure 10. FUNDING NEEDED TO MAINTAIN CURRENT PCI (71)



► Funding Shortfall (Current PCI)

Based on the two funding scenarios illustrated in Figure 8 and Figure 10 for the needs and available funds, the funding shortfall is $78 million over the next 5 years to maintain the current PCI. Table 3 shows the funding breakdown.

Table 3. Funding Shortfall (based on Current PCI of 71)

Goal	5-Year Needs ($ millions)	Available Funds ($ millions)	Funding Shortfall ($ millions)
Achieve BMP (PCI=71) in 5 years	$ 139	$ 75	**$ (64)**

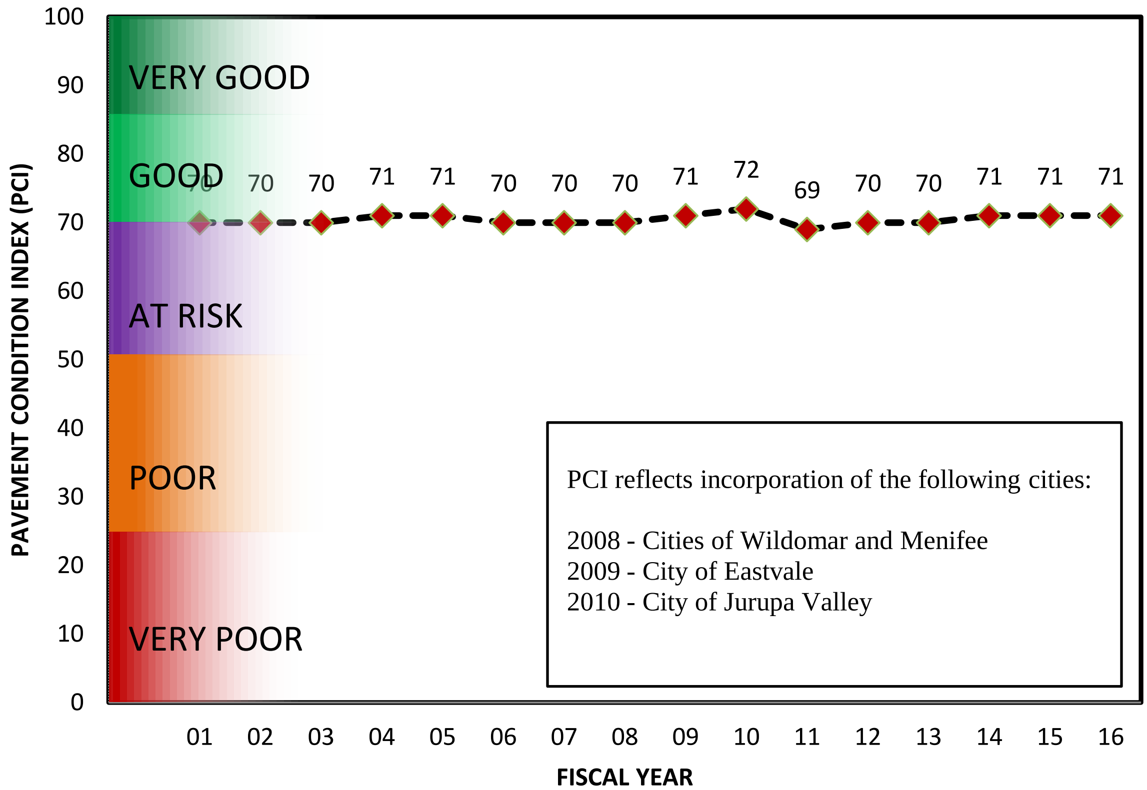
► Project Lists for Fiscal Year 2017

Lists of projects for rehabilitation and pavement preservation including slurry seal and chip seal are available in the County's website at:

http://rctlma.org/trans/Project-Information/TIP/Transportation-Improvement-Document

► Historical PCI

Figure 11. HISTORICAL PAVEMENT CONDITION TREND



► Road Maintained Miles

Riverside County maintains approximately 2,204 centerline miles of paved road as of the end of fiscal year 2016. The total miles may not reflect all new tract/subdivision roads being approved and entered into the county maintained public road system. There is approximately a 3 to 6 month lag time from the time a new road is fully constructed to the time it enters into the county maintained roadway system. Table 1 shows the breakdown of the countywide road network grouped by functional classification with the average network Pavement Condition Index (PCI). Table 4 through Table 9 depicts total miles and PCI by supervisorial district in pages 13 and 14.

Table 4. Total Maintained Miles (Countywide)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	LANE MILES
Arterial	448	959
Collector	564	1,129
Residential/Local	943	1,872
Gravel/Dirt	248	489
TOTAL	2,204	4,452
Average PCI [FY 2016]	**71**	

Table 5. Total Miles (District 1)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	LANE MILES
Arterial	116	268
Collector	72	146
Residential/Local	244	487
Gravel/Dirt	13	26
TOTAL	445	927
Average PCI	**73**	

Table 6. Total Miles (District 2)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	LANE MILES
Arterial	10	28
Collector	17	37
Residential/Local	39	78
Gravel/Dirt	7	14
TOTAL	73	157
Average PCI	**65**	

Table 7. Total Miles (District 3)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	LANE MILES
Arterial	142	307
Collector	154	309
Residential/Local	249	496
Gravel/Dirt	59	115
TOTAL	604	1,227
Average PCI	**71**	

Table 8. Total Miles (District 4)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	LANE MILES
Arterial	126	251
Collector	284	567
Residential/Local	241	478
Gravel/Dirt	143	286
TOTAL	794	1,583
Average PCI	**73**	

Table 9. Total Miles (District 5)

FUNCTIONAL CLASSIFICATION	CENTERLINE MILES	LANE MILES
Arterial	70	136
Collector	66	126
Residential/Local	123	243
Gravel/Dirt	26	50
TOTAL	286	557
Average PCI	**69**	

► Summary of Changes

Table 10 through Table 12 lists the changes to the 2016 Pavement Management Report (PMR) from the previous PMRs (2011, 2012, 2013, 2014, & 2015). These changes include maintained road miles, network conditions, PCI, and funding shortfall.

Table 10. Road Miles

Road Miles/PCI	PMR Year					
	2011	2012	2013	2014	2015	2016
Total Miles	2,147	2,179	2,164	2,156	2,200	2,204
PCI	69	70	70	71	71	71

Table 11. Road Condition

Road Condition	PMR Year					
	2011	2012	2013	2014	2015	2016
Good to Excellent [PCI 70-100]	64%	68%	66%	67%	67%	65%
At Risk [PCI 50-69]	17%	17%	20%	19%	20%	20%
Poor [PCI 25-49]	9%	7%	10%	10%	10%	10%
Very Poor [PCI 0-24]	10%	8%	4%	4%	3%	5%

Table 12. Funding Shortfall

Road Condition	PMR Year					
	2011	2012	2013	2014	2015	2016
Funding Req'd [PCI=75] ($ Mil)	248	296	283	317	334	338
Funding Shortfall ($ Mil)	(148)	(196)	**(183)**†	(217)	(259)	(263)

† denotes a decrease in funding shortfall from the previous year because of Prop 1B.

As shown in Table 12, the funding shortfall calculated for 2013 was reduced by $13 million from the 2012 funding calculation. The reduction is due, in part, to the Proposition 1B (Prop 1B) funds received in 2008, 2009, and 2011. These additional funds are also depicted in Figure 6 as spikes on the bar graph. Road projects utilizing the Prop 1B funds were mostly roads in the "Very Poor" category. Selecting road projects in this category resulted in lowering the percentage of the "Very Poor" roads from 10 percent in 2011 to 4 percent in 2013, as noted in Table 11.

PAVEMENT PRESERVATION

As defined by the Federal Highway Administration (FHWA) Pavement Preservation Expert Task Group[1], "Pavement Preservation is a program employing a network level, long-term strategy that enhances pavement performance by using an integrated, cost-effective set of practices that extend pavement life, improve safety, and meet motorist expectations." Pavement preservation represents a proactive approach in maintaining existing roadways to reduce costly, time-consuming rehabilitation and reconstruction and the associated traffic disruptions to the traveling public.

An effective pavement preservation program will treat pavements while they are still in good condition and prior to the need for major reconstruction work. By applying a cost-effective treatment at the right time, the pavement is restored almost to its original condition. Figure 12 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.

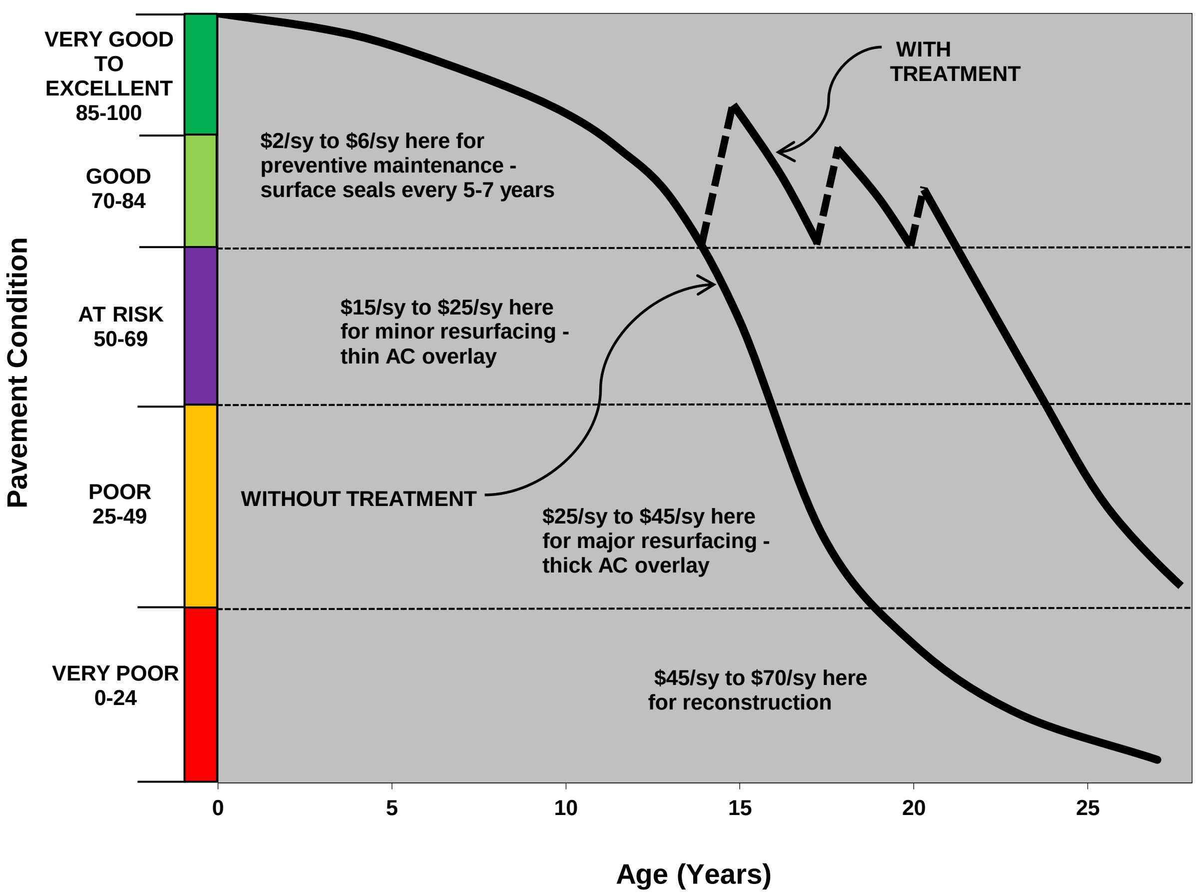


Figure 12. Pavement Deterioration Curve With and Without Treatment

[1] Pavement Preservation definition can be found at http://www.fhwa.dot.gov/pavement/preservation/091205.cfm

As depicted in Figure 12, the cumulative effect of systematic, successive preservation treatments is the postponement of costly resurfacing and reconstruction. During the life of a pavement, the cumulative discount value of the series of pavement preservation treatments is substantially less than the discounted value of the more extensive, higher cost of reconstruction and generally more economical than the cost of major resurfacing.

PAVEMENT MANAGEMENT PROGRAM

► Pavement Management Program – StreetSaver

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 a 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 optimizing 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. An example of a PMP is shown in Figure 13.

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 repair their roads. This approach makes use of limited funds for costly reconstruction where few roads can be repaired. Long-term use of this strategy will return the least performance for the public funds and result in decline of the overall quality of the jurisdictions' pavement network.

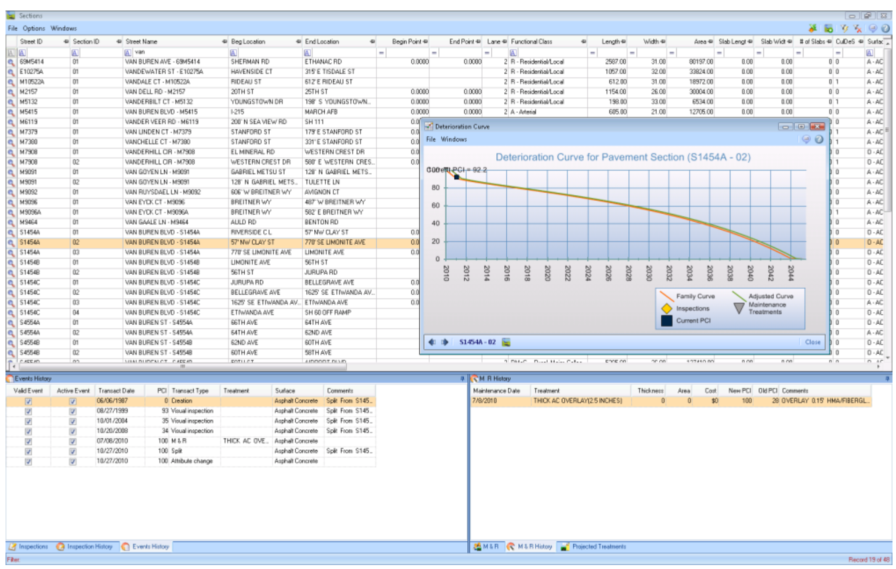


Figure 13. Pavement Management Program - StreetSaver

In 1998, the County began monitoring its roadway system using a PMP developed by the Metropolitan Transportation Commission (MTC), which is the transportation planning, coordinating, and financing agency for the nine-county San Francisco Bay. It is widely used by cities and counties throughout the State of California and used by some jurisdictions nationwide and other countries. In 2003, the MTC software was renamed to StreetSaver.

Inspection of pavement conditions is performed every year on one-fourth of the County's pavement network, which places all roads on a four-year inspection cycle. A field inspection or visual inspection survey is conducted by pavement raters (two-man crew) who walk each individual road segment evaluating the pavement for signs of distresses. In early 2012, the County switched its data collection approach from paper inspection sheets to a hand-held computer device, as depicted in Figure 14. Not only does a hand-held device accelerate the collection of pavement distress data, but it also reduces paper usage - an environmentally friendly methodology.

Figure 14. Tablet device use in road inspection.

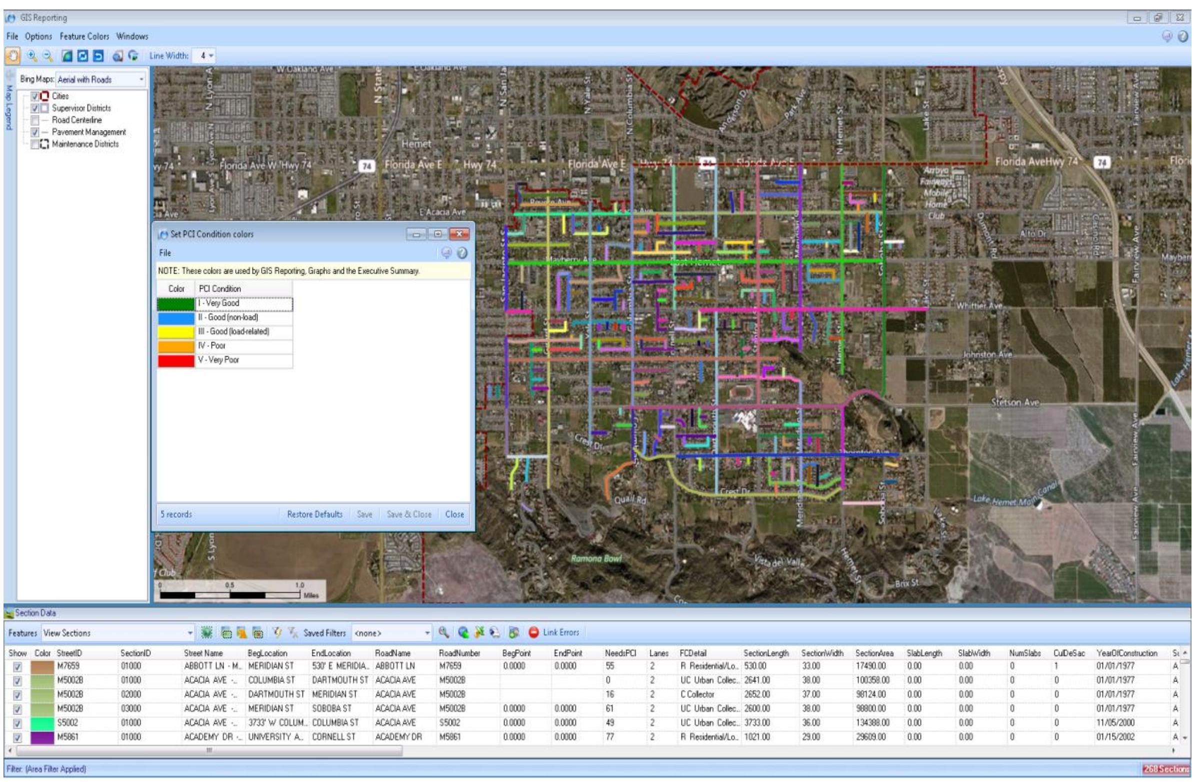


Figure 15. PMP result on GIS map.

The integration of the PMP with Geographic Information Systems (GIS) has provided the County a snapshot of the roadway network to better organize the data collected and facilitates in the decision-making in selecting roads to be included for treatment/repair in the upcoming fiscal year. An example of the PMP/GIS integration is shown in Figure 15.

► Data Collection Technique and Equipment

The County invests millions of dollars each year in pavement maintenance activities. Records of performance of the pavement maintenance treatments placed during these activities are crucial in order to determine which treatment alternative is the best option to use. With advancements in data collection practices and equipment, the County invested in a Ground Penetrating Radar (GPR) and a Falling Weight Deflectometer (FWD) in addition to its already established data collection methodology of using coring and visual inspection survey. Figure 16 and Figure 17 depict the road data collection equipment.

Figure 16. County's Coring Rig

The GPR is used to measure pavement layer thickness and detect groundwater or voids beneath the pavement. The FWD characterizes pavement structural condition. Data collected from this state of the art equipment provide new information that can be used to improve pavement management recommendations as well as support the County's pavement rehabilitation and design activities.

Figure 17. FWD and GPR Data Collection Equipment

IMPLEMENTATION OF PAVEMENT PRESERVATION USING BEST MANAGEMENT PRACTICES

In Riverside County, implementation of pavement preservation is just as important as other services provided to the public in terms of restoring and improving roadways for public safety. The maintenance activities performed through public contracts and in-house County forces include routine maintenance, responding to public safety concerns (repairing of potholes, patching localized deteriorated pavements, etc.), and pavement preservation treatments.

Preserving roads already in good condition rather than allowing them to deteriorate is the County's objective in spending the taxpayer's money cost effectively. Consistent with this approach, the costs associated in developing road treatments and repairs are based on achieving a roadway pavement condition using Best Management Practices (BMPs). BMPs is utilized when a targeted PCI is achieved, as illustrated in Figure 1 (page 1), "Relationship between PCI and Condition," of this report. Implementing this BMP improves the roadway condition to a level where roads only need preventive maintenance treatments (i.e., chip seals, slurry seals, cape seals). These treatments have the least impact on disruption to the public's mobility and private commerce. Furthermore, these types of treatments are more environmentally friendly than the next level of construction (thick overlay and reconstruction) that would be required.

► Seal Coat (Preventive) Treatment

A seal coat treatment follows the concept of preventive maintenance for preserving the pavement while it is still in good condition and prolonging its serviceable life. The following seal coat treatments are as described and implemented by the County by in-house forces and public contracts.

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 aggregate. Figure 18 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."

Figure 18. Spreading of chip over emulsion.

Slurry Seal

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, which is mixed and placed in a continuous basis using a truck mixer. 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 19. 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 four to six hours.

Figure 19. Spreading of slurry.

Cape Seal

Cape seal treatment consists of a bottom course of chip/scrub seal covered with a wearing course of slurry seal. In a cape seal application, covering a single layer of chip seal with slurry seal prevents the aggregate from the chip seal application from being dislodged especially for roads with curb and gutter.

Both pavement surface treatments are non-structural preventive maintenance applications that are classified as pavement preservation techniques. Such techniques can extend pavement life and improve safety.

"GREEN" MATERIALS

The focus of this section is on recycling and reuse of materials in construction projects. 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 thorough evaluation of material properties, past performance of the recycled material, benefit/cost analysis, and engineering judgment.

With high-volume 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 are a potential 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).

In the interest of energy conservation, the environment and reduction of greenhouse gases, state and federal agencies as well as contractors are placing an emphasis on building "green" in the highway construction industry. The use of Reclaimed Asphalt Pavement (RAP) in hot mix asphalt, base stabilization and subgrade treatment using the Full Depth Reclamation (FDR) process, 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

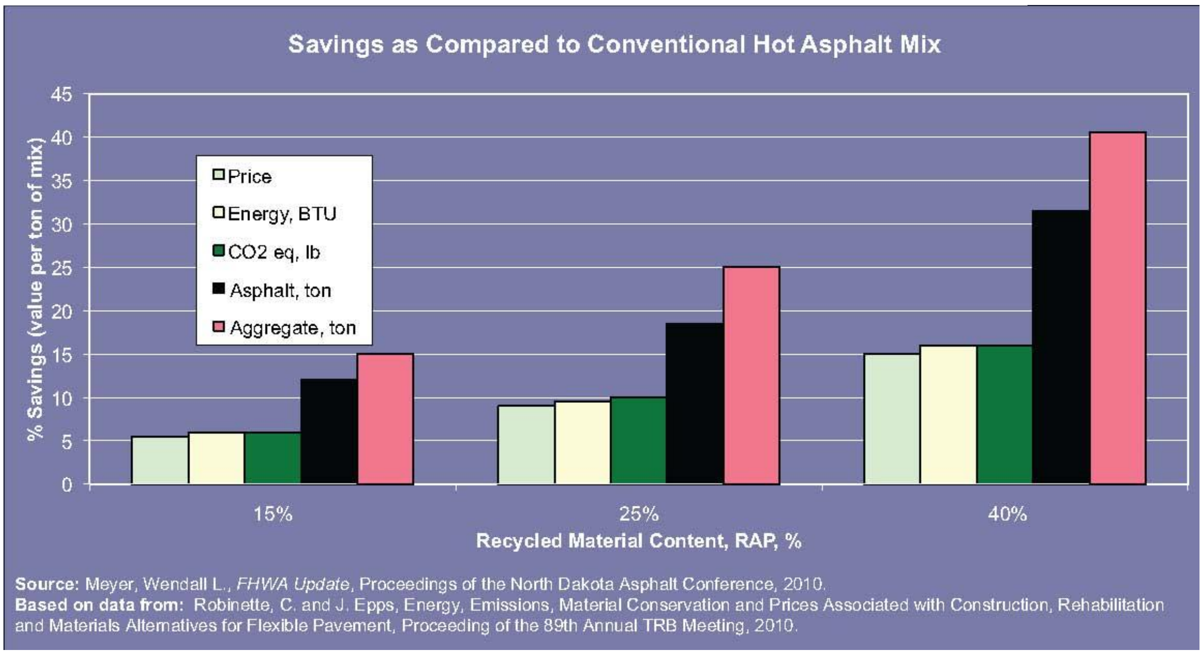
Reclaimed Asphalt Pavement (RAP) – removed/reprocessed asphalt concrete pavement – is a commonly recycled material incorporated in the production of new Hot-Mixed Asphalt (HMA). RAP can be generated from a number of different sources including cold milling, full-depth removal, and pulverize-in-place 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, Caltrans goal is 25 percent RAP in HMA. As of February 2013, Caltrans amended its Standard Specifications and increased the use of RAP in asphalt up to 25%.

In Riverside County, the percentage of RAP is 15 percent of the virgin aggregate. The use of more than 15% RAP may potentially cause some long-term durability issue with the asphalt because of stability, swell, and moisture vapor susceptibility of the RAP in the asphalt mix. In light of this concern, the County will continue to allow up to 15% RAP until Caltrans and the asphalt industry come up with solutions to address durability.

From the chart illustrated in Figure 20, 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 20. 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 149,000 tons of RAP in its pavement rehabilitation and reconstruction projects. This translates to approximately 131 lane miles of recycled county maintained roads and a reduction of 745,000 pounds of carbon emissions or the equivalent of about 66 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 to produce a stabilized material. The stabilized material is mixed with asphalt emulsion, then 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. The FDR methodology is ideal for straightaway roadways such as arterials and collector roads.

► 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 to a depth of 3 to 4 inches leaving a small amount of pavement to support the equipment during the construction process. The material is crushed, sized and mixed with an asphalt emulsion and other additives. Then the material is placed and compacted. Within two to five days of placing the CIR material, a layer of hot mix asphalt is laid down. 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. This process is also ideal for high volume roads.

► Rubberized Asphalt Concrete (RAC)

Rubberized asphalt concrete (RAC) is a road paving material made by blending ground tire rubber with asphalt to produce a binder, which is then mixed with conventional aggregate materials. This mix is then placed and compacted into a road surface. Benefits of using RAC are as follows:

<u>Cost-effective</u>
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.

<u>Durable, Safe and Quiet</u>

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

<u>Environmentally Friendly</u>

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.

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 381,000 scrap tires in its pavement rehabilitation projects. This translates to at least 318 lane miles of rubber treated county maintained roadway.

► Green 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):

- Reduction of 745,000 pounds of carbon emissions by substituting RAP in HMA.
- 381,000 scrap tires diverted from the landfill by substituting RAC in HMA.