Carson City Pavement Condition Analysis Final Report (August 2022)

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CONTENTS

INTRODUCTION AND PURPOSE

Carson City Public Works (CCPW) contracted with Applied Pavement Technology, Inc. (APTech) to analyze Carson City's (City) roadway pavement assets and forecast budget needs for the next 28 years, to 2050.

This report provides a detailed description of the current condition of pavement assets, examples of different pavement conditions, a review of pavement performance in Carson City, and budget scenarios to assist Carson City's elected officials in balancing City priorities.

Carson City is the capital of the State of Nevada. It was founded in 1864, covers about 157 square miles, and has a population of about 58,640 (April 1, 2020 census). CCPW is responsible for maintaining approximately 284 centerline miles of pavement. This equates to 52,265,798 square feet or 1.87 square miles of pavement.

ROADWAY PAVEMENT INVENTORY

CCPW maintains a database of all City roadways. The database, updated annually, was used to review pavement performance and to complete budget scenario analyses. Below is a detailed summary of roadway pavement assets that CCPW maintains, preserves, and rehabilitates.

Tables 1 and 2 provide information on pavement surface area, roadway functional classification, and Pavement Performance District (see figure 1). CCPW's network is predominantly comprised of local roads.

Table 1. Pavement area by roadway functional classification.

Functional Classification	City Classification	Area (ft^2)	Percentage of Network Area
Arterials	Regional	7,752,697	15%
Collectors		9,892,797	19%
Local	Local	34,620,304	66%
Total		52,265,798	100%

Table 2. Pavement area by Performance District.

Performance District	Functional Classification	City Classification	Area (ft^2)	Percentage of District Area
1	Arterials	Regional	2,039,278	20%
	Collectors		1,337,722	13%
	Local	Local	6,780,603	67%
Performance District 1 Total			**10,157,603**	**100%**
2	Arterials	Regional	2,442,486	24%
	Collectors		1,186,034	11%
	Local	Local	6,722,014	65%
Performance District 2 Total			**10,350,534**	**100%**
3	Arterials	Regional	988,173	9%
	Collectors		2,286,552	22%
	Local	Local	7,339,450	69%
Performance District 3 Total			**10,614,176**	**100%**
4	Arterials	Regional	1,356,593	12%
	Collectors		2,439,696	22%
	Local	Local	7,083,733	65%
Performance District 4 Total			**10,880,023**	**100%**
5	Arterials	Regional	926,167	9%
	Collectors		2,642,792	26%
	Local	Local	6,694,504	65%
Performance District 5 Total			**10,263,463**	**100%**

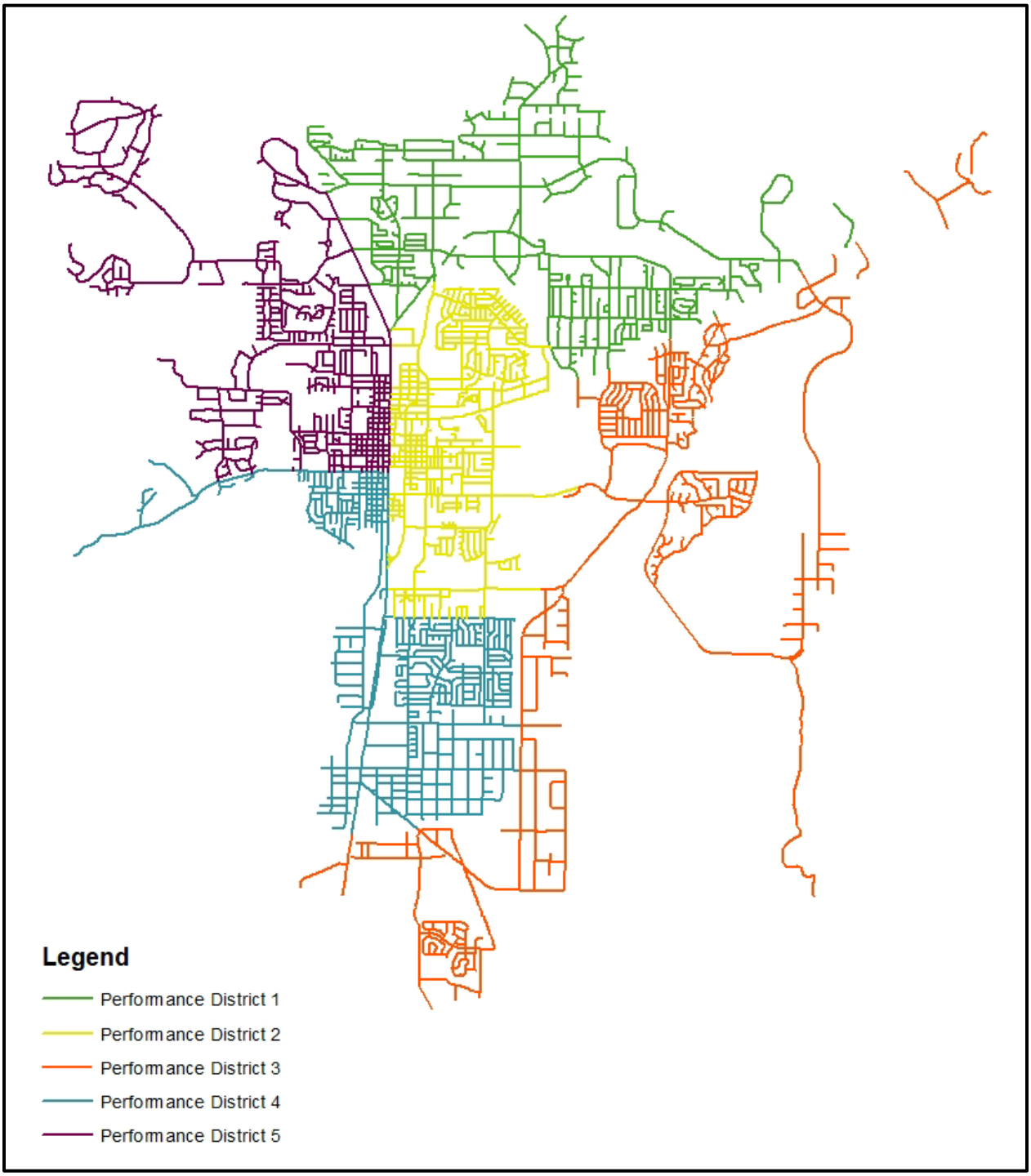

Figure 1. Carson City maintained roads by Performance District.

PAVEMENT CONDITION

Pavement Condition Index

CCPW has performed three network-wide pavement surveys in the last decade: in 2014, 2017, and 2021. The pavement surveys were carried out using automated data collection vans which drove the network and collected pavement distress data.

Distress data collected during those surveys was used to calculate a Pavement Condition Index (PCI) value for each of the 3,073 road sections in the pavement network. The PCI is a value ranging from 0 to 100, where 0 describes a severely distressed pavement and 100 describes a pavement in excellent condition. In the calculation of PCI, each distress type and severity has an associated deduct value. Structural distresses, like rutting and fatigue cracking, have much higher deduct values than others. Thus, small amounts of these distresses will lower a PCI value much faster than large amounts of other functional distresses (e.g., raveling and weathering). Table 3 provides an overview of the industry standard condition categories used by CCPW, along with typical distresses present in each category.

Table 3. PCI ranges and condition categories.

PCI Range		Condition Category		Typical Distresses Present
100	86	Good		Very little distress. Minor cracking.
85	71	Satisfactory		Mostly low-severity distress, with the possibility of some moderate-severity. Little to no fatigue cracking. Minor rutting.
70	56	Fair		Starting to see more moderate-severity distress, including some fatigue cracking. Patching and rutting are typically present.
55	41	Poor		Moderate- and high-severity cracking, including notable low- and/or moderate-severity fatigue cracking, patching, and rutting.
40	26	Very Poor		Significant amounts of cracking, including notable moderate- and high-severity fatigue cracking, raveling, and patching. Cracking is moderate- to high-severity. Rutting may approach 0.5 inches.
25	11	Serious		Significant amounts of cracking, including considerable amounts of moderate- and high-severity fatigue cracking, raveling, and patching. Majority of cracking is moderate- to high-severity. Rutting may approach 1 inch.
10	0	Failed		Significant amounts of cracking, including moderate- and high-severity fatigue cracking, raveling, patching. Cracking is generally high-severity. Possible high-severity rutting.

Figures 2 through 8 show representative images for each PCI condition category described in Table 3. There are multiple combinations of distress types, severities, and extent that may lead to the same PCI.

Figure 2, a photograph taken on Race Track Road, has no distresses visible (17% of the roads in Carson City are rated as Good).

Figure 2. Pavement in Good condition category (PCI 100-86).

Figure 3, a photograph taken on Silver Oak Drive, shows low- and moderate-severity longitudinal and transverse cracking (24% of the roads in Carson City are rated as Satisfactory).

Figure 3. Pavement in Satisfactory condition category (PCI 85-71).

Figure 4, a photograph taken on Deer Run Road, shows a combination of moderate-severity transverse cracking and low-severity alligator cracking (22% of the roads in Carson City are rated as Fair).

Figure 4. Pavement in Fair condition category (PCI 70-56).

Figure 5, a photograph taken on Fifth Street, shows a combination of low and moderate-severity longitudinal cracking and moderate-severity alligator cracking (17% of the roads in Carson City are rated as Poor).

Figure 5. Pavement in Poor condition category (PCI 55-41).

Figure 6, a photograph taken on North Lompa Lane, shows a combination of low and moderate-severity longitudinal and transverse cracking, low-severity patching, and a considerable amount of moderate-severity alligator cracking with low severity rutting (14% of the roads in Carson City are rated as Very Poor).

Figure 6. Pavement in Very Poor condition category (PCI 40-26).

Figure 7, a photograph taken on Deer Run Road, shows a combination of low and moderate-severity longitudinal and transverse cracking along with considerable amounts of moderate-severity alligator cracking with moderate-severity rutting (6% of the roads in Carson City are rated as Serious).

Figure 7. Pavement in Serious condition category (PCI 25-11).

Figure 8, a photograph taken on Brick Road, shows a combination of moderate- and high-severity alligator cracking and potholes (less than 1% of the roads in Carson City are rated as Failed).

Figure 8. Pavement in Failed condition category (PCI 10-0).

Current Network Conditions

Based on the PCI values for all the roadways, the current overall area-weighted average PCI for the City network is 62. This places the overall condition of the network near the middle of the Fair condition category (PCI 70-56). Tables 4 and 5 provide breakdowns of the average PCI values by facility type and Performance District, respectively. Note that these are average values, and that there is a distribution of condition values from very high to very low throughout the network.

Table 4. Average PCI by facility type.

City Classification	Area (ft^2)	Percentage of Network Area	Area Weighted PCI*
Regional	17,645,494	34%	74
Local	34,620,304	66%	56
All Roads	52,265,798	100%	62

*Refer to Table 3 on page 5 for condition category color legend.

Table 5. Average PCI by Performance District.

Performance District	City Classification	Area (ft^2)	Percentage of District Area	Area Weighted PCI*
1	Regional	3,377,000	33%	69
	Local	6,780,603	67%	57
	All Roads	10,157,603	100%	61
2	Regional	3,628,520	35%	80
	Local	6,722,014	65%	53
	All Roads	10,350,534	100%	63
3	Regional	3,274,725	31%	77
	Local	7,339,450	69%	58
	All Roads	10,614,176	100%	64
4	Regional	3,796,289	35%	79
	Local	7,083,733	65%	51
	All Roads	10,880,023	100%	61
5	Regional	3,568,959	35%	65
	Local	6,694,504	65%	60
	All Roads	10,263,463	100%	62

*Refer to Table 3 on page 5 for condition category color legend.

Figure 9 displays the distribution of pavement area by condition category. Approximately 41 percent of the roadway network area is in Good to Satisfactory condition with PCI values greater than 70. Roadways in Good or Satisfactory condition are typically excellent candidates for pavement preservation treatments and strategically timed pavement preservation treatments may extend the life of these roadways in a cost-effective manner, delaying the need for more costly treatments.

Approximately 39 percent of the roadways in the City are in Fair or Poor condition with a PCI between 40 and 70. Based on standard City practice, roadways in this condition category will likely require some form of rehabilitation work or pavement preservation work to restore or prolong performance. The remaining 20 percent of the City's roadways are in Very Poor, Serious, or Failed condition. Roadways in these conditions are generally candidates for more costly reconstruction or major rehabilitation.

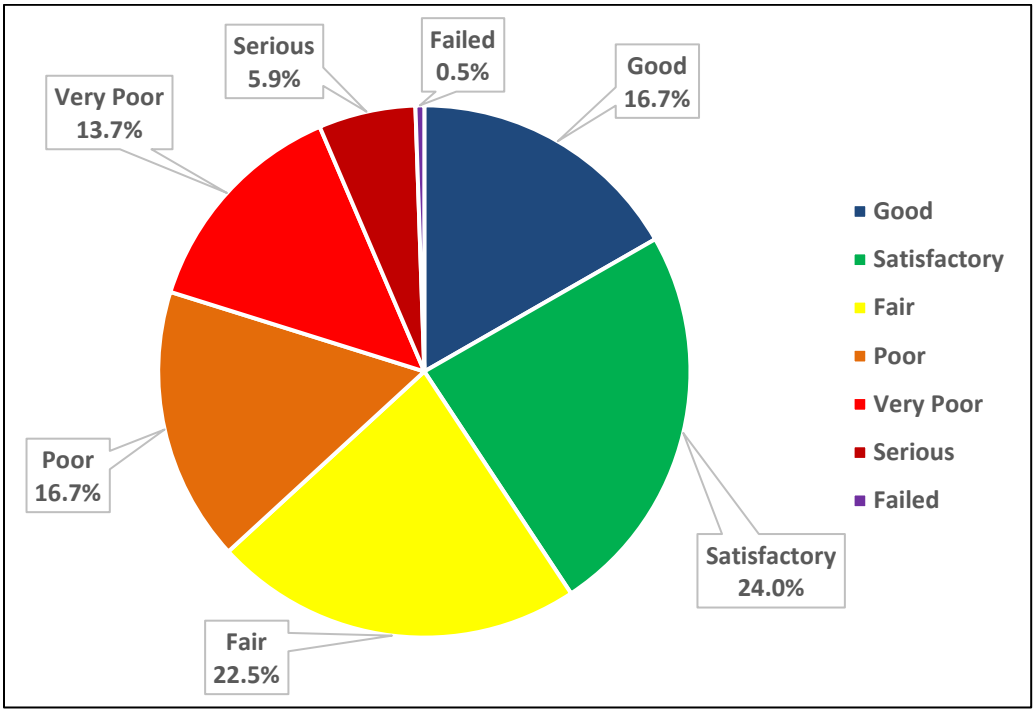

Figure 9. Distribution of network pavement area by condition category.

Figures 10 and 11 display the distribution of pavement area in the different condition categories by the functional classification of the roadway. Approximately 65 percent of the regional roads are in Good or Satisfactory condition, while only 28 percent of the local roads are in Good or Satisfactory condition.

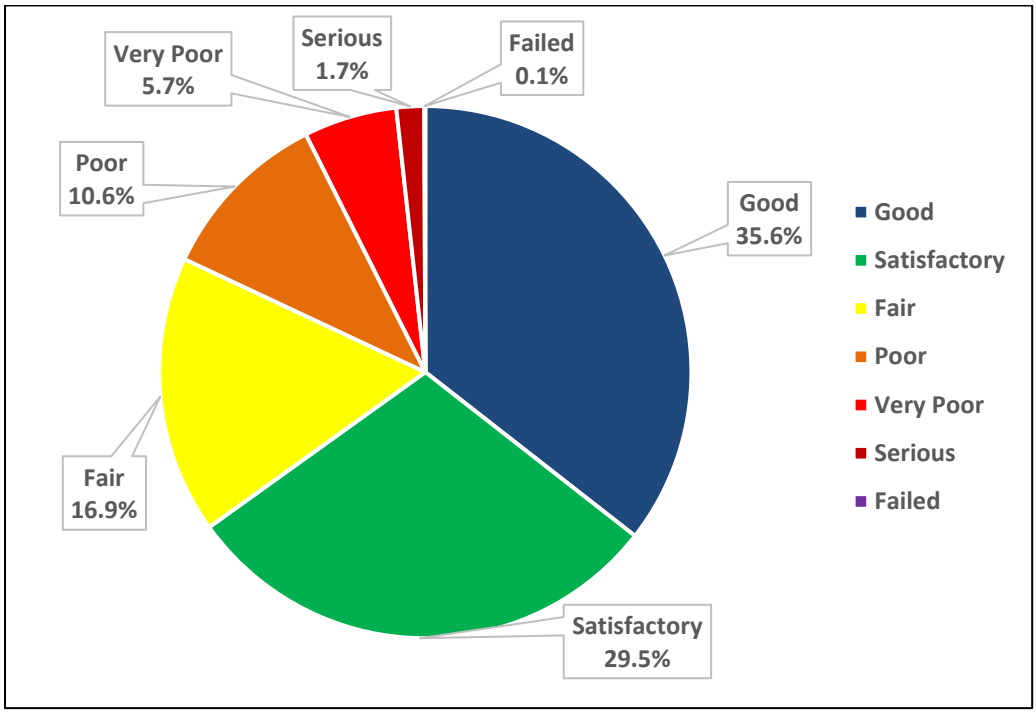

Figure 10. Regional roadways distribution of pavement area by condition category.

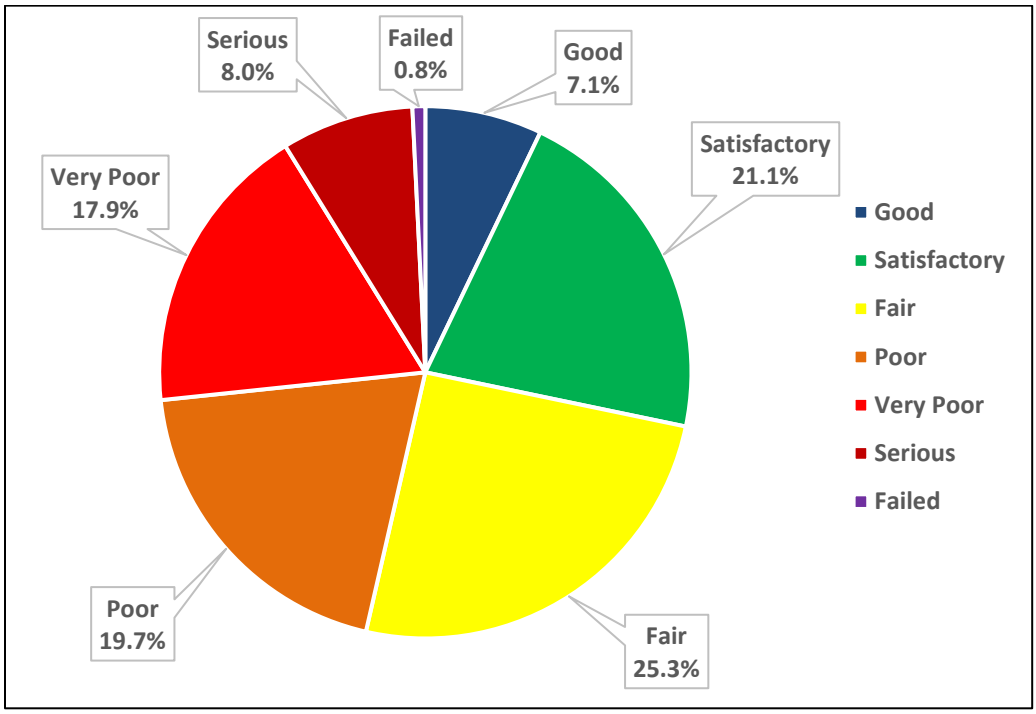

Figure 11. Local roadways distribution of pavement area by condition category.

PAVEMENT MANAGEMENT SYSTEM CONFIGURATION

Treatment Strategy

The Carson City Pavement Management Plan outlines the City's approach to maintaining, preserving, and rehabilitating the City's roadways. The plan identifies project evaluation criteria to consistently and transparently prioritize projects. The leading criteria include:

- Pavement Condition
- Preventive and Corrective Maintenance Schedule
- Roadway Functional Classification
- Traffic Volume
- Safety (high speed facilities)

The City's pavement maintenance schedule is guided by its pavement management software, which tracks pavement condition and work history, and can be used to model performance to help predict financial needs to proactively budget for roadway treatments (pavement repair, maintenance, and rehabilitation). The software assists in assigning and scheduling specific treatment strategies by condition category and calculates funding needs based on assigned unit costs. This allows the user to select the right treatment for the right pavement section at the right time.

Pavement maintenance includes routine maintenance actions that are applied to address a specific distress, such as crack sealing linear cracks, or patching a pothole. In general, pavement maintenance is divided into two approaches depending on the overall condition of the pavement: preventive and stopgap. Characteristics of each maintenance approach are provided below, along with the following definitions:

- Preventive maintenance: treatments applied to a pavement generally in good condition with the primary objective of slowing the rate of pavement deterioration.

- Stopgap maintenance: maintenance activities performed to keep a deteriorated pavement operational and safe.

The goal of preventive maintenance is to preserve the pavement system by slowing the rate of deterioration through the use of proactive treatments or by improving the surface condition. Since preventive maintenance treatments are usually very low in cost, their use is generally a cost-effective strategy for preserving network conditions. Preventive maintenance policies are established to define the type of maintenance action needed to correct each distress type observed during the pavement evaluation.

Surface treatments and thin overlays are common preventive treatments. These do not increase the pavement's structural capacity, but protect the existing structure from the elements that cause rapid aging, such as moisture intrusion and pavement oxidation that lead to structural deterioration. Additionally, surface treatments can be used to fill small surface distortions and improve skid resistance.

Stopgap maintenance is recommended when rehabilitation or reconstruction activities are warranted but funding is insufficient to perform the needed level of work. The goal of stopgap maintenance is to keep the pavement operational through the repair of distress type and severity level combinations that could create hazardous situations like the potential for tire damage, hydroplaning, or other safety concerns. Many of the treatments used in a preventive application are also used in stopgap applications. However, stopgap maintenance treatments are considered temporary and generally do not provide very many years of service.

A threshold PCI value (i.e., critical PCI) is used to distinguish between preventive and stopgap maintenance. CCPW defined this value to be 65 for regional roadways and 40 for their local roadways in their network (Pavement Management Plan). The Critical PCI identifies when major rehabilitation work should be considered. Preventive maintenance actions are only recommended for roadways above the critical PCI level. Below the critical PCI, stopgap maintenance could be applied but if funding is available the pavement is being considered for major maintenance and rehabilitation (M&R) in the near future. Major M&R is typically defined as an activity such as an overlay or reconstruction that would return the pavement to basically "new" condition and would result in a PCI of 100 (no distress) if implemented.

According to the National Center for Pavement Preservation (NCPP), it costs six to fourteen times less to use pavement preservation treatments to extend the life of pavement segments rather than waiting until the pavement reaches poor condition and repairing or replacing it. Preservation treatments have shorter expected lifespans, which causes concern among the public about more frequent applications and associated interruptions. However, research clearly shows that life-cycle costs for roadway maintenance are reduced by using pavement preservation approaches, keeping good roads in good condition while repairing those that have fallen below acceptable levels of condition for preservation. Figure 12 shows the benefit of using a pavement preservation approach.

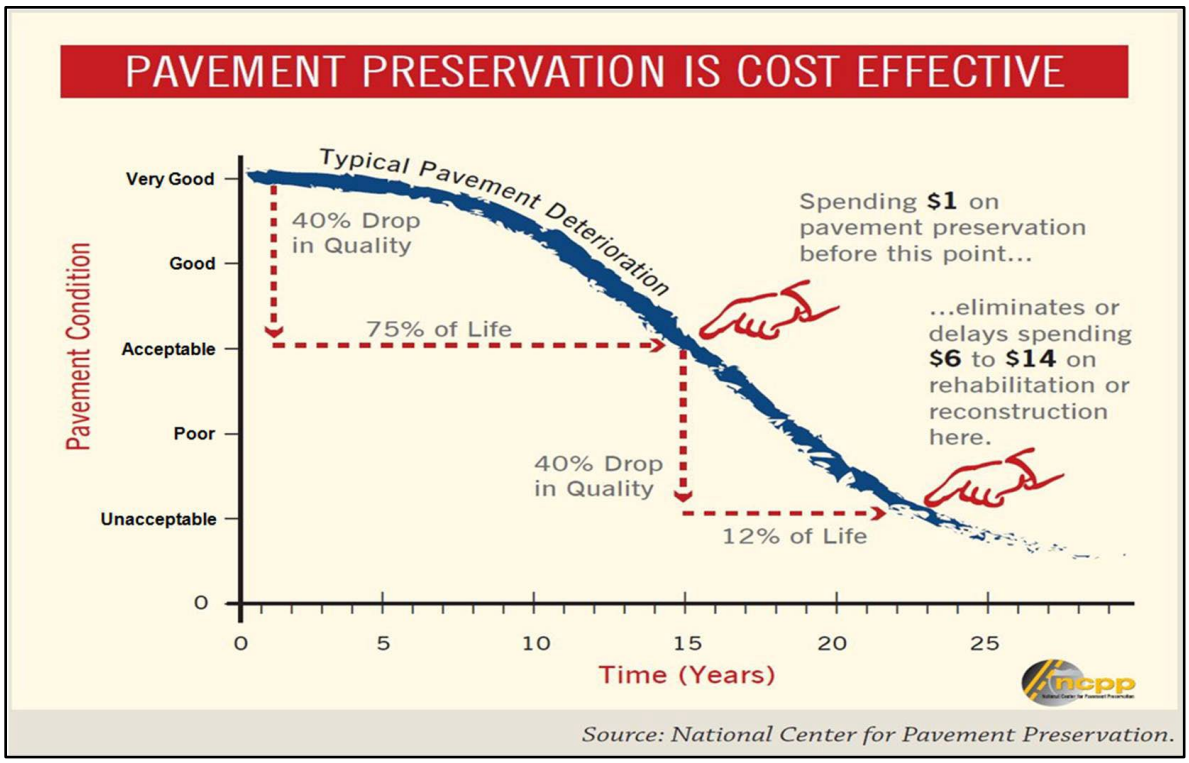

Figure 12. Pavement preservation cost vs. pavement rehabilitation cost.

Table 6 provides the list of treatment types (activity) currently considered in Carson City's pavement management software.

Table 6. CCPW Existing treatment types.

Activity	PAVER Budget Category	Cost[1]	Unit
Crack Sealing	Localized Preventive	$0.75	ft
Patching		$8.00	sq. ft
Pothole Filling		$6.00	sq. ft
Slurry Seal[2]	Surface Treatments	$0.32	sq. ft
Cape Seal[3]		$0.32	sq. ft
Cold Mill and Overlay - 2 Inches[4]	Major M&R	$3.00	sq. ft
Complete Reconstruction - AC		$4.00	sq. ft

[1] Costs do not include non-pavement incidentals (e.g., pavement marking, ADA compliance, engineering)
[2] Time to reach pre-treatment condition is 3 years and application interval is 5 years.
[3] Time to reach pre-treatment condition is 4 years and application interval is 6 years.
[4] Applies only to Regional Roads.

The pavement management software estimates preventive, stopgap, and major M&R costs based on the pavement condition of each roadway. Localized preventive treatment unit costs shown above were used to estimate maintenance costs for the entire pavement surface area, the results are summarized in Table 7. It is noteworthy to mention that the pavement management software interpolates unit costs between the PCI values shown. For example, a pavement section with a PCI of 75 will have an associated cost of \$0.025 per square foot for preventive maintenance ($0.01 + (75 - 80)\ x\ \frac{(0.01-0.04)}{(80-70)} = 0.025$).

Note that surface treatments are not recommended based on a cost by condition. These are calculated based on the unit costs shown in Table 6 and sections will only be targeted if they fall within the selected PCI range of 90 to 65 for regional roadways and 90 to 40 for local roadways, and a minimum of two years after a major M&R has been applied.

Table 7. Cost (per ft^2) by PCI range for preventive, stopgap, and major.

PCI	Preventive	Stopgap	PCI	Major M&R	
				Regional Roads	Local Roads
0	\$1.67	\$0.83	0	\$4.00	\$4.00
10	\$1.67	\$0.83	10	\$4.00	\$4.00
20	\$1.33	\$0.67	20	\$4.00	\$4.00
30	\$0.80	\$0.40	30	\$4.00	\$4.00
40	\$0.33	\$0.17	39.99	\$4.00	\$4.00
50	\$0.17	\$0.08	40	\$3.00	\$0.00
65	\$0.05	\$0.05	49.99	\$3.00	\$0.00
70	\$0.04	\$0.04	50	\$3.00	\$0.00
80	\$0.01	\$0.01	64.99	\$3.00	\$0.00
90	\$0.00	\$0.00	65	\$0.00	\$0.00
100	\$0.00	\$0.00	100	\$0.00	\$0.00

Performance Models

Performance models are used by the pavement management software to predict future condition. Based on the data obtained during the latest pavement survey completed, the models were reviewed and updated to improve their accuracy.

Currently there are two performance models within the CCPW software, one for polymer-modified, asphalt-surfaced roads and another for non-modified, asphalt-surfaced roads. Figure 13 provides a graphic showing the models .

Over time, as additional data becomes available (i.e., original construction records, new rounds of pavement inspections) performance models may be refined, and additional performance curves may be needed to better represent roadway performance. For example, the City may consider adding a separate model for regional and local roads due to prioritization of treatments. In addition, at some point consideration may be given to separate models for roads that have received different pavement preservation treatments. Periodic review of configuration items keeps a pavement management system aligned with current conditions and agency operations.

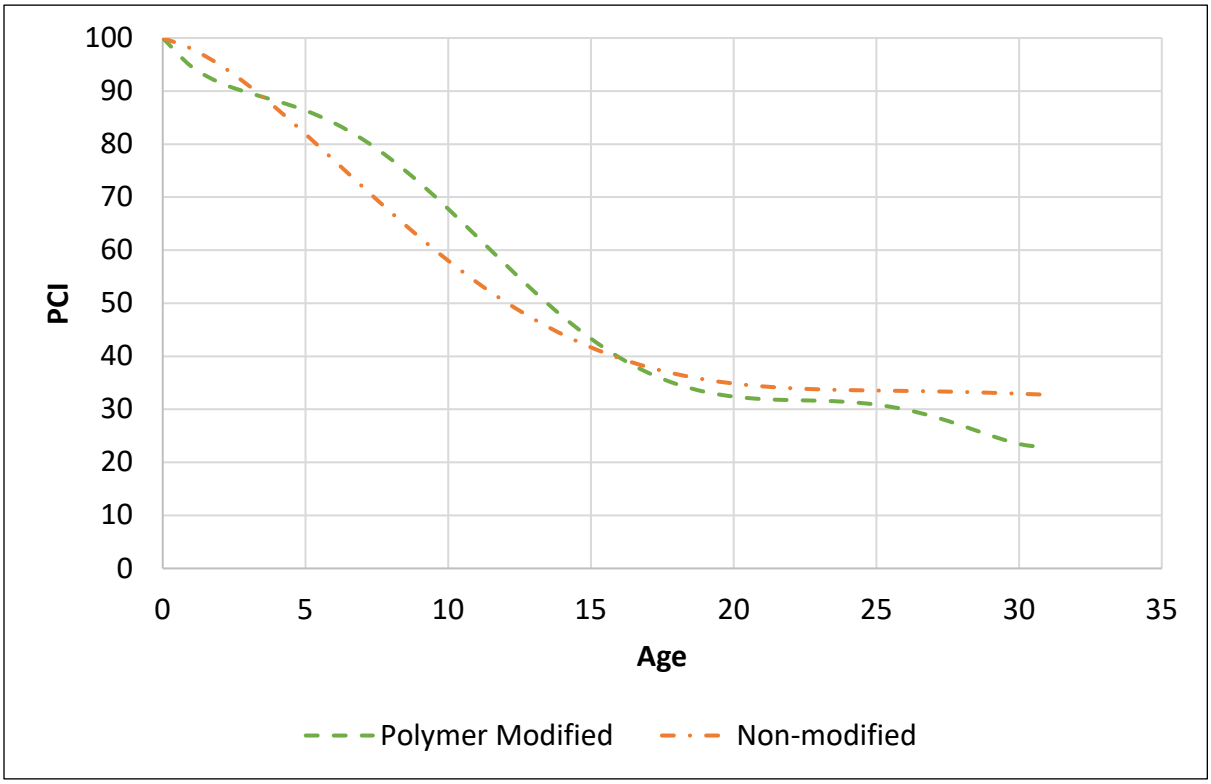

Figure 13. CCPW performance models.

BUDGET SCENARIO ANALYSES

Based on pavement conditions, treatment costs, performance models, and CCPW treatment strategies, the City's pavement management software was used to perform various budget and condition forecasting scenarios. The software uses pavement condition inspection data, pavement performance models, and treatment strategies to predict future network conditions or future budget requirements. The following discussion provides an overview of the analyses performed and results.

An analysis period up to 2050 (28 years) was selected by CCPW. Pavement management software analyses are typically carried out for shorter time periods (i.e., 5 or 10 years) because of the variability of inputs over time. Variables include accuracy of the pavement performance models (refined over time as more data becomes available); the introduction of additional performance models due to new materials, treatments, and technologies; significant changes in treatment unit costs; unforeseen environmental factors such as earthquake or flooding events; and reliability of funding. Pavement management software is capable of long-term analysis periods, but caution should be applied to long-term projections. To improve accuracy, scenario assumptions should be refined over time.

Five budget scenarios were analyzed as part of this project; two were based on constrained budgets, and three were based on target PCI conditions. Details of each scenario are summarized below:

Constrained Funding Scenarios

- **Current Revenue Levels:** CCPW estimated that it spends an average of approximately $1.4 million per year on preventive maintenance activities and $2 million on surface treatments and rehabilitation activities received from local sources (with a 0.68% increase per year over the analysis period). Additionally, there is a total of $18.7 million from a combination of the City's 1/8 cent infrastructure sales and a one-time federal transportation grant which was distributed over the first 5 years of the analysis period toward the rehabilitation of North Carson Street and William Street. This has been incorporated into the forecast to offset costs associated with the two mentioned corridors. Additionally, Carson City reasonably expects to receive $2.7 million in Transportation Formula Funding, this funding was distributed over the next 5-years for M&R on collector and arterial roads. This scenario predicts the future condition of the pavement network if current funding levels are maintained.

- **Current Revenue Levels increased by 100 percent:** CCPW wanted to analyze the impact to their network if local revenue were increased to an average of approximately $2.8 million per year on preventive maintenance activities and $4 million on surface treatments and rehabilitation activities (with a 0.68% increase per year over the analysis period). The additional $18.7 million for rehabilitation activities on North Carson Street and William Street and other $2.7 million from Federal Funding that is to be evenly distributed over the first 5 years of the analysis period was maintained since both revenue streams will conclude by 2027.

Target Pavement Condition Scenarios

The additional $18.7 million for rehabilitation activities on North Carson Street and William Street that is to be evenly distributed over the first 5 years of the analysis period was maintained for these scenarios. Additionally, the $2.7 million in Federal Funding distributed over the first 5 years for M&R on collector and arterial roads was also maintained.

- **Maintain Current Condition:** This scenario predicts the annual budget requirements to maintain the current area-weighted average network PCI of approximately 62 (Fair) over the 28-year analysis period.

- **Reach Target Conditions:** This scenario predicts the annual budget requirement to reach a specified area-weighted average PCI; the following two scenarios were analyzed:

    - Approved Pavement Management Plan scenario where regional and local roadways would reach an area-weighted average PCI of at least 75 and 70, respectively, in the initial 8 years and then maintain the target conditions over the remainder of the 28-year analysis period.

    - Modified Pavement Management Plan scenario, which is more in line with the City's current practice of roadway prioritization that focuses on roadways with higher volumes and connectivity, and addresses local roadways as funding becomes available. Regional and local roadways would reach an area-weighted average PCI of at least 70 and 50, respectively, by 2030 and then maintain target conditions over the remainder of the 28-year analysis period.

It is noteworthy to mention that when conditions are targeted, it is expected for the software to return a value that is not exactly the target. Due to the many variables that are involved in forecasting (e.g., network condition, analyses period, number of sections, budget, treatment strategy), it may not be possible for a scenario to reach the target. Therefore, multiple iterations were carried out to approximate the target values for the three target condition scenarios above, and in those cases where the software was unable to meet the target condition, if the values were greater or slightly below the targeted PCI the scenario was considered acceptable.

Assumptions

During conversations with CCPW, it was decided to account for roadway project incidentals that are typically encountered during surface treatments and rehabilitation projects. Assumed incidentals as a percentage of the total project costs are shown in table 8. The budgets for these categories were reduced accordingly for all scenarios because unit costs in the software only account for pavement-related construction. Additionally, an overall inflation rate of 2.46% was used. This value was calculated based on an average of the information from the Congressional Budget Office for 2022 (6.1%) and 2023 (3.1%), and a 2.3% assumption for the remaining years of the analysis period.

Table 8. CCPW Incidental Costs.

Category	Major M&R	Surface Treatment
ADA	20%	5%
Design/Project Management	12.5%	6.5%
Construction Management	8.5%	11.5%
Contingency	10%	10%
Striping	5%	15%
Total	**56%**	**48%**

Because the budgets for rehabilitation and surface treatments were combined, it was necessary to define a starting point that allows for a funding allocation balance between surface treatments and rehabilitation. This assumed roadways that are in good condition can be maintained in that condition while roadways that have reached the end of their service life (below the critical PCI) can be planned for rehabilitation. The initial funding allocation split between surface treatments and rehabilitation was assumed to be 30 percent for surface treatments and 70 percent for rehabilitation. Due to the length of the analysis period, there were multiple years where there was a considerable funding surplus from the 30 percent budget allocation for surface treatments. This surplus was moved to the rehabilitation treatment budget to incorporate additional rehabilitation work. Additionally, when there was surplus from localized preventive maintenance, it was used for rehabilitation and surface treatments.

While there are unit costs set up in the pavement management software for stopgap maintenance, Carson City has staff and budget dedicated to carry out routine stopgap maintenance activities throughout the network. Therefore, this maintenance category is excluded from all analyses to eliminate additional fund allocation to stopgap activities.

Tables 9 through 13 show the annual report card used by CCPW that summarizes the average area-weighted PCI for all facility types over the first 8 years of the analysis period for every budget scenario. These tables show the percentage change between the first and eighth year of the analysis period. Tables 14 through 18 show the same report card for every three years of the 28-year analysis period along with the percentage change between the first and twenty-eighth year of the analysis period.

Table 9: 8-year report card for current revenue levels.

Pavement Condition Index (PCI) - Annual Report Card											
Facility Type		Estimated PCI									Percent Change 2022 to 2030
		2022	2023	2024	2025	2026	2027	2028	2029	2030	
City-wide	Regional Roads	74	70	69	69	68	67	66	65	63	-14%
	Local Roads	56	51	48	45	43	41	39	38	36	-35%
	All Roads	62	57	55	53	52	50	48	47	46	-27%
Performance District 1	Regional Roads	69	65	65	64	65	65	66	67	65	-6%
	Local Roads	57	51	48	46	43	41	39	37	36	-37%
	All Roads	61	56	54	52	50	49	48	47	46	-25%
Performance District 2	Regional Roads	80	78	78	77	78	76	76	74	73	-8%
	Local Roads	53	48	45	43	41	39	37	36	35	-34%
	All Roads	63	58	57	55	54	52	51	49	48	-23%
Performance District 3	Regional Roads	77	74	73	70	70	68	66	64	63	-18%
	Local Roads	58	54	52	49	47	45	43	41	39	-32%
	All Roads	64	60	58	56	54	52	50	48	46	-27%
Performance District 4	Regional Roads	79	74	72	71	70	67	65	63	62	-21%
	Local Roads	51	46	44	42	40	38	37	36	35	-32%
	All Roads	61	56	54	52	50	48	47	45	44	-27%
Performance District 5	Regional Roads	65	59	57	60	58	60	58	56	53	-18%
	Local Roads	60	54	51	48	45	43	41	39	38	-37%
	All Roads	62	56	53	52	50	49	47	45	43	-31%

Table 10: 8-year report card for current revenue levels increased by 100 percent.

Pavement Condition Index (PCI) - Annual Report Card											
Facility Type		Estimated PCI									Percent Change 2022 to 2030
		2022	2023	2024	2025	2026	2027	2028	2029	2030	
City-wide	Regional Roads	74	72	73	73	73	73	73	73	74	0%
	Local Roads	56	51	48	46	43	41	40	38	37	-35%
	All Roads	62	58	56	55	53	52	51	50	49	-21%
Performance District 1	Regional Roads	69	69	76	74	74	71	73	76	75	8%
	Local Roads	57	51	48	46	43	41	39	37	36	-36%
	All Roads	61	57	57	55	53	51	50	50	49	-20%
Performance District 2	Regional Roads	80	79	78	79	82	80	81	80	81	2%
	Local Roads	53	48	45	43	41	39	38	36	35	-34%
	All Roads	63	59	57	56	55	54	53	52	51	-19%
Performance District 3	Regional Roads	77	76	76	75	74	72	75	75	74	-5%
	Local Roads	58	54	52	49	47	45	43	41	39	-32%
	All Roads	64	61	59	57	55	54	53	52	50	-22%
Performance District 4	Regional Roads	79	75	74	74	73	73	72	73	73	-8%
	Local Roads	51	46	44	42	40	38	37	36	35	-32%
	All Roads	61	56	55	53	51	51	49	49	48	-21%
Performance District 5	Regional Roads	65	62	59	63	60	65	65	64	66	2%
	Local Roads	60	54	51	48	45	43	41	39	38	-37%
	All Roads	62	57	54	53	51	51	49	48	48	-23%

Table 11: 8-year report card for maintaining current conditions.

Pavement Condition Index (PCI) - Annual Report Card											
Facility Type		Estimated PCI									Percent Change 2022 to 2030
		2022	2023	2024	2025	2026	2027	2028	2029	2030	
City-wide	Regional Roads	74	75	78	83	86	87	88	86	83	12%
	Local Roads	56	57	57	56	56	56	55	59	60	6%
	All Roads	62	63	64	65	66	66	66	68	68	9%
Performance District 1	Regional Roads	69	77	82	83	87	86	85	86	82	19%
	Local Roads	57	61	60	58	57	56	56	61	61	7%
	All Roads	61	66	67	67	67	66	66	70	68	12%
Performance District 2	Regional Roads	80	81	82	86	88	87	86	84	83	4%
	Local Roads	53	53	53	52	52	53	53	56	56	6%
	All Roads	63	63	63	64	65	65	65	65	66	4%
Performance District 3	Regional Roads	77	79	81	82	85	86	90	86	82	7%
	Local Roads	58	60	61	60	58	57	56	58	62	6%
	All Roads	64	66	67	67	67	66	66	67	68	6%
Performance District 4	Regional Roads	79	77	80	86	89	88	88	85	84	6%
	Local Roads	51	51	50	51	52	54	54	56	56	10%
	All Roads	61	60	61	63	65	66	65	66	66	8%
Performance District 5	Regional Roads	65	62	66	76	81	91	92	89	85	30%
	Local Roads	60	61	60	61	60	58	59	64	63	5%
	All Roads	62	62	62	66	67	70	70	73	70	14%

Table 12: Approved Pavement Management Plan Scenario

8-year report card for reaching target conditions of 75 and 70 for regional and local roads, respectively.

Pavement Condition Index (PCI) - Annual Report Card											
Facility Type		Estimated PCI									Percent Change 2022 to 2030
		2022	2023	2024	2025	2026	2027	2028	2029	2030	
City-wide	Regional Roads	74	76	79	83	87	87	88	86	83	12%
	Local Roads	56	59	59	58	58	57	57	63	63	12%
	All Roads	62	65	65	67	67	67	67	70	70	12%
Performance District 1	Regional Roads	69	77	82	84	87	86	85	86	82	19%
	Local Roads	57	62	62	60	59	57	57	66	65	14%
	All Roads	61	67	69	68	68	67	66	72	71	16%
Performance District 2	Regional Roads	80	81	83	87	88	86	86	84	83	4%
	Local Roads	53	55	55	55	55	55	55	61	61	14%
	All Roads	63	65	65	66	67	66	66	69	69	9%
Performance District 3	Regional Roads	77	79	81	82	86	86	90	86	82	7%
	Local Roads	58	61	62	61	60	59	57	61	64	11%
	All Roads	64	67	68	68	68	67	67	69	70	9%
Performance District 4	Regional Roads	79	78	80	86	89	87	88	85	83	6%
	Local Roads	51	53	53	53	55	56	55	60	59	16%
	All Roads	61	62	62	65	67	67	67	69	68	11%
Performance District 5	Regional Roads	65	62	67	76	82	91	92	88	84	30%
	Local Roads	60	62	61	62	61	59	59	66	64	7%
	All Roads	62	62	63	67	68	70	71	73	71	15%

Table 13: Modified Pavement Management Plan Scenario

8-year report card for reaching target conditions of 70 and 50 for regional and local roads, respectively.

Pavement Condition Index (PCI) - Annual Report Card											
Facility Type		Estimated PCI									Percent Change 2022 to 2030
		2022	2023	2024	2025	2026	2027	2028	2029	2030	
City-wide	Regional Roads	74	75	77	81	83	86	88	86	84	13%
	Local Roads	56	57	56	55	54	53	53	56	56	0%
	All Roads	62	63	63	64	64	64	65	66	65	5%
Performance District 1	Regional Roads	69	77	79	81	85	85	86	86	83	20%
	Local Roads	57	60	58	56	54	53	53	58	57	0%
	All Roads	61	65	65	64	65	63	64	67	65	7%
Performance District 2	Regional Roads	80	80	82	84	88	87	87	84	84	5%
	Local Roads	53	52	52	51	51	50	50	52	52	-1%
	All Roads	63	62	63	63	64	63	63	63	63	1%
Performance District 3	Regional Roads	77	79	80	82	82	85	90	87	83	7%
	Local Roads	58	59	60	59	57	56	54	57	60	3%
	All Roads	64	65	66	66	65	65	65	66	67	4%
Performance District 4	Regional Roads	79	77	80	84	87	87	88	86	84	6%
	Local Roads	51	50	49	49	50	51	50	52	52	2%
	All Roads	61	60	60	62	63	64	63	64	63	3%
Performance District 5	Regional Roads	65	62	64	74	75	87	93	89	85	32%
	Local Roads	60	61	60	59	57	56	56	61	59	-1%
	All Roads	62	62	61	64	64	66	68	71	68	10%

Table 14: 28-year report card for current revenue levels.

Pavement Condition Index (PCI) - Annual Report Card												
Facility Type		Estimated PCI										Percent Change 2022 to 2050
		2022	2025	2028	2031	2034	2037	2040	2043	2046	2050	
City-wide	Regional Roads	74	69	66	62	59	56	52	48	46	43	-41%
	Local Roads	56	45	39	35	33	31	31	30	29	28	-50%
	All Roads	62	53	48	44	42	40	38	36	35	33	-47%
Performance District 1	Regional Roads	69	64	66	66	64	60	55	51	50	48	-30%
	Local Roads	57	46	39	35	33	32	31	31	30	30	-48%
	All Roads	61	52	48	45	43	41	39	37	37	36	-41%
Performance District 2	Regional Roads	80	77	76	72	69	67	64	59	56	54	-33%
	Local Roads	53	43	37	34	32	31	30	29	29	27	-48%
	All Roads	63	55	51	47	45	44	42	40	38	37	-42%
Performance District 3	Regional Roads	77	70	66	61	58	54	50	46	43	41	-47%
	Local Roads	58	49	43	37	34	31	30	29	28	26	-55%
	All Roads	64	56	50	45	41	38	36	34	33	31	-52%
Performance District 4	Regional Roads	79	71	65	61	57	53	50	45	42	39	-50%
	Local Roads	51	42	37	34	32	31	30	29	29	28	-46%
	All Roads	61	52	47	43	41	39	37	35	33	32	-48%
Performance District 5	Regional Roads	65	60	58	52	48	46	41	41	38	35	-46%
	Local Roads	60	48	41	36	34	32	31	31	30	29	-52%
	All Roads	62	52	47	42	39	37	35	34	33	31	-50%

Table 15: 28-year report card for current revenue levels increased by 100 percent.

Pavement Condition Index (PCI) - Annual Report Card												
Facility Type		Estimated PCI										Percent Change 2022 to 2050
		2022	2025	2028	2031	2034	2037	2040	2043	2046	2050	
City-wide	Regional Roads	74	73	73	73	72	71	68	65	62	58	-21%
	Local Roads	56	46	40	35	33	32	31	30	29	28	-50%
	All Roads	62	55	51	48	46	45	43	42	40	38	-38%
Performance District 1	Regional Roads	69	74	73	74	76	70	71	66	66	66	-4%
	Local Roads	57	46	39	35	33	32	31	31	30	29	-48%
	All Roads	61	55	50	48	47	45	45	43	42	42	-32%
Performance District 2	Regional Roads	80	79	81	80	78	77	73	70	69	71	-12%
	Local Roads	53	43	38	34	32	31	31	30	29	28	-48%
	All Roads	63	56	53	50	48	47	46	44	43	43	-32%
Performance District 3	Regional Roads	77	75	75	72	71	74	69	65	64	57	-26%
	Local Roads	58	49	43	38	34	32	30	29	29	27	-54%
	All Roads	64	57	53	48	45	45	42	40	39	36	-43%
Performance District 4	Regional Roads	79	74	72	72	68	69	68	61	56	51	-35%
	Local Roads	51	42	37	34	32	31	30	29	29	28	-45%
	All Roads	61	53	49	47	45	44	43	40	38	36	-41%
Performance District 5	Regional Roads	65	63	65	68	65	65	58	60	55	48	-27%
	Local Roads	60	48	41	37	34	32	32	31	30	29	-51%
	All Roads	62	53	49	47	45	44	41	41	39	36	-42%

Table 16: 28-year report card for maintaining current conditions.

Pavement Condition Index (PCI) - Annual Report Card												
Facility Type		Estimated PCI										Percent Change 2022 to 2050
		2022	2025	2028	2031	2034	2037	2040	2043	2046	2050	
City-wide	Regional Roads	74	83	88	79	79	78	80	78	76	74	0%
	Local Roads	56	56	55	60	60	63	61	61	58	56	0%
	All Roads	62	65	66	66	66	68	67	67	64	62	0%
Performance District 1	Regional Roads	69	83	85	78	81	75	79	81	75	81	18%
	Local Roads	57	58	56	62	61	63	60	61	58	57	0%
	All Roads	61	67	66	67	68	67	66	68	64	65	7%
Performance District 2	Regional Roads	80	86	86	79	80	81	80	77	80	76	-5%
	Local Roads	53	52	53	57	59	63	63	61	59	57	7%
	All Roads	63	64	65	65	67	69	69	67	66	63	1%
Performance District 3	Regional Roads	77	82	90	79	80	83	78	79	79	71	-8%
	Local Roads	58	60	56	62	60	63	59	59	56	54	-7%
	All Roads	64	67	66	67	66	69	65	65	63	59	-7%
Performance District 4	Regional Roads	79	86	88	80	76	74	82	77	72	70	-12%
	Local Roads	51	51	54	56	58	61	62	60	59	55	8%
	All Roads	61	63	65	64	64	65	69	66	63	60	-1%
Performance District 5	Regional Roads	65	76	92	80	76	80	80	78	76	71	9%
	Local Roads	60	61	59	63	62	65	61	62	58	57	-5%
	All Roads	62	66	70	69	67	70	67	67	64	62	0%

Table 17: Approved Pavement Management Plan Scenario

28-year report card for reaching target conditions of 75 and 70 for regional and local roads, respectively.

Pavement Condition Index (PCI) - Annual Report Card												
Facility Type		Estimated PCI										Percent Change 2022 to 2050
		2022	2025	2028	2031	2034	2037	2040	2043	2046	2050	
City-wide	Regional Roads	74	83	88	79	79	79	81	79	77	75	1%
	Local Roads	56	58	57	63	62	67	66	70	69	70	25%
	All Roads	62	67	67	68	68	71	71	73	72	72	16%
Performance District 1	Regional Roads	69	84	85	78	81	77	80	83	77	82	19%
	Local Roads	57	60	57	65	61	66	64	68	66	70	24%
	All Roads	61	68	66	69	68	70	69	73	70	74	22%
Performance District 2	Regional Roads	80	87	86	79	79	81	80	78	81	77	-3%
	Local Roads	53	55	55	61	63	68	68	71	70	70	33%
	All Roads	63	66	66	67	69	73	72	73	74	73	16%
Performance District 3	Regional Roads	77	82	90	79	80	82	80	80	80	73	-5%
	Local Roads	58	61	57	64	61	67	64	69	70	70	20%
	All Roads	64	68	67	69	67	71	68	72	73	71	11%
Performance District 4	Regional Roads	79	86	88	80	77	75	83	78	73	70	-12%
	Local Roads	51	53	55	59	62	67	71	72	72	71	39%
	All Roads	61	65	67	66	67	70	75	74	73	71	16%
Performance District 5	Regional Roads	65	76	92	80	76	81	81	79	77	72	10%
	Local Roads	60	62	59	65	63	68	65	70	67	69	16%
	All Roads	62	67	71	70	68	72	70	73	70	70	13%

Table 18: Modified Pavement Management Plan Scenario

28-year report card for reaching target conditions of 70 and 50 for regional and local roads, respectively.

Pavement Condition Index (PCI) - Annual Report Card												
Facility Type		Estimated PCI										Percent Change 2022 to 2050
		2022	2025	2028	2031	2034	2037	2040	2043	2046	2050	
City-wide	Regional Roads	74	81	88	80	78	77	76	74	73	70	-5%
	Local Roads	56	55	53	56	55	57	55	55	52	50	-11%
	All Roads	62	64	65	64	63	64	62	61	59	57	-8%
Performance District 1	Regional Roads	69	81	86	78	81	75	75	79	73	77	12%
	Local Roads	57	56	53	58	56	59	57	57	54	53	-7%
	All Roads	61	64	64	65	64	65	63	65	60	61	0%
Performance District 2	Regional Roads	80	84	87	80	79	81	78	75	79	74	-7%
	Local Roads	53	51	50	52	53	55	53	52	49	48	-10%
	All Roads	63	63	63	62	62	64	62	60	60	57	-9%
Performance District 3	Regional Roads	77	82	90	79	79	80	75	75	73	69	-11%
	Local Roads	58	59	54	60	58	59	55	55	52	50	-14%
	All Roads	64	66	65	66	64	66	61	61	58	56	-13%
Performance District 4	Regional Roads	79	84	88	80	74	71	77	72	67	64	-19%
	Local Roads	51	49	50	52	53	53	54	52	51	48	-6%
	All Roads	61	62	63	62	60	59	62	59	57	54	-12%
Performance District 5	Regional Roads	65	74	93	81	77	77	75	73	71	66	1%
	Local Roads	60	59	56	59	57	59	56	57	53	52	-14%
	All Roads	62	64	68	67	64	65	62	62	59	57	-9%

As illustrated in Figure 14 and tables 9 through 14, the current revenue level scenario shows a decline in network condition over the analysis period, starting at a PCI of 62 and declining to a PCI of 46 in 8 years and a PCI of 33 in 28 years. Regional roads will have a slightly lower deterioration rate than local roads over the first 8 years primarily due to their higher priority; however, they will still decline considerably throughout the analysis period. This rate of decline would indicate that in a few years more and more roadway segments in the City's network will require rehabilitation work, and the agency will struggle to maintain roads in acceptable condition. This signifies that the current annual budget is insufficient to maintain network conditions given current treatment assumptions and funding. Increasing the revenue 100 percent has a relatively small impact over the entire network; a 100 percent budget increase will increase the overall network PCI 5 points at the end of the analysis period when compared to the current budget.

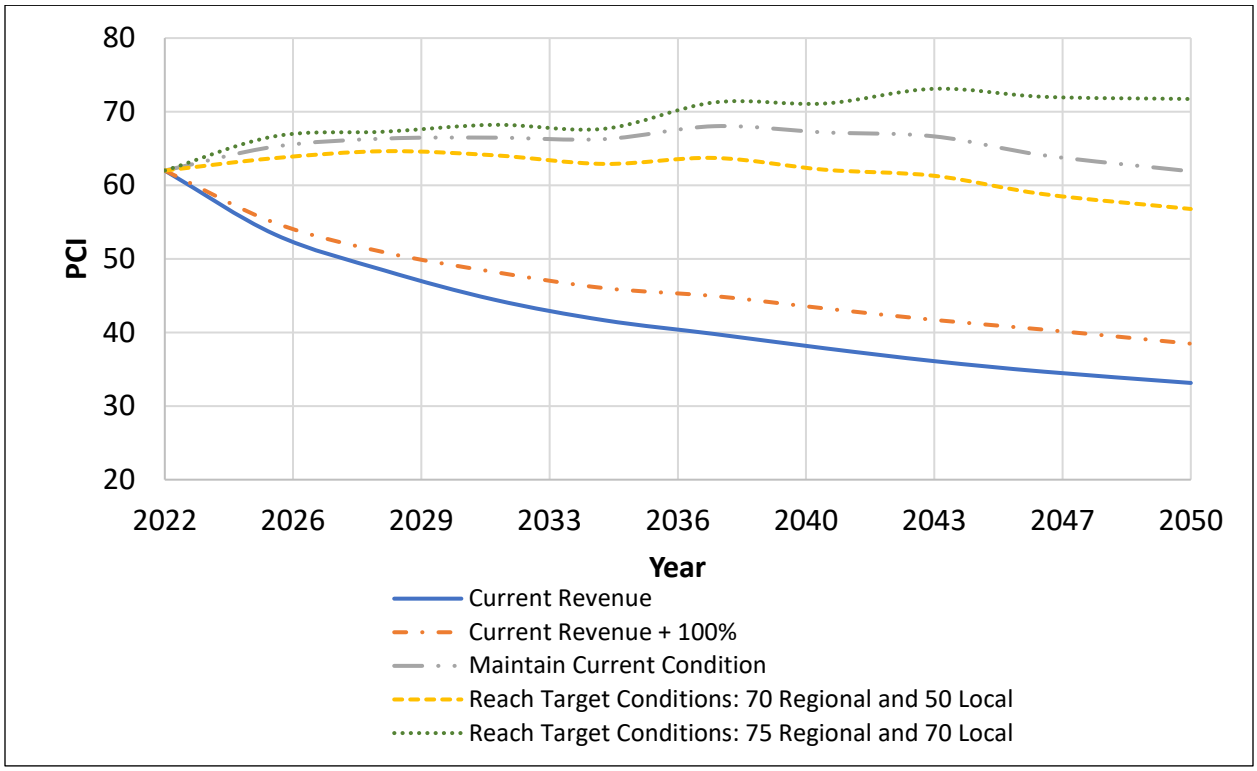

Figure 14: Chart of PCI over time for analyzed budget scenarios.

Figure 15 shows the average annual budgets for every scenario. The difference between the current annual revenue and the annual budget required to maintain the network in its current condition is approximately $21.09 million.

The difference between the current annual revenue and the annual budget required to meet the City's approved Pavement Management Plan pavement condition targets (75 for regional roads and 70 for local roads) is $25.43 million.

The difference between the current annual revenue and the annual budget required to meet the proposed modified pavement condition targets (70 for regional roads and 50 for local roads) is $17.90 million.

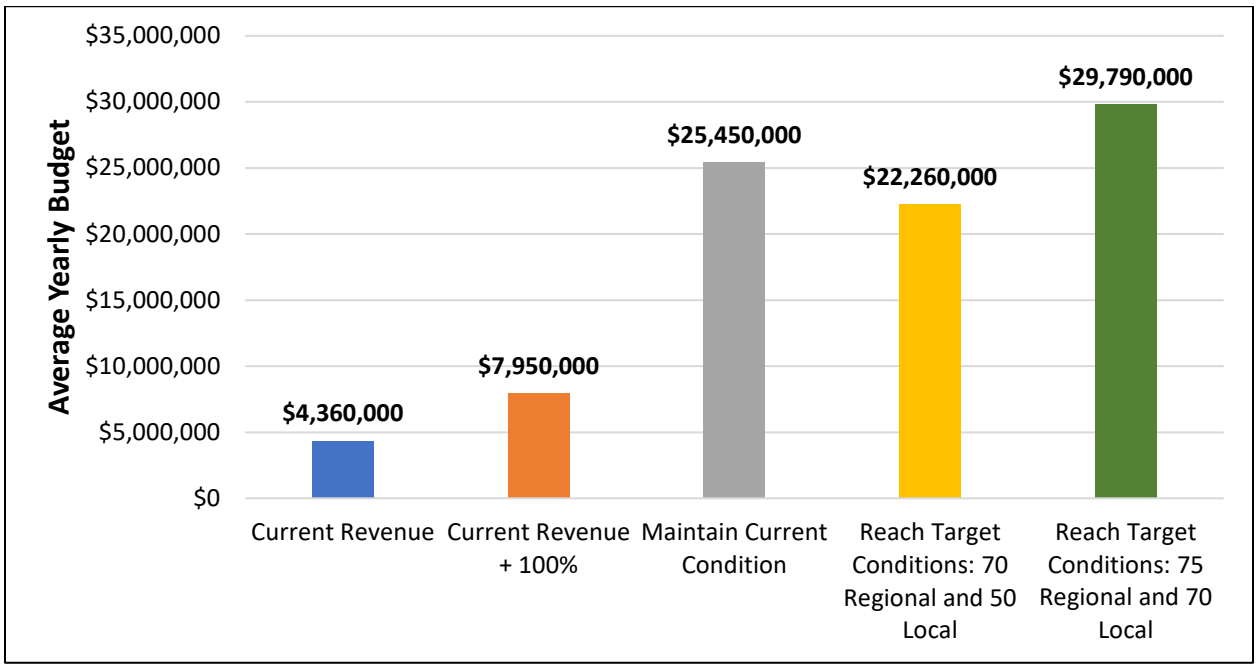

Figure 15: Average annual budget per scenario.

If the current revenue is not considerably increased, the agency will face a network in Poor condition within 8 years and a Very Poor network in 28 years. Figures 16 through 21 show the forecasted condition categories by percentage of network area for the overall network, regional roads, and local roads for 2030 and 2050 respectively.

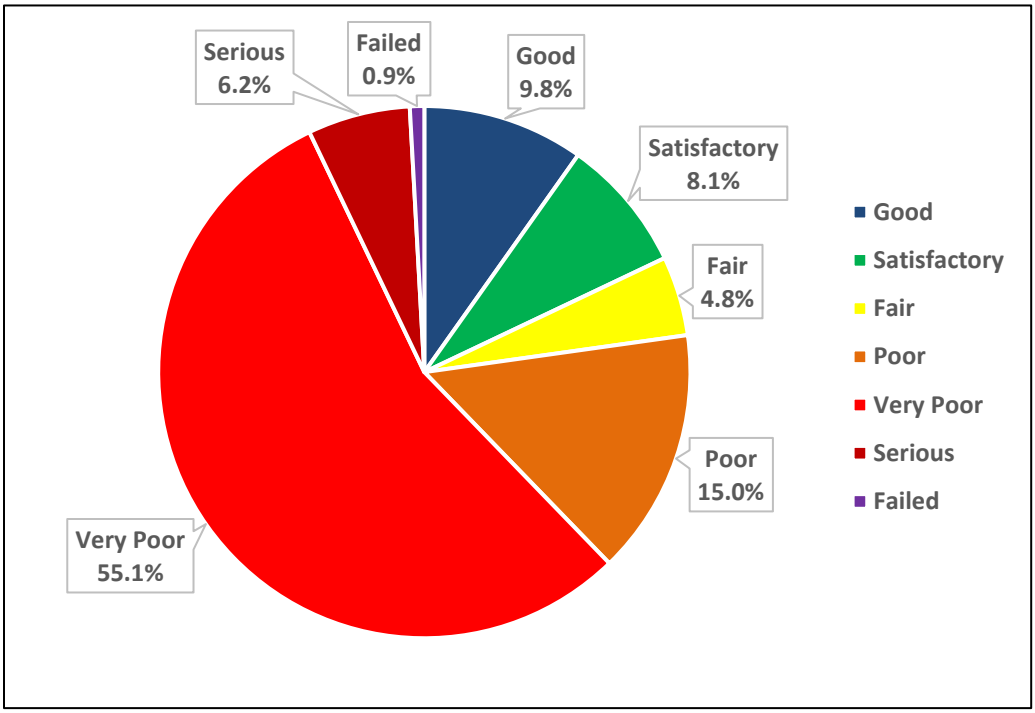

Figure 16. Forecasted Network distribution of pavement area by condition category in 2030.

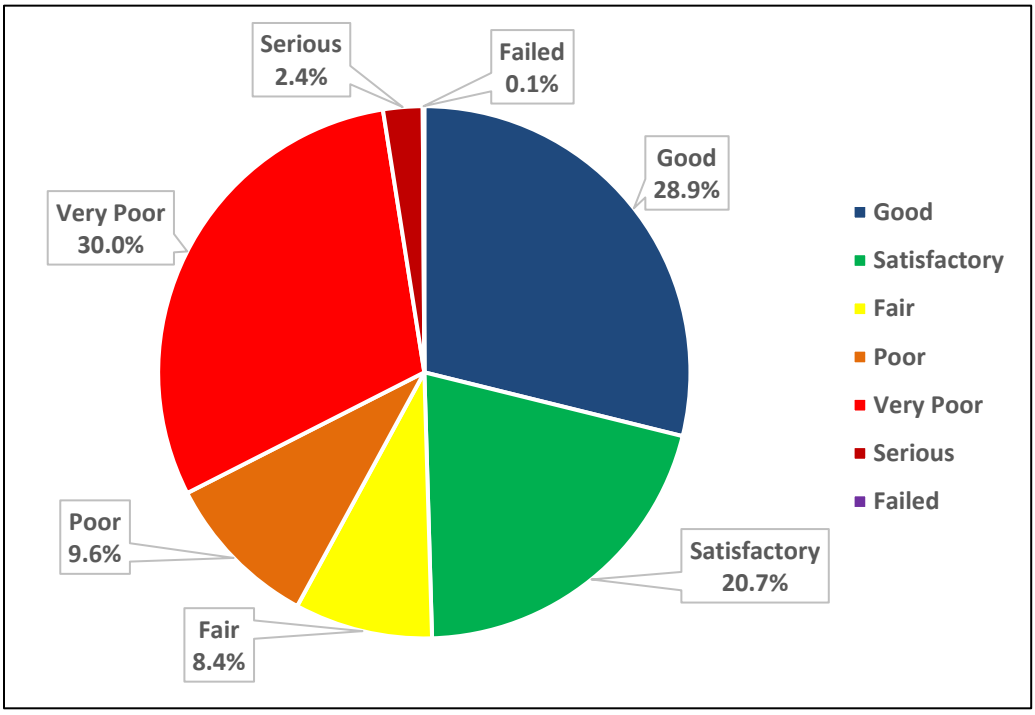

Figure 17. Forecasted Regional Roads distribution of pavement area by condition category in 2030.

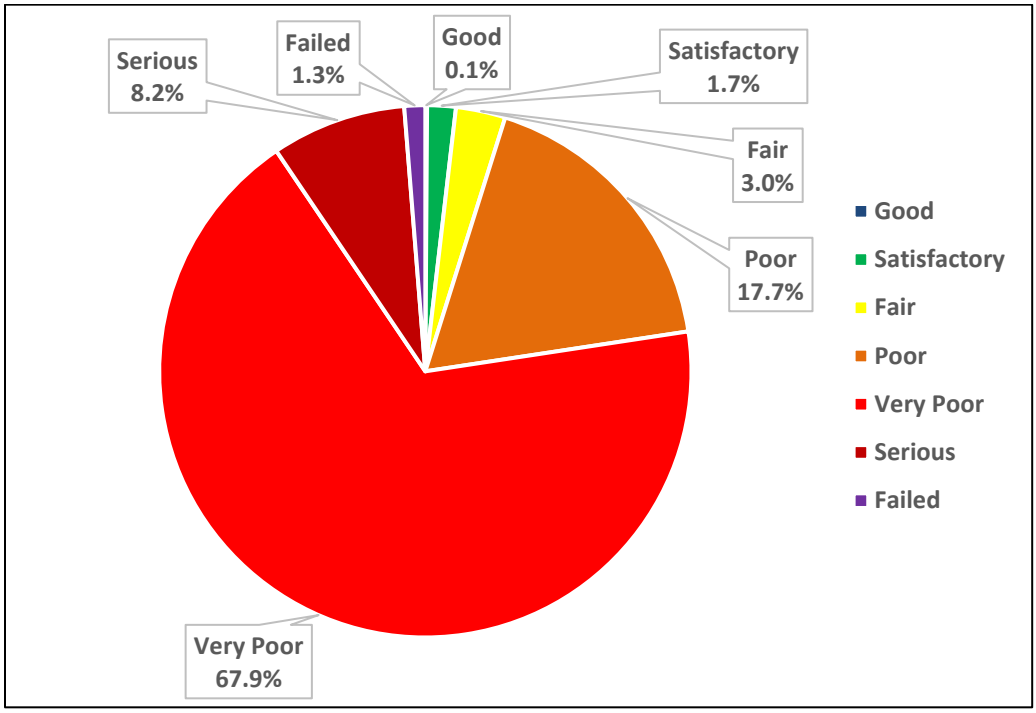

Figure 18. Forecasted Local Roads distribution of pavement area by condition category in 2030.

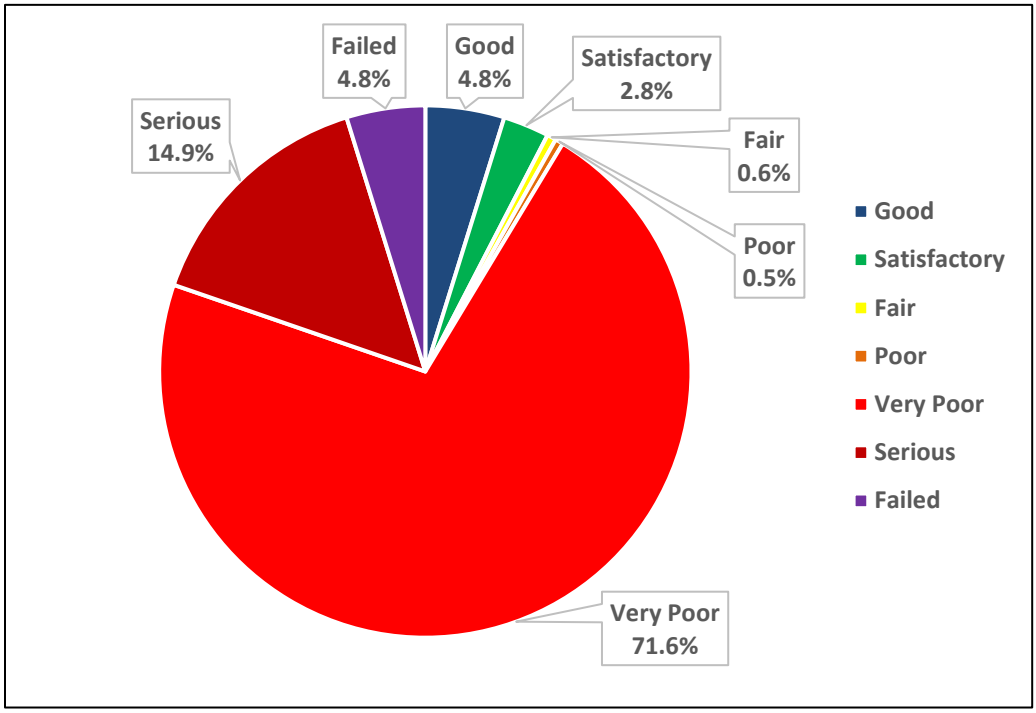

Figure 19. Forecasted Network distribution of pavement area by condition category in 2050.

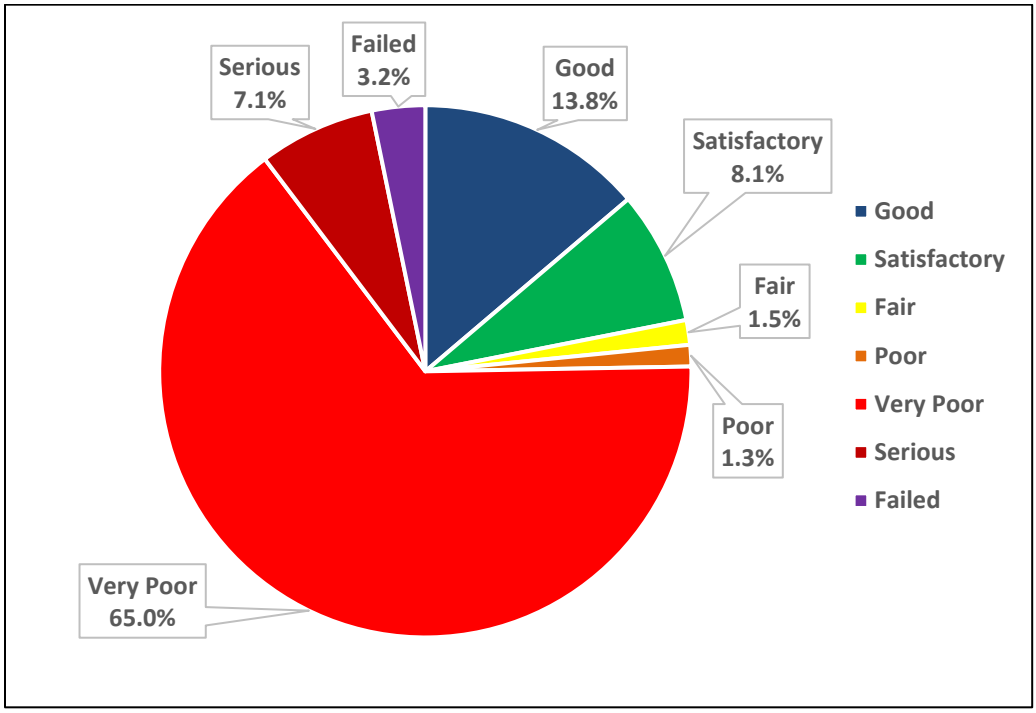

Figure 20. Forecasted Regional Roads distribution of pavement area by condition category in 2050.

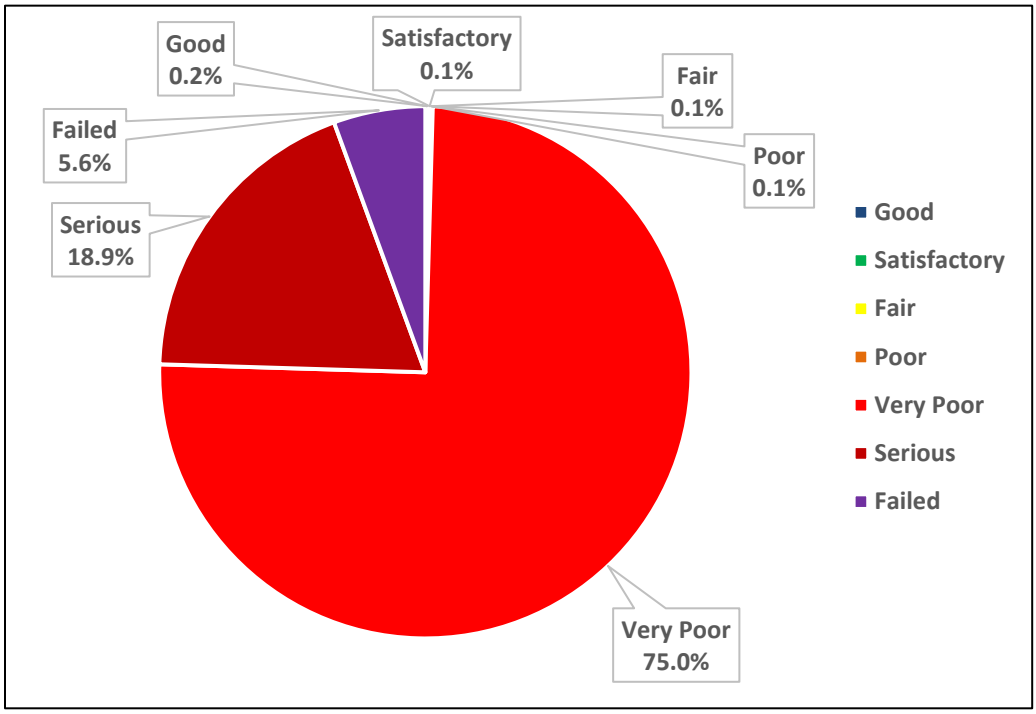

Figure 21. Forecasted Local Roads distribution of pavement area by condition category in 2050.

SUMMARY AND CONCLUSIONS

Carson City Public Works asked APTech to update the configuration of their PAVER pavement management system, document the condition of the City's road network based on the 2021 data collection effort, and analyze a number of maintenance and rehabilitation scenarios. The goal was to provide Carson City Public Works with a condition forecast based on their existing budget and approved Pavement Management Plan.

The 2022 area-weighted average network PCI is 62, placing the network average in the Fair condition category. The following summarizes the findings from analyzing the PCI data and M&R planning scenarios:

- At the current revenue of approximately $4.36 Million per year, the overall area-weighted average of the network would be a 46 by 2030 and 33 by 2050.
- Increasing the current revenue by 100 percent would have a relatively small impact on the overall condition of the network. At this budget level the PCI for the network would reach a 49 by 2030 and a 38 by 2050.
- The required annual funding to maintain the current PCI of 62 for the next 28 years is $25.45 Million. Due to current conditions and the network size, the cost to maintain the network at this level is fairly high due to substantial M&R work needs.
- Budget projections to achieve the targets of 75 for regional roads and 70 for local roads, approved in the Pavement Management Plan was performed. To achieve these area-weighted averages, the agency would require an annual budget of $29.79 Million dollars.
- Budget projections to achieve a Modified Pavement Management Plan more in line with the City's current practice of roadway prioritization with PCIs of 70 for regional roads and 50 for local roads was performed. To achieve these area-weighted averages, the agency would require an annual budget of $22.26 Million dollars.
- The condition of the City roadway network has reached the point that the rate of decline is greater than current funding levels or even funding with reasonable increases can sustain. If the City desires to overcome the declining trend it will need to seek alternative funding mechanisms to significantly increase its investment in road M&R. It is recommended that the results of this analysis be used to demonstrate to decision makers the condition of the roadway network, and the impact of decisions that do not address the needs.
- It is also recommended that while planning for M&R work the City maintains their use of preservation treatments such as crack sealing, patching, and surface treatments, to preserve the roads currently in good condition. This will prevent them from declining in condition and adding additional requirements for expensive M&R work.